Hot-Dip Galvanizing Costs Less & Lasts Longer

AMERICAN GALVANIZERS ASSOCIATION

COVER PHOTOS:

Top photo	Black Sea Export Terminal Constanta, Romania Valmont Coatings
Middle photo	Muskingum River Parkway (Ohio S.R. 22) Zanesville, Ohio Gregory Galvanizing & Young Galvanizing
Bottom photo	Mono Palm Site Concealed PCS Pole Pierpoint Bay, California Aztec Galvanizing Services - Arizona Galvanizing

HOT-DIP GALVANIZING COSTS LESS & LASTS LONGER

The selection of a corrosion protection system for steel products is made from a variety of different coatings, each one with a unique set of characteristics. Those characteristics include method of application; adhesion to the base metal; corner, edge and thread protection; and coating hardness, density and thickness. All affect the corrosion protection system's applicability for the project. As well, each coating system must be evaluated for the relative economics and expected service-life.

When compared with paint systems, hot-dip galvanizing after fabrication has comparable initial application costs and, almost always, lower life-cycle costs. In fact, the lower life-cycle costs of a hot-dip galvanized project make galvanizing the smart choice for today *and* tomorrow.

In most cases, hot-dip galvanizing provides superior performance characteristics when compared to paint and other coatings. Those characteristics include:

- Barrier and cathodic protection for 30 - 75 years, depending upon environment,
- Metallurgical bond strength > 3600 psi (25 MPa),
- Complete coverage and coating integrity inside tubular sections and in hard-to-reach places,
- Uniform edge/corner coating thickness, and
- Abrasion resistance.

Coating Selection

Unquestionably, hot-dip galvanizing provides long-term corrosion protection. However, the selection of galvanizing as the preferred coating system is not complete without considering the economic variables. Those variables include:

- Original coating cost,
- Maintenance costs (touchup, maintenance repaint, full repaint), and
- Indirect costs (site accessibility, loss of productivity during maintenance, commuter delay).

Because neither the timing nor costs of future maintenance can be precisely predicted, the selection of the most economical system cannot be exact. In addition, depreciation of capital invested, tax treatment for investment and maintenance costs, and the time-value of money must be considered. All of these factors can change over time.

Cost Analysis

Using data collected in nationwide surveys of the hot-dip galvanizing industry (conducted by the American Galvanizers Association) and the paint industry (conducted by the National Association of Corrosion Engineers), an economic analysis of original and life-cycle costs provides an interesting comparison.

Original Costs

Although not recommended as reflecting the true cost of a corrosion protection system, original costs are sometimes the primary determinant for selection. As can be seen in Figure 1 (page 2), hot-dip galvanizing's original cost is compared to those of four typical paint systems. Hot-dip galvanizing is more economical from an initial cost standpoint for all but the one-coat zinc-rich paint and the two-coat acrylic waterborne paint. This is the case when galvanizing is compared to many of the commonly used industrial paint systems. Additionally, hot-dip galvanizing may be even more economical when the project calls for small-weight-per-beam-length structural steel and/or assemblies, because of the efficient handling of many pieces in the galvanizing process.

Life-cycle Costs

Because of the long life of the hot-dip galvanized coating and its virtually maintenance-free performance, galvanizing is consistently a better value than paint over a structure's life. Galvanizing durability and lifetime performance make it the logical choice when it is the lowest original cost system. However, as the material's weight-per-beam-length increases, galvanizing may be initially more expensive than some paint systems. In these cases, life-cycle cost information must be examined to discover the true value of hot-dip galvanizing.

Life-cycle cost is the analysis of the true cost of a coating system over its entire service-life. It considers original costs, touchup costs, maintenance costs, repainting costs, inflation, and opportunity costs. So, using the standard formula for the time-value of money, the true cost in present day dollars (NPV) is calculated as:

$$NPV = NFV/(1+R)^n \text{ where } NFV = \text{current cost}(1+I)^n$$

Where: NPV, net present value
NFV, net future value
R, interest rate
n, lifetime of the project
I, inflation rate

Galvanizing is considerably more economical over the project's lifetime than even the simplest of one- or two-coat paint systems, as is strongly demonstrated in Figure 1.

If the practical maintenance cycle for paint is not strictly adhered to, life-cycle costs could be significantly higher than presented in Figure 1.

