Preparing Hot-Dip Galvanized Steel for

POWDER COATING

Seven steps to prepare your next hot-dip galvanized steel project for powder coating.

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PREPARING HOT-DIP GALVANIZED STEEL FOR POWDER COATING

The Bridge of Lions in St. Augustine, Florida, utilizes a duplex system of powder coating over hot-dip galvanized (HDG) steel for corrosion protection.

Duplex systems, such as paint or powder coating over hot-dip galvanized steel, have been used for years as a means to enhance corrosion protection. Powder coating over hot-dip galvanized steel provides the owner/specifier with effective corrosion protection, while still allowing the structure to achieve a desired color or aesthetic. Duplex systems are becoming increasingly common and popular because of this combination of benefits. Additionally, specifiers may opt to powder coat rather than paint to avoid expending the environmentally detrimental volatile organic compounds (VOC's) present in liquid paints.

Successfully powder coating over hot-dip galvanized steel is relatively simple. Similar to the paint over galvanizing process, proper surface preparation is key to creating an effective bond between the powder coating and the galvanized surface. Galvanized steel requires slightly different preparation steps according to the surface condition. Thus, proper preparation relies on correctly identifying the galvanized surface condition, and then following the appropriate cleaning and profiling steps to achieve optimum bonding of the powder coating to the hot-dip galvanized steel. For detailed instruction on preparing the surface, refer to ASTM D7803: *Standard Practice for Preparation of Zinc (Hot-Dip Galvanized) Coated Iron and Steel Product and Hardware Surfaces for Powder Coating.*

Workers prepare the galvanized surface for powder coating by filing any bumps, runs, or drips created during the galvanizing process.

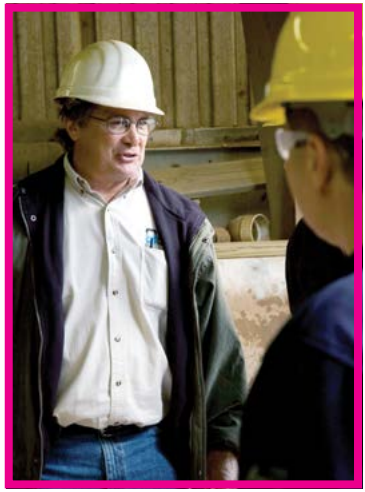
The hot-dip galvanized coating is formed when iron in the steel reacts with zinc in the galvanizing kettle. This metallurgical reaction is a diffusion process, creating a growth of zinc-iron intermetallic layers perpendicular to the steel surface. Zinc, like all metals, is chemically active and when exposed to the atmosphere will attract oxygen, water vapor, and carbon dioxide to its surface to form zinc compounds. The rate of zinc compound formation is determined by a number of variables, including the amount of time since the part was withdrawn from the kettle, the temperature of the part, and the humidity in the atmosphere.

Creating a successful duplex system of powder coating over galvanized steel requires the following seven steps:

- Communicate with the Galvanizer
- Determine Condition of the Surface
- Clean the Surface
- Profile the Surface
- Bake
- Powder Coat
- Cure the Powder Coating

Communicate with the Galvanizer

Communication between the fabricator, specifier, powder coater, and galvanizer is vital before galvanizing. The various parties may desire special handling or require alterations to the design to facilitate the galvanizing process and/or the application of the powder coating. Furthermore, if the galvanizer is aware the part will be powder coated after galvanizing, precautions can be taken to avoid processes that may interfere with the powder coating adhesion.



If notified, the galvanizer can avoid galvanizing processes that could inhibit powder coating adhesion.

Many galvanizing facilities either immerse the part in a water-quench or passivation bath to cool the parts to facilitate quick handling as well as prevent the formation of wet storage stain. The passivation prevents the formation of excessive zinc compounds, but also interferes with powder coating adhesion to the galvanized coating and can lead to blisters and peeling.

