Meet The Experts
at MSC's Online Chats

GALVANIZING STRUCTURAL STEEL

On October 9, 2001, Tom Langill, Technical Director for the American Galvanizing Association, and Kimberly Dunham, Marketing Manger for the American Galvanizing Association hosted an on-line chat with the structural steel community. The following is an edited transcript of the questions and answers from that chat.

Q: Why is the coating appearance sometimes bright and sometimes dull?

A: Shiny vs. dull? Galvanized coatings are made up of a series of corrosion-inhibiting, abrasion-resistant zinc/iron alloy layers, typically covered by a layer that is almost pure zinc. Newly galvanized parts with this typical pure outer zinc layer are highly reflective. Parts will become less reflective naturally, over time, as the galvanized part weathers and a tenacious zinc carbonate patina forms. It is important to note that corrosion prevention does not depend upon coating appearance. Surface dulling occurs naturally, and neither compromises nor enhances corrosion protection. Galvanized coatings are formed by a chemical process during which steel and zinc metallurgically bond, forming a series of corrosion-inhibiting, highly abrasion-resistant zinc/iron alloy layers. The chemistry of the steel being galvanized influences galvanized coating appearance. Galvanized coatings on steels with common chemistries are typically shinier than are coatings on reactive steels, which tend to produce matte gray coatings. Galvanized coatings are specified for their corrosion resistance. While a gray or matte appearance may occur, the corrosion protection afforded is no different than that provided by shinier galvanized coatings. The corrosion resistance of matte coatings, mil for mil, is equal to the more typical bright, shiny galvanized coating. When possible, the galvanizer should be advised of the grade of steel selected in order to determine whether to make accommodations in the galvanizing process.

Q: I've heard painting over galvanized steel is difficult. How is it done so that the paint adheres to the zinc?

A: Successfully painting hot-dip galvanized steel, also known as a duplex system, does not have to be difficult or confusing. Just like painting over anything else, proper surface preparation is crucial to ensuring effective adhesion. The two keys to proper surface preparation are:

- cleaning (to remove surface contaminants), and
- profiling (to allow good mechanical bonding).

If hot-dip galvanized steel is to be painted, arrangements must be made to eliminate the quenching step. Sometimes, galvanized steel is passivation-quenched immediately after galvanizing; quenching solutions interfere with paint adhesion and must be removed prior to painting. Whichever method of preparation is used, care must be taken not to remove too much of the zinc coating. Highly acidic or basic cleaning solutions remove some of the zinc coating; so does high-pressure sweep-blasting. Naturally, the more zinc removed, the less corrosion protection provided. With the exception of alkyds, there are many paint formulations entirely compatible with hot-dip galvanized coatings. Because paint formulations are constantly changing, paint manufacturers should be consulted regarding which of their products are best suited for duplex coating galvanized steel. For additional information on surface preparation, consult ASTM D-6386. Additionally, the AGA has a publication, *Duplex Systems: Painting Over Hot-Dip Galvanized Steel*, which is available to download

free from our web site, www.galvanizeit.org.

Q: How do you weld on galvanized steel? I know there are some recommendations to prevent zinc fume sickness.

A: Welding fabrications before and after galvanizing is common. Requirements to allow for this are relatively simple to implement. Both welding before and after galvanizing are compatible with the objective of providing superior corrosion protection. It is essential to understand that considerations for welding galvanized steel (as for galvanizing welded steel) must be integrated into the overall structural fabrication design. All commonly practiced welding and cutting techniques (gas metal arc, shielded metal arc, manual metal arc, oxyacetylene, friction, resistance) can be used on galvanized steel (see American Welding Society's [AWS] specification D-19.0, Welding Zinc Coated Steel). AWS D-19.0 calls for welds of galvanized steel on areas that are free of zinc, which indicates that you should either grind off or burn off the zinc coating prior to welding galvanized steel. Welding galvanized steel should always be done in well-ventilated locations to minimize fume inhalation. The AWS publication, ANSI/ASC Z-49.1, Safety and Cutting in Welding, covers all aspects of welding safety and health. The AGA has a recently written white paper, *Welding and Hot-Dip Galvanizing*, which is available free of charge from the AGA. Drop me an e-mail at marketing@galvanizeit.org and we'll get a copy to you.