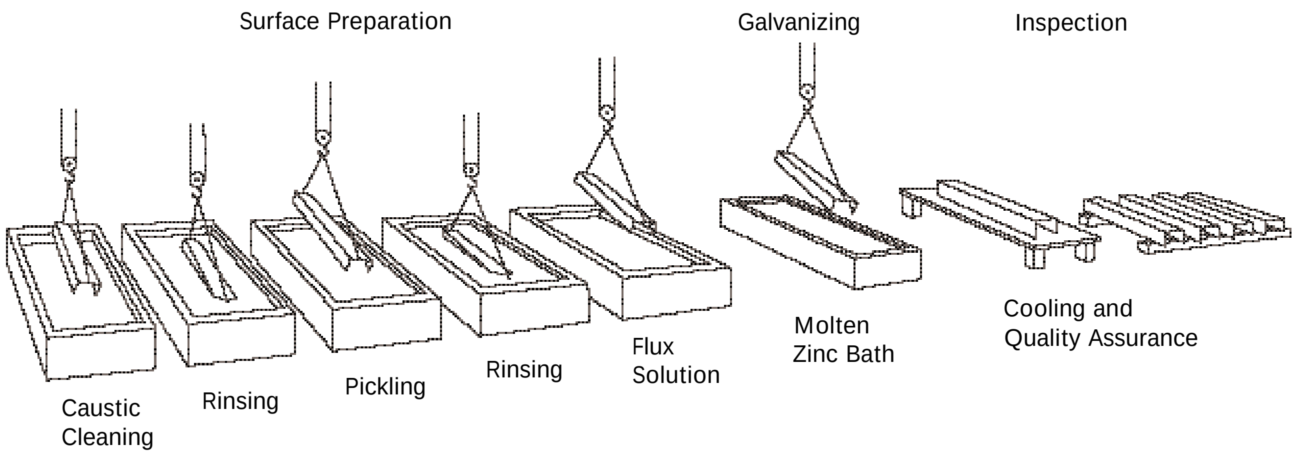
Figure 1

APPLIED COST OF HOT-DIP GALVANIZING & FOUR SELECTED PAINT SYSTEMS - ORIGINAL & LIFE-CYCLE

Coating System	Original Cost ($/sq. ft.)	Life-Cycle Cost ($/sq. ft.) 30-Year Project Performance
Hot-Dip Galvanizing	**$1.67**	**$1.67**
Inorganic Zinc	$0.87	$2.72
Acrylic Waterborne Primer/ Acrylic Waterborne Topcoat	$1.33	$4.20
Inorganic Zinc Primer/High-Build Epoxy/Acrylic Urethane	$2.28	$5.34
Latex Primer/Latex Intermediate/ Latex Topcoat	$1.71	$6.42

Notes:
1. U.S. Dollars
2. Galvanizing data from 2001 nationwide industry survey
3. Paint data from 1998 NACE Paper #509
   - 5% increase in paint material cost/year since 1998
   - 3% increase in paint preparation cost/year since 1998
4. Maintenance repaint at 5% rust, moderately industrial environment, practical maintenance cycle

Figure 2



HOT-DIP GALVANIZING PROCESS

A proven cost-effective and durable corrosion protection system, hot-dip galvanizing entails cleaning steel in a series of chemical solutions and then immersing the steel in a bath of molten zinc metal. The zinc from the bath and iron from the steel metallurgically combine to form the galvanized coating that protects the underlying steel from corrosive attack. Figure 2 provides an illustration of the galvanizing process steps.

HOT-DIP GALVANIZING — PERFORMANCE CHARACTERISTICS & ADVANTAGES

Barrier & Cathodic Protection

There are two main methods to protect steel from corrosion: barrier and cathodic. Barrier protection simply shields the steel surface from the environment. With the exception of zinc, most coatings - such as paints - provide only barrier protection. Any scratch, penetration, pinhole, or porosity resulting from age, handling or usage compromises the coating and allows corrosion of the underlying steel to begin. Cathodic protection allows an element such as zinc to act as the anodic area on the steel. As the anode, zinc preferentially corrodes, keeping the cathode (base steel) intact. This sacrificial action is also known as "galvanic protection;" only galvanizing delivers an economical combined cathodic and barrier coating protection to steel.

Galvanized coatings' excellent field performance results from zinc's intrinsic corrosion resistance and its ability to form a dense, protective layer on the surface. While fresh zinc surfaces are quite reactive, a thin layer of protective reaction products forms upon exposure to the atmosphere. This stable, protective layer is essential to reducing zinc's corrosion rate, a rate that is approximately 10 to 100 times less than that of steel, depending upon the environment (see Figure 3).

