Hot-Dip Galvanized Steel vs. Zinc-Rich Paint

Galvanized sign structure

Hot-Dip Galvanized Steel		Characteristic	Inorganic Zinc-Rich Paint (ZRP)	
		Service Life/Durability[a]		
> 100 years[b]		Rural	27 years[c]	
> 90 years		Urban	17 years	
> 70 years		Industrial	12 years	
> 50 years		Marine	12 years	
Exceeds ASTM A 123 minimum (> 3.9 mils for 1/4" thick steel)		**Coating** Thickness	Variable - may not meet required minimum due to applicator skill	
Exterior & Interior		Coverage	Exterior surfaces only	
Edge & Corner thickness ≥ flat surfaces		Consistency	Edge & Corner thickness < flat surfaces	
Direct[d]	Indirect	**Life-Cycle Cost**[e]	Direct[c]	Indirect[f]
$1.76/ft^2	$0	Rural	$1.27/ft^2	$ 6.35 - $12.70/ft^2
$1.76/ft^2	$0	Urban	$1.74/ft^2	$ 8.70 - $17.40/ft^2
$1.76/ft^2	$0	Industrial	$2.27/ft^2	$11.35 - $22.70/ft^2
$1.76/ft^2	$0	Marine	$2.27/ft^2	$11.35- $22.70/ft^2
Yes - 100% zinc metal Zinc metal is anodic to steel		**Cathodic Protection**	Maybe - Zinc % may be too low for conductivity/Binding materials may not be conductive, minimizing cathodic protection	
No base steel corrosion		**2000 Hour Immersion Test**	Paint absorbed water & underfilm corrosion of the substrate steel occurred	
No effect on performance		**Ultraviolet Ray Exposure**	No severe degradation	
Alloy layers are harder than base steel DPN hardness ranging from 179 - 250		**Abrasion Resistance**	Moderate; DPN hardness approximately 33% less than HDG	
-100 C to 350 C		**Performance Range Temperature**	Deterioration at 250 C	
Documented, timed, scientific sequence		**Application** Surface Preparation	Function of human expertise, intolerant of improper cleaning/profiling	
Observable completion of metallurgical reaction		Procedure	Constant agitation of mixture, regulation thickness & drying time per pass	
24/7/365 - all weather		**Application**	Requires specific temperature & humidity conditions	
~ 3600 psi		**Bond Strength to Steel**	~ 600 psi	
90' - 120' long by 6' - 8' wide/deep		**Size Range of Products**	Unlimited	

Corroding painted pole

[a] To 5% rust on substrate steel
[b] Zinc Coating Life Predictor, Zhang, 2001
[c] NACE Paper 06318, Helsel, Melampy, Wissmar, 2006
[d] Galvanizing Industry Survey, 2006
[e] 50-year life, 3% inflation, 7% interest rate, 100,000 sq. ft./typical mix of structural products
[f] Federal Highway Administration, RD-D1-156, Vermani

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Characteristic Notes

Service Life/Durability

- The primary criteria for comparison of hot-dip galvanizing (HDG) to zinc-rich paints (ZRP) is durability in use.
- HDG is maintenance free and commonly prevents any corrosion of the substrate steel for 50-75 years in most atmospheric environments (industrial, urban, marine, and rural) with millions of data points to support that statement (see chart lower right).
- Zinc-rich paint manufacturers qualify such claims only with estimates of when field maintenance will be required and how many times it is required in order to meet a designed service life.
- Salt Spray Test (simulating a marine environment): Laboratory testing of zinc corrosion systems is not appropriate to establish relative performance between systems. Zinc corrosion mechanisms in accelerated testing are very different from real world corrosion mechanisms.
    - However, HDG exhibited zero base steel corrosion after 1500 hours of salt spray testing, at which time testing was stopped.
    - Significant base steel attack was observed on ZRP coated coupons after 1000 hours.[a]
- Damp Sulphur Dioxide Test (simulating an industrial environment):
    - HDG steel samples exhibited no signs of base steel corrosion after 40 cycles of the test.
    - ZRP showed base steel corrosion and severe edge corrosion after 9 cycles.

Coating

- The HDG coating generally exceeds the minimum coating thickness requirement of ASTM standards; based largely on the chemistry of the substrate steel and surface condition of the steel prior to cleaning.
- HDG applies zinc throughout a fabrication or tubular piece, even into difficult-to-reach corners and crevices. The diffusion reaction between molten zinc and iron in steel is perpendicular to all surfaces and thus edge and corner coating thickness is the same as or greater than the coating thickness on flat surfaces.
- ZRP coating thickness is variable and based on the expertise of the applicator. ZRP typically leaves difficult-to-reach areas unprotected from corrosion.

