# Good Chemistry

BY GEOFF WEISENBERGER

**MSC pays a visit to an Aztec Galvanizing facility in Texas and provides a step-by-step look at the process of applying a protective zinc coating to steel.**

**"YOU CAN DRIVE A MILE AND PASS 10 COMPLETELY DIFFERENT USES OF GALVANIZED STEEL."** These are the words of Dale Williams, division sales manager with Aztec Galvanizing Services, as we drive from Aztec's Ft. Worth headquarters to its plant in Crowley, Texas. We're on our way to take an up-close-and-personal look at the hot-dip galvanizing process, that wonderful chemical reaction that adds a silver-gray anti-corrosive coating to steel.

Along the way, Williams points out multiple real-world applications of Aztec's services, including a hospital featuring non-exposed galvanized structural steel beams; the Ft. Worth Convention Center, where steel braces holding up the canopies are galvanized; and several examples right outside our moving car—the galvanized supports for highway signage. In addition, he notes, galvanizing has made a big push in parking garages, where beams are not only exposed to view, but to the elements as well.

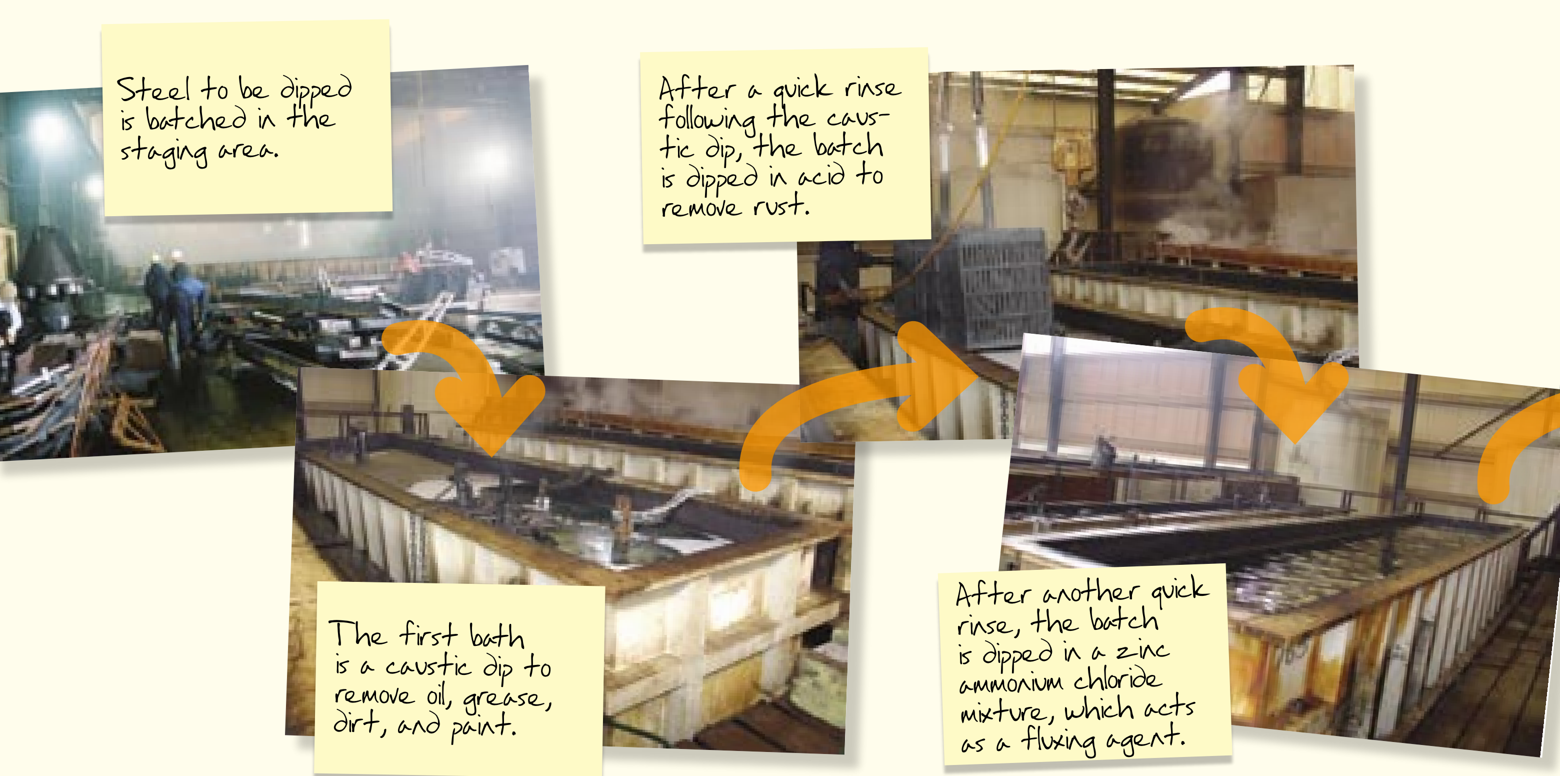
Sitting in the back seat with Tim Pendley, Aztec's vice president of operations, I ask why one of the most conspicuous uses of mass amounts of exposed structural steel—bridges—doesn't generally employ galvanizing. "As much as we would like to do bridge sections, some kettles don't match the requirements of bridge spans," he answers, referring to the longer members that steel bridges typically employ; Aztec has several zinc kettles across the U.S., the longest of which (58 ft) is at the plant we're on our way to visit. (For a list of other galvanizers and their kettle sizes, see our Steel Galvanizer Listing on page 63.)

