



Guide to
Preparing
Hot-Dip
Galvanized
Steel for

Paint



Learn five key steps
to prepare your next
hot-dip galvanized steel
project for paint.

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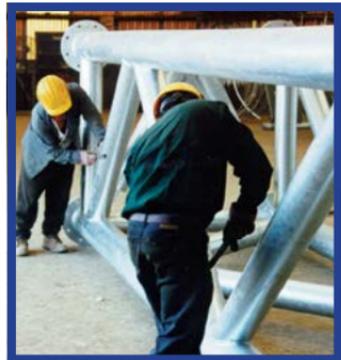
Guide to Preparing Hot-Dip Galvanized Steel for Paint



The Thurston Avenue Bridge utilizes a duplex system of paint over hot-dip galvanized (HDG) steel for corrosion protection

Duplex systems, such as paint over hot-dip galvanized steel, have been used for decades as a means to enhance corrosion protection. Painting over hot-dip galvanized steel provides the owner/specifier with effective corrosion protection, while still allowing the structure to be painted for color or aesthetic reasons. Duplex systems are becoming increasingly common and popular because of this combination of benefits.

Successfully painting over hot-dip galvanized steel is relatively simple. Just like painting on any other surface, proper surface preparation is key to creating an effective bond between the paint 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 paint to the hot-dip galvanized steel. For detailed instruction on preparing the surface, refer to *ASTM D 6386: Practice for Preparation of Zinc (Hot-Dip Galvanized) Coated Iron and Steel Product and Hardware Surfaces for Painting*.



Workers prepare the surface of a galvanized structure for paint by filing off any bumps, runs, or drips created during the galvanizing process.

The hot-dip galvanized coating is formed when the iron in the steel reacts with the zinc in the galvanizing kettle. This metallurgical reaction is a diffusion process, creating a growth of 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rate of zinc compound formation is determined by a number of variables, including the amount of time since the part was withdrawn from the kettle, the temperature of the part, and the humidity in the atmosphere.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 requires the following five steps:



- **Communicate with the galvanizer**
- **Determine the condition of the surface**
- **Clean the surface**
- **Profile the surface**
- **Paint**

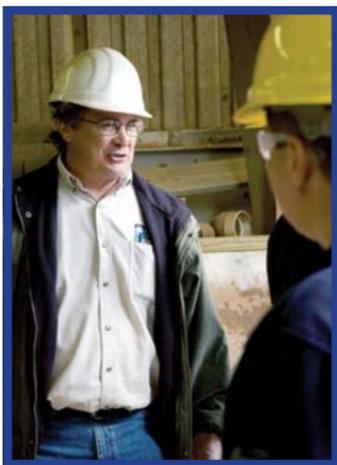
Communicate with the Galvanizer

Communication between the fabricator, specifier, painter, 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 paint. Furthermore, if the galvanizer is aware the part will be painted after galvanizing; precautions can be taken to avoid any processes that may interfere with the adhesion of the paint system.

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 paint adhesion and can lead to paint peeling.

There are also two surface imperfections that can inhibit paint 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 paint coatings and thereby cause adhesion problems. Therefore, dross particles must be ground flat to match the surrounding zinc coating. If it is not possible to grind the coating flat, the part is not acceptable for painting.

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 painting.



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

Determine the Condition of the Surface

Determining the condition of the galvanized surface is critical in employing the proper surface preparation. Galvanized surfaces can be classified as newly galvanized, partially weathered, or fully 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 dull gray, indicating a zinc-iron intermetallic outer layer, or a combination of both.



Whether bright or dull, 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 dull 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 paint system.

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

“...the condition of the galvanized surface is critical in employing the proper surface preparation.”

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. The zinc compounds, mostly zinc oxide and zinc hydroxide, must be removed before painting.

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 become excessive 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 painted.

Partially weathered galvanized steel is the most common galvanized surface condition when painting, 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.

Fully Weathered

Fully weathered galvanized steel has zinc compounds covering the entire surface. The main compound in the fully weathered surface is zinc carbonate. Zinc carbonate is tightly adhered to the surface, is not water soluble, and does not wash off the surface when water hits the part. In this state, the zinc compounds should not be removed, as the paint performs better when the compounds are left on the surface.

