ICZ: Congress
Oct. 25, 2011
Sao Paulo

American Galvanizers Association

- Non-profit trade association dedicated to serving the after fabrication hot-dip galvanizing industry
- Provides technical support on innovative applications and technological developments in hot-dip galvanizing for corrosion protection

- The purpose of this seminar is to inform and educate architects, engineers, and other specifiers about hot-dip galvanized steel and how it can address the growing corrosion problem throughout South America.

Learning Objectives

- Upon completion of this congress, you will be able to:
  - Recognize the corrosion issues confronting South America
  - Describe how zinc coatings, specifically hot-dip galvanizing, can protect against steel corrosion
  - Incorporate sound corrosion protection into the design of steel products that can significantly reduce maintenance costs over the life of a project

Tour of the City

The Corrosion Problem

25-30% could be eliminated if adequate corrosion protection systems were employed

$1.6 trillion investment necessary
to maintain America's infrastructure

27% of the nation's bridges are
structurally deficient or functionally obsolete

Poor road conditions cost
motorists $54 billion a year
in repairs and operating costs

Current patch-and-pray approach is ineffective

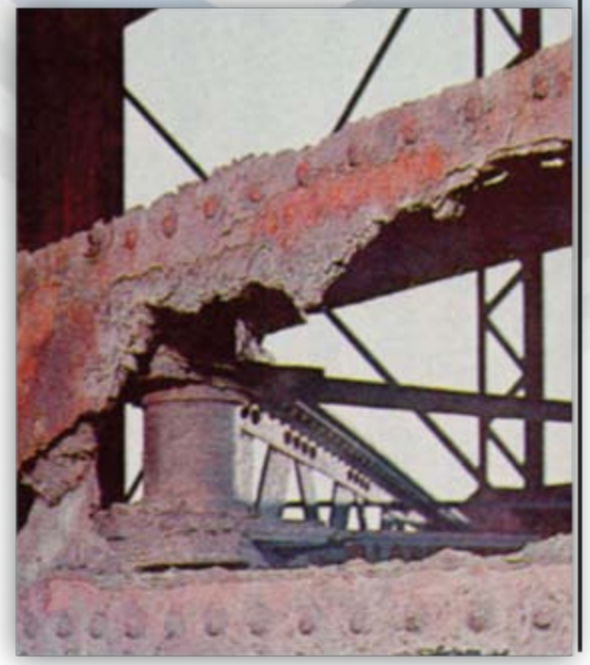
Annual $11 billion shortfall to replace aging drinking water facilities

The paint coating on this frame failed to adequately protect the steel

Corners and edges are a common place for corrosion to begin as paints tend to thin in these areas

Case Study

Williamsburg
built in 1903 in New York City



1991 inspection revealed severe corrosion
direct cost of repairs was $750 million
indirect cost approximately $8.2 billion

Corrosion Costs

- $$$ - Increased Taxes
  - $2.2 Trillion USD annually (worldwide)
  - In US - approximately 3% of the GDP
  - $423 BIL (2009)
- Natural Resources
  - Production, materials, & energy consumption
- Hazardous
  - Public safety, property damage, environmental contamination
- Public Outcry
  - Traffic, detours, inconvenience, indirect impact to business

The Solution:
Hot-Dip Galvanizing

Suncor Energy – Odyssey Project

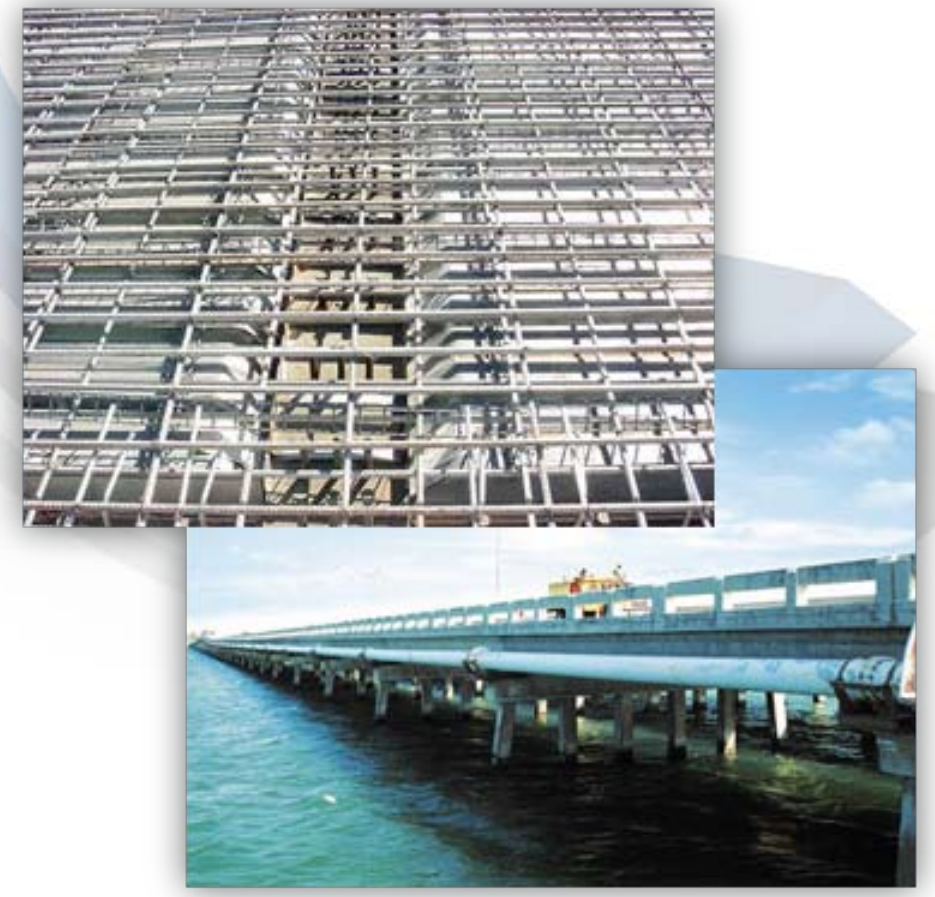
Date Galvanized
2006

Components Galvanized
Walkways, rails, pipe

Environment
Industrial

Location
Commerce City, CO

Boca Chica Bridge



Date Galvanized
1972

Components Galvanized
Reinforcing steel, deck

Environment
Marine

Location
Florida Keys, FL

Harrisburg Airport Transportation Facility

Date Galvanized
2004

Components Galvanized
Columns, girders, splice plates, tubing, and stair frames

Environment
Urban

Location
Harrisburg, PA

Hot-Dip Galvanizing Process

HDG Process: Surface Preparation

- Thorough cleaning is necessary as zinc will only adhere to clean steel
  - **Degreasing** – removes dirt, oils, organic residue
  - **Pickling** – Removes mill scale and oxides
  - **Fluxing** – Mild cleaning, provides protective layer