While a longer kettle might seem like an easy solution, Pendley explains that you get to a point where it's not profitable to keep expanding kettle length, since not every steel batch being dipped is a long-span member. Double dipping—one end, then the other—isn't really an option either, he says, since bridge spans often have a built-in camber, and the high temperature required for galvanizing can inadvertently remove this camber.

### What it Is

The galvanizing process, discovered in the 1700s, adds a protective zinc coating to steel and prevents oxidization. Zinc and iron react to one another through a diffusion process, creating a four-layer zinc-iron alloy. Pendley estimates that roughly 23 percent of steel in the U.S. is galvanized, while the percentage in Europe is substantially greater.

The process itself is fairly straightforward and really hasn't changed much in the last 200 years. The material-handling aspect—which has evolved from using a mule, a rope, and a pulley to pull the steel in and out of the kettles, to automated lifts—is where the biggest changes have taken place, Pendley says.



### Where it All Happens

The Crowley plant, which services about 300 fabrication customers, can operate 24 hours a day, although it currently runs about 18 hours a day. It was built in 2001 to replace a smaller nearby plant that opened in 1967. Aztec adjusts its service prices monthly, based on the price of zinc; it was $1.86 per lb the last time Pendley checked.

As we arrive at the plant, Pendley explains that venting is a crucial step for steel elements that will be put through the galvanizing process, particularly with hollow pieces. When moisture trapped inside an element becomes super-heated, it can generate 3,800 psi of pressure and blow a steel piece apart. Aztec makes sure to check steel for proper venting before putting it through the galvanizing process, and in cases where steel isn't vented properly, they contact the fabricator and perform the venting themselves on-site using torching or drilling.

### Down the Line

We start the tour at one end of the facility, a long, steel-framed metal building with garage-style doors running the length on both sides. This is the staging area, where steel pieces of all shapes and sizes wait to be galvanized. The most unusual item to be dipped today is a circular segment from a large piece of mechanical farming equipment.

It's a humid, cloudy day, and there's a lot of condensation in the plant. But weather conditions have no effect on the galvanizing process, so there's plenty of activity to observe. Looking down the plant from the staging area, we watch several batches of steel being transported by cranes from vat to vat. There are six vats in all:

1 Steel comes into the facility in various stages of cleanliness, so the first "bath" that a steel batch takes after the staging area is a high-pH (above 14) caustic dip, which removes oil, grease, dirt, and paint. "That acts as a giant washing machine," says Pendley. Sodium hydroxide is the primary chemical in the dip, which also includes proprietary emulsifiers and surfactants. The metal rests in the caustic bath for 15 minutes to an hour, depending on its condition.