There are also two surface imperfections that can inhibit powder coating adhesion; dross and skimming inclusions. Dross particles are made up of zinc and iron and look like pimples. They are sharp and angular atop the coated surface and tend to protrude through powder coatings and thereby cause adhesion problems. Therefore, dross particles must be ground flat to match the surrounding zinc coating profile. If it is not possible to grind the coating flat, the part is not acceptable for powder coating.

Zinc skimming particles can also attach to the coating during removal from the zinc bath. Zinc skimmings are particles of zinc oxide that form on the top of the molten zinc bath. Although skimming inclusions are not cause for rejection of the galvanized part, they should be removed before powder coating.

Determine the Condition of the Surface

Determining the condition of the galvanized surface is critical to employing the proper surface preparation. Galvanized surfaces for powder coating can be classified as newly galvanized or partially weathered. Properly identifying the surface is important because each condition requires a different amount of cleaning and/or profiling.

Newly Galvanized

Newly galvanized steel has been exposed to the atmosphere for no more than 48 hours and has few zinc compounds on the surface. The coating can be bright and shiny, indicating an all-zinc outer layer, or matte gray, indicating a zinc-iron intermetallic outer layer, or a combination of both.

Whether bright or matte, the key factor in the newly galvanized condition is a lack of zinc compounds on the surface, which simplifies the cleaning. Some newly galvanized parts, those with a matte gray, can have a rough surface texture, while bright and shiny parts are often smooth. Regardless if the surface is rough or smooth, profiling the surface by sweep blasting is necessary to ensure the adherence of the powder coating.

It is important to correctly determine the condition of the galvanized surface to be powder coated.

Partially Weathered

Partially weathered galvanized surfaces have a build-up of zinc compounds and, possibly, organic contaminants such as dirt, dust, oil, or grease. The compounds become attached to the zinc coating by electrostatic forces, and can be expected to release from the surface over time. First, the organic compounds need to be cleaned off the galvanized surface. Then zinc compounds, mostly zinc oxide and zinc hydroxide, must be removed before powder coating.

If the parts are stacked too tightly or the humidity is excessive, partially weathered galvanized parts may show signs of wet storage stain. This white powder is created when zinc oxide and zinc hydroxide form a thick layer on the surface. If the partially weathered part shows signs of wet storage stain, the storage stain must be removed before the part can be powder coated.

Partially weathered galvanized steel is the most common galvanized surface condition when powder coating, and also the most difficult to prepare. The partially weathered surface condition is present from two days to about one year after galvanizing, depending on temperature variation and humidity factors.

"DETERMINING THE CONDITION OF THE GALVANIZED SURFACE IS CRITICAL TO EMPLOYING THE PROPER SURFACE PREPARATION."

Clean the Surface

Once the condition of the galvanized surface has been properly identified, the next step is to clean the surface. There are three steps to proper cleaning:

- Remove bumps, runs, & drips (both newly galvanized & partially weathered)
- Remove organic materials (only for partially weathered)
- Rinse and dry (both newly galvanized and partially weathered)

Remove Bumps, Runs, and Drips

The smoothing step requires the removal of any excess zinc produced when withdrawing the steel from the zinc bath. Small bumps and runs can cause concerns if the part is to be powder coated. As the steel is lifted out of the bath, the liquid zinc drains back into the kettle; however, at times the liquid zinc does not drain quickly enough and freezes to the surface or edge of a part. A run is excess zinc that freezes along the part, and a drip is excess zinc that freezes as it falls off the edge of the part, creating an icicle-like zinc spike.

Another surface condition that must be addressed is dross particles. The zinc-iron intermetallic dross particles float in the zinc bath and can be trapped in the outer layer of the coating. Dross particles are thicker than the coating and cause bumps or pimples on the surface. All bumps, runs, drips, and dross particles must be smoothed so they will not protrude through the powder coating.

Sharp icicles created during the galvanizing process must be filed off.

The excess zinc areas (runs, drips, or dross particles) cannot be cleaned by chemical steps so they must be removed by mechanical cleaning such as grinding or filing the surface smooth and flat. The most common practice for removal is to use a hand grinder and lightly abrade away the excess zinc. The grinding and filing must be completed before the chemical cleaning of the part, so the dust and powder from mechanical cleaning can be removed by chemical cleaning. Since pure zinc is a soft metal, care must be taken to remove only the excess zinc material and leave a flat surface without removing the underlying zinc coating.