HDG Process: Galvanizing

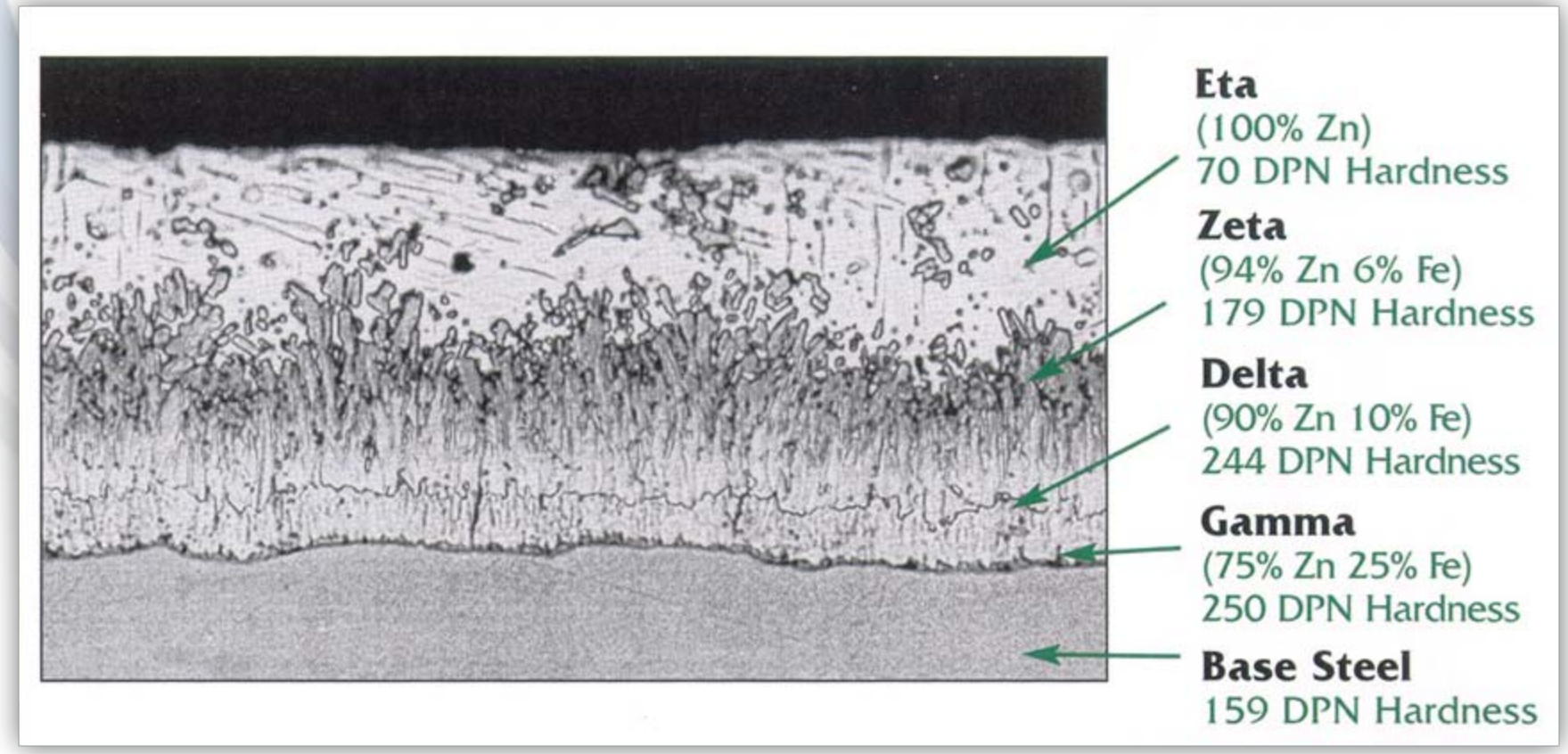
- Steel immersed in bath of molten zinc (~830 F)
- > 98% pure zinc, up to 2% additives (Al, Bi, Ni)
- Zinc reacts with iron in steel to form coating
- Reaction is complete when steel reaches bath temperature

HDG Process: Inspection

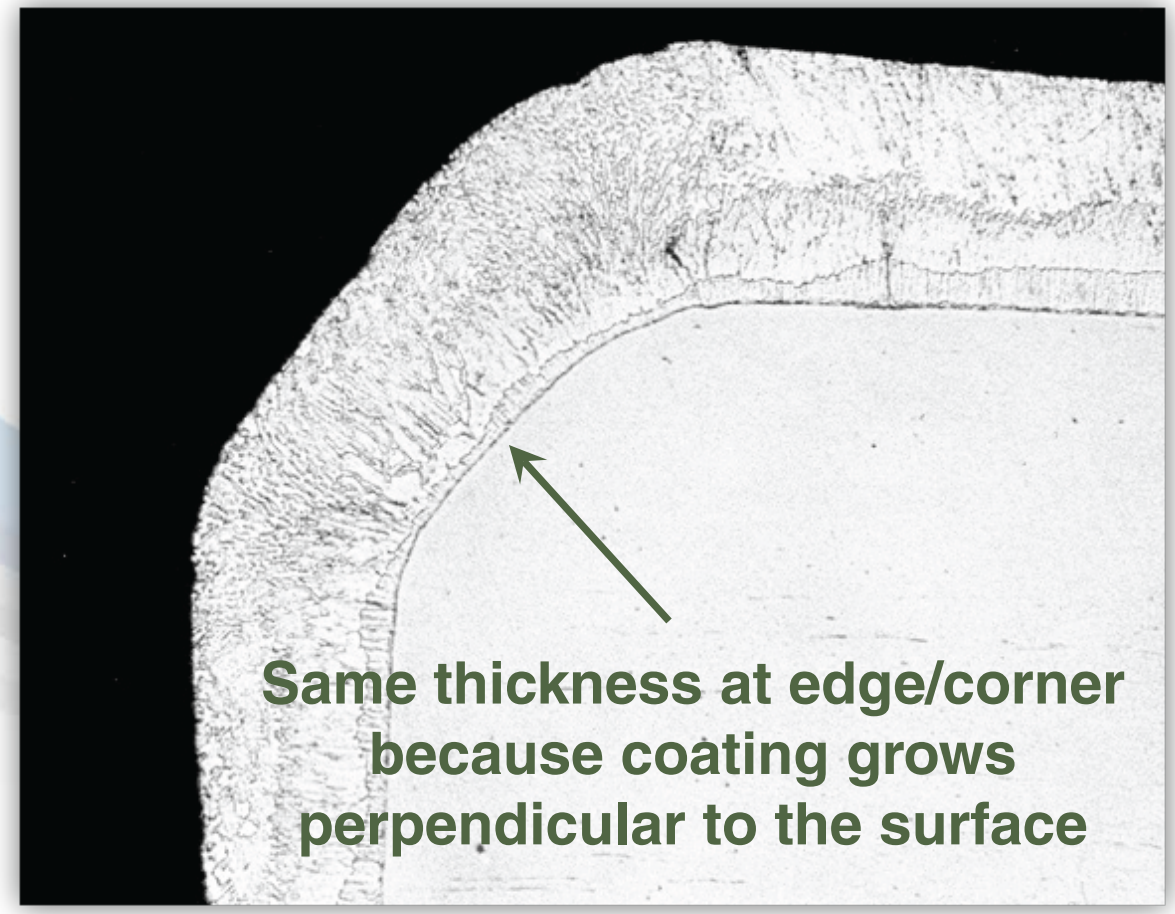
- Steel is inspected after galvanizing to verify conformance to specs
- Visual inspection to identify any surface defects
- Magnetic thickness gauge to check coating thickness

