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TRANSPORTATION RESEARCH BOARD

Performance and Benefits of Metalizing and Duplex Coating

November 18, 2021

@NASEMTRB
#TRBwebinar

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Learning Objective

Design steel bridge with coatings that best fit their environments and provide the longest service life for steel bridges

Using Metalizing to Enhance Durability of Steel Bridges

November 18, 2021, 2PM

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First A Little Fun ☺

- Should metalizing be spelled with 1 or 2 L's?
- Is electroplating a form of metalizing?
- Is galvanizing a form of metalizing?

Merriam – Webster:

To coat, treat, or combine with a metal.

Topics We Will Discuss Today:

- What is corrosion?
- What is metallizing and Why Does It Work?
- Pros and Cons
- Bridge Case Studies
- Metalizing Used to Cathodically Protect Steel Reinforcement Embedded in Concrete

Corrosion :

- Corrosion is the degradation of a material caused by exposure to its environment.
  - Plastics
  - Metals
  - Inorganic molecules
  - Organic molecules
  - Everything corrodes......

Corrosion :

Corrosion is the oxidation of ferrous iron (2^+) to ferric iron (3^+)

$$4Fe^{2+}(aq) + 4H^+(aq) + O_2(aq) \rightarrow 4Fe^{3+}(aq) + 2H_2O(l)$$

ferrous

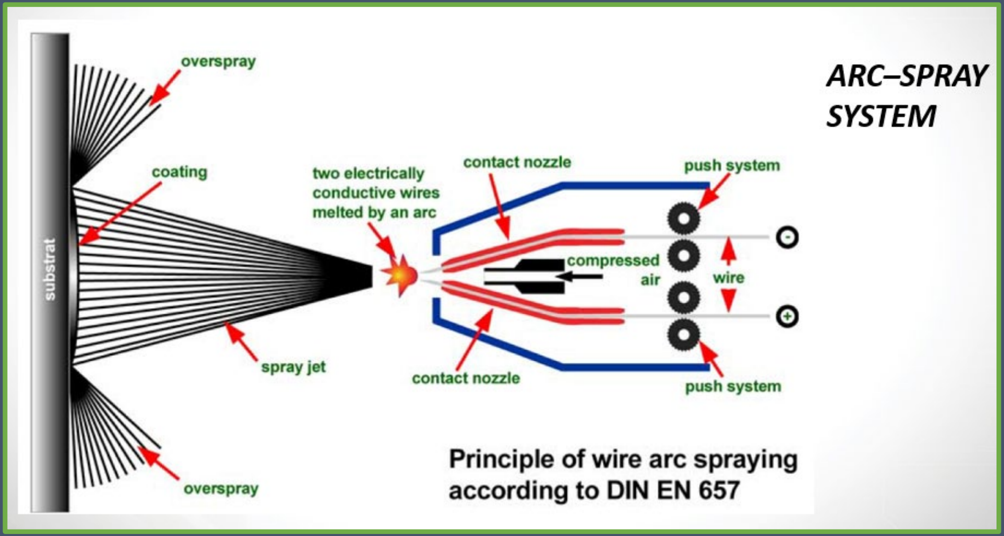
ferric

How Does Metalizing Lessen Corrosion?

- **It provides a barrier between the steel and the environment.**
- **It is galvanic/sacrificial – it corrodes preferentially to protect the steel. Metalizing acts as a sacrificial anode similar in function as the galvanizing applied to steel lighting structures and guardrails.**
- **When used on concrete, it can cathodically protect steel reinforcement.**

How is Metalizing Applied?

- **An aluminum or zinc wire (or alloy of the 2) is melted using flame or electricity and sprayed onto a steel substrate.**
- **Common wire compositions are 99% Zn, 99% Aluminum, but the most commonly used is 85% Zn/15% Al due to improved applicability and adhesion.**



Pros and Cons of Metalizing

Pros	Cons
Better durability	Better surface preparation: SSPC SP5, flame hardened.
Improved life cycle cost	Higher initial cost
Cold weather friendly	Harder to apply
No curing period – It can be applied in one pass and can be re-coated immediately.	To maximize durability, a sealer is needed
	Finish coat needed for aesthetics

Case Study 1:
Castleton on Hudson Approach Spans

- **Metallizing of approximately 200,000 SF of steel beneath open steel grating.**
- **Metallizing of deck stringers within 5’ of any deck joint.**
- **Metallizing was applied during the 2000 and 2001 construction season, utilizing flame spray.**
- **All metallizing was applied in accordance with NYSTA project specifications in effect at the time.**

Specification Requirements

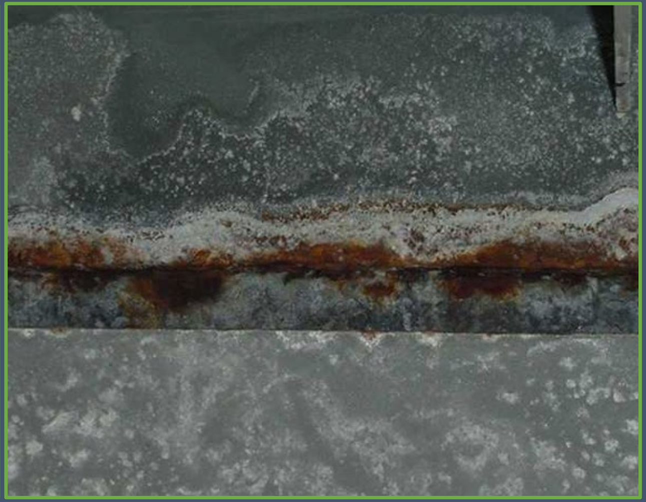
Case Study 1

- **85/15 metallizing, at a thickness of 8 to 10 mils.**
- **Surface preparation was SSPC-SP5 (White Metal Blast) -**
  recyclable abrasive was permitted.
- **Sealer was not specified.**
- **Chloride remediation was 15 ųg/cm².**
- **There was a 30-day time limit to apply subsequent coats of metallizing.**
- **Minimum adhesion was 700 psi.**

How Did It Perform?

Case Study 1

- The un-sealed metalizing was subjected to magnesium chloride deicing salts during the winters of 2001 and 2002.
- The metalizing deteriorated quickly.



Case Study 2:
Rainbow Bridge, Niagara Falls, NY

- **Complete coatings removal and metallizing of the steel**
- **Tourism and pedestrian use dictated coatings work to be performed during winter.**
- **Aesthetic MCU overcoat applied over metallizing due to highly visible nature of structure.**
- **Work performed from 2002 – 2004.**

Specification Requirements

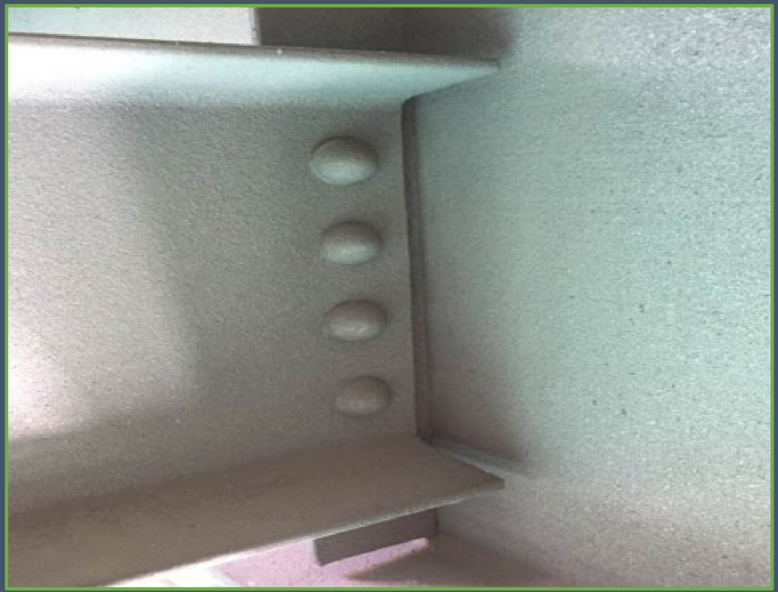
Case Study 2

- **85/15 metallizing, at a thickness of 8 to 12 mils.**
- **Surface preparation was SSPC-SP5 (White Metal Blast) – expendable abrasive was required.**
- **An MCU Sealer was specified and applied within 8 hours of metallizing application.**
- **Chloride remediation was 5 ųg/cm².**
- **There was a 30-day time limit to apply subsequent coats of metallizing.**
- **Metallizing was to be applied in a single shift**
- **Minimum adhesion was 700 psi.**

How Did It Perform?

- **Metallizing performing well after 2 decades.**
- **A small number of problem areas isolated to areas of joint leakage.**

Case Study 2



Case Study 3:
Stickney Point Bridge, Sarasota, Fl.

- Steel repair and recoating of Stickney Point Bridge (SR 72).
- This is the main route in and out of Siesta Key. Affluent area along with tourism drove project schedule.
- Metallizing was chosen to maximize service-life.
- First metallizing project on FL’s West Coast.

Specification Requirements

Case Study 3

- **FDOT Technical Special Provisions**
- **Florida DOT, Section 561, "Coating Existing Structural Steel"**
- **SSPC-CS 23.00/AWS C.2.23/NACE No. 12, "Application of Thermal Spray Coatings (Metalizing) of Aluminum, Zinc, and Their Alloys and Composites for the Corrosion Protection of Structural Steel."**
  - Note: TSP referenced CS-23 in its entirety, and only discussed those items that changed from joint standard.

Specification Requirements

Case Study 3

- **Key Requirements/Issues**
  - **Soluble Salts**
  - **Edges, Connections, Fasteners**
  - **Blasting, Metallizing, Sealing and Adhesion Testing must be done in one shift**
  - **Caulking**
  - **Anchor Profile**
  - **Clear Coat – After Repairs, Degradable Dye**
  - **Dry Film Thickness Measurements – SSPC PA-2**

Specification Requirements

Case Study 3

- **NACE No. 1 / SSPC-SP5, "White Metal Blast"**
- **Deeper Anchor Profile – Minimum 2.5 mils**
- **Contractor / Applicator Pre-Qualification**
- **Adhesion Testing – ASTM D4541**
- **Flexibility – Mandrel Testing**
- **8-12 Mils DFT, Multiple Passes, 3' x 3' Work Area**
- **Distance from the Substrate**

Case Study 4:
Bridge of Lions, St. Augustine, Fl.

