

HOT-DIP GALVANIZING

COSTS LESS, LASTS LONGER

**INFORMATION AND CASE
STUDIES EXAMINING THE
COST-EFFECTIVE NATURE OF
HOT-DIP GALVANIZING**



American Galvanizers Association

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above:

Cortez Blue Condominiums
San Diego, California

cover photo:

Arizona State University Parking Garage
Tempe, Arizona

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HOT-DIP GALVANIZING COSTS LESS AND LASTS LONGER



Chanhassen Pedestrian Bridge, Chanhassen, Minn.

Specifiers select steel corrosion protection systems from a variety of different coatings, each 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.

Two common steel corrosion protection systems are paint and hot-dip galvanizing. Many specifiers hold the misconception hot-dip galvanizing is more expensive on an initial basis; however, when compared with paint systems, hot-dip galvanizing after fabrication has comparable initial application costs.

Furthermore, hot-dip galvanizing almost always has a lower life-cycle cost. In fact, the lower life-cycle cost of hot-dip galvanized steel makes 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.

GALVANIZING CHARACTERISTICS

- Barrier and cathodic protection for 40 - 75 years without maintenance, depending upon environment
- Metallurgical bond strength > 3600psi (25 MPa)
- Complete coverage and coating integrity inside tubular sections and in hard-to-reach places
- Uniform edge/corner coating thickness
- Abrasion resistance

Coating Selection

Unquestionably, hot-dip galvanizing provides long-term corrosion protection. However, the selection of galvanizing as the preferred coating system over any other corrosion protection system is not complete without considering the economic variables for each system.

ECONOMIC VARIABLES

- Initial coating cost
- Maintenance cost (touch-up, maintenance repaint, full repaint)
- Indirect cost (site accessibility, loss of productivity during maintenance, commuter delay)

Because neither the timing nor the cost of future maintenance can be precisely predicted, the selection of the most economical system cannot be either.

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 the life of the project.

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 KTA Tator, Inc.), an economic analysis of initial and life-cycle cost provides an enlightening comparison.

“...an economic analysis of initial and life-cycle cost provides an enlightening comparison...”

Figure 1: Initial Costs of Common Coating Systems

Coating System	No. of Coats	Initial Cost (USD/ft ²)	AEAC (USD/ft ² /year)	Total Project Cost (USD)
Hot Dip Galvanizing ¹	1	1.92	0.14	\$19,200
Acrylic Waterborne - 3 coat	3	2.51	0.58	\$79,802
Alkyd - 2 coat	2	1.52	0.78	\$107,507
Surface Tolerant Epoxy - 2 coat	2	2.11	0.41	\$55,923
Surface Tolerant Epoxy/Surface Tolerant Epoxy/Polyurethane	3	3.05	0.54	\$74,721
Epoxy	3	2.76	0.49	\$67,519
Epoxy/Epoxy/Polyurethane	3	2.95	0.59	\$81,236
Epoxy Zinc/Epoxy	2	2.09	0.35	\$48,289
Epoxy Zinc/Polyurethane	2	2.29	0.41	\$56,055
Epoxy Zinc/Epoxy/Polyurethane	3	3.07	0.48	\$66,207
Inorganic Zinc	1	1.31	0.23	\$32,099
Inorganic Zinc/Epoxy	2	2.09	0.35	\$48,261
Inorganic Zinc/Expoxy/Polyurethane	3	3.07	0.47	\$64,302
Zinc Rich Moisture Curing Urethane/Polyurethane/Polyurethane	3	3.33	0.51	\$69,731

NOTES:

- * 50-year project life
- * C3: Medium corrosion environment
- * Typical mix of sizes and shapes (250ft²/ton)
- * 10,000 ft² project/40 tons
- * 3% inflation, 7% interest

¹ Does not include any fabricator mark-up that may be applied

Initial Costs

Although not recommended as reflecting the true cost of a corrosion protection system, initial costs are sometimes the primary determinant for selection. As can be seen in Figure 1 (see above), hot-dip galvanizing's initial cost is compared to those of typical paint systems. Hot-dip galvanizing is more economical from an initial cost standpoint than all but the one-coat zinc-rich paint and the two-coat alkyd 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's durability and lifetime performance make it the logical choice when it is the lowest initial cost system. As the material's weight-per-beam-length increases, galvanizing may be initially more expensive than some paint systems. However, in these cases, when life-cycle cost information is examined, hot-dip galvanizing is almost always more economical.