Hot-Dip Galvanized Coating Characteristics

Metallurgical Bond

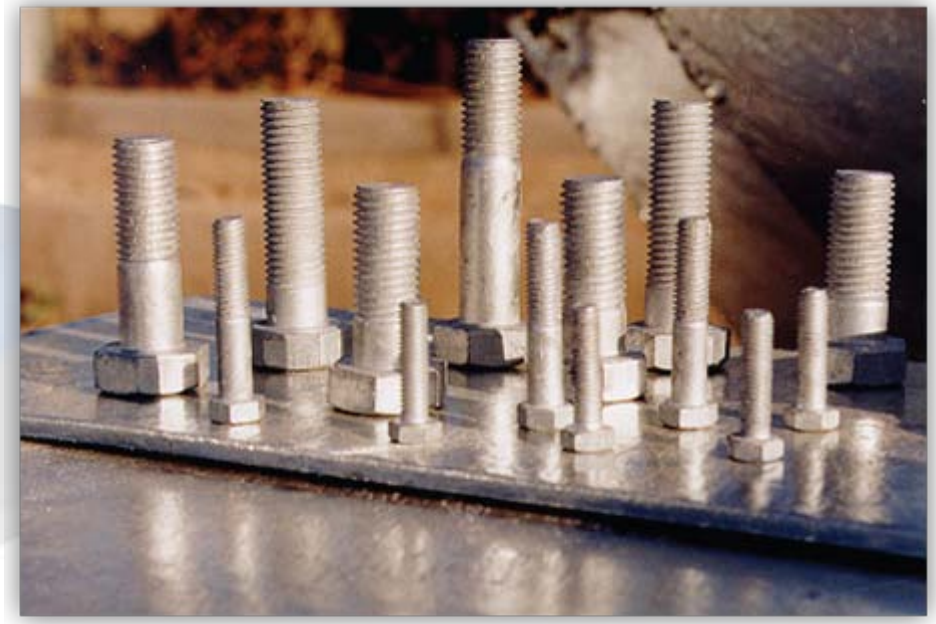


Edge Protection



Complete Coverage

Interior coverage



Fully-coated threads

Barrier Protection

Barrier protection resists corrosion by isolating the steel from electrolytes in the environment

