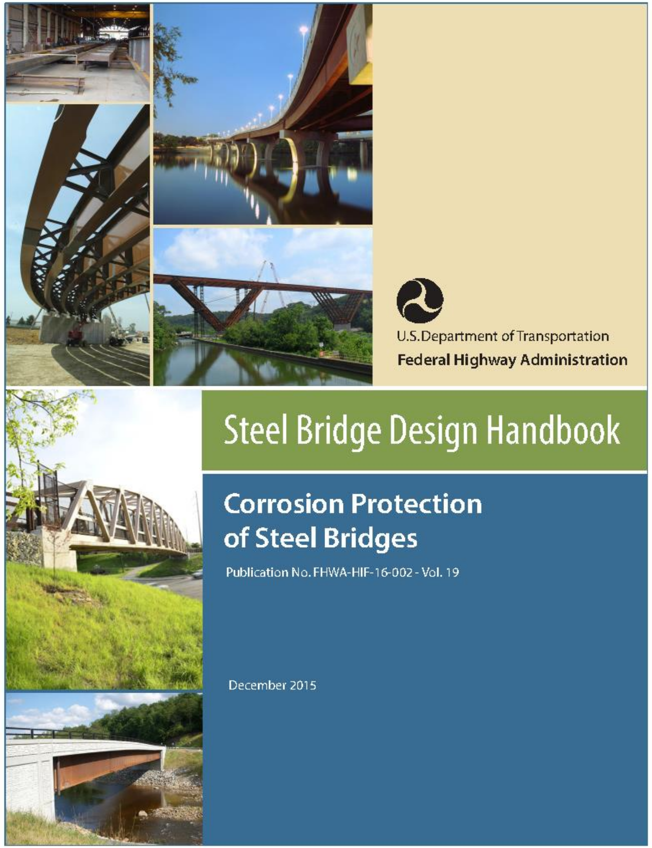
Modern Corrosion Protection Systems (Part 1)

Jeff Carlson

Smarter.
Stronger.
Steel.

FHWA – SBDH, Volume 19



NSBA Webpage

Go to: aisc.org/nsba/corrosionprotection

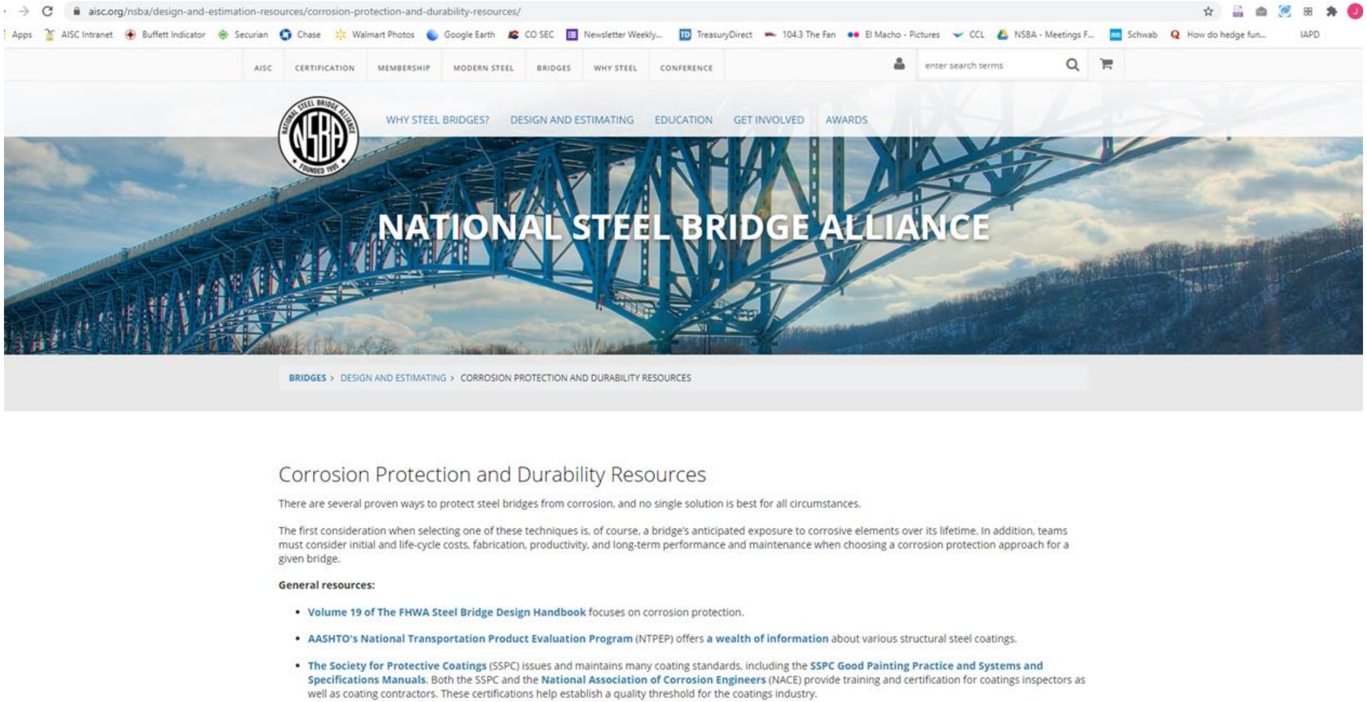


Photo: Eads Bridge Over the Mississippi River, St. Louis, Missouri

Mitigation Strategies for Steel Bridges

What's Right For you?

- Uncoated Weathering Steel (UWS)
- Liquid Applied Coatings
- Thermal Spray Coatings (TSC, aka - Metallizing)
- Hot-Dip Galvanizing (HDG)
- A709-50CR (previously known as A1010)

The Default System

- Start with the least cost. Move to the next system if there is a compelling reason to do so!

