

Cover: Close up of zinc coated steel showing familiar spangle resulting from hot dip galvanizing

Inset:
The Joffre Nitrogen
Operations make
extensive use of zinc
coatings for corrosion
protection. Most
structural steel is hot dip
galvanized.

HOT DIP GALVANIZING CORROSION PROTECTION WITH ZINC

Steel used to construct chemical plants requires corrosion protection.

The proven effectiveness of zinc in controlling corrosion makes it an ideal choice for protecting structural steel. Hot dip galvanizing is generally the most effective method of applying zinc to steel.

A National Bureau of Standards study in the late 1970s estimated corrosion costs in the United States to be 4.2% of the Gross National Product. Based on this estimate, current corrosion costs in North America would be over \$200 billion a year. The study also found that 15% of this annual figure could be avoided by making the best possible use of existing technology. Galvanizing is usually the most cost effective, readily available corrosion protection technology.



Construction of the Joffre Nitrogen Operations.

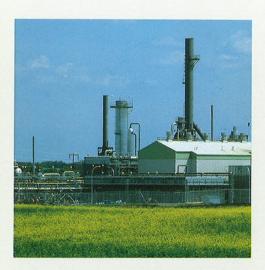
Corrosion prevention systems are specified based on a facility's design life, the service environment, coating appearance and lifetime costs. It is up to the architect, designer, specifier and builder to ensure that plant owners receive the best value for their capital investment. In the majority of cases, zinc applied by hot dip galvanizing is the best coating system to satisfy these criteria.

CHEMICAL PLANT APPLICATIONS

Cominco Fertilizers

The Alberta Energy Company and Cominco Fertilizers have constructed four new facilities in which hot dip galvanizing was selected over painting for the structural steel; an anhydrous ammonia plant at Joffre, Alberta, a load-out facility at Chigwell, Alberta, and ammonia storage and distribution facilities in Leal, North Dakota and Vanscoy, Saskatchewan. Galvanizing was found to be economical, to allow faster construction and to provide maintenance-free corrosion protection.

A cost comparison was done for hot dip galvanizing versus painting. Based on the planned life of these facilities, the initial coating costs and future maintenance expenditures, galvanizing is expected to be the more economical protective coating. For some facilities, even the initial cost of galvanizing was less expensive than painting. At the Leal facility, total fabrication costs of major components were 13% less



Cominco Fertilizers' Joffre Nitrogen Operations, Joffre, Alberta.



Du Pont's nylon plant in Seaford, Delaware.

because galvanizing was specified in favour of a mild exposure paint system.

The use of galvanized steel also facilitated construction of the Joffre Nitrogen Operations. The toughness of the zinc coating allowed support details to be assembled, galvanized and then erected with minimal surface damage. The erection of galvanized sections eliminated the need for time consuming and costly field painting. Any surface damage that did occur during construction, or from field welding, was easily touched up with zinc-rich paint or by metallizing.

Cominco Fertilizers has found hot dip galvanizing to be an economical means of achieving long term corrosion protection of steel. Plant operations personnel are pleased with the performance of zinc coatings.

E.I. Du Pont de Nemours Company Inc.

Based on 30 years of experience with galvanized coatings in North America, Du Pont has found coating performance to be excellent and the selection of galvanizing justified. Galvanizing is generally specified for outdoor applications in products such as structural steel, checker plate and grating, corrugated sheet for roofing and siding, metal decking and pipe for handrail.

Du Pont has found the initial costs of galvanizing to be up to 50% less than a high quality corrosion resistant 3-coat paint system. One study actually showed that dismantling and re-galvanizing a 30 year old fence was less expensive than cleaning and painting it in place.



Sterling Chemicals' petrochemical plant in Texas City, Texas.



Monsanto's Krummrich Plant in Sauget, Illinois.

Monsanto Chemical Company

Monsanto engineers have found that the selection and intelligent use of protective coatings is an important weapon in their constant battle to lower operating costs.

The engineers feel that the main functions of protective coatings are to protect their initial investment, keep maintenance costs to a minimum and prevent production downtime. To satisfy these criteria, Monsanto makes extensive use of hot dip galvanizing in their plants. Specific applications include structural steel, floor plate, pipe, anchor bolts, small vessels, flare stacks and ductwork.