- **Steel repair and recoating of Bridge of Lions - SR A1A**
- **National Register of Historic Places**
- **Opened in 1927.**
- **Metallizing was applied 2008.**
- **Double leaf bascule**
- **Main route between the beaches and historic St. Augustine.**
- **Hurricane evacuation route - affluent and high tourist area.**

Specification Requirements

Case Study 4

- **FDOT Technical Special Provision**
  - **Qualified Personnel: CP specialist, PE, or 5 years experience with TSM.**
  - **TSM technician with at least 1 year of experience, contractor must have a minimum of 3 years experience.**
- **SSPC SP5 Near White Metal Blast.**
- **2.5 mil angular profile (every 1000 ft2/auto, 20ft2/manual blast)**
- **Only new abrasive allowed**
- **99.9% zinc, 1/8" wire.**
- **500 psi adhesion strength.**
- **Coating 8 - 12 mils**

Specification Requirements

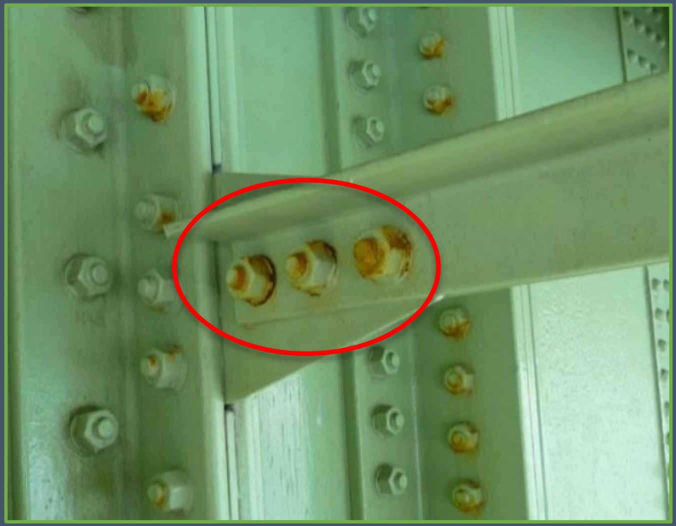
Case Study 4

- Duplex coating:
  - Metallizing 8-12 mils
  - Epoxy 4-6 mils
  - Polyurethane 2-4 mils
  - Polyurethane clear coat 1-2 mils
- Some steel was removed, transported to a shop for rehabilitation.
- Some steel was rehabilitated in place.

How Did It Perform?

- **By 2012, after four years, areas of corrosion and delamination were observed.**






Case Study 4

How Did It Perform?

Case Study 4

- **Detailed examination determined that localized failures were do to either localized application or preparation errors.**
- **Overall condition of the coating system was excellent.**
- **Localized repairs have been performed…. Its early in the estimated life-cycle - Stay tuned.**

Conclusions:

Case Study 4

- **Metalizing and duplex coatings can provide extended service life.**
- **Metalizing can be cost effective.**
- **Metalizing should be sealed if there is any possibility of exposure to deicing salts.**
- **Access to properly trained and qualified metalizing applicators is key.**
- **Metallizing can be successfully applied in winter months under the appropriate conditions.**
- **PROJECT SPECIFICATION AND QUALITY ASSURANCE IS PARAMOUNT!!!!**

ANY QUESTIONS

I am glad to help, and you don't need a work order. Just ask!

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Materials Investigation into the Comparative Performance of Metalized Coating Systems

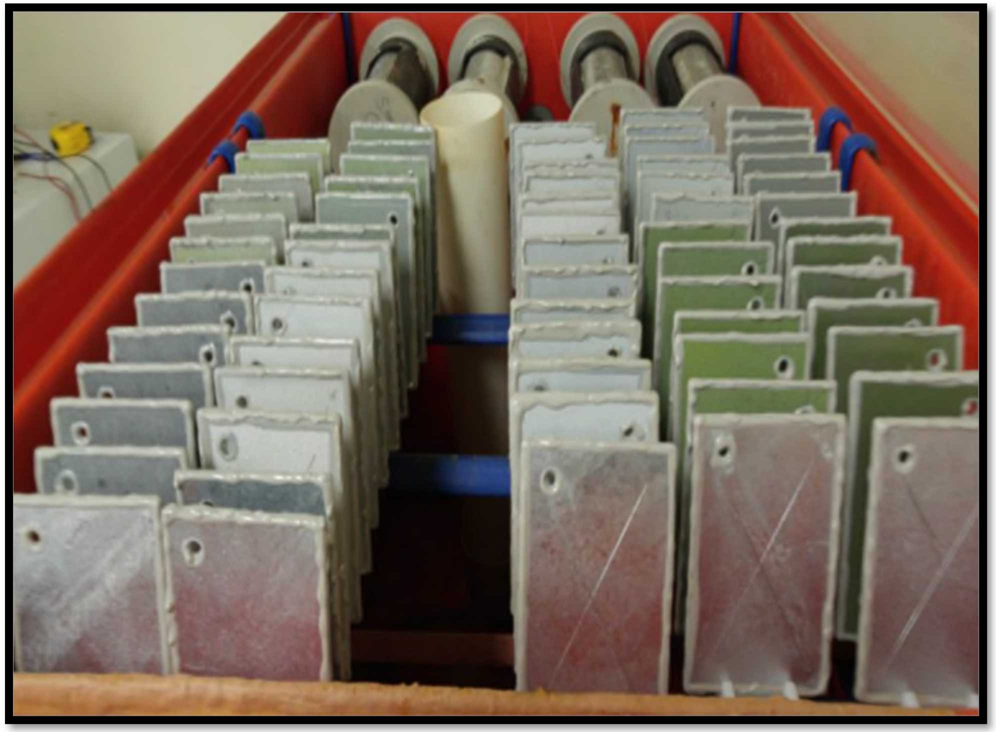
Tim McCullough
Florida Department of Transportation

Systems under Test

Surface Preparation	Primer	Finish
Blast SSPC SP-5	Zinc Metalizing (99% Zn)	- -
Blast SSPC SP-5	Zinc Metalizing (99% Zn)	Epoxy Seal Coat
Blast SSPC SP-5	Zinc Metalizing (99% Zn)	Aluminum Metalizing (99% Al)
Blast SSPC SP-5	Aluminum Metalizing (99% Al)	- -
Blast SSPC SP-5	Aluminum Metalizing (99% Al)	Epoxy Seal Coat
Blast SSPC SP-5	Zn/Al Metalizing (85% Zn/15% Al)	- -
Blast SSPC SP-5	Zn/Al Metalizing (85% Zn/15% Al)	Epoxy Seal Coat
Blast SSPC SP-10	IOZ (Ethyl Silicates, min. 77% Zinc)	Epoxy Seal Coat

Test Design

Test	Resistance to High Heat and Humidity	
Method	ASTM B117 (Scribed, Unscribed)	
Evaluation Period	3 years, 5 months (30,000 hrs.)	5 years, 0 months (42,720 hrs.)
Measurable	Visible Condition	Adhesion, Metallography



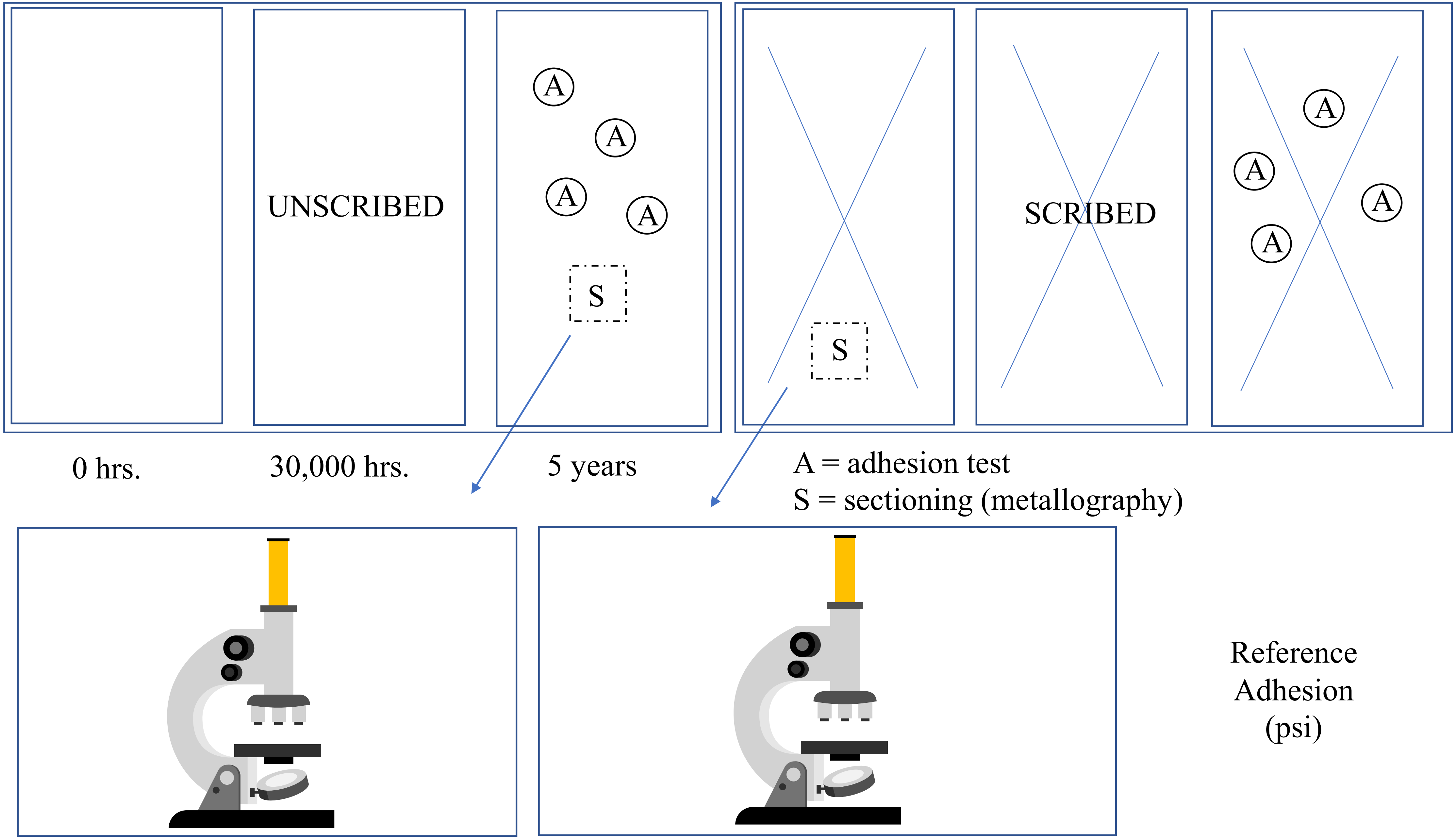
Condition of the panels prior to the start of the B117 salt fog testing

Results[1]

Coating System	5- Years Adhesion (PSI)	Initial Ranking
Aluminum Metalizing (99% Al) Epoxy Seal Coat	1,532	1
IOZ (Ethyl Silicates, min. 77% Zinc) Epoxy Seal Coat	927	2
Zinc Metalizing (99% Zn) Aluminum Metalizing (99% Al)	923	3
Zinc Metalizing (99% Zn) Epoxy Seal Coat	837	4
Zinc Metalizing (99% Zn)	834	5
Zn/Al Metalizing (85% Zn/15% Al) Epoxy Seal Coat	765	6
Zn/Al Metalizing (85% Zn/15% Al)	522	7
Aluminum Metalizing (99% Al)	450	8