Fully weathered galvanized coatings are the simplest surface condition to paint. This condition is present from one year of exposure to the atmosphere until all the zinc coating has been consumed by protecting the underlying steel, which will take decades. Painting of weathered galvanized steel can significantly extend the service life of the corrosion protection system.

Clean the Surface

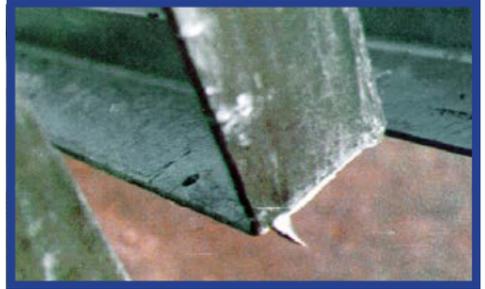
Once the condition of the galvanized surface has been properly identified, the third preparation step is to clean the surface. There are three steps to cleaning the surface:



- **Remove bumps, runs, and drips**
- **Remove organic materials**
- **Rinse and dry**

Remove bumps, runs, and drips

The first 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 painted. 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.



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

Another surface condition that must be addressed is the removal of 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 paint coating.

Runs, drips, or dross particles can be removed by grinding or filing the surface smooth and flat. Since pure zinc is a soft metal, care must be taken to remove the excess zinc material and leave a flat surface without removing the underlying zinc coating.

The excess zinc areas cannot be cleaned by chemical steps so they must be removed by mechanical cleaning. The most common practice for removal is to use a hand grinder and lightly abrade away the excess zinc until the surface is flat and smooth. 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.

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 painting. Zinc coating repair methods are described in the specification ASTM A 780 and include spray metallizing, zinc solder or repair stick, and zinc-rich paints.

Remove organic chemicals

Once the galvanized surface is smooth, step two 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



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

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.



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

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 organics back onto the galvanized surface.

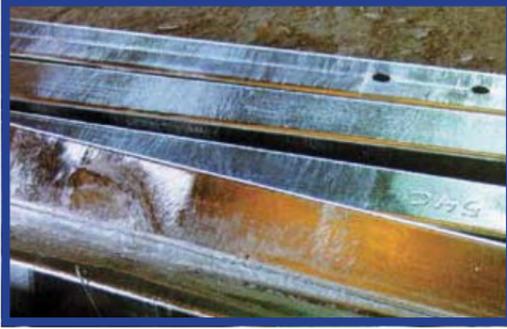
Rinse and Dry

Finally, step three 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



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

of the acid cleaner. After the fresh water rinse, the part should be dried before proceeding to the profiling step. The time after drying until the part is painted should be kept to a minimum (no more than 12 hours) to avoid any further development of zinc compounds on the surface.



Newly galvanized steel, seen above, only requires grinding drips and runs flat and a rinse/dry prior to painting.

As stated before, each of the three different 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 paint, requires all three steps. Fully weathered galvanized steel skips step one, as grinding the surface at this stage would not be beneficial. The zinc patina is fully formed and tightly adhered to the fully weathered surface, creating a more successful duplex system. Therefore, fully weathered galvanized steel only requires the removal of organic materials and a rinse and dry. If unable to determine the condition, it must be assumed the surface is partially weathered, and all cleaning steps must be followed.



The zinc patina on a piece of fully weathered steel, seen left, will create a more successful duplex system when left on the surface.



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 paint. Profiling the surface means to roughen all surfaces to be painted to promote better paint adhesion. There are four potential 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. 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.

A standard blasting process uses a 90 degree angle to the part and would probably 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, or organic media such as corn cobs or walnut shells, or stone materials such as corundum or limestone.

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 A 780.

“Roughening all surfaces that will be painted promotes better paint adhesion.”

Wash Primer

Profiling the surface can also be done by treating the surface with a wash primer. The process is based on three primary components: a resin, a pigment, and an acid. These three components react with the zinc surface to form a thin film no more than 13 microns thick. The wash primer may be applied successfully using spray, and can also be applied by using a brush or roller. The drying time for this system before painting depends on the particular product and the manufacturer's recommendation.