2 After the batch is dipped in the caustic fluid, it must be neutralized, so it's dipped in water.

3 The third step is an acid bath, which removes any oxidization. Either sulfuric or hydrochloric acid is used for this "pickling" process. The industry started with sulfuric acid, which the Crowley plant uses, but hydrochloric eventually became more available. The two acids attack oxide in different ways. Sulfuric finds fissures in the oxide layer, penetrates next to the base metal, and removes the oxide layer. Hydrochloric acid is a bit more forgiving on the base metal in that it simply dissolves the oxide layer. The acid bath lasts between 7 and 15 minutes, depending on the metal's rust condition. Metal with heavy oxides might stay in for up to 30 minutes.

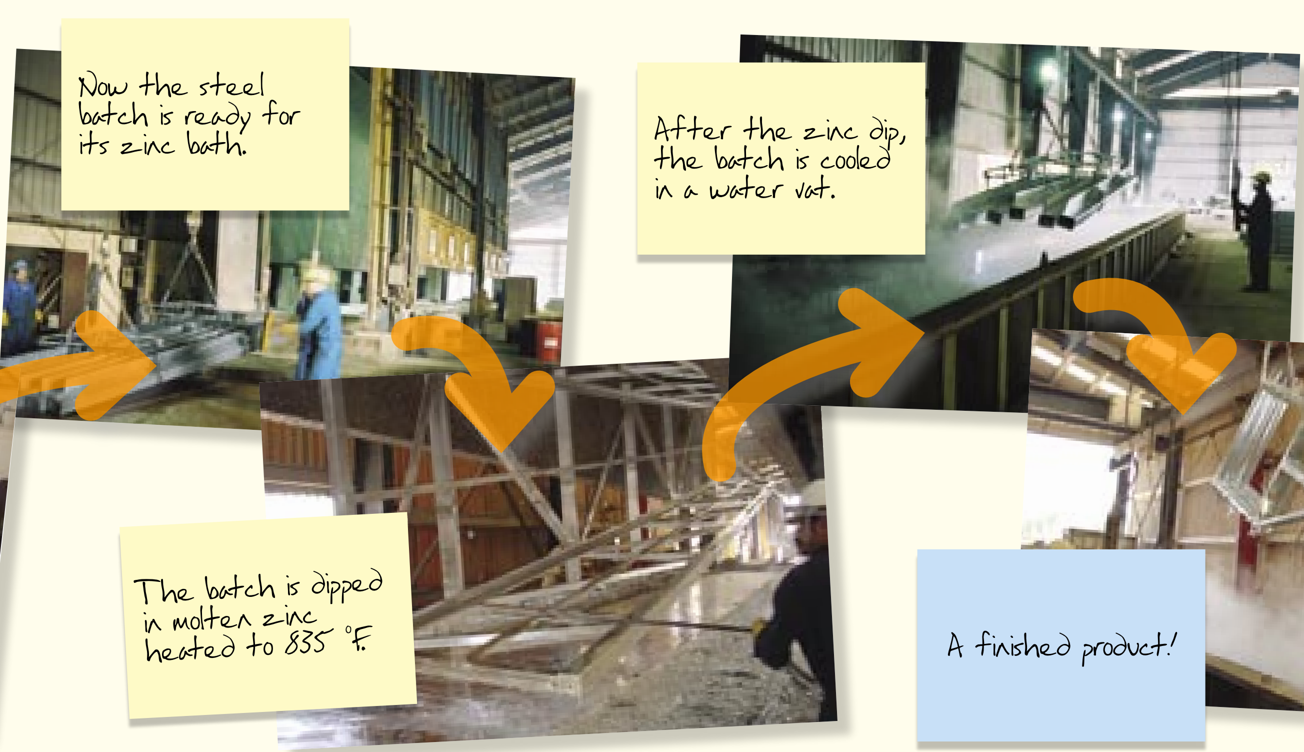
4 Step 4 is another water bath to rinse off the acid.

5 The final bath before the actual zinc dip is a low-pH zinc ammonium chloride mixture, which acts as a fluxing agent. It also contains a chlorine salt that encapsulates the metal and prevents it from oxidizing again.