UWS → Paint → TSC / Galv → 50CR

Uncoated Weathering Steel (UWS)

Grade	Yield Strength (ksi)
36	36
50	50
50S	50
50W	50
HPS 50W	50
HPS 70W	70
HPS 100W	100
50CR	50
QST 50	50
QST 50S	50
QST 65	65
QST 70	70

From ASTM A709

- Grade designations ending in "W" are weathering grades.
  - They develop a stable patina that provides barrier corrosion protection
  - The patina controls the rate that oxygen can reach the bare steel underneath

Uncoated Weathering Steel (UWS)


Source: FHWA

Provides "barrier" protection

Source: Crampton et. al., 2013

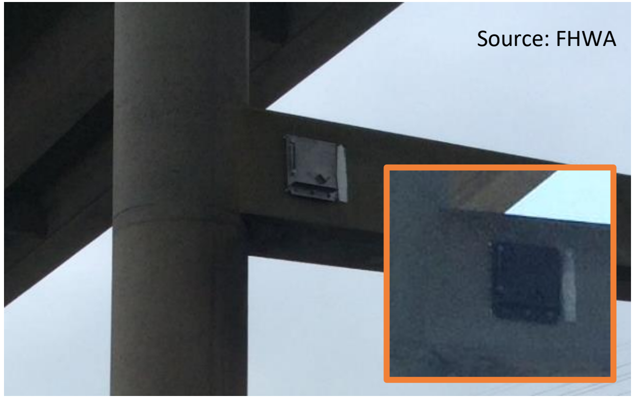
Well formed patina has a dark-chocolate, almost purple hue. Also has fine pinholes.

ASTM A709-50CR

- ~11% chrome
- Ferrite / tempered martensite (formally it's a martensitic stainless steel)
- Develops a brown colored patina like weathering steel

6yr. exposure McLean, VA (vertical)

3 yr. exposure Hampton Roads, VA (horizontal)

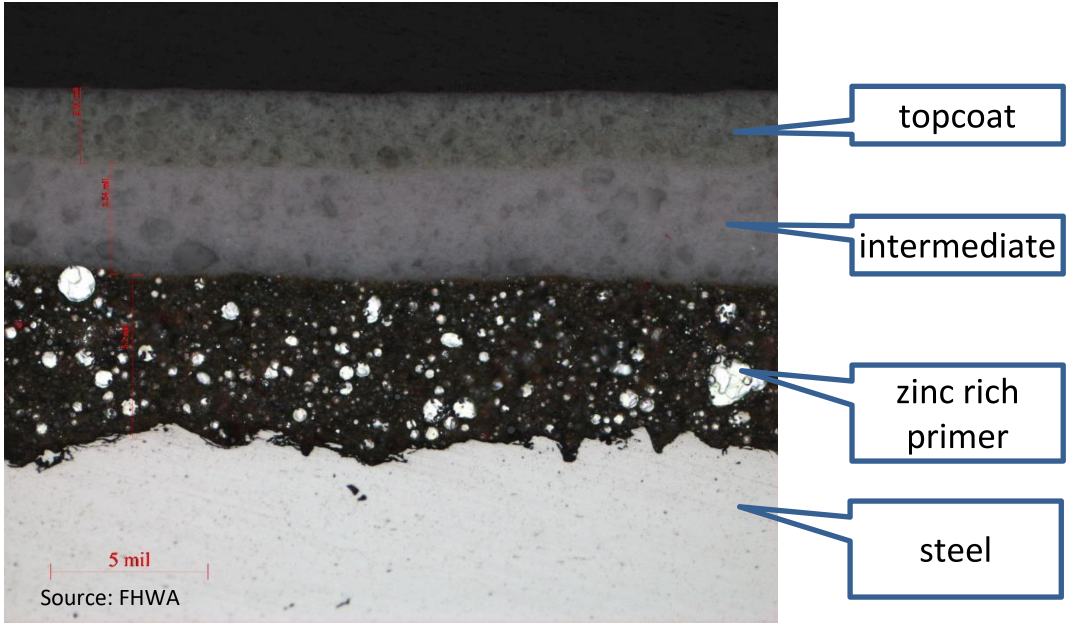


9 mo. And 3 yr. (inset) exposure North Topsail, NC (vertical)

Modern Liquid Applied Coatings

Types & Definitions:

- IOZ – Inorganic Zinc Primer
- OZ – Organic Zinc Primer
- E – Epoxy (intermediate coat)
- U – Urethane (topcoat)

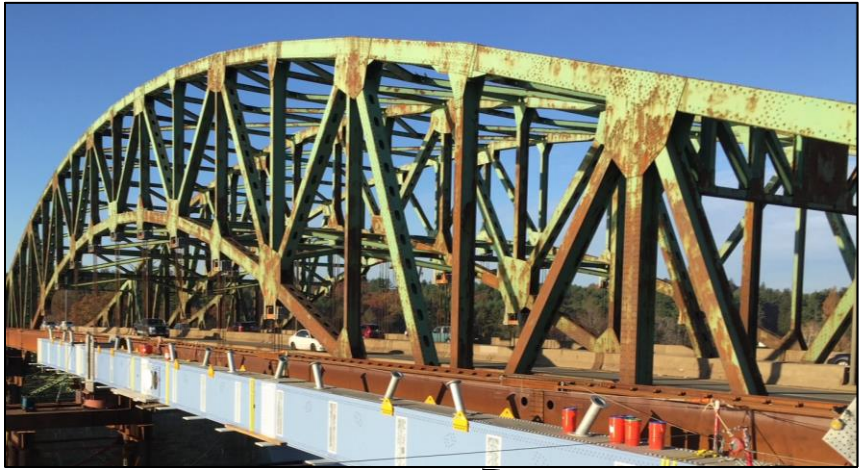


The Misperception Dilemma

Whittier Bridge - Massachusetts

This bridge utilized the <u>old lead paint systems</u> prior to implementation of current practices.