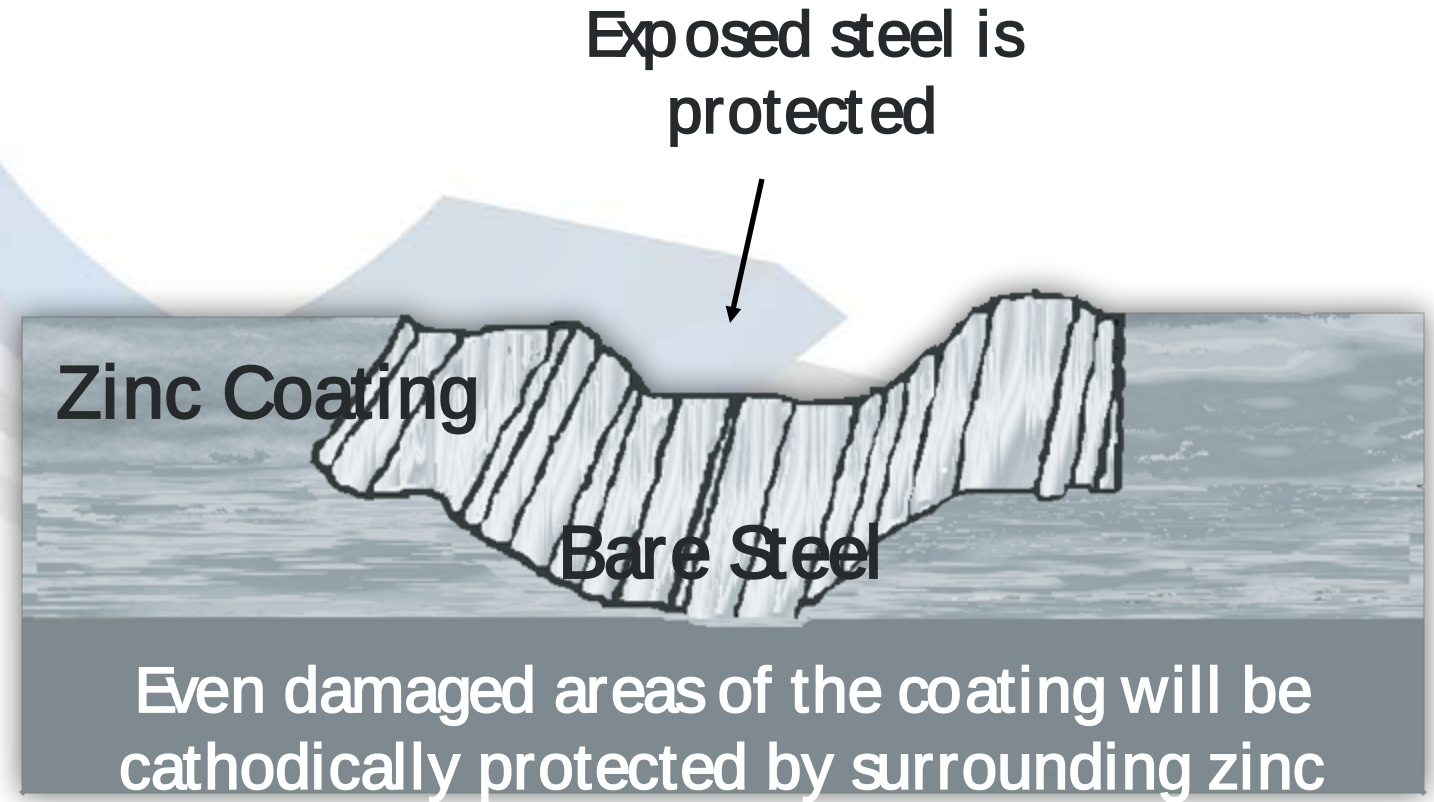
Cathodic Protection

ZINC = ANODE

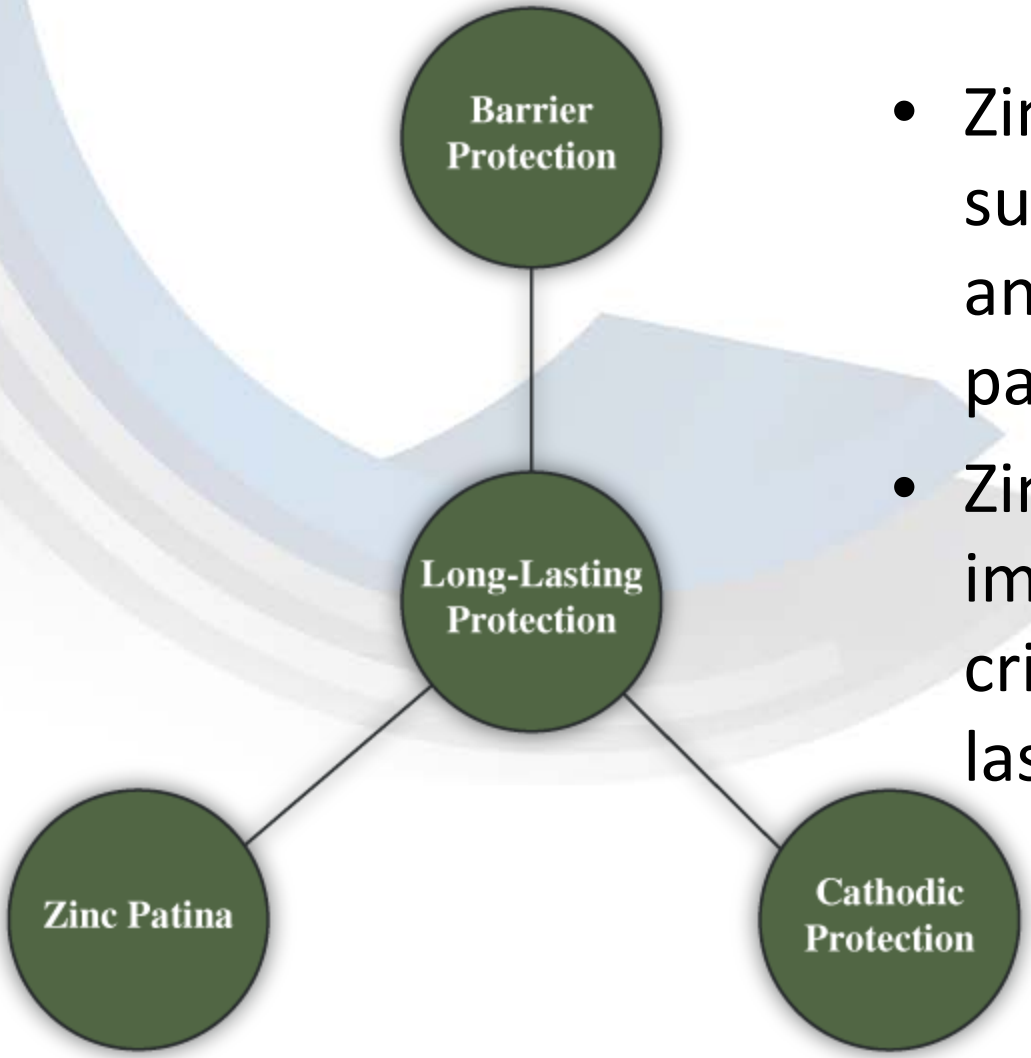
STEEL = CATHODE

This arrangement of metals determines what metal will be the anode and cathode when the two are put in a electrolytic cell (arrangement dependent on salt water as electrolyte).

Cathodic Protection: Sacrificial Zinc

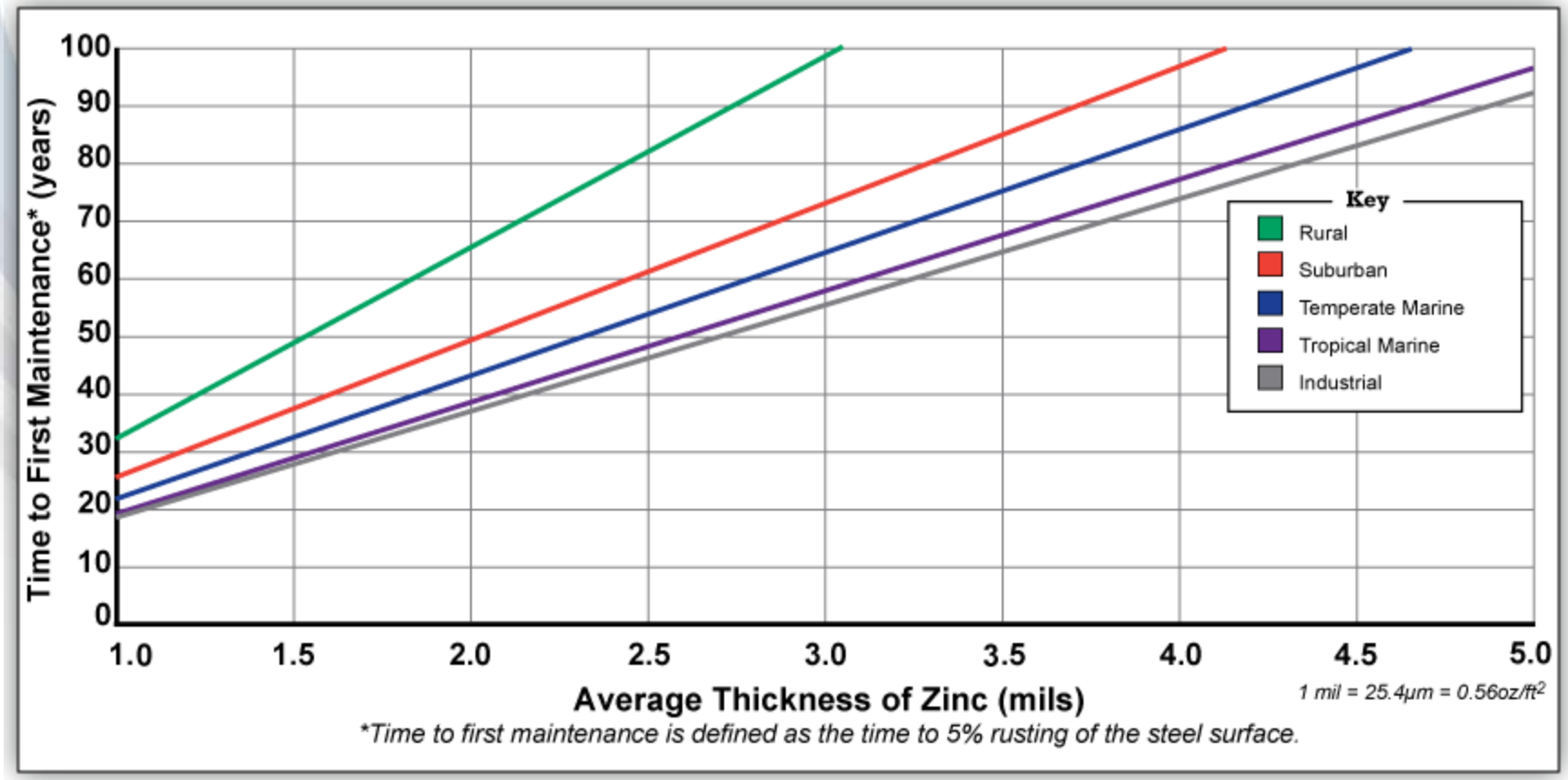


Zinc Patina



- Zinc byproducts build on surface of steel during wet and dry cycles, forming patina
- Zinc Patina is passive and impervious making it a critical part of HDG's long-lasting protection