If the grinding process removes too much zinc, the grinder will begin to produce sparks, indicating it has reached the base steel. When sparks fly, the coating must be repaired before powder coating. Zinc coating repair methods are described in the specification ASTM A780, *Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings,* and include spray metallizing, zinc solder or repair stick, and zinc-rich paints.

Grinding and filing must be completed before the chemical cleaning of a part

Remove Organic Contaminants

Once the galvanized surface is smooth, the next step for partially weathered galvanized steel involves removing all organic contaminants from its surface. Organic contaminants can be removed with an alkaline solution, acidic solution, or solvent cleaning. A mild alkaline solution, a mixture of ten parts water and one part alkaline cleaner, can remove all organics from the surface without damaging the galvanized coating. The alkaline solution can be brush applied or used with a power washer; however, if power washing the pressure must be held below 1450 PSI to ensure the zinc coating is not damaged.

Organic contaminants can also be removed with a mild acidic solution, a mixture of 25 parts water to one part acid. The acidic solution will also slightly etch the zinc coating and leave the surface a dull gray color. Acidic solutions are usually brush applied and should be thoroughly rinsed off the part with fresh water no later than two to three minutes after application. It is good practice to rinse the part twice after using acidic solutions for cleaning.

Finally, solvent cleaning, applying solvents to the surface using a clean cloth, can be used. The cloth will pick up the organics, so it must be changed often to avoid re-depositing them onto he galvanized surface.

Organic contaminants can be removed using alkaline or acidic solutions, or solvent cleaning.

Rinse and Dry

The final cleaning step uses fresh water to rinse the surface of any cleaning solutions. When using acid cleaning solutions, a second fresh water rinse is recommended to remove all traces of the acid cleaner. After the fresh water rinse, the part should be dried before proceeding to the profiling step. It is desirable to use heated drying to accelerate the complete removal of moisture from the surface.

Rinse and dry with fresh water to rid the surface of any cleaning solutions.

As stated before, each of the two surface conditions requires a different combination of these steps. Newly galvanized steel must have all bumps, runs, and drips ground flat, but can skip step two (removal of organic materials), because there is little or no accumulation of organics on newly galvanized surfaces. Upon completion of step one, the surface only requires a rinse and dry. Partially weathered galvanized steel, which is the most common surface condition to powder coat, requires all three steps. If unable to determine the condition, it must be assumed the surface is partially weathered, and all cleaning steps must be followed.

Sweep blasting is the preferred method of profiling because of the soft nature of the zinc surface.

Profile the Surface

Upon completion of cleaning, the galvanized surface must be profiled to provide an anchor for the powder coating. Profiling the surface means to roughen all surfaces before powder coating to promote better adhesion. There are three optional methods to profile the surface.

Sweep Blasting

The first method to provide a profile on the surface is to sweep or brush blast the part per SSPC SP16. Sweep blasting is preferred over standard blasting because the zinc surface is relatively soft and a standard blast would remove most of the coating. Sweep blasting is angled onto the surface at 30 to 60 degrees to remove only the zinc compounds and not the zinc metal layer. Avoid standard blasting process because it uses a 90 degree angle to the part and will remove most of the galvanized coating.

The abrasive material must be chosen with care to provide a stripping action without removing excess zinc layers. One material used successfully is aluminum/magnesium silicate. Particle size should be in the range of 200 to 500 micrometers. Other potential materials are soft mineral sands with a Mohs hardness of five or less, organic media such as corn cobs or walnut shells, or stone materials such as corundum or limestone. Do not use any blasting material with iron in the blast media, as this will cause powder coating adhesion issues and contaminate the galvanized coating.