The Colorful History of Steel Bridge Paint Systems

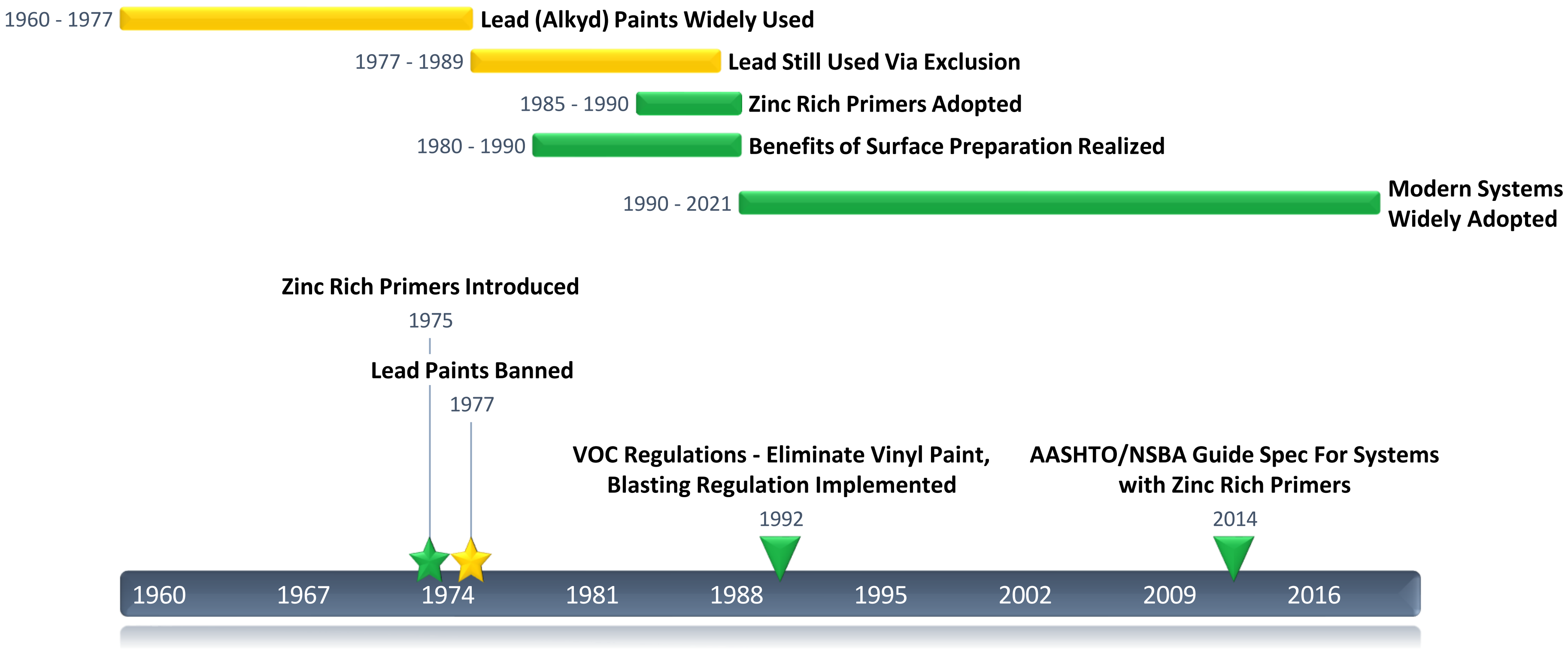


1960 - 1977 **Lead (Alkyd) Paints Widely Used**

1990 - 2021 **Modern Systems Widely Adopted**

1960 1967 1974 1981 1988 1995 2002 2009 2016

The Colorful History of Steel Bridge Paint Systems



Old Liquid Applied Coatings

Modern Liquid Applied Coatings

This bridge utilized a modern 3-coat paint system. Built in 1998.