Sterling Chemicals Inc.

Sterling used galvanized steel pipe racks at their Texas City, Texas petrochemical plant. The galvanized racks have been maintenance free since their installation in the harsh industrial/coastal environment. The oldest pipe rack installation has been in service for 30 years and has maintained a coating thickness greater than the ASTM minimum thickness specification for new zinc coatings applied by hot dip galvanizing.

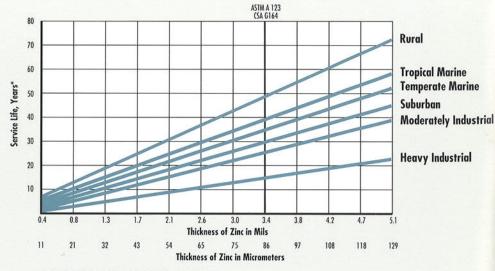
A LIFETIME OF PERFORMANCE

When building a costly industrial facility, a major consideration is ensuring that the facility's design life is attained. Corrosion can weaken improperly protected structures prematurely, making expensive repairs or replacement necessary. Zinc's corrosion rate is only a small fraction of that of steel because of the protective corrosion product layer which forms on the zinc surface. This allows a thin coating of zinc to last for the life of a facility with little or no maintenance requirements. Hot dip galvanized coatings are typically 4 to 8 mils thick and provide long term corrosion protection even in aggressive atmospheric environments (Figure 1).

In certain situations, it may be necessary for galvanized steel to be immersed in liquids. Galvanizing is suitable for these applications when the liquid's pH is between 6 and 12.5 and the temperature does not exceed 55°C (130°F). Operating under these conditions allows a stable, protective film to form on the zinc surface.



Galvanized structural beam emerging from a bath of molten zinc.



*Service Life is defined as the time to 5% rusting of the steel surface. Courtesy of the American Hot Dip Galvanizers Association

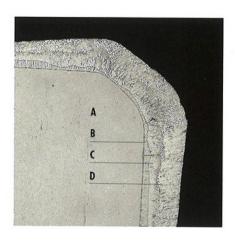
Figure 1

WHY GALVANIZING WORKS

The excellent corrosion resistance of hot dip galvanized steel is due to the twofold nature of the coating. The zinc coating provides barrier and cathodic protection to the underlying steel surface.

During the galvanizing process, steel reacts with molten zinc to form a series of zinc-iron alloy layers which, together with the outer zinc layer, are metallurgically bonded to the steel surface. The resulting barrier coating has a very low corrosion rate (Figure 1) and, because of the hard alloy layers, is highly resistant to mechanical damage. Galvanized steel is much less susceptible to coating damage from handling than is painted steel.

As the name implies, hot dip galvanizing requires complete immersion of the work piece in molten zinc. This process ensures a uniform coating on all surfaces, even on those areas not normally accessible to mechanical applicators.

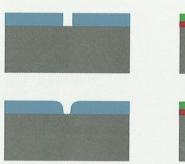


Zinc corrodes preferentially to steel and provides cathodic protection to areas of bare steel (up to 1/4 inch wide) accidentally exposed in service. The sacrificial nature of zinc prevents the steel from corroding adjacent to the galvanized coating, thus preventing undercutting and blistering of the protective film. In comparison, exposed steel on painted surfaces will corrode immediately. The resulting rust occupies several times the volume of steel from which it was formed, causing the lifting and subsequent flaking of the adjacent paint film (Figure 2).

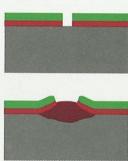
This photomicrograph of a typical galvanized coating shows distinct layers: the underlying steel (A), the hard zinc-iron alloys (B & C), and the overlay of zinc (D). Note that whereas most paint coatings thin out at corners, the galvanized coating maintains a uniform thickness, offering extra corrosion protection in these vulnerable areas.

A break in the zinc coating creates a galvanic cell. The zinc around the damaged area will corrode instead of the steel. Steel becomes cathodic (does not corrode) when it is in contact with zinc.

The steel rusts where the paint film has been damaged. Rust creeps under the paint film, which is lifted from the the steel surface. Corrosion continues until the damaged area has been repainted.