Q: What is the ASTM Spec for galvanizing for structural steel shapes?

A: The ASTM spec that covers structural steel shapes is ASTM A123/123M. After-fabrication, batch hot-dip galvanizers, including those that are members of the AGA, galvanize to ASTM A123/123M, *Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products*; A153/153M, *Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware*; and/or A757/757M *Specification for Zinc-Coated (Galvanized) Steel Bars for Concrete Reinforcement*. These specifications include details for minimum average coating thickness grade by material category and weight of zinc coating for various classes of material. Because the coating thickness is determined by thickness of steel and steel chemistry, galvanizers have little, if any, control over the thickness of the coating obtained. For standard structural shapes and plates, ASTM A123/123M requires a minimum average coating thickness of 3.9 mils. Industry surveys, however, indicate that the standard galvanizing process would produce a coating of between 5 and 7 mils of zinc to such a product. Hot-dip galvanized fasteners, depending upon diameter, will have from 1.7 to 3.4 mils (43-86 microns) of zinc coating.

Q: Can I tell the galvanizer how much zinc to put on the steel? I know the more zinc the better so why not apply it very thick?

A: Galvanizers have little, if any, control over the thickness of zinc coating. Zinc coating development depends primarily upon steel chemistry. All other controls are secondary or tertiary controls in the process.

Q: Does galvanizing change the mechanical properties of the steel?

A: In a nutshell, No. The mechanical properties of steels typically galvanized are not affected by any step in the galvanizing process. However, hydrogen embrittlement is of concern for steels of ultimate tensile strength of 150 ksi (1100 MPa). During the chemical reaction between steel, rust and the chemicals used in the pickling stages of the galvanizing process, hydrogen is produced and absorbed by the steel. To conclude, the very small grain structure of high-strength steel prevents the hydrogen from being expelled during immersion in the molten zinc. When put under stress in use, the steel may become brittle and fracture.

Q: Do you have to make bolt holes bigger to accommodate the galvanizing thickness?

A: Clearance holes should be oversized holes to account for coating thickness on the thread and on the inner diameter of the hole. Threaded holes should be cut after galvanizing to accommodate the coating on the threads of the fastener. The coating on the threads will protect the inner diameter of the hole.

Q: I know that steel sometimes distorts when galvanized. Why and how can it be prevented?

A: Steel being galvanized progresses through a temperature cycle upon immersion and withdrawal from the galvanizing bath. Because parts are immersed at an angle, uneven heating occurs, creating a temperature profile along the part being galvanized. This temperature profile allows the steel's internal stresses to be relieved at different times in the immersion cycle. These stresses may cause changes in shape and/or alignment (distortion and warping). The guidelines for safeguarding against warping and distortion during hot-dip galvanizing of steel assemblies are outlined in ASTM A384.

Q: What is the bond strength between the zinc and steel? We have high maintenance costs in the field for paint because of rough handling and scratches. Can galvanizing eliminate field touchup?

A: The bond between zinc and steel is on the order of several thousand psi, versus barrier coatings,

which have a bond strength between steel and coating on the order of a few hundred psi. Galvanized coatings' bond strength provides superior abrasion resistance. Galvanizing provides cathodic protection so that small scratches and damage in the field do not need to be touched up. ASTM A 780 provides guidelines to follow with respect to touch-up and repair. Areas suitable for touch-up and repair are defined in ASTM A123.

Q: I live on a farm and it seems that the siding we use on the barns and silos doesn't last as long as it used to. What is the difference between today's galvanized steel and that of 30 years ago?