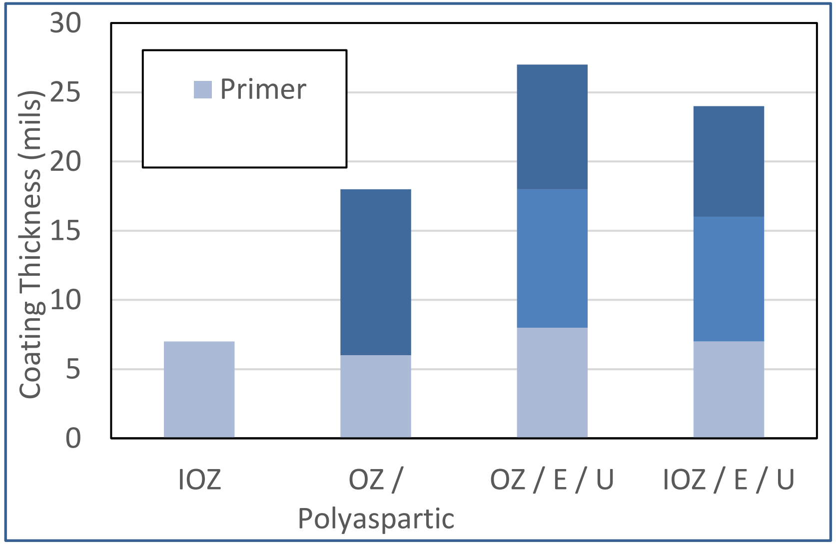
Liquid Applied Coatings

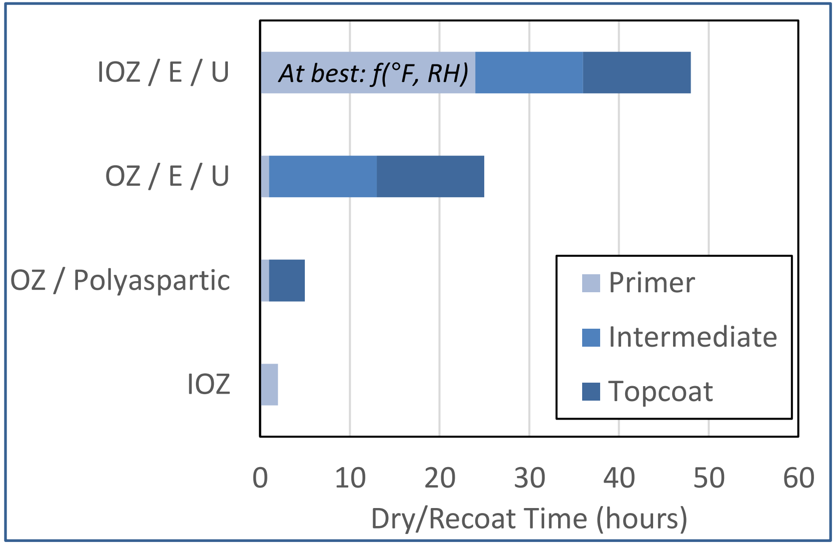
- Primarily “barrier” protection, however zinc-rich primer provides “cathodic” protection if exposed

Source: Chris Stuvek

Liquid Applied Coatings – Cost Implications

Consult With
Local Fabricator





Source:
Random selection of qualified systems from http:\\data.ntpep.org\SSC (except for single-coat IOZ)

Source:
Medlock, R. (2020). “Two-Coat OZ/Polyaspartic Topcoat System for New Bridge Construction. Presentation delivered to Subcommittee AHD30(2), Annual Meeting of the Transportation Research Board.

Liquid Applied Coatings

Workhorse systems

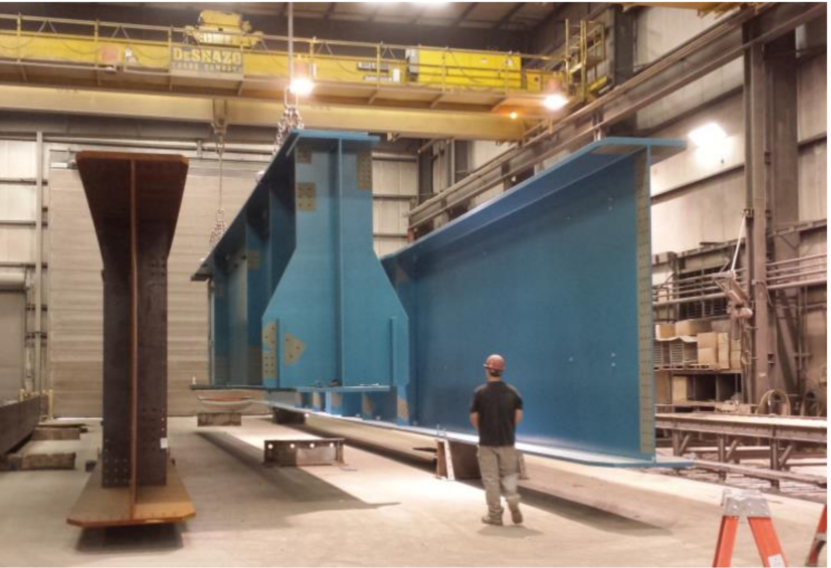
- 3-coat, OZ/Epoxy/Urethane
- 3-coat, IOZ/Epoxy/Urethane

Innovative systems

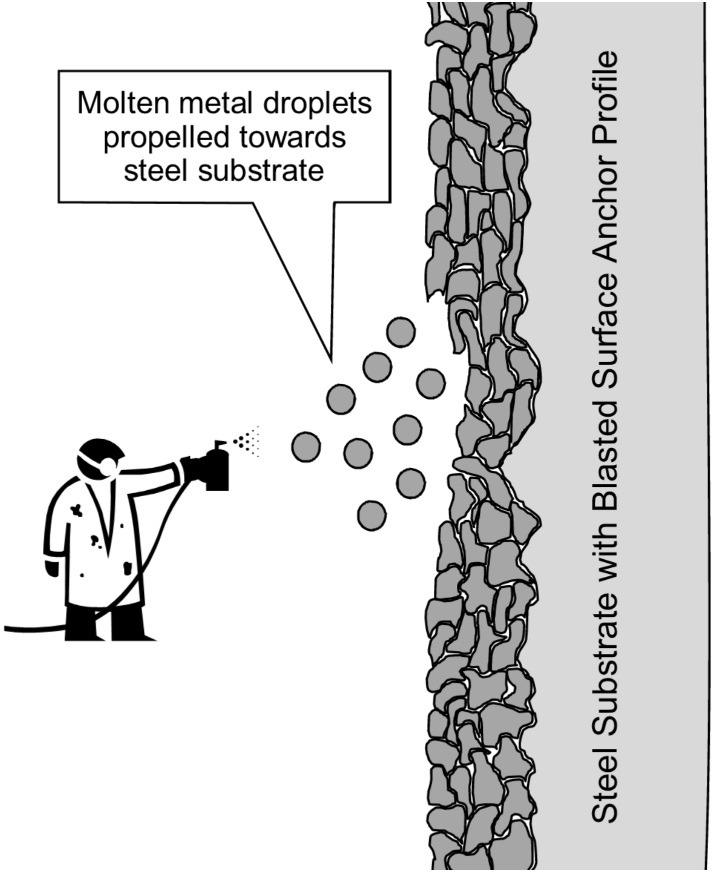
- IOZ only
- IOZ with acrylic topcoat
- 2-coat, OZ/polyaspartic