Life-Cycle Cost

- The total direct cost of a corrosion protection system is the sum of the initial cost and maintenance costs over the design life of the project/facility.
- HDG typically has no maintenance costs and so the initial cost is the total life-cycle cost.
- ZRP usually requires several maintenance cycles and is most commonly top-coated to deliver adequate corrosion protection, making the life-cycle cost far greater than HDG.
- In addition to the direct life-cycle costs, there are substantial indirect costs, such as traffic pattern disruption, plant shutdown, and accidents/injury. Depending on the industry (transportation, water/wastewater, buildings), the indirect costs to maintain a corrosion protection system such as ZRP ranges from 5-10 times the direct costs.

Cathodic Protection (vee cuts of 10mm x 115mm)

- HDG steel showed no signs of substrate steel corrosion after 1500 hours exposure in salt fog testing.
- ZRP coated steel exhibited red rust on the exposed area after only 24 hours, and after 550 hours red rust was evident over all of the exposed surface.

Immersion Test (2000 hours in corrosive mine water)

- HDG exhibited no base steel corrosion, as the HDG steel samples formed stable surface deposits (zinc salts).
- A substantial increase in nominal thickness of the ZRP coating indicated swelling due to water absorption, resulting in the formation of voluminous corrosion products underneath the coating.

[a] South African Bureau of Standards Study

UV Exposure

- HDG coatings are not affected by UV light.
- UV attack on ZRP is initially not severe.

Abrasion Tests

- HDG's zinc-iron alloy layers are harder than the base steel and data indicate it has three times the abrasion resistance of ZRP.[a]

Temperature Test

- In a 15 minute exposure in temperatures up to 350 C, HDG coatings did not change.
- ZRP deteriorated at 250 C and became powdery at 350 C, even when cooled to room temperature.[a]

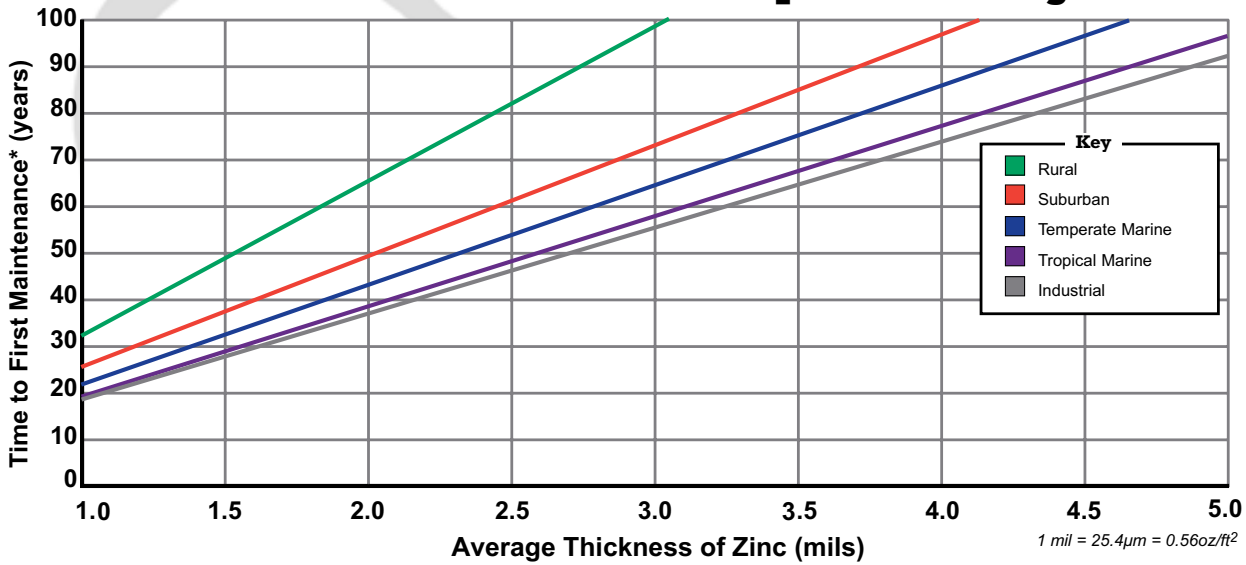
Bond Strength

- The bond of zinc to steel produced by the HDG process is on the order of 3600 psi, making it very difficult to damage the coating.
- The bond strength of zinc-rich paints is on the order of 600 psi, allowing for normal coating damage caused by rough handling and everyday wear and tear.

Application

- HDG is factory controlled and can be done 24/7, 365 days a year.
- The proper application of ZRP requires specific temperature and humidity conditions.

Service Life Chart for Hot-Dip Galvanizing



1 mil = 25.4µm = 0.56oz/ft²

**Time to first maintenance is defined as the time to 5% rusting of the steel surface.*