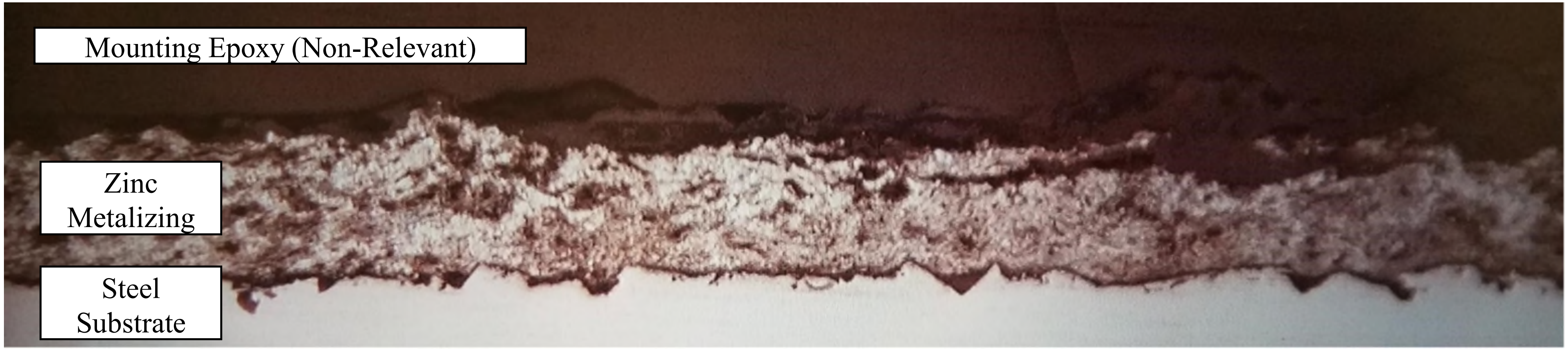
Presentation

System Name (Description)



Zinc Metalizing (99% Zn)

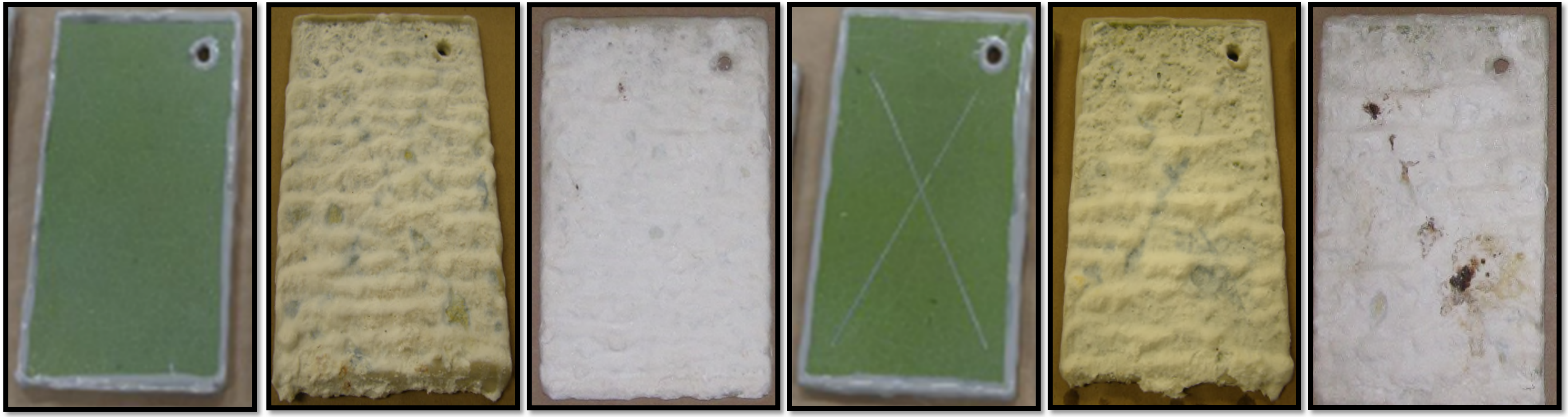
Condition of the panels at 0 hrs., 30,000 hrs., 5 years; Left (Unscribed) & Right (Scribed)



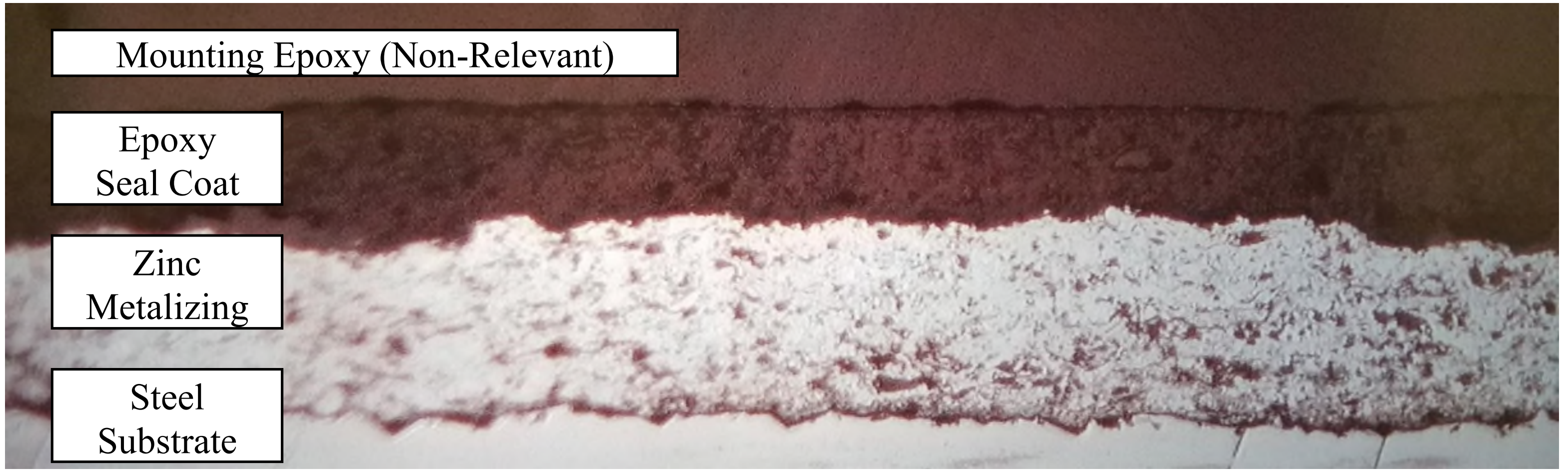
Adhesion 834 psi

Image taken using Optical Microscope after 5-yrs. in the salt fog chamber (350x).

Zinc Metalizing (99% Zn) + Epoxy Seal Coat



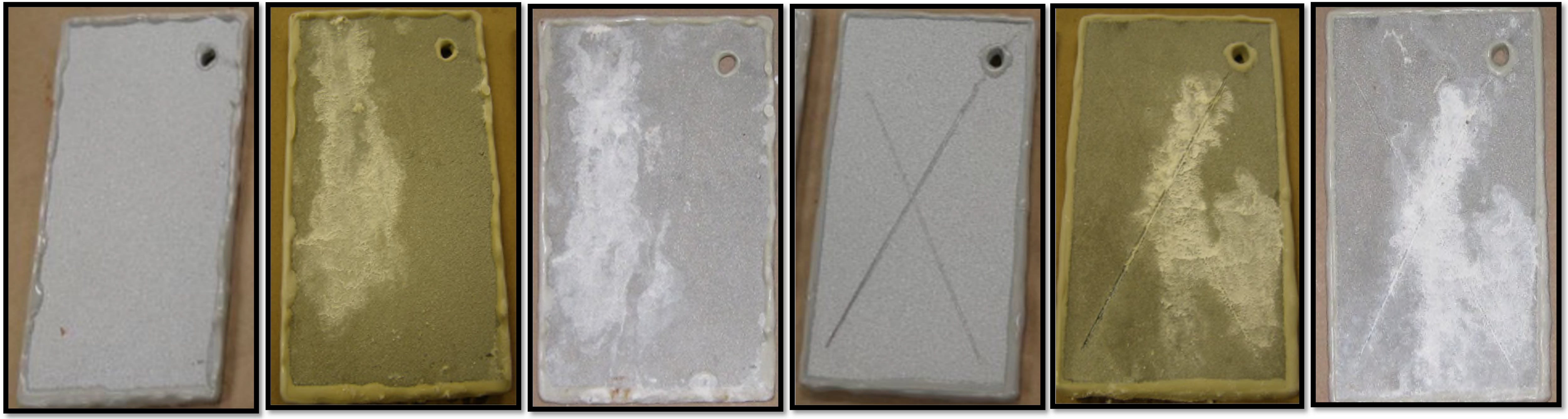
Condition of the panels at 0 hrs., 30,000 hrs., 5 years; Left (Unscribed) & Right (Scribed)



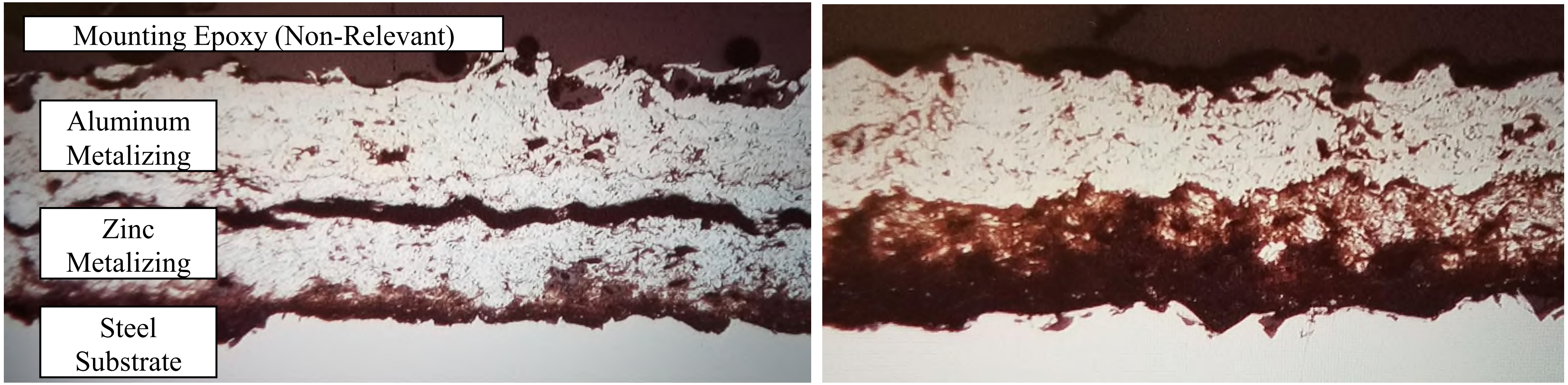
Adhesion 837 psi

Image taken using Optical Microscope after 5-yrs. in the salt fog chamber (350x).

Zinc Metalizing (99% Zn) + Aluminum Metalizing (99% Al)



Condition of the panels at 0 hrs., 30,000 hrs., 5 years; Left (Unscribed) & Right (Scribed)

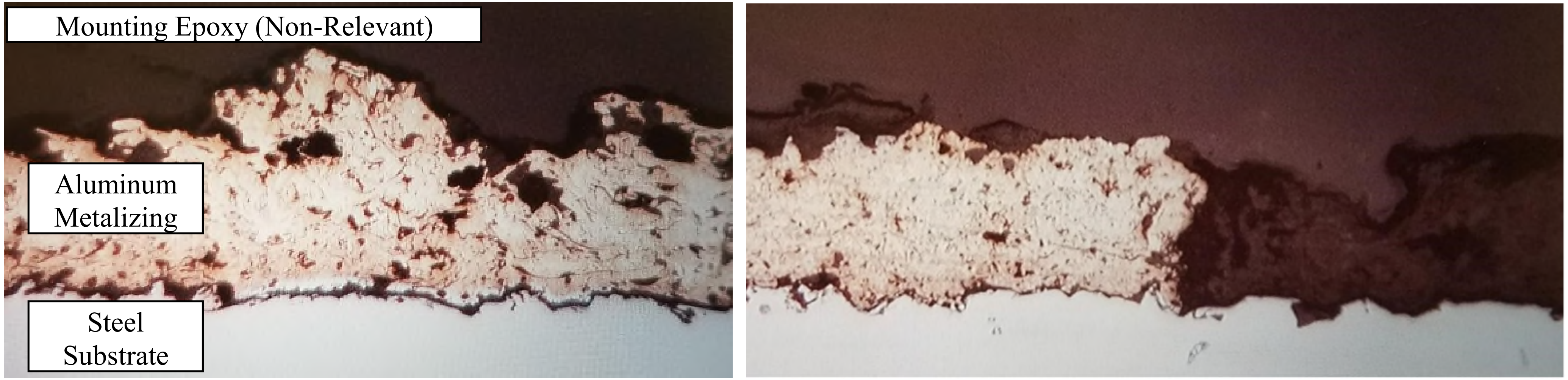


Adhesion 923 psi

Image taken using Optical Microscope after 5-yrs. in the salt fog chamber (350x).