Tappan Zee Replacement

- Considered metalizing, IOZ, OZ
- Chose OZ due to time savings



Thermal Spray Coatings (TSC) – aka Metallizing



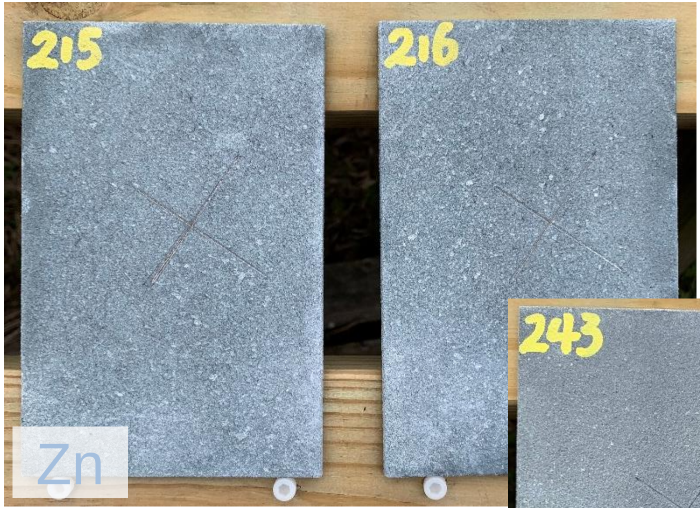
<u>Common Alloys</u>

Aluminum (Al)

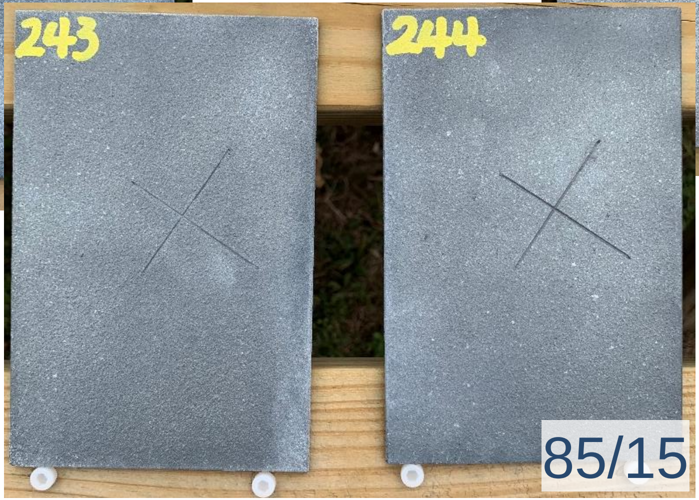
85/15 (Zn/Al) -------------------- Most common

Zinc (Zn)

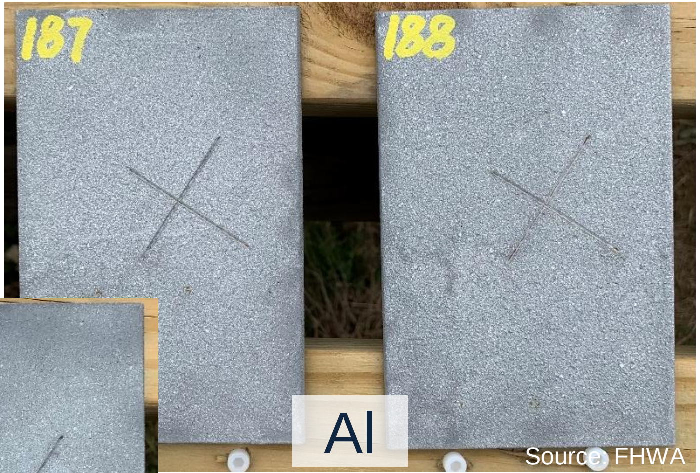
Thermal Spray Coatings (TSC)