It is important to note that hot-dip galvanized zinc coatings have a much higher density than zinc-rich paint coatings. Specifically, three to six mils (76-152 microns) of zinc-rich paint, depending upon the paint formulation, would need to be applied to equal the zinc content of just 1.7 mils (43 microns) of hot-dip galvanized coating. The lower zinc content detracts from the cathodic protection of a zinc-rich paint system.

Metallurgical Bond

During the galvanizing process, steel is immersed in molten zinc. Through diffusion, the zinc metallurgically bonds to the steel, creating a series of

Figure 3

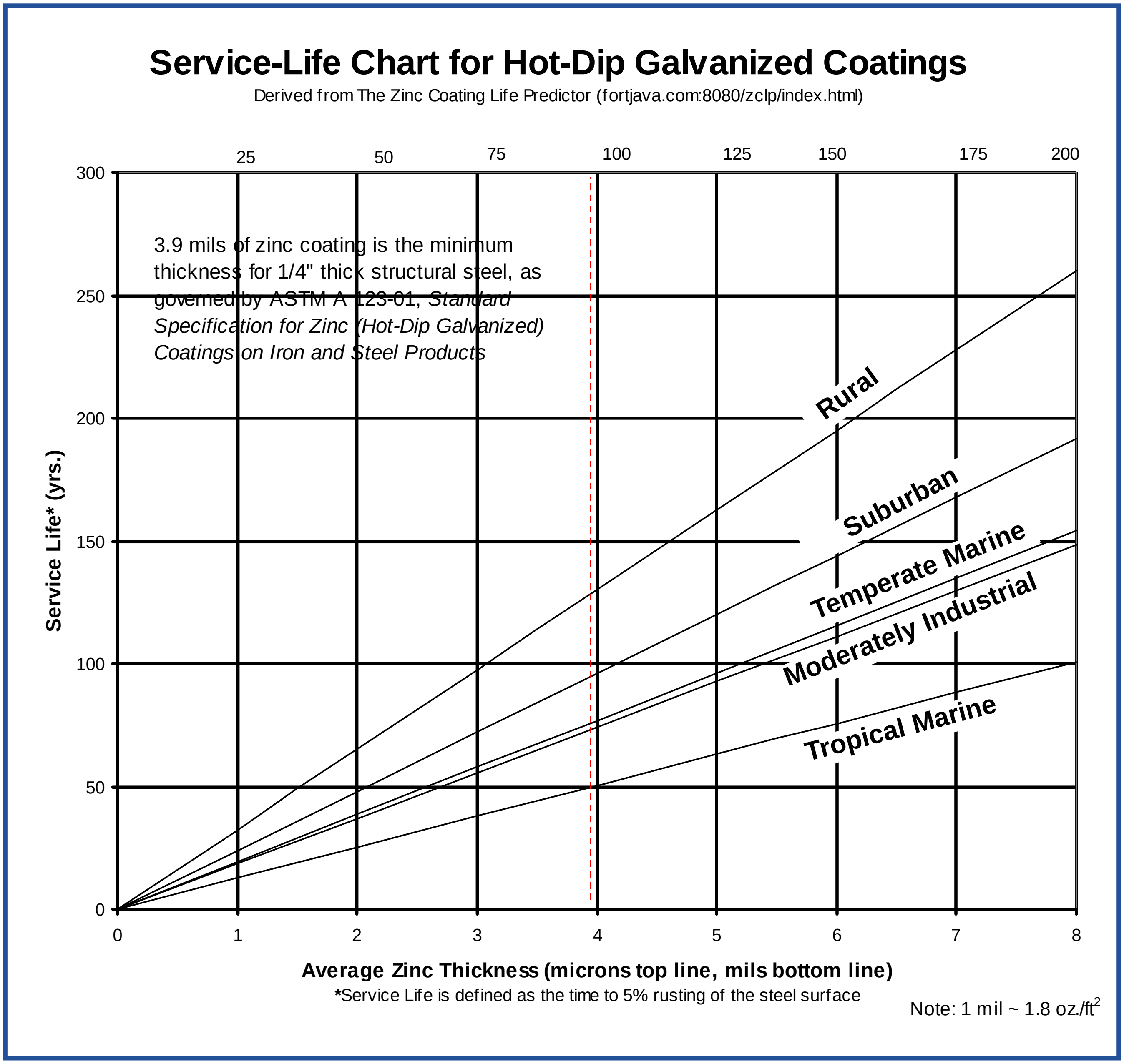
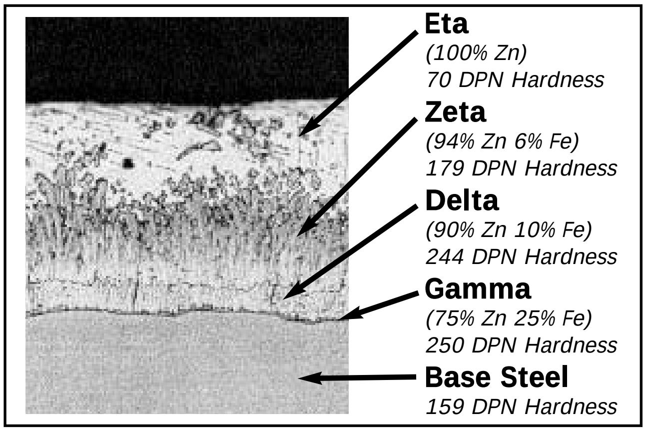