Life-cycle cost is the analysis of the true cost of a coating system over its entire service-life. It considers initial costs, touch-up costs, maintenance costs, repainting costs, inflation, and opportunity costs.

So, using the standard formula for time-value of money, the true cost in present day dollars (NPV) is shown in the box below.

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

Where:

- NPV, net present value
- NFV, net future value
- r, interest rate
- n, lifetime of the project
- i, inflation rate

The calculation is complex and cumbersome; however, with the automated life-cycle calculator hosted at www.galvanizingcost.com, anyone with internet access can run a life-cycle cost comparison. Another way to look at life-cycle analysis is to calculate the average annual equivalent cost (AEAC), which converts the entire stream of present and future costs to a present worth, i.e. takes NPV and distributes that sum in equal amounts over the structure's life.

The formula for AEAC is as follows:

$$AEAC = NPV [r(1+r)^n / (1+r)^n - 1]$$

Life-Cycle Cost Calculation

To appreciate the full implication of the total life-cycle cost for a project, it is imperative to understand all of the variable performance components of hot-dip galvanizing and paint systems that affect the total.

The online life-cycle cost calculator (www.galvanizingcost.com) considers all of these variables in its analysis.

Environment

Foremost, the environment where the project is located determines the corrosion rate of the galvanized steel zinc coating and the durability of paint systems. For paint systems, depending on the nature of the environment, there may be touch-up painting, maintenance painting, and full repainting required once or more before the service life of the project is reached. Relative performance may be estimated based on the type of environment (see below) where the painted project is located.

ISO ATMOSPHERIC ENVIRONMENTS	
C2: Low	- atmospheres with low levels of pollution, most rural areas
C3: Medium	- Urban and industrial atmospheres, moderate sulfur dioxide pollution; coastal areas with low salinity
C5-I: Very High, Industry	- Industrial areas with high humidity and aggressive atmospheres
C5-M: Very High, Marine	- Coastal and offshore areas with high salinity

For hot-dip galvanizing, only projects with a very long service life in the harshest environment ever require any maintenance to meet the project life expectancy.

As Figure 2 indicates, the galvanizing industry, using data from around the world, has estimated hot-dip galvanized steel durability in five different environments. Hot-dip galvanizing is expected to provide maintenance-free performance for 70 years, even in an industrial environment. This variable affects the life-

cycle cost calculation because steel and different coating systems corrode at different rates based on environmental factors.

Note, the corrosion kinetics involved with hot-dip galvanized steel are quite different than the corrosion of steel coated with paint or powder. Environments affect corrosion for each differently and so for paints a marine environment is the harshest while for galvanized steel an industrial environment is the most aggressive.

Structural Member Type

Small structural steel members and complex fabricated assemblies are efficiently handled and coated with zinc in the hot-dip galvanizing process. As the size of the steel members increases in terms of weight per lineal foot, immersion time in the bath of molten zinc increases, and thus the cost per square foot increases.