Time to First Maintenance



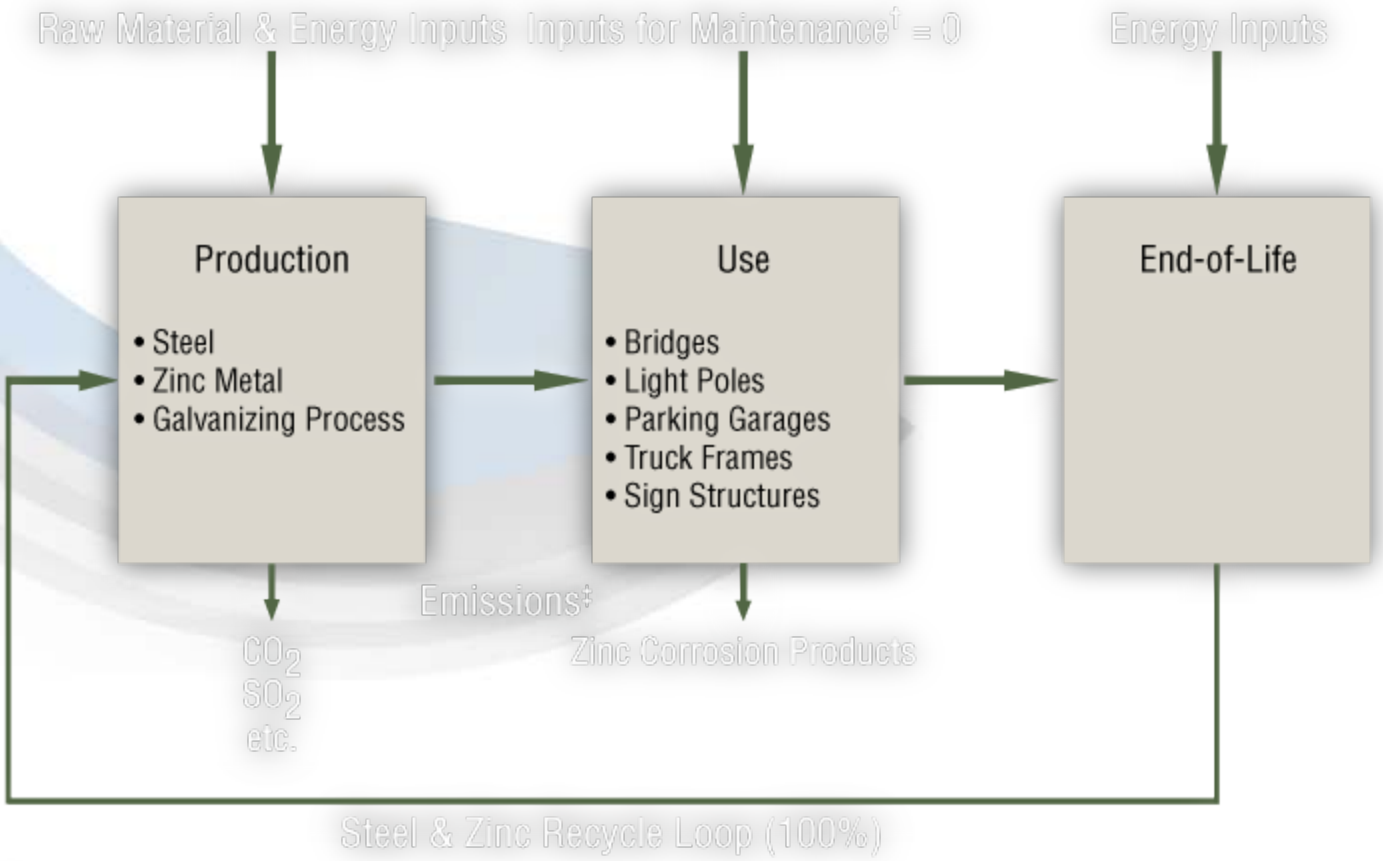
Sustainability: Galvanizing is Green

- Zinc and steel are 100% recyclable
  - Properties of zinc (and steel) do not degrade with reprocessing
  - Zinc is a natural element in the Earth's crust
  - Recycled content contributes to LEED
- Galvanizing's maintenance-free durability ensures no additional energy, materials, or emissions during use

Hot-Dip Galvanizing & LEED®

- Points always achievable
  - *Materials & Resources (MR) Credit 4: Recycled Content* (2 points – 20% recycled content)
  - *Innovation in Design (ID) Credit 1: Path 2 Exemplary Performance* (1 point exceeding by 10% (30%))
- Points to consider job-by-job
  - *MR Credit 5:Regional Materials*
  - *MR Credit 3: Materials Reuse*
  - *ID Credit 1: Path 1 Innovation in Design*
  - *ID Credit 1: Path 2* (other areas)

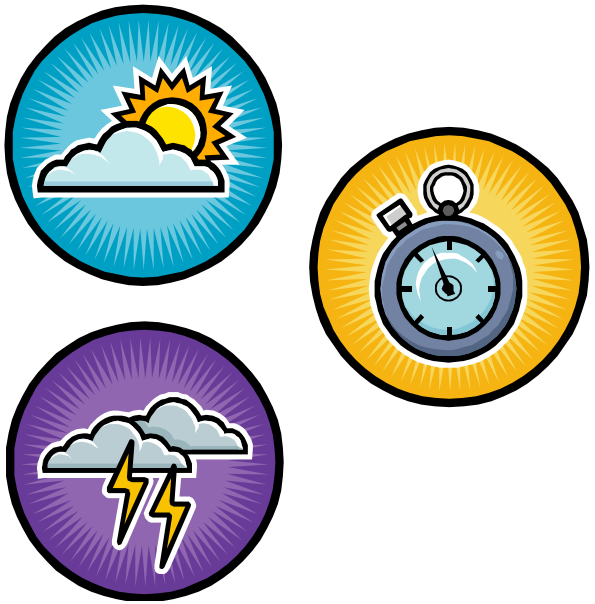
Life-Cycle Assessment (LCA) of HDG



† For all but the most aggressive, corrosive environmental conditions, there are no energy or raw material inputs during use (75+ years).
‡ For hot-dip galvanized steel, naturally occurring zinc oxide, zinc hydroxide, and zinc carbonate.