<u>Aluminum Metalizing (99% Al)</u>

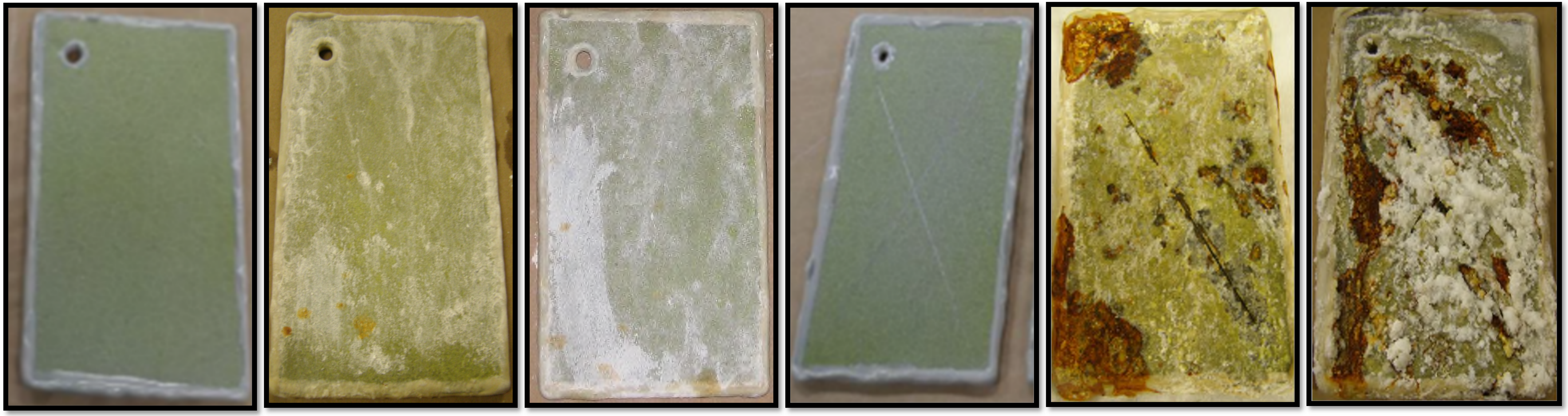
Condition of the panels at 0 hrs., 30,000 hrs.*, 5 years; Left (Unscribed) & Right (Scribed tests ended at 20,000 hrs.)



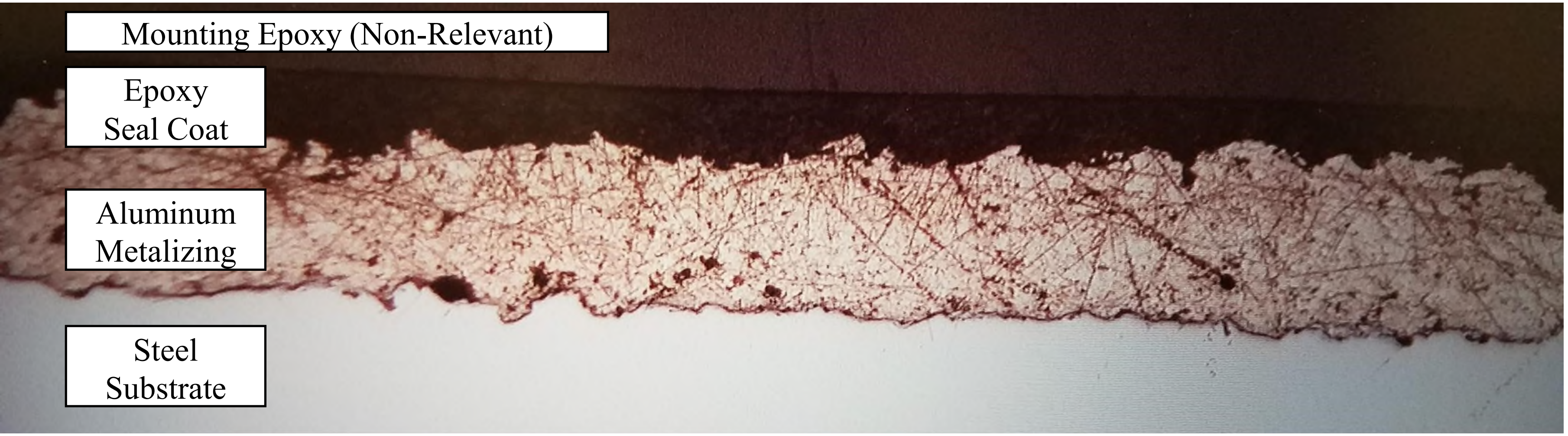
Adhesion 450 psi

Image taken using Optical Microscope after 5-yrs. in the salt fog chamber (350x).

Aluminum Metalizing (99% Al) + Epoxy Seal Coat



Condition of the panels at 0 hrs., 30,000 hrs.*, 5 years; Left (Unscribed) & Right (Scribed tests ended at 21,000 hrs.)

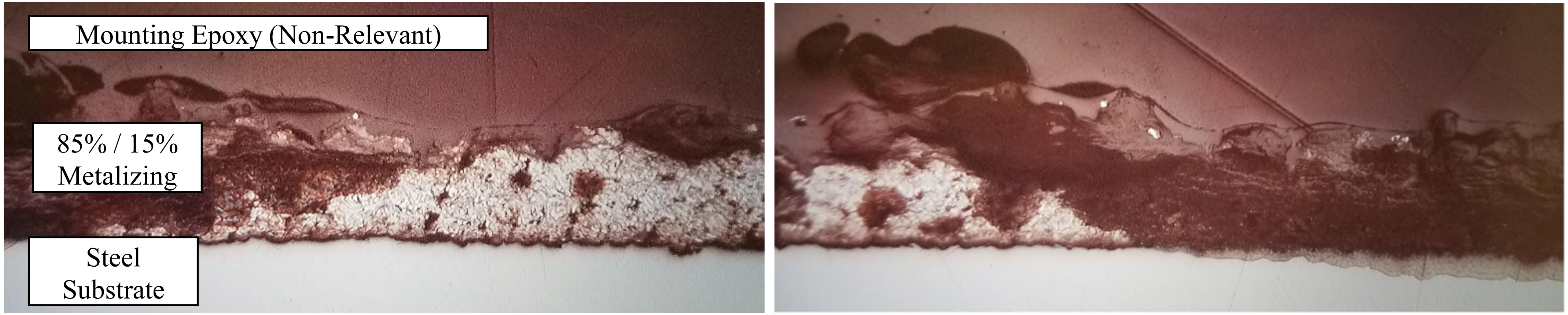


Adhesion 1,532 psi

Image taken using Optical Microscope after 5-yrs. in the salt fog chamber (700x).

Zinc/Aluminum Metalizing (85% Zn / 15% Al)

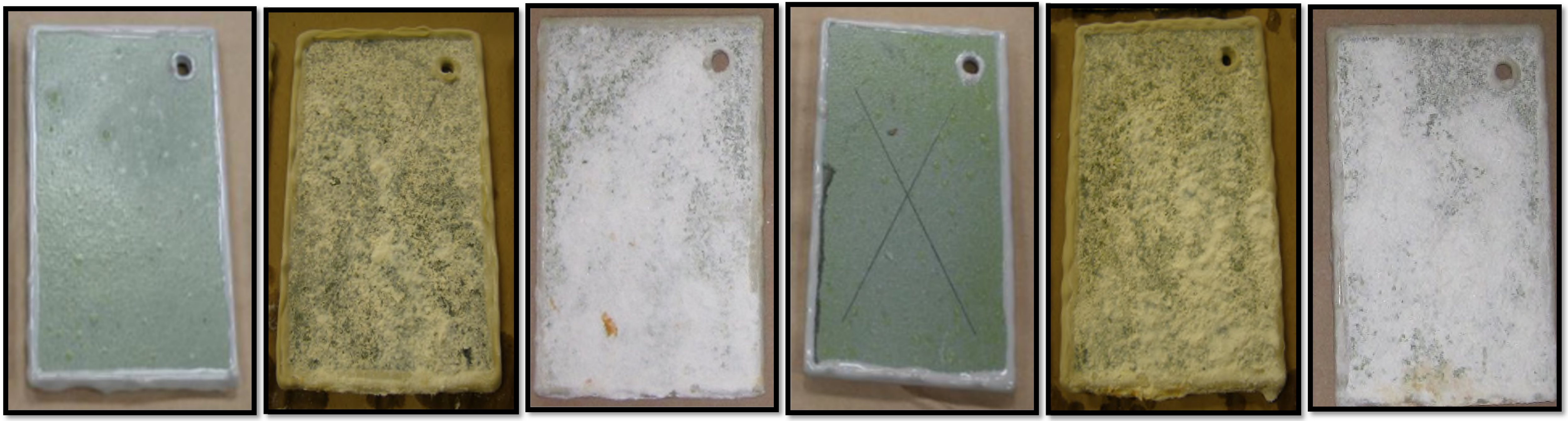
Condition of the panels at 0 hrs., 30,000 hrs., 5 years; Left (Unscribed) & Right (Scribed)



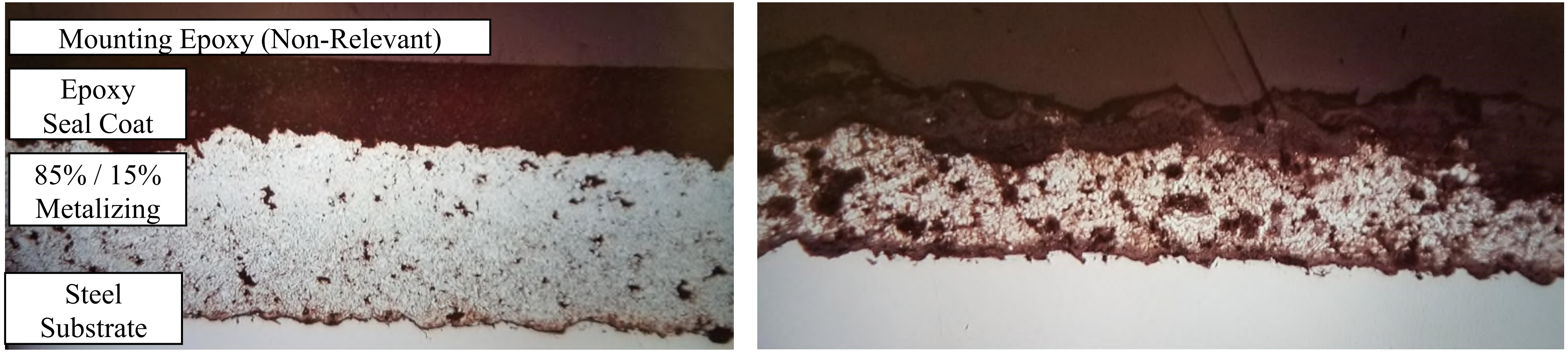
Adhesion 522 psi

Image taken using Optical Microscope after 5-yrs. in the salt fog chamber (350x).