Figure 4

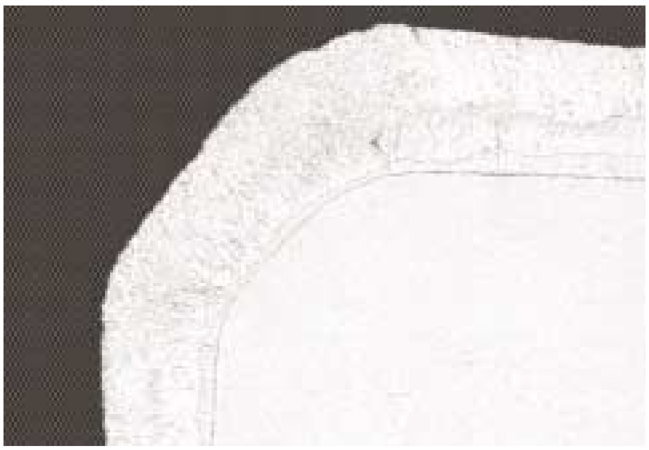


three zinc-iron alloy layers (see Figure 4). The zinc coating's adhesion strength is measured on the order of several thousand pounds per sq. in. (dynes per sq. cm.). In addition, the zinc coating resists abrasion and is as dense as the base steel.

Complete Coverage & Coating Integrity

Because galvanizing is a total immersion process, all parts of the steel fabrication are coated and protected, including areas inaccessible to paint sprayers or brushes. Furthermore, the integrity of the galvanized coating is assured because zinc will metallurgically bond only to clean steel. Any uncoated steel is immediately apparent as the work is withdrawn from the molten zinc bath and is promptly repaired, ensuring a fabrication with complete coverage and coating integrity.

Figure 5



Coating Uniformity

By nature of the zinc coating structure's growth through metal diffusion, hot-dip galvanizing guarantees a uniform coating thickness on all coated surfaces, including edges, corners and threads (see Figure 5). This uniform coating eliminates any weak links and provides excellent corrosion protection at these critical points.

Zinc coatings' expected service-life directly relates to coating thickness: the thicker the coating, the longer the service-life. Although the galvanizer has some control over coating thickness by using additives in the molten zinc bath and controlling immersion time and withdrawal rate, the overwhelming determinant of coating thickness is steel chemistry.

Abrasion Resistance

Unlike paint, which is easily scratched, the zinc-iron alloy layers that make up the galvanized coating have hardness values that meet or exceed the values for most grades of structural steel (see Figure 4, page 5). This makes galvanized steel excellent for applications particularly susceptible to abrasion, such as stairs and walkways.

Summary

The qualitative analysis of various corrosion protection systems indicates hot-dip galvanizing to be the premier choice. It is a durable barrier and cathodic protection system with a metallurgical bond an order of magnitude greater than paint’s. The galvanized coating provides complete coverage inside tubular sections and in hard-to-reach places. It provides uniform thickness and protection on edges and corners and is abrasion resistant. When all of these performance characteristics are considered in conjunction with low original and life-cycle costs, hot-dip galvanizing is the logical choice.