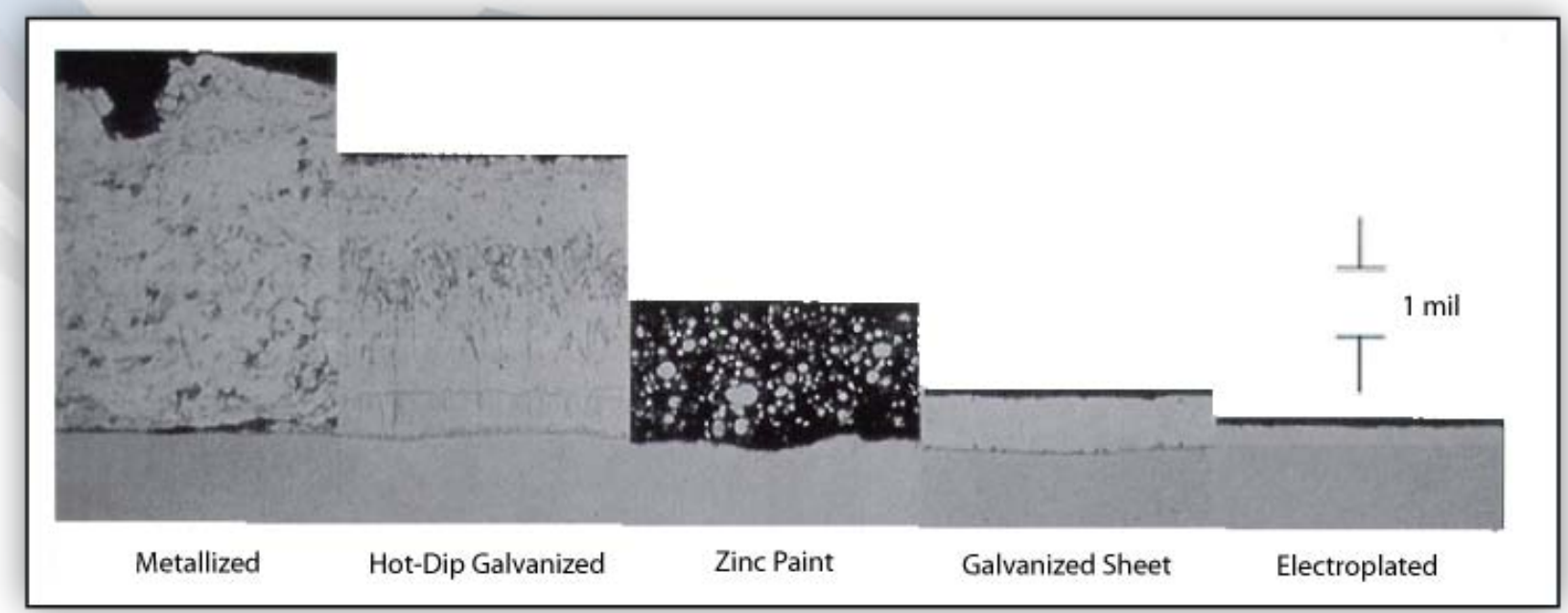
Additional Benefits: Variety & Availability

Available 24/7/365 with no temperature or humidity requirements



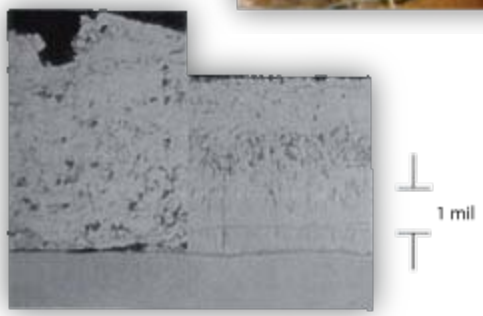
Other Zinc Coatings for Corrosion Protection

Zinc Coatings Comparison

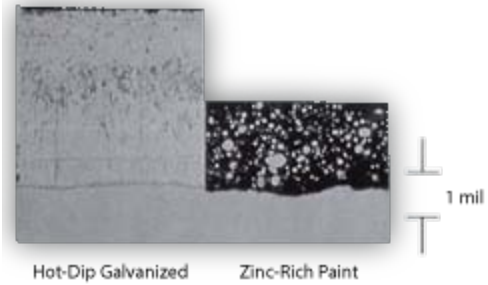


Metallizing

- Zinc wire or powder melted and sprayed onto the surface
- Shop or field application
- 85% as dense as HDG
- Mechanical bond and no alloy layers

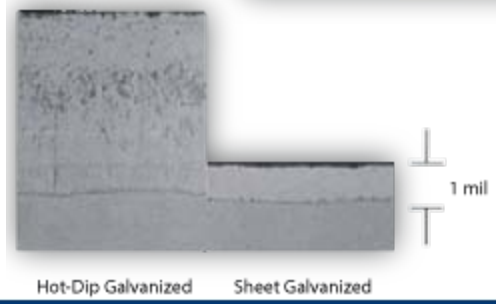


Zinc-Rich Paints



- Zinc dust in organic or inorganic binders
- Erroneously referred to as “cold galvanizing”
- Cathodic protection is dependent on
  - Conductive binder
  - Zinc particles in contact
  - % of zinc in dry film

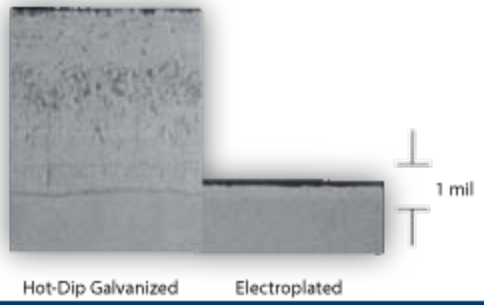
Continuous Sheet Galvanizing



- Continuous in-line hot-dip process for sheet, strip, wire
- Coating thickness and alloy layers are minimal
- Common Products
  - G60, G90
  - Galvannealed (Zn-Fe)
  - Galvalume (Zn-Al)

Electroplated

- Zinc applied to steel sheet, strip and small parts by electro-deposition
- No alloy layers, thin coating of pure zinc
- More expensive than sheet galvanizing