A: The product you're describing is a sheet product, not after-fabrication hot-dip galvanized steel. There are two common practices for applying the zinc in hot-dip galvanizing. One involves the application of zinc onto steel sheet as it is passed as a continuous ribbon of steel through a bath of molten zinc at high speeds. Hence, the term "continuous" hot-dip galvanizing. As one coil is being processed through the coating bath, another is being welded to the trailing edge of the first coil. Thus, the process is truly "continuous"; the coating line may indeed operate continuously for days without interruption. The other process involves the application of a zinc coating to the surface of steel parts after the parts have been fabricated. This process is not a continuous process in that the parts are immersed as a discrete "batch" into the zinc bath. Hence, the names "batch", "after fabrication" and "general" galvanizing are applied to this process. However, it's our understanding that the typical coating applied to sheet products is significantly thinner than coatings applied in the past and therefore the service-life is shortened.

Q: How long does galvanized steel last? We specify jobs for petro-chem plants, pulp and paper plants, and power generation.

A: Galvanizing is the choice for corrosion protection because the stable, non-reactive zinc patina that develops after several months of atmospheric exposure provides a coating that delivers maintenance-free performance for decades. With a corrosion rate $^{1}/_{10}$ to $^{1}/_{30}$ that of ungalvanized steel (as determined by ASTM in-field studies since the 1920s), depending on the environment (industrial – most aggressive, to rural – least aggressive), the thicker the zinc coating, the longer lasting the corrosion protection. Variables in the environment that determine the service life (corrosion rate) include:

- chlorides
- humidity
- rainfall
- salinity
- sulfur dioxide
- temperature

The AGA has a publication, *Hot-Dip Galvanizing for Corrosion Protection: A Specifier's Guide*, which is available to download free from our web site, www.galvanizeit.org. Service-life predictor information is available in this publication.

Q: How can galvanized steel be repaired if it needs touchup? My galvanizer uses a process called cold galvanizing. I thought all galvanizing required hot zinc.

A: Cold galvanizing is actually zinc-rich paint, not immersing steel into molten zinc to form a metallurgical bond. The process of "cold galvanizing" is described in ASTM A780.

Q: A senior engineer at our company says that the fabrication requirements to have steel galvanized are difficult. Is that true?

A: Throughout North America, a variety of sizes of hot-dip galvanizing kettles are available, allowing a wide size-range of structural fabrications to be galvanized. Designing and fabricating in modules suitable for the available galvanizing facilities allows almost any component to be galvanized. For oversized fabrications, best practice suggests that they be designed in modules or sub-units and assembled after galvanizing.

Vent and drain holes are necessary to include in structural fabrications, primarily to allow air to be evacuated from within and around the fabrication, allowing the fabrication to be completely immersed in the molten zinc and for the excess zinc to drain out and away from the part. The secondary reason for vent and drain holes is that, if fabrications to be galvanized are not properly vented, moisture or gas trapped in overlapping or contacting surfaces flashes to steam. The resulting pressure increase can rupture the fabrication. Additionally, trapped moisture that flashes to steam can result in localized uncoated surfaces. If cleaning solution or rinse waters are trapped in a blind or closed joining connection, they are converted to superheated steam or gas when immersed in molten zinc at temperatures of more than 800°F (430C) and can develop a pressure of 3600 psi (25 MPa). It is important to understand that items being galvanized are immersed in and withdrawn from all cleaning solutions and molten zinc at an angle. Vent holes should be located at the highest point and drain holes at the lowest point as mounted during the galvanizing process. The AGA has a publication addressing numerous design considerations, *The Design of Products to be Hot-Dip Galvanized* After Fabrication, which is available to download free from our web site, www.galvanizeit.org.

Q: Since we use a lot of galvanized fencing, stock panels, pens and troughs, is the zinc harmful to our animals?

A: Zinc, a micronutrient, is friendly to the environment and to biological organisms. It's essential to life and has been used for many

years in the agricultural industry with no known detrimental effect to animal life.

Q: Why can't high strength bolts be galvanized? I would like to use them for many designs. Also, since I can't get a high coefficient of friction with galvanized steel, what do you suggest?