Zinc/Aluminum Metalizing (85% Zn / 15% Al) + Epoxy Seal Coat



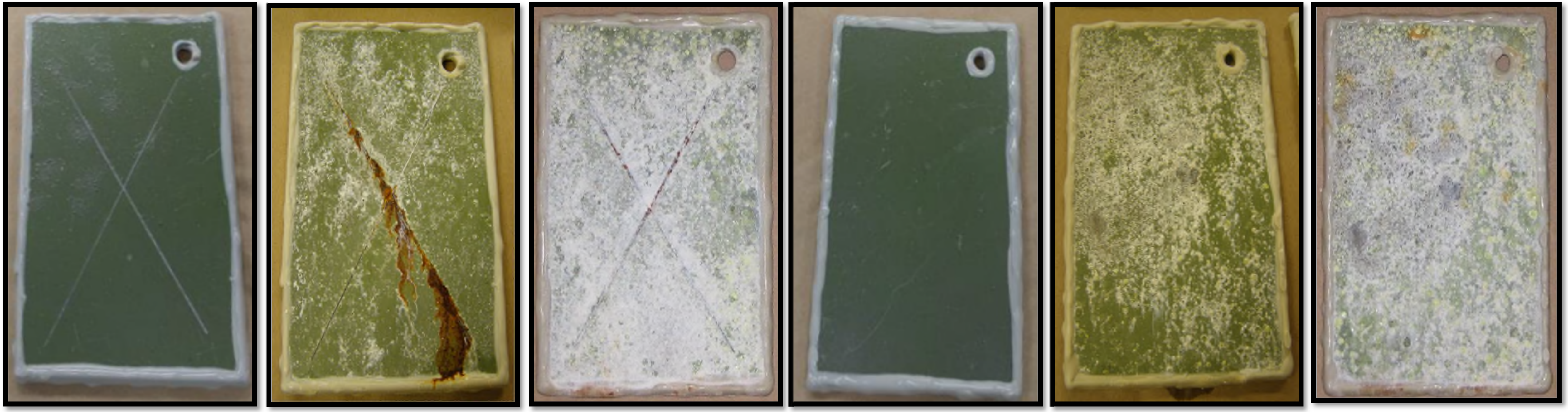
Condition of the panels at 0 hrs., 30,000 hrs., 5 years; Left (Unscribed) & Right (Scribed)



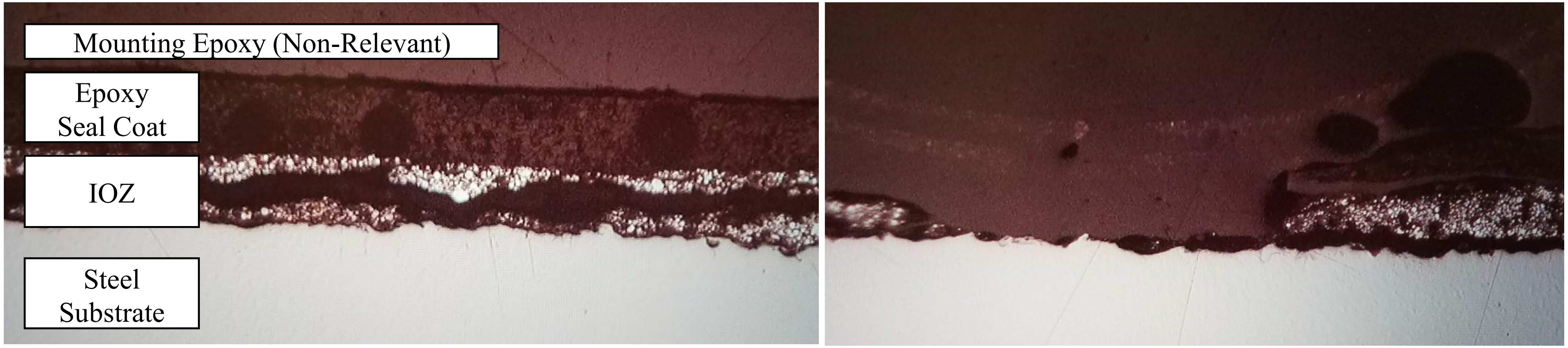
Adhesion 765 psi

Image taken using Optical Microscope after 5-yrs. in the salt fog chamber (700x Left & 350x Right).

Inorganic Zinc (Ethyl Silicate, min. 77% Zinc) + Epoxy Seal Coat



Condition of the panels at 0 hrs., 30,000 hrs., 5 years; Left (Unscribed) & Right (Scribed)



Adhesion 927 psi

Image taken using Optical Microscope after 5-yrs. in the salt fog chamber (700x Left & 350x Right).

Results$_2$

Coating System	Notes & Observations
Zinc Metalizing (99% Zn)	Surface generates heavy oxides over time. Microscopy confirms reactivity, surface break down.
Zinc Metalizing (99% Zn) Epoxy Seal Coat	Surface generates heavy oxides over time.. Microscopy shows excellent overall condition.
Zinc Metalizing (99% Zn) Aluminum Metalizing (99% Al)	Surface generates some oxides over time. Reactivity of zinc metalizing primer may undermine the performance of aluminum topcoat.
Aluminum Metalizing (99% Al)	Surface generates heavy oxides and corrosion. Microscopy shows complete failure of system.
Aluminum Metalizing (99% Al) Epoxy Seal Coat	Surface generates few oxides when undamaged, but heavy oxides and corrosion when damaged. Microscopy shows confirms excellent performance when left undamaged. Failure when damaged.
Zn/Al Metalizing (85% Zn/15% Al)	Surface generates heavy oxides and some corrosion. Microscopy confirms failure of system.
Zn/Al Metalizing (85% Zn/15% Al) Epoxy Seal Coat	Surface generates medium oxides and some corrosion over time. Microscopy shows confirms reactivity, surface break down near damaged areas; and excellent performance when left undamaged.
IOZ (Ethyl Silicates, min. 77% Zinc) Epoxy Seal Coat	Surface generates moderate oxides and some corrosion over time. Microscopy shows a fractured but functional underlying primer.

Recommendations

Adhesion tests were somewhat informative as to the general condition of metalizing but did not prove to be a reliable method to correlate with performance, during 5-year assessment.

Zinc metalizing appears to react to the corrosive environment, but, that effect in lessened when topcoated.

In general, seal coats appear to positively influence the long-term performance of all metalized coating systems. Uncoated metalizing systems are not recommended for use in marine or corrosive environments. It may be appropriate to investigate other topcoats to improve on the breakdown of organic epoxies, which may be weakened by UV exposure (the combined effects of saltwater and UV exposure were not studied in this test).

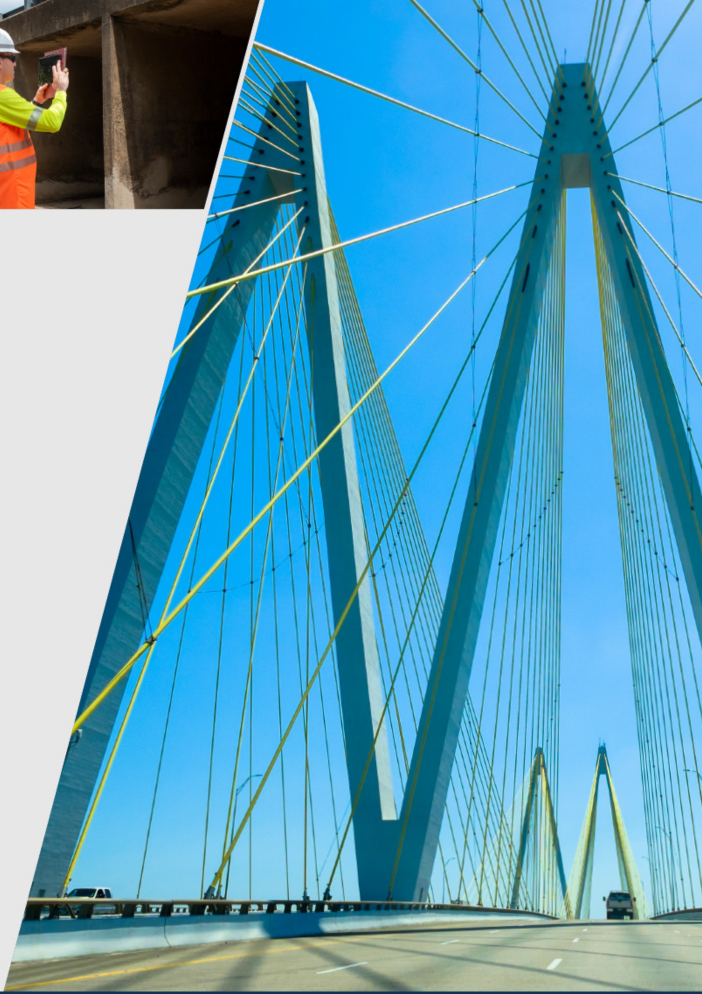
If the structure can be erected or coated without damage, a coating system made of 99% aluminum metalizing with an epoxy seal coat performed very well. Unfortunately, the coating did not perform well when damaged. It would become a critical step for the Owner to specify the repair of any damaged area.

99% zinc metalizing and 85/15 zinc/aluminum metalizing with epoxy seal coats performed well, however the surface generated a relatively thick layer of oxides, which may limit the ability to inspect during scheduled maintenance. This visible condition may cause some owners to be unable to determine the underlying condition of the structure. The metalizing appears to be reacting to the corrosive environment and slowly breaking down and that should be taken into consideration when specifying a service life.

Inorganic zinc rich primer with epoxy seal coats performed well, however, the surface generated a moderate level of oxides, which may limit the ability to inspect during scheduled maintenance.

If the goal is to achieve a 100-year service life future research may consider testing the performance of a scribed panel, repaired repaired with a manufactured recommended coating. Inorganic topcoats should also be included in future studies to address the impact of UV exposure (compared with epoxies) and to determine the best overall material selection when specifying a seal coat.

NSBA/TxDOT Thermal-Spray Metalizing Study



Johnnie S. Miller, PE

Coatings and Traffic Materials, Materials and Tests Division

Project Overview

Thermal Spray Metalizing

- Joint Standard SSPC-CS 23.00/AWS C.2.23/NACE No. 12, "Specification for the Application of Thermal Spray Coatings (Metallizing) of Aluminum, Zinc, and Their Alloys and Composites for the Corrosion Protection of Steel"
  - "…the application of zinc and aluminum alloys to steel substrates by melting feedstock with heat from combustion or electric arc and propelling the molten metal particles onto the substrates using compressed air or another gas."

Application Requirements

- AASHTO/NSBA S8.2/SSPC-PA 18, “Specification for Application of Thermal Spray Coating Systems to Steel Bridges”
  - Apply at least 8 mils of TSC, unless otherwise specified.
  - Apply sealer to seal pores. Required when topcoating TSC with incompatible coating.