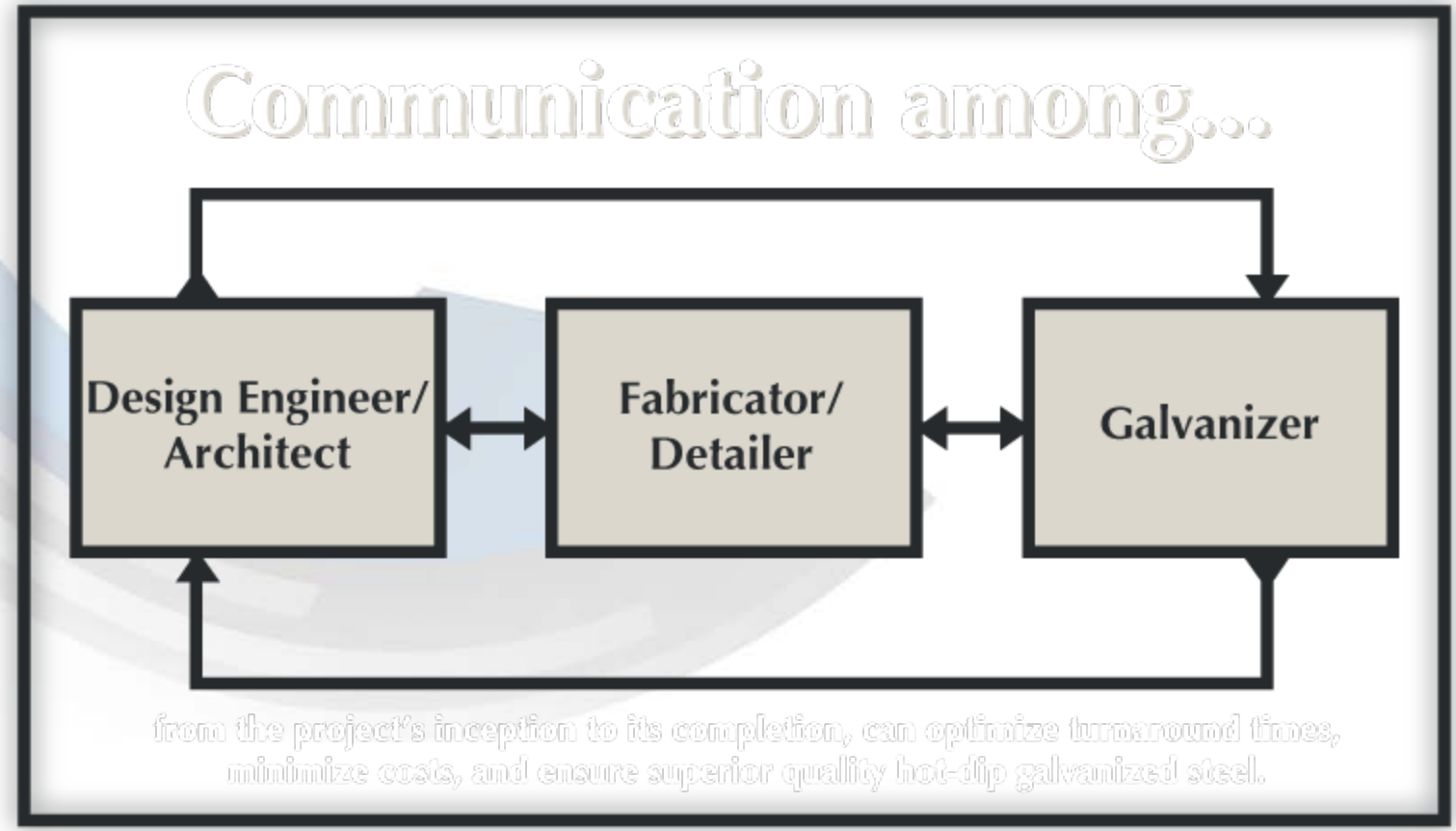


Zinc (Mechanical) Plated

- Only used for fasteners and small parts
- Tumbled in drum with zinc powder, glass beads, and proprietary chemicals
- Mechanical bond

Design & Fabrication

Communication is Key

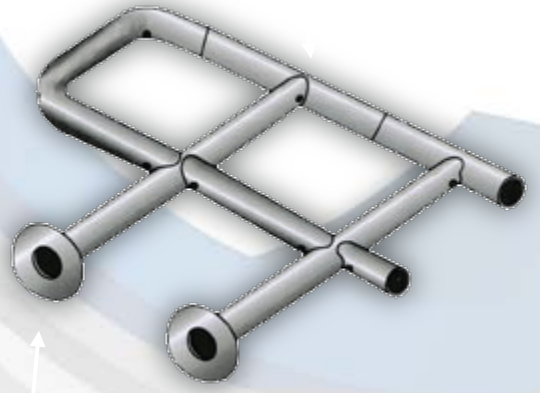


Suitable Materials for Galvanizing

Hot-Dip Galvanized Fasteners

Galvanized fasteners are recommended for joining hot-dip galvanized structures

Venting & Drainage



- Hollow structures must have vent and drain holes
- Allows moisture to escape and zinc to drain upon withdrawal

Dissimilar Thicknesses

- Heat and cool at different rates
- Can cause warping or distortion
- Best practice = design with similar thicknesses

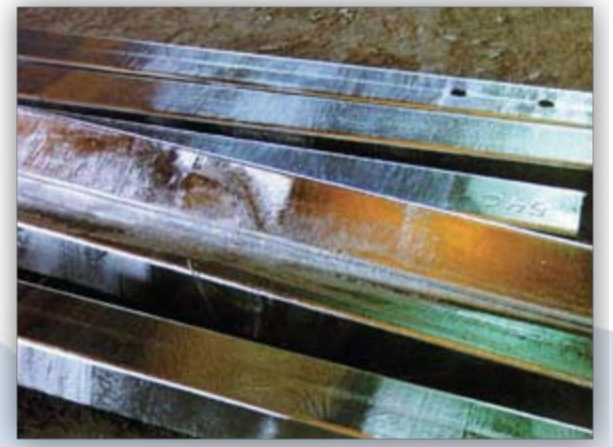
Material Handling

- Hoists and cranes used to process the steel
- Chains, wires, or other devices used to hold the material
- Weight is also an important factor

Galvanizing Oversized Pieces

- Average kettle length is 40 feet (North America)
- Many kettles 50-60 feet
- Progressive dipping used for larger pieces
- Communicate with galvanizer during design process

Coating Appearance: Newly Galvanized



Weathering of Galvanized Steel

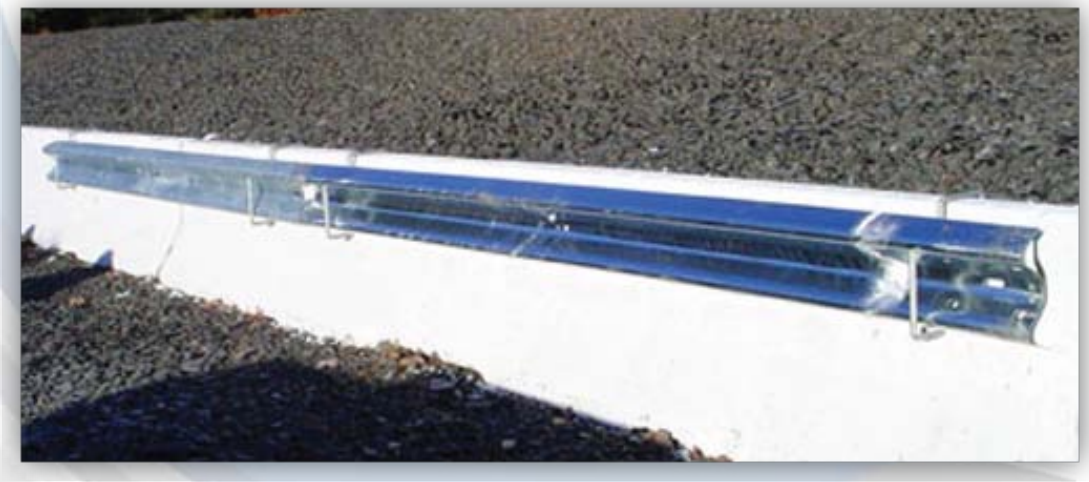


Photo taken 12/18/02

Photo taken 03/28/03

Duplex Systems
Painting/Powder Coating
Hot-Dip Galvanized Steel

Why Paint Galvanized Steel?