Source: FHWA

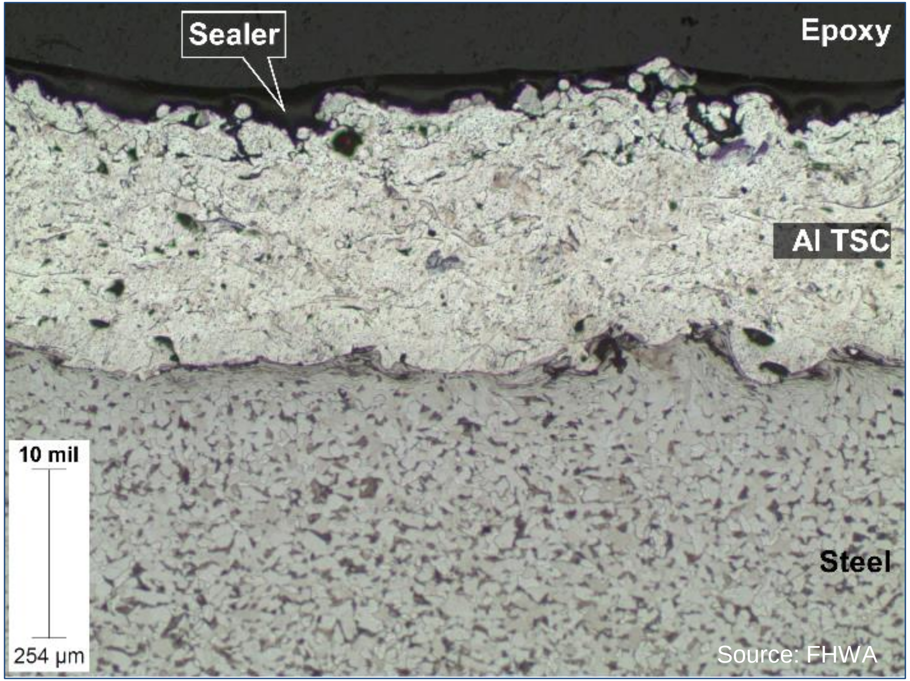


Source: FHWA



Source: FHWA

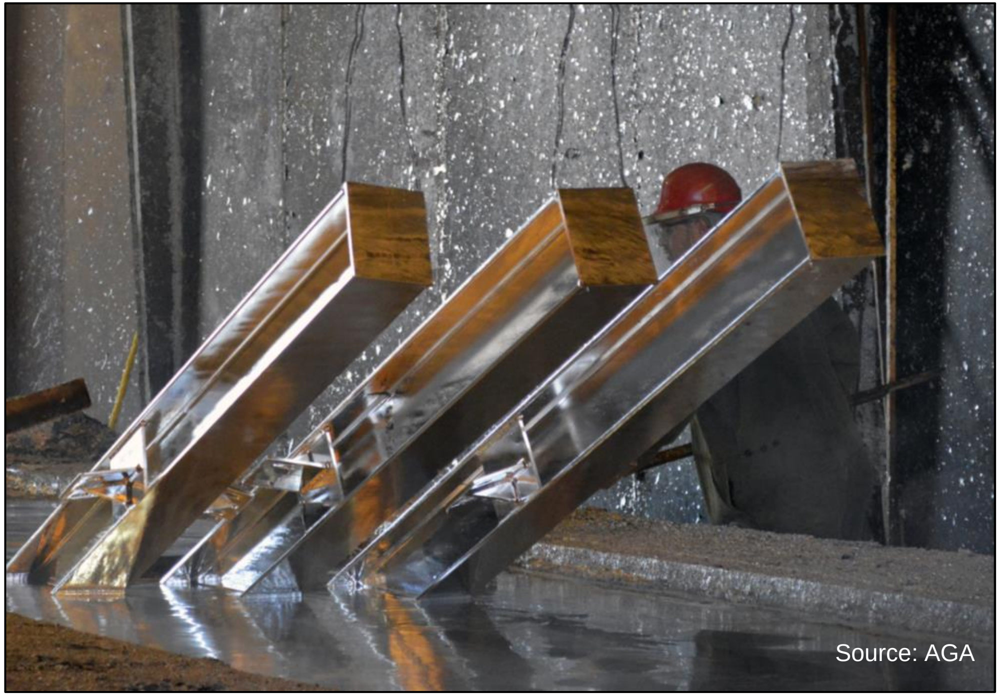
Thermal Spray Coatings (TSC)



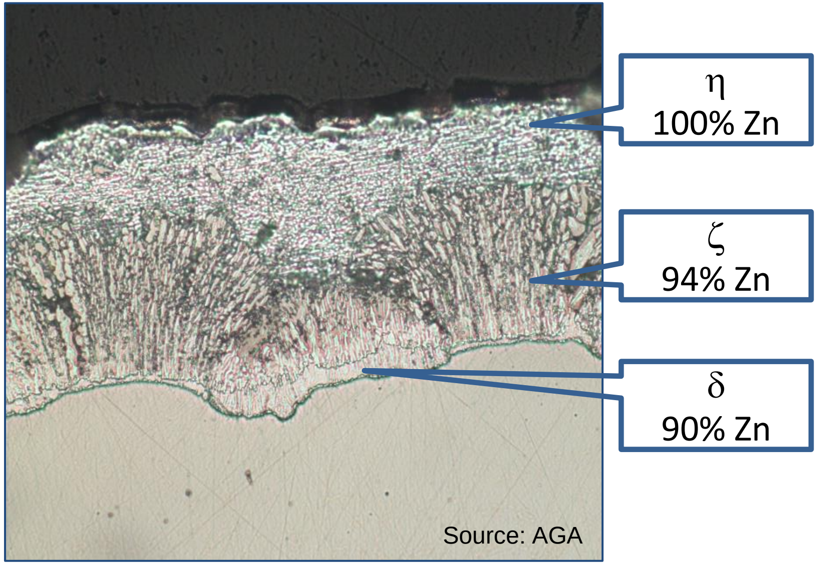
Mostly “cathodic” protection

- TSC are porous – sealing is common, but not necessary
- Sealers are low-viscosity, liquid applied coatings meant to penetrate through pores
- Mechanical process, whereas HDG is chemical process