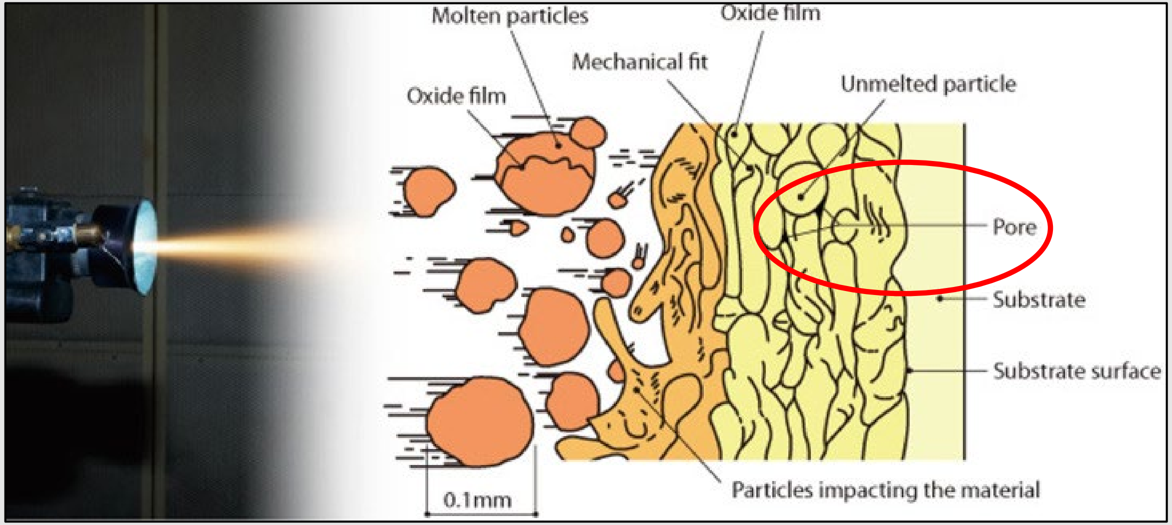


Photo courtesy of ScienceDirect.com

TSC Material & Equipment

- Three common material choices:
  - 99% Zinc
  - 99% Aluminum
  - 85% Zinc/15% Aluminum alloy (85/15)
- TSC Equipment
  - Combustion (flame) wire spray
  - Combustion (flame) powder spray
  - Electric arc spray

Arc-spray system

Flame spray system

Powder spray system

Photo courtesy of GPI

TxDOT TSC Projects

- SH361@Redfish Bay
- SH35@Lavaca Bay Causeway
- SH87@Intracoastal Canal

NSBA/TxDOT Project Goals

- Determine the efficacy of Thermal-Sprayed Metalizing (TSM) compared to Inorganic Zinc (IOZ) coatings in corrosion control for structural steel
- Establish the minimum TSM coating thickness to achieve acceptable corrosion control
- Evaluate the impact of sealers on delaying the initiation of corrosion on TSM steel

Study Variables

TSM Material Composition

- 99% Zinc
- 85/15 Zinc/Aluminum
- 99% Aluminum
- Controls:
  - Untreated panels
  - IOZ painted panels (2 materials evaluated)

TSM Layer Thickness

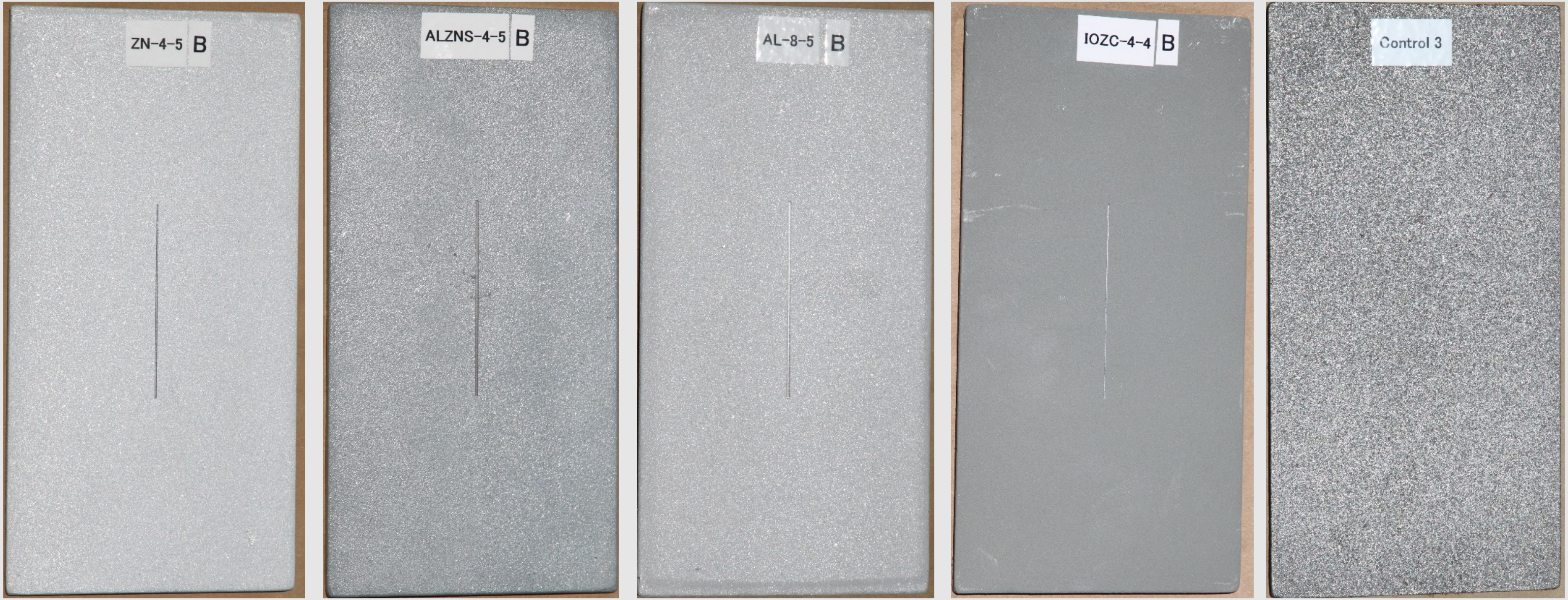
- 4 mil thick
- 8 mil thick
- IOZ paint applied at 4 mil

Effects of Seal

- Sealed with penetrating epoxy sealer
- No seal
  - IOZ painted panels are unsealed

- 6 panels for each combination of conditions
- 3 placed in corrosion cabinet, 3 placed at marine exposure site in Corpus Christi
  - 4 of each set were scribed, so that each of the 3 panel sets in each location has an unscribed control

Study Variables – Sample Panels



- IOZ materials are from two different manufacturers

Exposure Conditions

Corrosion Cabinet Protocol: ASTM G85-A5

- 500 hour cycles
- 1 hr salt fog on, 1 hr dry
- Fog: 0.05% sodium chloride and 0.35% ammonium sulfate by mass

Exposure Site

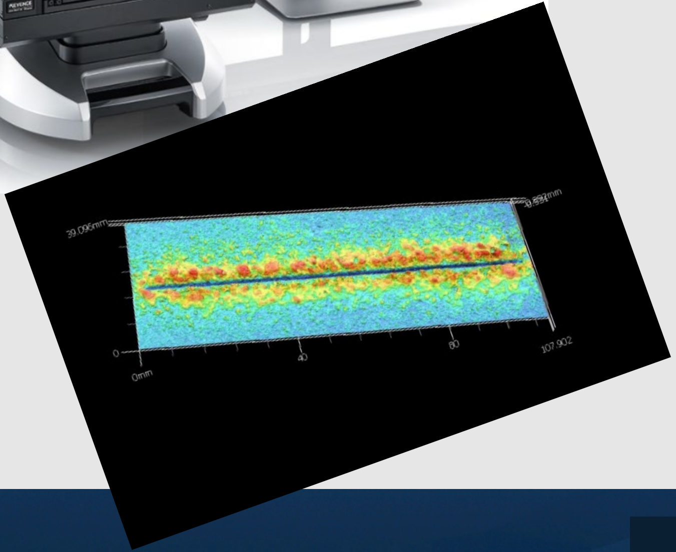
- Panels installed in June 2018

Analysis Protocol

- Exposure Site
  - Panels are photographed every 6 months
- Corrosion cabinet
  - Panels are photographed after every cycle
  - Panels are weighed to track mass loss due to corrosion
  - Scribe volume is measured with a 3D microscope to quantify scribe creep
    - New instrument, analysis using this method began after 4000 hours
- Panels will be taken to failure, time to failure will be recorded

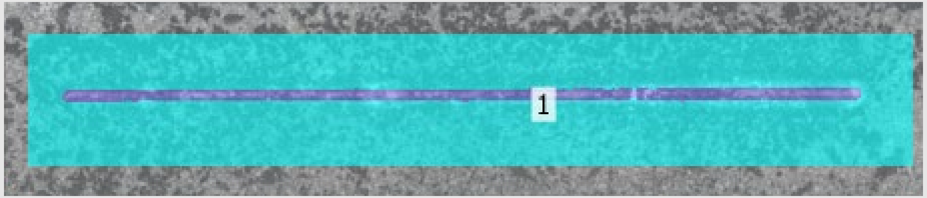
Analysis Protocol – Structured Light Microscope Set-up

- Keyence VR-5000 Wide-Area 3D Measurement System
  - The microscope emits structured light through several double-telecentric lenses
  - Distortions in the light bands caused by height differences on samples are converted to height using triangulation
  - Software uses height data to calculate volume of concave spaces after setting a baseline level
  - Data collection and analysis can be automated to minimize human error

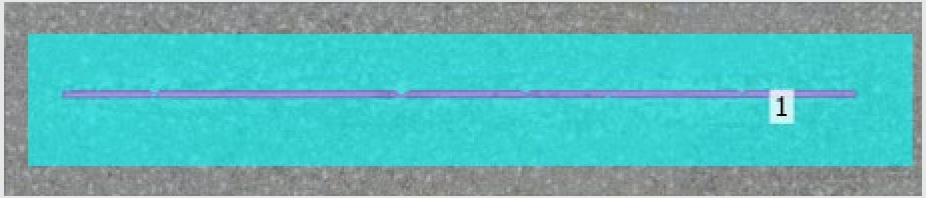


Analysis Protocol – Scribe Creep Measurements

- Scribe volume and length are measured with 3D Microscope for all panels, at least 5 scans per sample for validation of data
  - An automated program scans a prescribed area and performs calculations with pre-set parameters
  - An algorithm removes noise from variations in texture and warping of panels
  - Cross-sectional area of scribes are calculated from scribe volume and length for each panel
- Instrument was acquired after 4000 hrs in corrosion cabinet, so initial data is not available
  - *Changes of scribe dimensions for each panel* will allow quantification of scribe creep and allow performance ranking of each material condition