Sweep blasting of zinc should not be greater than 40 PSI

Sweep blasting of zinc should not be greater than 40 PSI while using these abrasive materials. The substrate should be maintained at a temperature greater than three degrees centigrade above the dew point temperature. If the blasting step removes too much zinc coating, the zinc may be repaired by the process described in ASTM A780.

"ROUGHENING ALL SURFACES THAT WILL BE POWDER COATED PROMOTES BETTER POWDER COATING ADHESION."

Zinc Phosphate Solution

Another method of profiling the galvanized surface is to passivate the surface with a zinc phosphate solution. The zinc phosphate reacts with the zinc metal on the surface of the part to form a layer of zinc compounds that are tightly bonded to the surface. This layer protects the surface from oxidation and gives a rough profile for good powder coating adherence.

Zinc phosphate is applied by dipping the part in a tank of zinc phosphate solution. The part is then rinsed with fresh water and allowed to dry before the powder coating process begins. It is desirable to use heated drying to accelerate the complete removal of water from the surface.

Surface Grinding

The final method of profiling galvanized surfaces is to grind the surface to be powder coated. The grinding will roughen the surface to make a good anchor profile for the powder application and adherence. A removal of up to one mil is acceptable, but the grinder should not be applied with enough force to completely strip the zinc coating. Afterwards, the surface should be blown off with compressed air. In some atmospheric conditions, such as high humidity, temperature, etc., the formation of zinc oxide on the surface will begin very quickly, so powder coating should be applied immediately. Zinc oxide formation is not visible to the unaided eye; therefore, in any atmosphere, powder coating should be started as soon as possible after surface preparation.

Grinding roughens the surface to make a good anchor for the powder application and adherence.

Bake

After the galvanized surface has been cleaned and profiled, the part is ready for the next step, baking. This step is extremely important to prevent pinholes and blisters in the powder coating, commonly known as outgassing. Water and air molecules can be trapped in the zinc coating and must be removed through the baking process. The part should be thermally treated in an oven to remove residual moisture prior to powder application to reduce pin-holing and blistering. The temperature of the baking oven should be 30 degrees centigrade above the temperature used to cure the powder. The part should be baked until the part reaches the oven temperature or a minimum of one hour. The part should then be cooled to a temperature that allows the powder application.

Ovens are used to bake galvanized steel prior to powder coating to prevent outgassing.

Powder Coat

Powder coating should follow baking as soon as possible so there is little or no time for zinc oxidation to begin. Consult the powder manufacturer for information on powder compatibility with zinc coatings. Apply the powder to the galvanized part in accordance with the manufacturer's instructions. Powder is typically sprayed onto the galvanized surface. A good practice is to powder coat a sample piece of galvanized steel to check the overall coating appearance before coating the final piece.

Consult the powder manufacturer for info on compatibility

Cure the Powder Coating

After the powder application the part should be placed in the curing oven. The oven temperature should be set at the value recommended by the powder manufacturer. The curing time should follow the manufacturer's instructions. Since the powder material contains no curing agent, it is critical to the powder coating process to provide an environment where the powder can bond to the galvanized coating.

"THE KEY TO SUCCESSFULLY POWDER COATING HOT-DIP GALVANIZED STEEL IS SURFACE PREPARATION."

The Woodwards Building W Tower in British Columbia utilized a duplex system of powder coating over hot-dip galvanized steel to protect its exposed decorative steel elements from corrosion without detracting from the building's aesthetics.

Summary

A successful duplex system begins at the drawing board. By communicating with the galvanizer up front, any treatments or surface concerns that would impede powder coating adhesion can be avoided. Communication before the project begins can help determine the division of responsibilities by deciding who is responsible for each step of the process. This can eliminate mistakes and omissions when powder coating over galvanized steel.

In addition to what the galvanizer can control, it is imperative to properly identify the surface condition, and follow the appropriate cleaning steps. Finally, profiling the surface to provide a rough anchor for the powder coat will create a effective duplex system. The key to successfully powder coating hot-dip galvanized steel is surface preparation. Following these seven steps will ensure a beautiful, long-lasting, and outstanding duplex system of powder coating over hot-dip galvanizing.

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