Galvanizing Costs Less - Case-studies

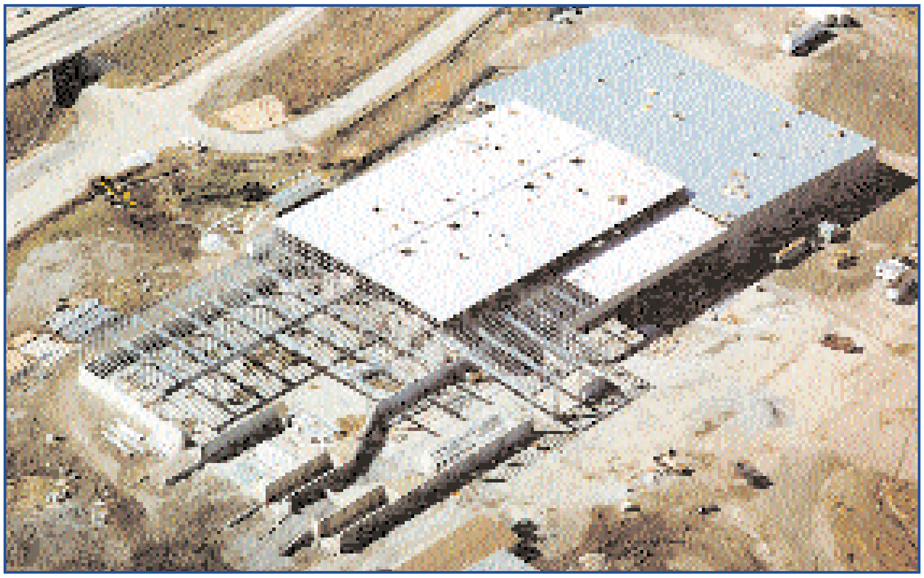
Industrial Facility

The construction of four buildings comprising a solid-waste recycling facility for the city of Chicago creates a perfect case-study for the selection process of a corrosion protection system. In this case, the selection process compared the use of hot-dip galvanizing to paint.

The Calumet industrial facility's original specifications called for:

- 7,400,000 lbs. (3,356,854 kg.) of structural steel,
- 470,000 sq.ft. (43,664 sq.m.) of building, and
- Three-coat epoxy paint.

Calumet Industrial Facility



Driven by the design engineer, who was familiar with the benefits of hot-dip galvanizing, and a fast-track schedule that would make painting a potential delaying and cost-increasing factor, the contractor offered a substantial rebate to the city if the specification was changed to galvanizing. The final specification was changed to 7,400,000 lbs. (3,356,854 kg.) of galvanized structural steel. Further examination of the decision to galvanize showed hot-dip galvanizing to be:

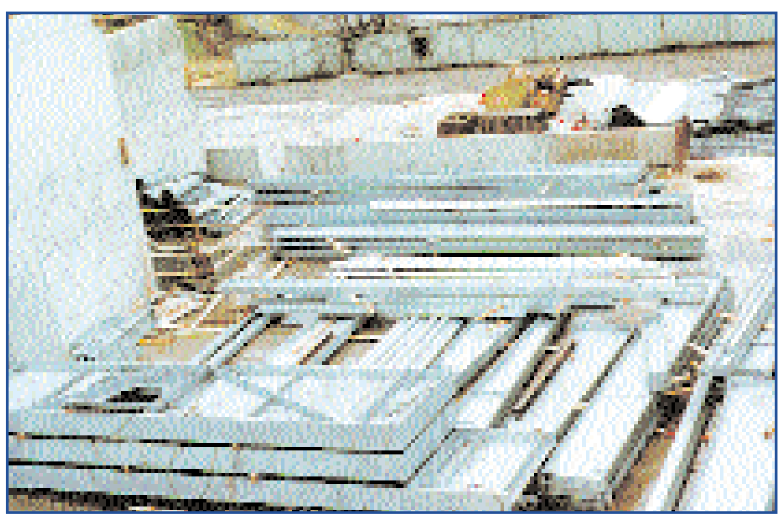
- lowest in original cost, and
- the lowest life-cycle cost for this facility.

The city of Chicago is the beneficiary of the decision to galvanize. The project was delivered on schedule and for less money than a painted facility would have been.

Additional benefits to the city in specifying galvanizing include:

- extremely low field touchup costs,
- 48-hour turnaround time for steel to be galvanized, and
- no maintenance requirements for decades.