A: A325 bolts can be, and commonly are, galvanized. What you're referring to most likely is the concern with galvanizing A490 bolts. The common assumption is that high-strength bolts cannot be galvanized because of the heat to which they are exposed in the galvanizing process. In reality, it is the cleaning solutions used in the process that can cause problems, specifically embrittlement, in high-strength bolts. In Europe, high-strength bolts are galvanized, but they are mechanically cleaned and then flash-pickled prior to immersion in the molten zinc bath. Steps are being taken in the U.S. to allow for a similar procedure, but at this time it is not permissible to galvanize A490 bolts in the U.S. The coefficient of friction significantly increases when the galvanized surface is roughened using a non-carbon steel brush (brass or stainless are suggested). Another material to increase the friction is a layer of zinc silicate paint in the area of the contacting surfaces.

Q: Is galvanized steel safe to use on pipe transporting drinking water?

A: Galvanized steel can be NSF-certified on a case-by-case basis, usually only used for large diameter (greater than 4 inches) pipe for conveyance of potable water.

Q: I've seen some steel with a white powdery substance on the surface. What is it and is it harmful?

A: The white, powdery substance is the first phase of formation of the zinc patina, which consists of zinc oxide. This converts to zinc hydroxide and then zinc carbonate. It is not harmful.

Q: How many galvanizers are there in the U.S?

A: Galvanizers are located throughout North America. A list of the member galvanizers of the AGA can be found at our web site, www.galvanizeit.org. There are a variety of galvanizing facility types, including captive, job shops, fence, wire, etc. There are approximately 200 general galvanizing facilities in North America.

Q: What are the most common uses for galvanized steel?

A: The most common uses for galvanized steel include bridge and highway products, electrical distribution and transmission, agricultural and food processing, water and marine environments, reinforcing steel, petro/chem, pulp and paper, recreation, transportation.

Q: Can galvanized steel be used in contact with other metals?

A: Yes, galvanized steel can be used in contact with other metals, including aluminum, stainless and weathering steel, among others. The key consideration is relative areas of cathodic vs. anodic areas. For plain carbon steel and some types of stainless steel, electrolytic action between the two meals can take place when condensation/moisture is in the environment, and that situation should be avoided.

Q: What is the largest piece of steel that can be galvanized?

A: There is a kettle in Kansas that is 82 feet long. Average kettle size is 40-50 feet in length. Kettle dimensions are available on our web site, www.galvanizeit.org.

Q: With an 82' kettle, how big a piece can be galvanized?

A: That galvanizer does "progressively dip," and can galvanize $1^{1}/_{3}$ the length of the kettle. Anything in excess of that, the galvanizer should be consulted in advance.

Q: I need specific information about structural details when the steel is going to be galvanized. Do you have that information?

A: We have a guide to details. If you'll e-mail me your mailing address later, to marketing@galvanizeit.org. I'll send you a copy.

Q: The OSHA standard requires certification that the galvanized steel meets the minimum slip requirements. Would my galvanizer be able to provide this information? Or, where would I obtain this information?

A: Galvanized steel performs in slip the same as plain carbon steel, so there should be no special precautions when a galvanized steel beam is used during erection. We haven't developed information of this sort at this time. If you want the data, contact Dr. Tom Langill at the association (800.468.7732, tlangill@galvanizeit.org).

Q: I've only seen gray galvanizing. Does it come in other colors? My grandmother is a sculptor and likes to use things that last but she also likes colors.

A: Zinc can't be colored. It's either shiny silver or matte gray. It

can be painted, but the zinc itself is only silvery-bluish.

Q: What is the difference between "metalizing" and galvanizing?

A: Metalizing is spraying molten zinc powder or wire onto cleaned steel. There is no metallurgical bond, but there is adhesion of the powder / wire to the steel surface. The coating obtained is significantly thinner than that of hot-dip galvanized coatings.

Q: In the past we experienced some difficulties with some galvanized poles. Some galvanized poles fell off the truck and shattered like glass. Do you know what may have caused this to happen?

A: Embrittlement probably was the culprit. This could have been caused by steel processing or by the cleaning process used in the galvanizer's facility. It's difficult to determine specifically, because that occurrence is very rare.

Q: When shouldn't galvanizing be specified?

A: Galvanizing shouldn't be specified for highly acidic environments (food handling with citrus materials, areas of pulp and paper mills where cleaning acids exist in the microenvironment), highly alkaline environments, or for very high temperature applications (over 400°F).