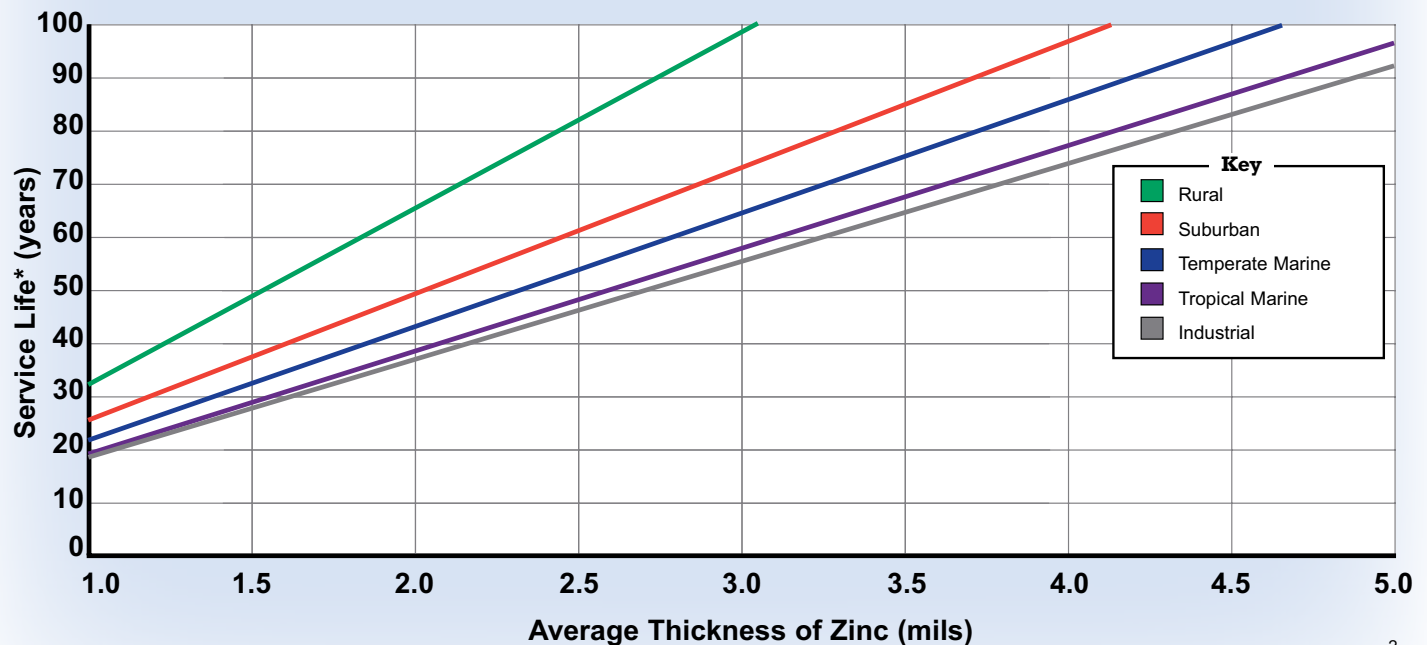
Conversely, painting/powder coating of small structural members or complex fabricated assemblies is more expensive than simple, more massive structural sections. As the initial cost varies depending on the size and shape of the steel pieces, the life-cycle cost will also change.

Surface Preparation

All surface cleaning required in the hot-dip galvanizing process is simple, batch immersion in caustic, acid, and fluxing solutions. Surface preparation for paint/powder coatings may be blast or hand power, conventional or automated, using expendable or recyclable abrasives.

There are different initial costs associated with each surface preparation method, therefore this variable will affect the life-cycle cost calculation.

Figure 2: Service Life of Hot-Dip Galvanized Coatings



*Service life is defined as the time to 5% rusting of the substrate steel surface.

1 mil = 25.4µm = 0.56oz/ft²



A galvanized coating can be applied independent of inclement weather conditions.

Location of Application

Galvanizing is always applied in a shop-controlled environment and is independent of weather. Paint and powder coatings may be applied in a shop, in the field, or in some combination of both, but are always dependent on temperature and humidity conditions. Field application costs, whether the initial topcoat or a maintenance repainting, are always significantly higher than shop application costs.

Material

Zinc metal comprises the hot-dip galvanized steel coating. It is applied via the same general method by all galvanizers. There are many different paint types (acrylic, epoxy, polyurethane)

and each has unique labor requirements including mixing as a two-pack product. Because of the unique labor requirements, the initial cost of each paint system varies.