Hot-Dipped Galvanizing



- Dipping steel in ~830^{o}F zinc creates the chemical bond



Both “barrier” and “cathodic” protection

Hot-Dipped Galvanizing

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


Source: AGA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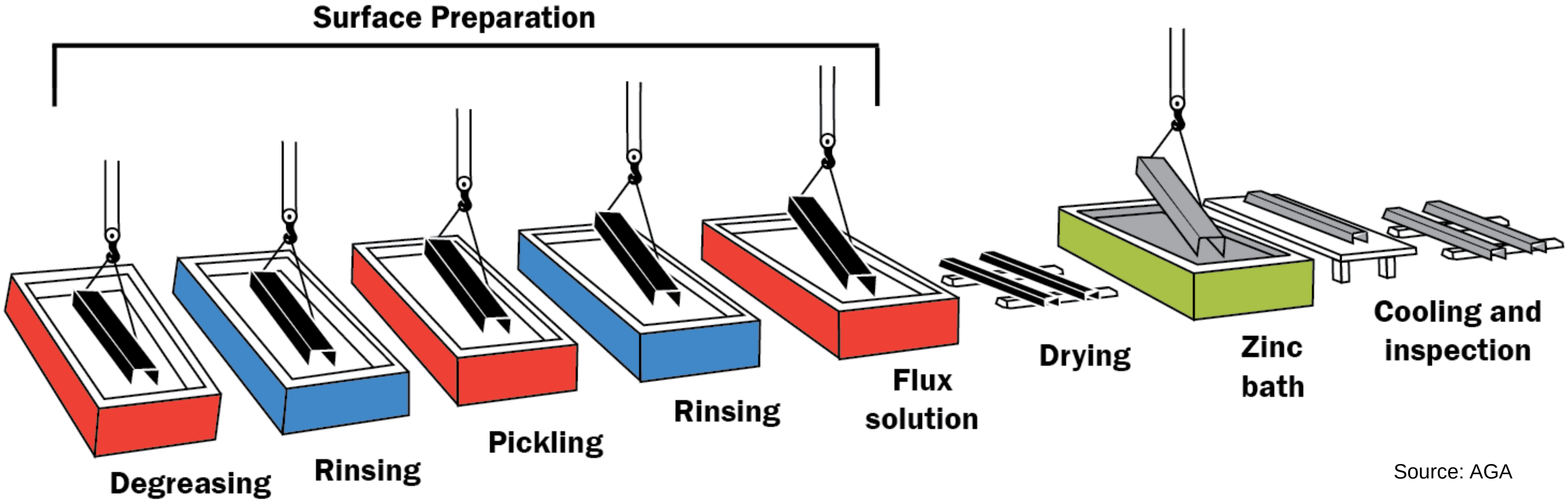
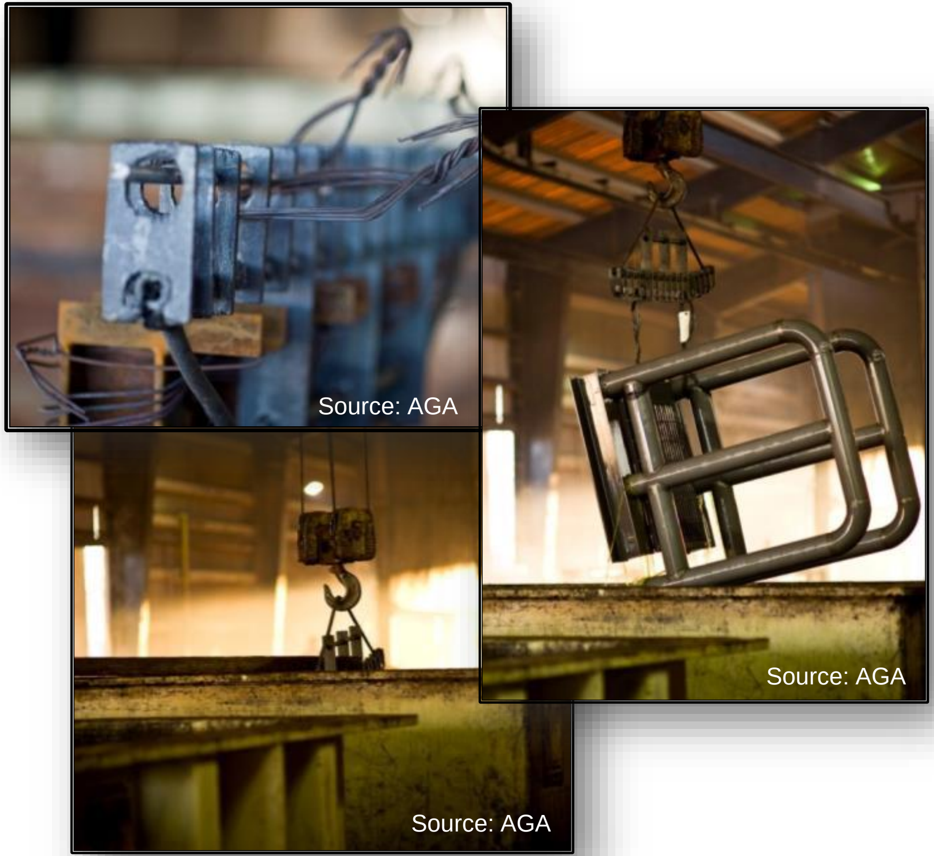
Hot-Dipped Galvanizing



Source: AGA

Hot-Dipped Galvanizing – Surface Preparation

- Thorough cleaning is necessary as zinc will only react with clean steel
- Three cleaning solutions:
  - **Degreasing** – removes dirt, oils, organic residue
  - **Pickling** – removes mill scale and oxides
  - **Fluxing** – mild cleaning, protective layer
- Unclean areas will not grow zinc coating