Zinc Coating



Paint Coating

Figure 2

TROUBLE FREE OPERATIONS

Galvanized steel will require little or no maintenance for the life of the average chemical plant. Painted steel, because of its shorter life expectency, will require regular repainting. Apart from the out-of-pocket expenditures associated with this work, repainting can also cause major operational disruptions. The erection of scaffolding, sandblasting, painting and clean-up, will limit plant capacity as production units are shut down to allow this maintenance work to take place. Weather, environmental contamination from old paint and the quality of a contractor's workmanship are some elements of uncertainty that must also be accepted during repainting.

It is sometimes desirable to paint galvanized steel for reasons such as: colour coding, safety markings, aesthetics or for added protection in particularly aggressive environments. In many instances the resulting duplex system (zinc coating + paint) has been found to have synergistic benefits.

The paint film extends the life of the galvanized coating by providing additional barrier protection for the zinc layer. As the paint film begins to break down, galvanizing extends the life of paint because the zinc corrosion product will not undercut or cause blistering of the paint coating. In fact, the zinc corrosion product will actually retard further coating damage by sealing pores and cracks in the paint film.

As with any paint coating, its success is dependent upon surface preparation and paint system selection. In order to ensure coating compatibility with galvanizing, guidance should be sought from paint manufacturers and galvanizers.



Joffre Nitrogen Operations.



ECONOMICS

In general, galvanizing costs are proportional to the weight of the structure being galvanized. Therefore, galvanizing costs will increase only slightly as the surface area per ton of work piece increases. By comparison, painting costs are directly proportional to the surface area being painted. Painting costs will increase significantly as the surface area per ton of steel increases (Figure 3). Thus the initial cost of galvanizing can be less than painting, especially on lighter members that have high surface areas such as floor grates, transmission towers and pipe racks.

A true economic comparison of galvanizing versus painting requires looking beyond initial costs. All coating costs over the life of a project must be identified and calculated. A cash flow analysis must be done to determine the present value of future expenditures. Construction schedules and production disruptions are additional factors influencing final costs.

Predicting the costs of hot dip galvanizing accurately is easy since the zinc coating will usually last for the life of the facility, and purchase price is the one and only major expenditure associated with it.

By contrast, paint systems have a predictably shorter lifespan and require regular repainting. Expenditures on materials, labour and equipment will be necessary to provide continuous protection over the plant's life. In most cases the present value of these expenditures will be greater than the one time cost of galvanizing.

When the initial costs of galvanizing are lower than painting, galvanizing is clearly the favoured protective coating. Even if galvanizing is initially more expensive, it is usually a more economical coating when all costs are tallied over the project's life.

The relationship between the galvanizing curve and the paint lines is based on (i) a pricing survey conducted by the American Hot Dip Galvanizers Association (for structural sections) and (ii) the "Paint and Coating Selection and Cost Guide" by Brevoort and Roebuck, 1985 and 1988.

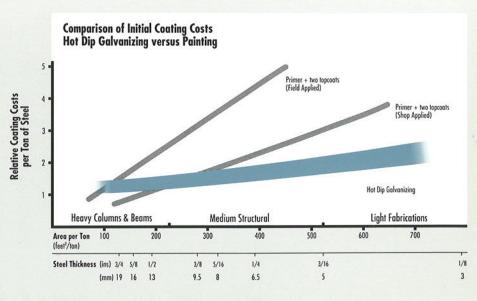


Figure 3

WHAT'S YOUR ANALYSIS?

The local environment, plant emissions, coating appearance, economic analysis and project design life are all factors that will affect the selection of a corrosion prevention system. Cominco encourages chemical plant specialists to analyze, scrutinize and put zinc coatings to the test --

because experience shows that:

- No other coating can match the barrier and cathodic protection that zinc provides steel.
- Hot dip galvanizing is usually substantially less expensive than painting over the life of a project.
- Facilities for hot dip galvanizing are within reach of most Canadian and U.S. locations.
- Galvanized steel can be painted in colours of your choice, adding extra corrosion protection.

Zinc coatings applied by hot dip galvanizing are an effective, economical means of achieving long term corrosion protection for steel. Zinc coatings protect your investment.