Financial

Interest rate and inflation are key two components of the financial equation used to calculate life-cycle cost. The value of money fluctuates over time; thus, it is necessary to evaluate the impact both have on the initial investment in a project and any future expenditure on maintenance.

Money saved on the initial cost of a project/corrosion protection system would earn interest over the life of the project but selecting the lower cost project/corrosion protection system may require substantial investment in maintenance over the life of the project. The net difference may actually determine in financial terms the best corrosion protection system for a project.

Summary

The qualitative analysis of various corrosion protection systems indicates hot-dip galvanizing is the premier choice, especially because of its maintenance-free durability for decades. Galvanizing simply lasts for 50-60 years in even the harshest of environments. Too often this choice is superseded by a short-sighted quantitative, initial cost calculation, even though hot-dip galvanizing is very competitive with the initial cost of most common high-performance paint systems.

A thorough calculation of total project costs includes a life-cycle cost analysis; and when all maintenance costs are considered, hot-dip galvanizing remains the logical choice.

Galvanizing Costs Less Case Studies

Calumet 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.

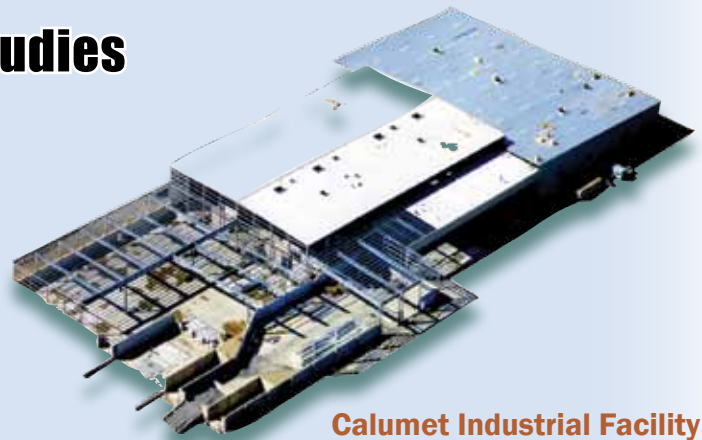
The Calumet industrial facility's building specifications called for:

ORIGINAL SPECIFICATIONS:

- 7,400,000 lbs. (3,356,854 kg) of structural steel
- 470,000 ft² (43,664 mi²) of building
- Three-coat epoxy paint

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 pounds (3,356,854 kg) of galvanized structural steel.



Calumet Industrial Facility

Further examination of the decision to galvanize showed hot-dip galvanizing was:

REASONS FOR SELECTING HDG:

- lowest in initial cost
- the lowest life-cycle cost for this facility

Analyzing a typical paint system and using standard financial variables, it is not difficult to estimate the life-cycle cost of this project.

The life-cycle cost analysis (derived from the life-cycle cost calculator at www.galvanizingcost.com) for the Calumet Industrial Waste Facility would be similar to that shown in Figure 3 (below).

As you can see, the annual cost to maintain the facility had it been painted would be approximately four times greater than for galvanizing. 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:

BENEFITS OF GALVANIZING:

- Extremely low field touch-up cost
- 48-hour turnaround time for steel to be galvanized
- No maintenance requirements for decades

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

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

Figure 3: Life-Cycle Cost Analysis for Calumet Industrial Facility from www.galvanizingcost.com

Paint Operation Paint Initial Cost/Ft ² : 2.25					
Painting Operation	Original Painting	Touch-up Year 17	Maintenance Reprint Year 23	Full Reprint Year 32	Total
Cost in current currency	2.25	1.35	2.36	4.51	\$10.57
NFV costs at 3% inflation	2.25	2.23	4.66	11.87	\$21.01
NPV costs at 7% interest	2.25	0.71	0.98	1.36	\$5.30
Average Equivalent Annual Cost/Ft² = 0.40					
Total Paint Project Cost: \$4,902,903.00					