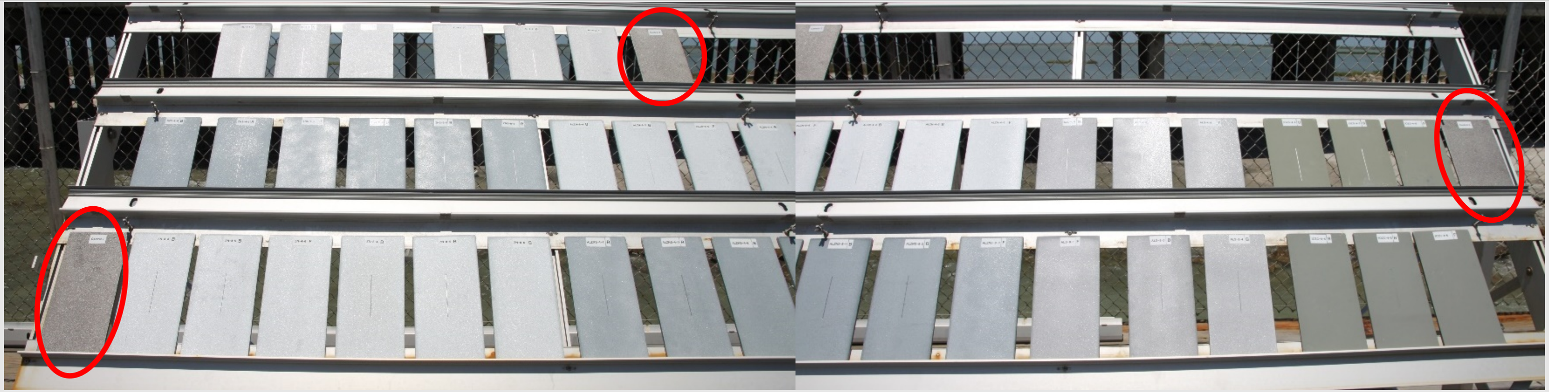
85/15 Zn/Al, 4 mil panel, sealed - 69.1 mm^3



99% Zn, 8 mil panel, sealed - 32.2 mm^3

Photos: Exposure Site, Initial vs 29 months

June 2018 Installation

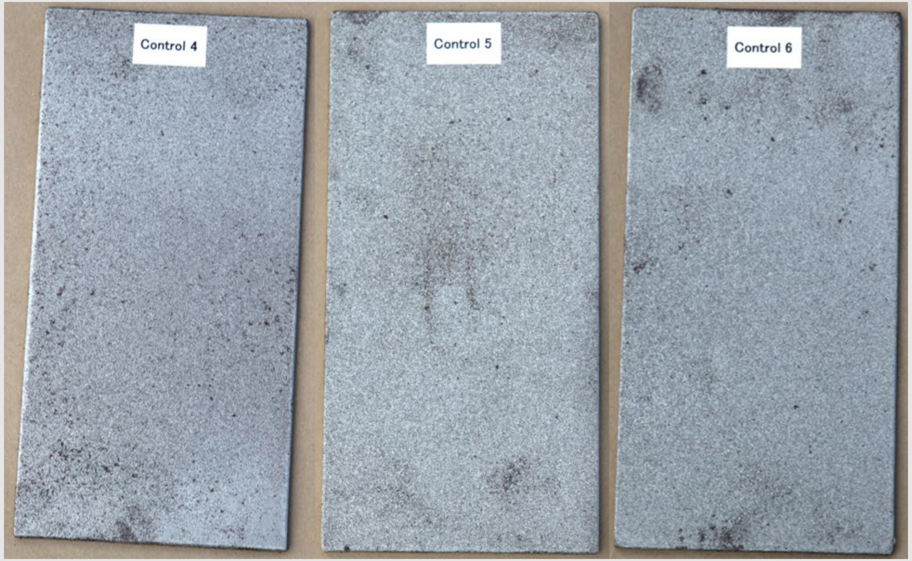


Control panels are circled

November 2020

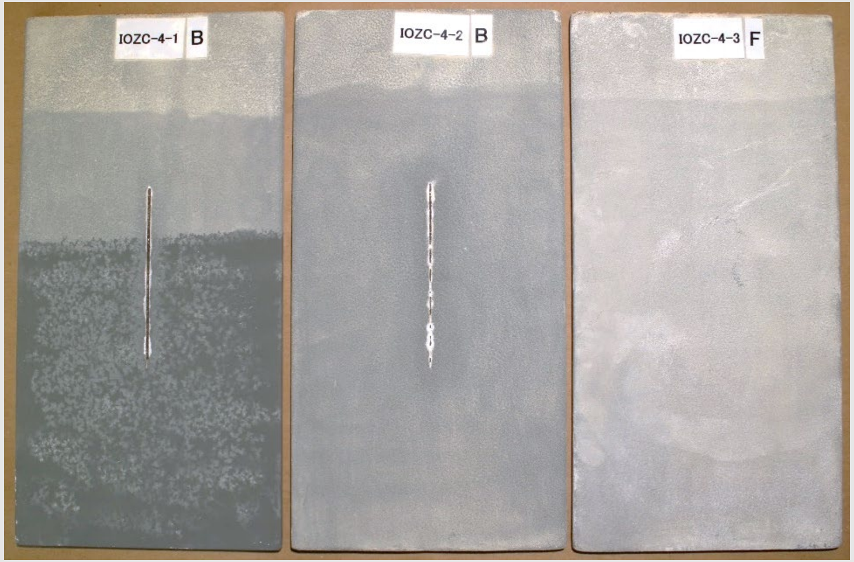
Photos: Initial and After 4000 hrs (Corrosion Cabinet)

- Control panels



Photos: Initial and After 4000 hrs (Corrosion Cabinet)

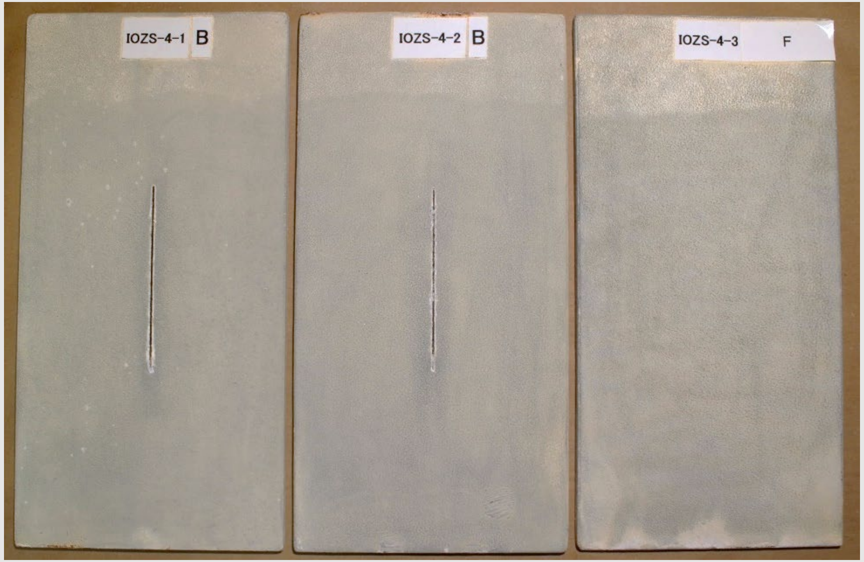
- Coating Manufacturer 1



Color bands on IOZC-4-1 are from studies to identify the best method for removing salt and corrosion product build-up from panels for imaging. The darker color represents cleaning achieved via sonication. However, sonication was not effective for metalized panels, so pressure washing was used. Top sections of panels were not pressure washed.

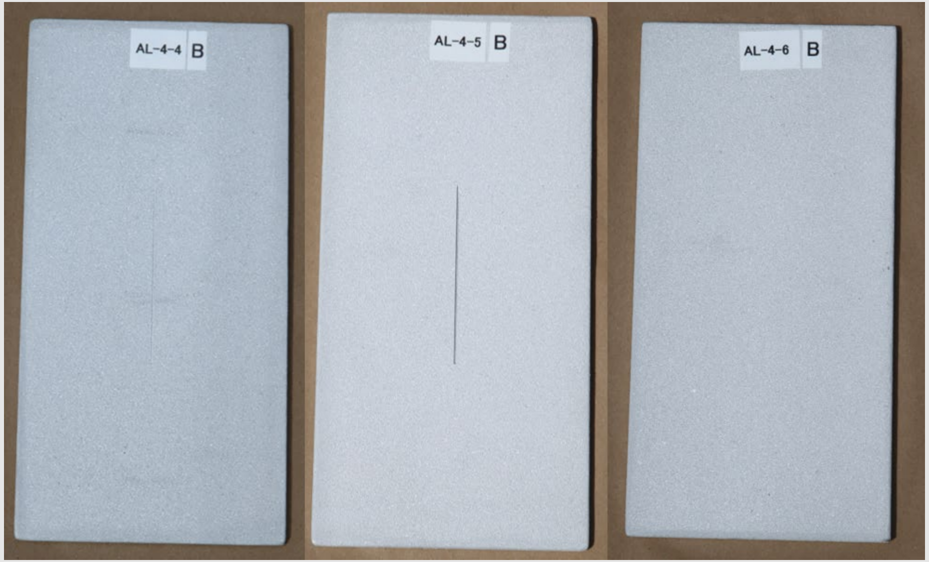
Photos: Initial and After 4000 hrs (Corrosion Cabinet)

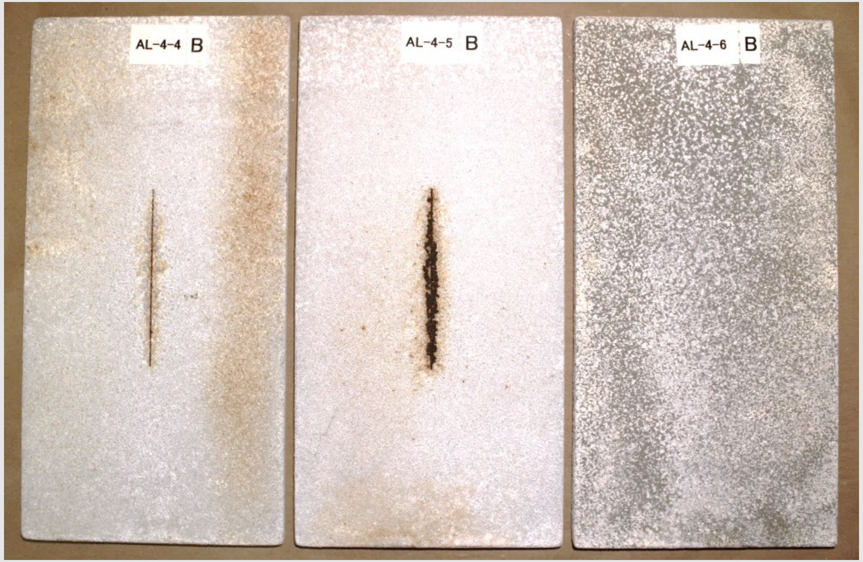
- Coating Manufacturer 2



Photos: Initial and After 4000 hrs (Corrosion Cabinet)

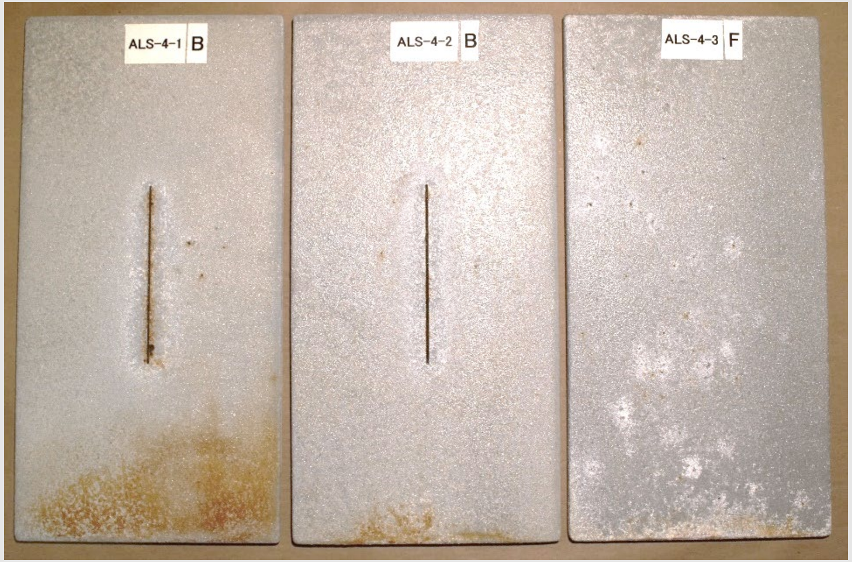
- 4 mil Aluminum, unsealed





Photos: Initial and After 4000 hrs (Corrosion Cabinet)