6 It's zinc time! The batch is dipped in a kettle that holds just under 2 million lb of 835 °F molten zinc. The bath is 99% pure zinc, along with a small amount of aluminum and other proprietary chemicals. "The exciting part about hot-dip galvanizing is that you immerse it in the bath, and the reaction takes place by Mother Nature," says Pendley. Once the base metal reaches the 835 °F mark, which usually takes about 3½ minutes, the reaction is complete.

We observe several batches being lowered into the zinc bath, and as each is immersed, a protective panel lowers to keep zinc from splattering over the side of the vat. When the panel is raised, I ask how close I can get to the vat. "You can go right up to it, but you don't want to stick your finger in it," laughs Pendley.

Once a batch is removed from the zinc, it is officially galvanized—a finished product. There is no cure time, although each batch is typically dipped in a vat of water for cooling. We watch as one batch, a bundle of hollow steel tubes, emerges from the cooling vat. A worker taps it to remove excess water, essentially turning it into a




Photos by Geoff Weisenberger and Dale Williams.

makeshift musical instrument. The members of Blue Man Group would be proud.

The entire process takes roughly an hour. To maximize productivity, the Crowley plant lines up jobs such that while one batch is in one bath, another batch is in the bath preceding it, and so on. Also, Aztec bundles its steel orders together in an effort to maximize crane capacity. In addition, there are two lifts for the zinc kettle, one at the front and one at the back, so two batches can be hot-dipped simultaneously.

We take a look at a completed batch, which began as a painted, rusty piece of metal and is now a silver-gray commodity—a dramatic transformation. Williams gives it a good once-over. Once the steel is galvanized, he explains, quality control is essentially built in, as defects or holes in the coating are visible to the naked eye. "If it looks good, it is good," he says. If there are defects, the steel can be put through the entire process again.

### The Green Factor

As we head back outside to the materials yard—steel that's waiting to be galvanized resides outside the staging area of the building, and finished products are stored at the opposite end, waiting to be carted away—Pendley and Williams point out another advantage of galvanizing: sustainability. Steel itself is promoted as a sustainable structural material, but it's not as well known that other facets of the steel industry, such as galvanizing, can be sustainable as well.

Rick Wood, manager of the Crowley plant, provides a run-down of how the fluids in each of the tanks are handled. Once a year the caustic tank solution is pumped over to a rinse tank, and the sludge is removed from the tank, treated, and sent to a landfill as a non-hazardous waste. The solution is pumped back over to the caustic tank and re-built to operational specifications. Acid tank solutions are changed out every three months or so, depending on the production level. The spent acid is sent to a deep injection well site for disposal. Water from the caustic rinse and acid rinse tanks are used to build new caustic and acid solutions. The preflux solution and tank goes through the same cleaning and recycling process used for the caustic solution and tank.

The zinc used at the plant is 100 percent recyclable, and 30 percent of the zinc in North America comes from recycled sources. Aztec removes dross from the kettle about every two weeks. Dross is slag material that's created from small particles of iron coming off the steel being dipped; the iron particles are encapsulated by zinc, and because they're heavier than zinc, fall to the bottom of the kettle. Aztec sells the dross to a company that recycles the zinc from the dross, then sells the zinc back to Aztec.

In addition, zinc oxide that forms during the galvanizing process is ladled off the top of the kettle and processed in a machine that separates the zinc from the zinc oxide. The zinc is returned to the kettle and the zinc oxide material is sold to the same company that recycles the zinc from the dross. From there, the zinc oxide can be used in a number of applications, including health-care products, cosmetics, animal feed, and paint.

When it comes to the kettle itself, Pendley notes that you can typically get seven years of life out of a kettle. We drive past a new one sitting in the materials yard on our way out of the plant.

It's been an educational morning, but now it's time for lunch. We head to a local BBQ restaurant—excellent brisket—where dipping meat in the tangy sauce reminds me of steel being dipped in the various vats at the plant. And it dawns on me that the same rule that applies to a galvanized piece of steel applies to BBQ: If it looks good, it is good. MSC