Hot-dip Galvanizing Operation HDG Initial Cost: 0.18/lb OR 1.44/Ft ²			HDG vs Paint	
Galvanizing Operation	Original Galvanizing	Total		
Cost in current currency	1.44	\$1.44	\$4,902,903	
NFV costs at 3% inflation	1.44	\$1.44	- 1,332,000	
NPV costs at 7% interest	1.44	\$1.44	\$3,570,903	
Average HDG Equivalent Annual Cost/Ft² = 0.11			Reduced Cost by:	
Total HDG Project Cost: \$1,332,000			73%	

Caribbean Power Plant

Located in Puerto Rico’s corrosion-conducive environment, just 500 yards from the Caribbean’s salt water and in a moderately industrial setting, the power plant, including a turbine building and two coal-fired boilers, initially was specified to be painted.

Only after diligent efforts by the galvanizer, fabricator, and design team did the owner reconsider the decision to apply a two-coat paint system and ultimately, opt to galvanize the steel used in construction.

ORIGINAL SPECIFICATIONS:

- 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 250ft²/ton (36m²/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 shipping by barge would be utilized



Caribbean Power Plant

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 (NACE) paper #477, *Costing Considerations for Maintenance and New Construction Coating Work*, was used to compare to the initial and life-cycle costs for hot-dip galvanizing.

Figure 4: Life-Cycle Cost Analysis for Caribbean Power Plant from www.galvanizingcost.com

Paint Operation				
Paint Initial Cost/Ft²: 1.50				
Painting Operation	Original Painting	Touch-up Year 17	Maintenance Repaint Year 23	Total
Cost in current currency	1.50	0.90	1.58	\$3.98
NFV costs futures value at 3% inflation	1.50	1.49	3.11	\$6.10
NPV costs Present value at 7% interest	1.50	0.47	0.66	\$2.63
Average Equivalent Annual Cost/Ft² = 0.21				
Total Paint Project Cost: \$6,575,333				

“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 analysis of cost and comparison to hot-dip galvanizing would have entailed typical data as shown in *Figure 4* (see facing page). In addition, the physical and logistical advantages of galvanizing were presented to 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.

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:

BENEFITS OF GALVANIZING

- On a life-cycle basis, galvanizing 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
- When compared to the alternative two-coat shop-applied paint system, galvanizing 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 or 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 cost on the fabricator.

- For a practical maintenance plan in the first 25 years of project, the life-cycle cost for galvanized steel in the power plant would be nearly nonexistent! When 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.
- Galvanized steel is durable and requires little, if any, shop or field touch up. The tight schedule would not allow the extensive and expensive touch up required of painted steel that would have been shipped in roll-on/roll-off trailers (this required extensive tie-down, wrapping, and loading standards in order to protect painted material), barged and erected.

Figure 4: Life-Cycle Cost Analysis for Caribbean Power Plant from www.galvanizingcost.com, continued

Hot-dip Galvanizing Operation HDG Initial Cost: 0.18/lb OR 1.44/Ft ²		
Galvanizing Operation	Original Galvanizing	Total
Cost in current currency	1.44	\$1.44
NFV costs futures value at 3% inflation	1.44	\$1.44
NPV costs Present value at 7% interest	1.44	\$1.44
Average HDG Equivalent Annual Cost/Ft² = 0.12		
Total HDG Project Cost: \$3,600,000		

HDG vs Paint
\$6,575,333
- 3,600,000
\$2,975,333
Reduced Costs by:
45%



After converting the specification of the Caribbean Plant project to hot-dip galvanizing, not only was the project delivered in a timely manner, but it also was completed at approximately 45% less cost than if it had been painted.



The owner, fabricator, and design firm all agree making the decision to galvanize the power plant's steel was key in delivering an operational plant on the best possible schedule and within budget.

Additionally, they are convinced the life-cycle cost 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.

“The life-cycle cost of galvanizing versus paint dictated a clear direction for this project.”



above:

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Houston, Texas



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