Acrylic Pretreatment

The third method of profiling the galvanized surface for painting is an acrylic passivation pretreatment. This system has an acidic element that etches and roughens the galvanized coating and then deposits an acrylic layer to facilitate paint adhesion.

The application methods for these water-based treatments are: dipping, flow coating, spraying, or other appropriate means. Following application, the acrylic passivation coating is dried in an oven or by air before painting.

Surface Grinding

If necessary, power tools such as grinders or sanders can be used to roughen the surface of the galvanized steel to produce a surface profile suitable for paint adhesion. A removal of up to 1 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 be very quickly, so the paint coating should be applied immediately. Zinc oxide formation is not visible to the unaided eye; therefore, in any atmosphere, painting should be started as soon as possible after surface preparation.

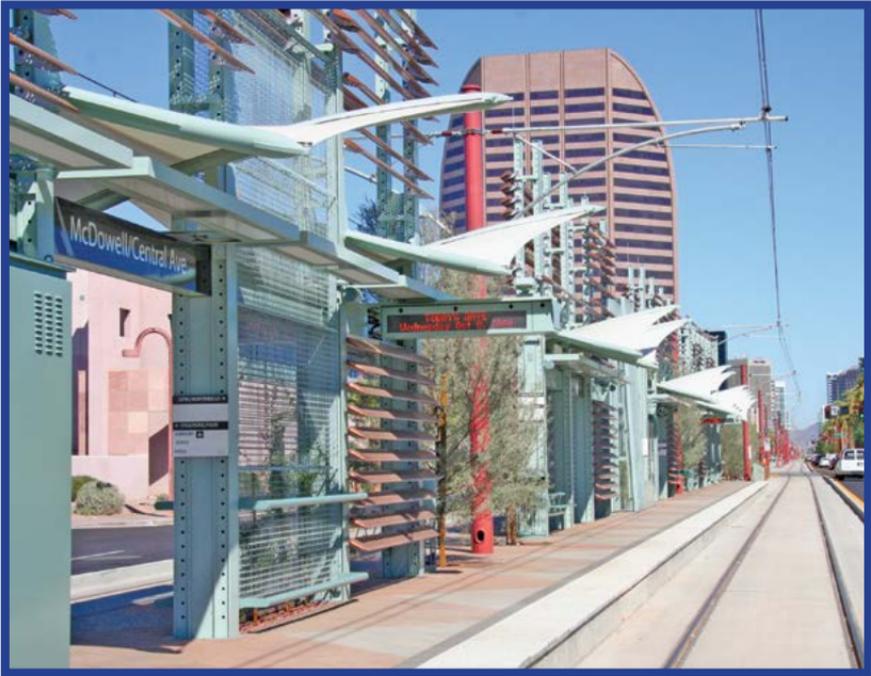


Painting

After the surface of the galvanized part has been cleaned and roughened to provide a profile, the part is ready for the final step, painting. Paint can be applied by brushing or spraying onto the galvanized surface. Please follow the paint manufacturer's recommendations regarding air conditions and application methods.

Painting should begin as soon as possible after cleaning and profiling. There are some paint systems not compatible with zinc coatings; consult the paint manufacturer for information on paint compatibility with zinc coatings.

“The key to successfully painting hot-dip galvanized steel is surface preparation.”



The paint over HDG steel corrosion protection system will protect this light rail station structure for generations to come.

Summary

A successful duplex system begins at the drawing board. By communicating with the galvanizer upfront, he/she can avoid any treatments that would impede paint adhesion. In addition to what the galvanizer can control, it is imperative to properly identify the surface condition, and follow the appropriate cleaning steps for that surface condition. Finally, profiling the surface and selecting paint formulations compatible with zinc coatings will provide a successful duplex system.

Proper surface preparation is critical to producing a high-quality duplex system. Following these five steps will ensure a beautiful, long-lasting, and successful duplex system of paint over hot-dip galvanizing.



American Galvanizers Association

6881 S. Holly Circle, Suite 108

Centennial, CO 80112

Phone: 720-554-0900

www.galvanizeit.org

aga@galvanizeit.org

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