- Aesthetics
  - Branding
  - Architect's preference
- Identification
  - Safety
- Hostile environment
  - Chemical plants
- Repair or extend the life of existing galvanized articles

Galvanized Surface Condition

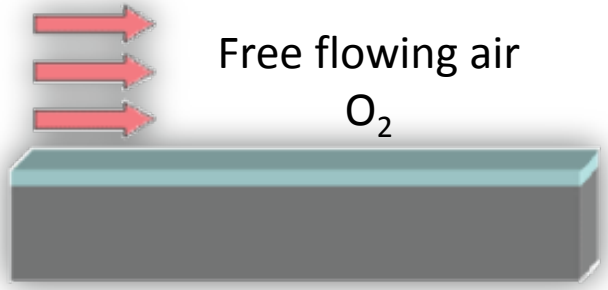
- Proper surface preparation is critical for successful duplex systems
- Galvanized surface condition will dictate the preparation required
  - Newly galvanized
  - Partially weathered
  - Fully weathered

Passivation Cycle

Time

0 – 48 hrs

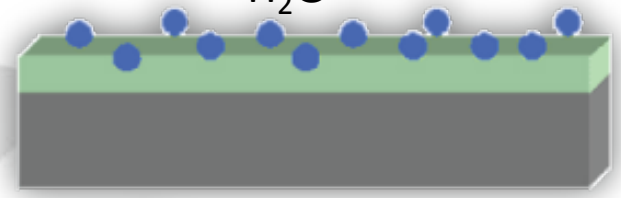
Zinc Oxide
ZnO

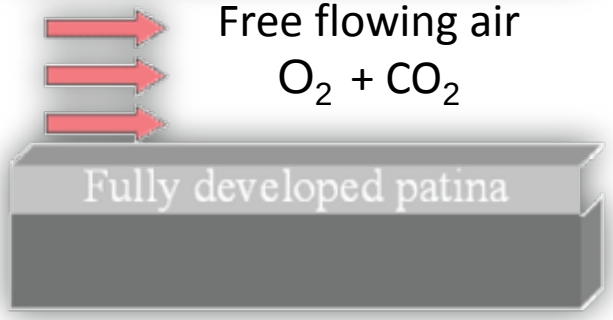


Moisture from rain (dew)
H_2O

48 hrs – 6 mos

Zinc Hydroxide
$Zn(OH)_2$





6 mos – 2 yrs

Zinc Carbonate
$2ZnCO_3 \cdot Zn(OH)_2$

Synergistic Effect

- Systems work in synergy
  - Paint is barrier for zinc
  - Zinc prevents underfilm corrosion from forming
- Minimizes paint peeling and flaking
- Paint & Galvanizing provide 1.5x – 2.5x sum of the systems alone
- Extends maintenance cycle of paint

Hot-Dip Galvanizing
Costs Less Lasts Longer

The Cost of Corrosion Protection

- Initial cost will always factor into decision
- Life-cycle cost analysis is more complete
  - Includes all future maintenance costs
  - Provides total cost of the project over its life
- Life-cycle cost calculation automated online at www.galvanizeit.org/galvanizingcost/

Quantitative Analysis

- Data Sources:
  - Paint – 2008 KTA Tator paper
    - Nationwide survey of the paint industry
    - Presented at NACE 2009
  - Galvanizing – 2008 AGA Industry Survey
- Project Parameters
  - Standard mix of steel (structural, tubing, plate)
  - 30,000 ft^2 project
  - Moderately industrial environment

Initial Cost Parameters

- Paint
  - Material (one- or two-pack product, number of coats, etc)
  - Shop cleaning labor
  - Shop/field application
  - Field labor
- Galvanizing
  - Process is inclusive of all cleaning, material, and labor

Initial Cost

Coating System	$/ft²	Total
Inorganic Zinc	$1.35	$40,410
Hot-Dip Galvanizing	$1.60	$48,000
Inorganic Zinc/Epoxy	$2.16	$64,800
Acrylic WB Primer/ Acrylic WB Intermediate/ Acrylic WB Topcoat	$2.55	$76,620
Inorganic Zinc Primer/ Epoxy/ Polyurethane Topcoat	$3.17	$94,950

Life-Cycle Cost

- Maintenance costs calculated on a practical maintenance cycle (vs. ideal)
  - Unique to each paint system
  - Manufacturer recommended cycles provided in the KTA Tator paper
- NACE model for NFV and NPV calculations
  - 2% inflation; 4% interest
- 50-year life
- Maintenance repaint at 5% rust

Life-Cycle Cost ($/ft^2)
60-Year Life

Coating System	
Hot-Dip Galvanizing	$1.60
Inorganic Zinc	$5.16
Inorganic Zinc/Epoxy	$8.07
Inorganic Zinc Primer/Epoxy Intermediate/ Polyurethane Topcoat	$10.04
Acrylic WB Primer/ Acrylic WB Intermediate/ Acrylic WB Topcoat	$14.82

Total Cost of 60-Year Project

Coating System	
Hot-Dip Galvanizing	$48,000
Inorganic Zinc	$154,800
Inorganic Zinc/Epoxy	$242,100
Inorganic Zinc Primer/ Epoxy/ Polyurethane	$301,200
Acrylic WB Primer/ Acrylic WB Intermediate/ Acrylic WB Topcoat	$444,600

Galvanized Steel Projects

7th Avenue Light Rail Transit

Date Galvanized
2005

Components Galvanized
Columns, arms, light posts, handrails, benches, hardware

Environment
Urban

Location
Calgary, AB

Michigan/M-102 Bridge Rail

Date Galvanized
2007

Components Galvanized
Guide rails

Environment
Urban

Location
Detroit, MI

Harley Davidson Museum

Date Galvanized
2008

Components Galvanized
I-beams, columns, gusset plates, and cross bracing

Environment
Urban

Location
Milwaukee, WI

San Joaquin Solar Farm

Date Galvanized
2007

Components Galvanized
Frames, hardware

Environment
Industrial

Location
Oakdale, CA

Bergen County Bridge

Date Galvanized
2009

Components Galvanized
Trusses, floor beams, flooring-diaphrams, supports, rail, plates

Environment
Suburban

Location
Fairlawn/Patterson, NJ

AGA Resources

- www.galvanizeit.org
- aga@galvanizeit.org
- 1-800-HOT-SPEC (1-800-468-7732)
- Technical Library
- AGA KnowledgeBase
  - www.galvanizeit.org/aga/knowledgebase
- *Galvanizing Insights*
  - Quarterly e-newsletter

Questions & Comments