The engineers and contractor readily admit that the project simply could not have been built on schedule and within budget had hot-dip galvanizing not been specified. For the city of Chicago, galvanizing does cost less and last longer.



Power Plant

Located in Puerto Rico's corrosion-conducive environment, just 500 yards from the Caribbean Ocean's salt water and in a moderately industrial setting, the new power plant, including a turbine building and two coal-fired boilers, initially was fatefully specified to be painted. It was only after diligent efforts by the galvanizer, fabricator and design team that the owner reconsidered the decision to apply a two-coat paint system and, ultimately, opted to galvanize the steel used in the construction.

Original considerations included:

- Over 10,000 tons (9,072 metric tonnes) of steel would need to be fabricated and erected.
- The fabrication items were a mix of heavy, medium and light structural steel, averaging 350 sq. ft./ton (36 sq.m./metric tonne), including thousands of miscellaneous plates, angles and connection pieces.
- Permit issues and Hurricane George led to a three-year project construction delay.
- The final fabrication and painting schedule was undetermined until just before drawings were released for construction.
- Cold and wet weather were variables to be considered in the installation and painting process.
- The final determination had not yet been made whether to apply the two-coat paint system in the fabrication shop or to apply the primer in the shop and top-coat in the field.
- Thousands of loose plates, angles and connection material required coating, assembling, packaging and shipping.
- Hundreds of beams and braces had 10 or more plates attached to each end.
- Roll-on/roll-off trucking and shipment by barge would be utilized.

The galvanizer encouraged the engineer and owner to consider not only the initial cost data, but also the life-cycle cost data for the originally specified shop primer and field topcoat paint system, and the two-coat shop-applied system.

The material and labor cost data included in the National Association of Corrosion Engineers paper #477, Costing Considerations for Maintenance and New Construction Coating Work, 1996, was used to compare to the initial and life-cycle costs for hot-dip galvanizing. In addition, the physical and logistical advantages of galvanizing were presented for the owner's, fabricator's and design team's consideration. The resulting overview and decision to galvanize the structural steel presented the owner with a win/win position both economically and in scheduling fabrication and erection.

Reasons for Selecting Hot-Dip Galvanizing:

The life-cycle cost of galvanizing versus paint dictated a clear direction for this project. The durability of galvanized steel during shipment, erection and throughout the structure's lifetime was evident. In addition, the ability to galvanize material 365 days a year with quick turnaround time (hours, not days) made galvanizing the most practical and economical choice. Specifically:

- Hot-dip galvanizing, based on a life-cycle cost, was an impressive 34% of the cost of a shop primer only. A field-applied top-coat would present higher cost, create delays in final erection and limit access for other trades to complete construction.

- Hot-dip galvanizing, when compared to the alternative two-coat shop-applied paint system, was just 16% of the cost on a life-cycle basis.
- Galvanizing is independent of weather and would provide corrosion-protected fabrications to the job site within hours of receipt of the black steel. Even under ideal weather conditions, the three to four days required to shop-apply the two-coat paint, allow drying time, reassemble and load with particular caution would not meet schedule demands.
- Galvanizing economically handles parts and fabrications of all sizes throughout the process. In particular, on this project all of the fabrications were welded or loose-bolted prior to shipment to the galvanizer, thus eliminating the reassembly of parts and reduction of lost and missing parts. Thousands of fabricated members had an unusual number of loose pieces that would have required painting and drying prior to assembly. The logistical details and shop floor-space requirements made painting impractical and imposed hidden costs on the fabricator.
- Galvanized steel is durable and requires little, if any, shop or field touchup. The tight schedule would not allow the extensive and expensive touchup required of painted steel that would have been shipped in roll-on/roll-off trailers (this requires extensive tie-down, wrapping and loading standards in order to protect painted material), barged and erected.
- For a practical maintenance plan in the first 25 years of the project, the life-cycle costs for galvanized steel in the power plant would be nearly nonexistent! When the time-value of money, repair costs and shutdown costs were evaluated for a painted steel plant, the decision to galvanize was, once again, proven to be the most economical corrosion system.

Caribbean Power Plant

The owner, fabricator and design firm all agree that making the decision to galvanize the power plant's steel was key in delivering an operational plant on best possible schedule and within budget. Additionally, they are convinced that the life-cycle costs to maintain the galvanized steel will be so minimal over the next 20 - 30 years and the shutdowns to repair so infrequent, that their decision will provide additional profit for generations to come.