Relative Cost of Coating Systems

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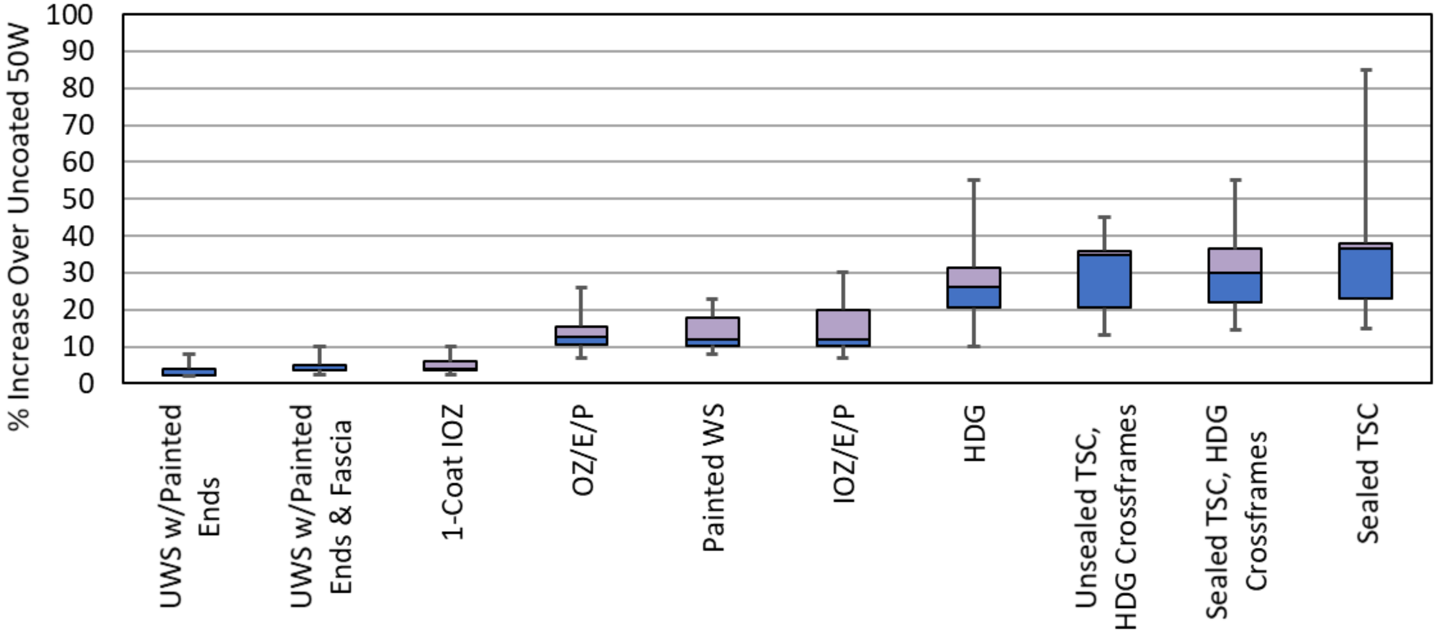
2020 Cost of Coatings Survey

Relative % cost increase* over ASTM A709 Grade 50W (unpainted)



Note: VERY important to know the capability and expertise of the local fabricators regarding TSC!!!

* - defined as FOB cost delivered to jobsite.

Recall……The Default System

- Start with the least cost. Move to the next system if there is a compelling reason to do so!

UWS → Paint → TSC / Galv → 50CR

Cost of Corrosion Protection Example

Total Length = 350 ft (2-175 ft spans)

Width = 60 ft

Total Area = 350 ft x 60 ft = $\underline{21{,}000\ ft^2}$

Example (cont)

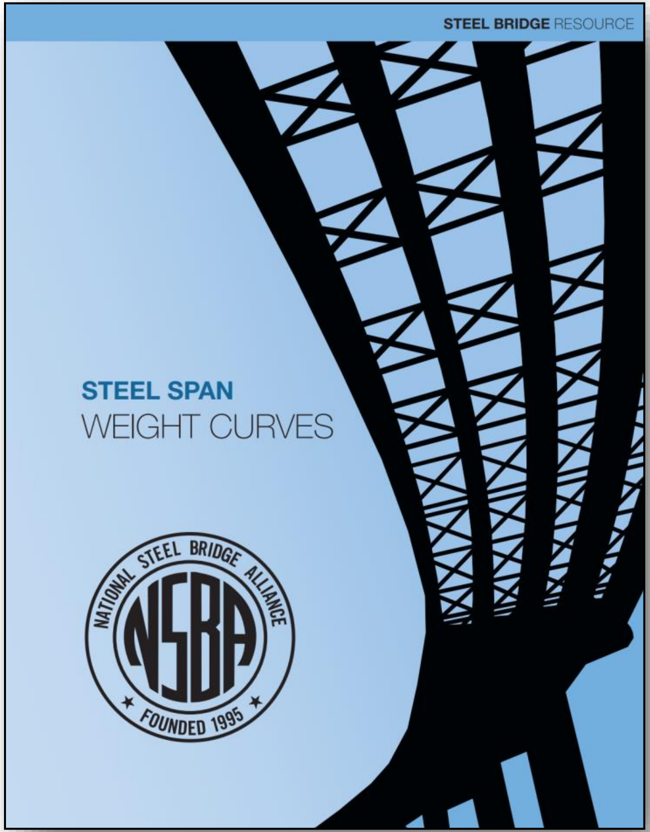
<u>Using NSBA Span/Weight Curves:</u>

Assuming: 2-span, 9’ to 11’ girder spacing, 175’ span length, routine fabrication

➡ Weight of steel = 35 psf

Total weight of steel = 21,000 ft^2 x 35 psf

➡ 735,000 lbs = 368 tons



Example (cont)

For straight, routine, steel bridge – for illustration purposes……assume $1.00/lb (UWS) for fabrication and delivery

735,000 lbs x $1.00/lb = $735,000 cost of steel for fab and delivery

Example (cont)

Compare to other systems

- UWS Cost = $735,000 (baseline)

System	% Inc	$/lb	$ Steel	Diff from Baseline
SIOZ	6%	$1.06	$779,000	$44,000
OZ/E/P*	13%	$1.13	$831,000	$96,000
TSC/HDG	30%	$1.30	$956,000	$221,000

* - IOZ/E/P is an approximate 16% increase over UWS

Thank you

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