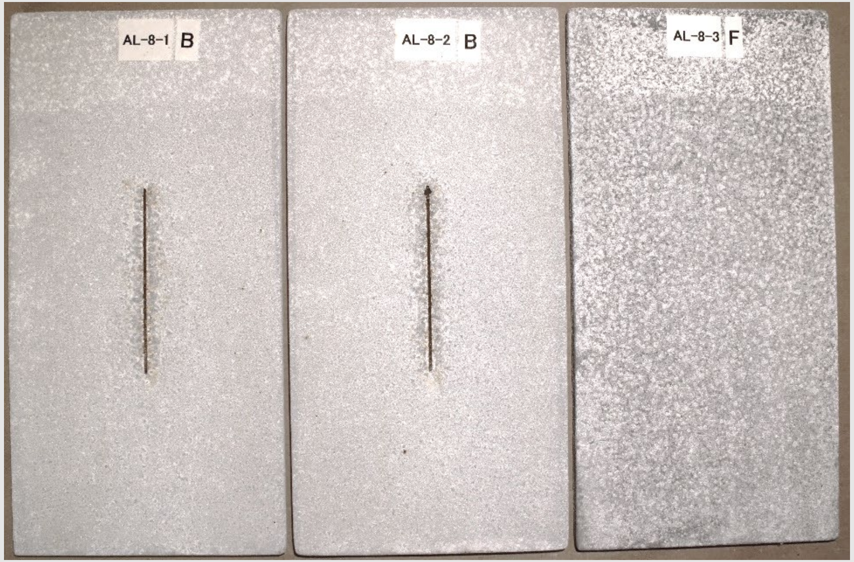
- 4 mil Aluminum, sealed



Seal degraded on 1, mostly intact on 2 and 3

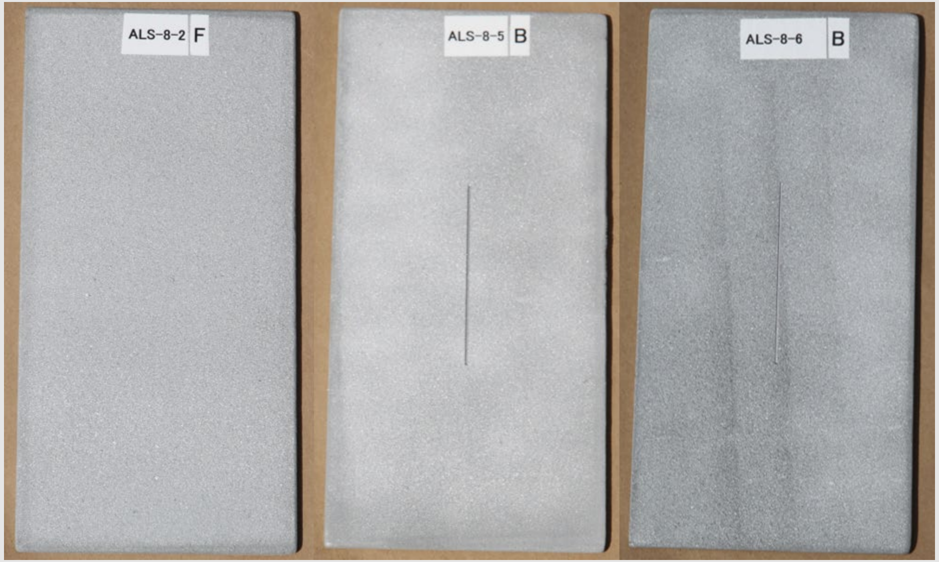
Photos: Initial and After 4000 hrs (Corrosion Cabinet)

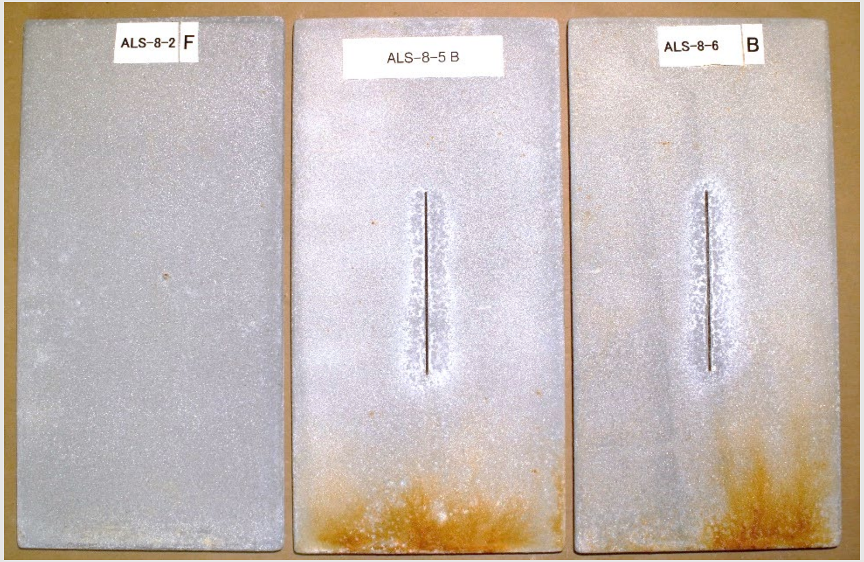
- 8 mil Aluminum, unsealed



Photos: Initial and After 4000 hrs (Corrosion Cabinet)

- 8 mil Aluminum, sealed

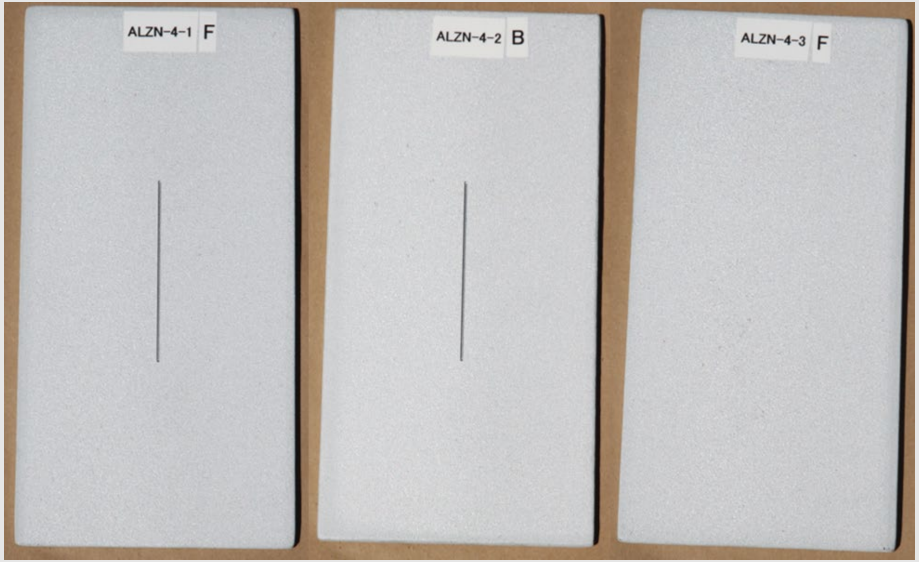


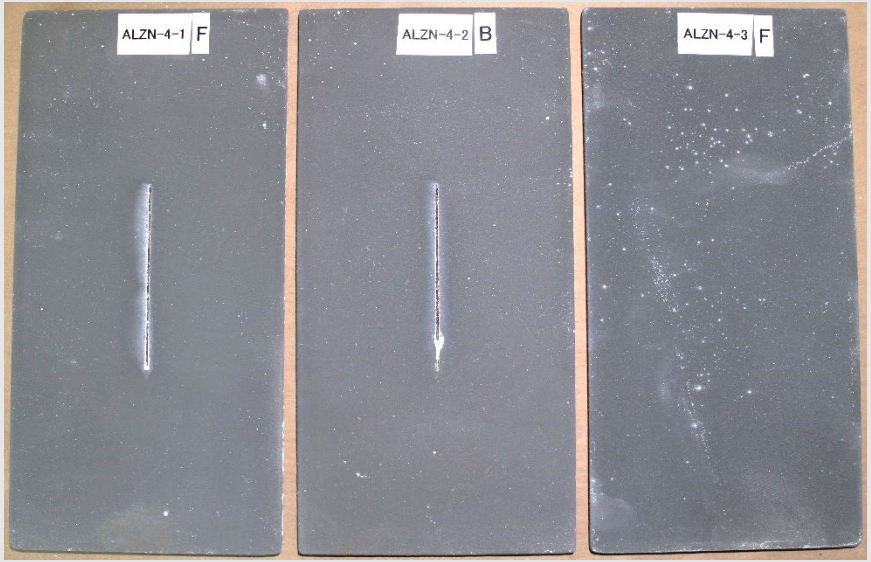


Seal degraded on all panels

Photos: Initial and After 4000 hrs (Corrosion Cabinet)

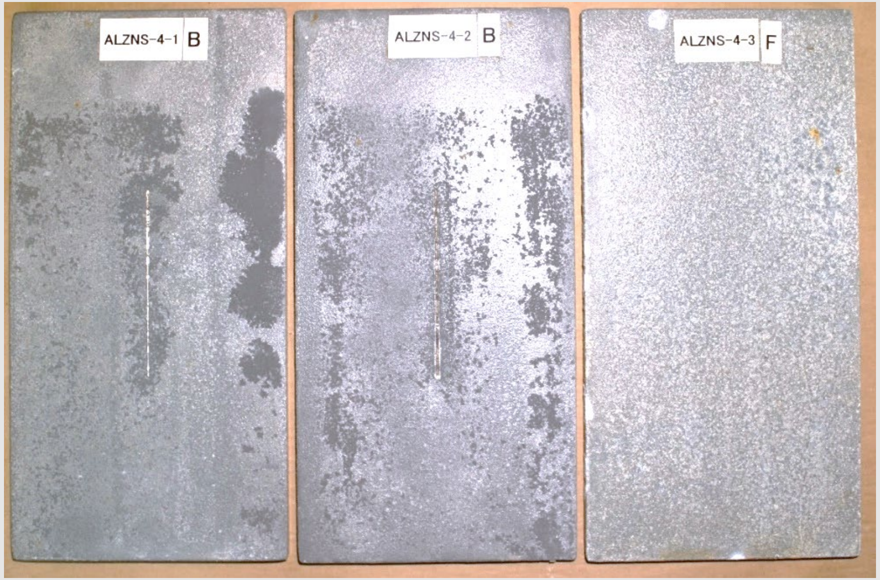
- 4 mil 85/15 Zinc/Aluminum, unsealed





Photos: Initial and After 4000 hrs (Corrosion Cabinet)

- 4 mil 85/15 Zinc/Aluminum, sealed

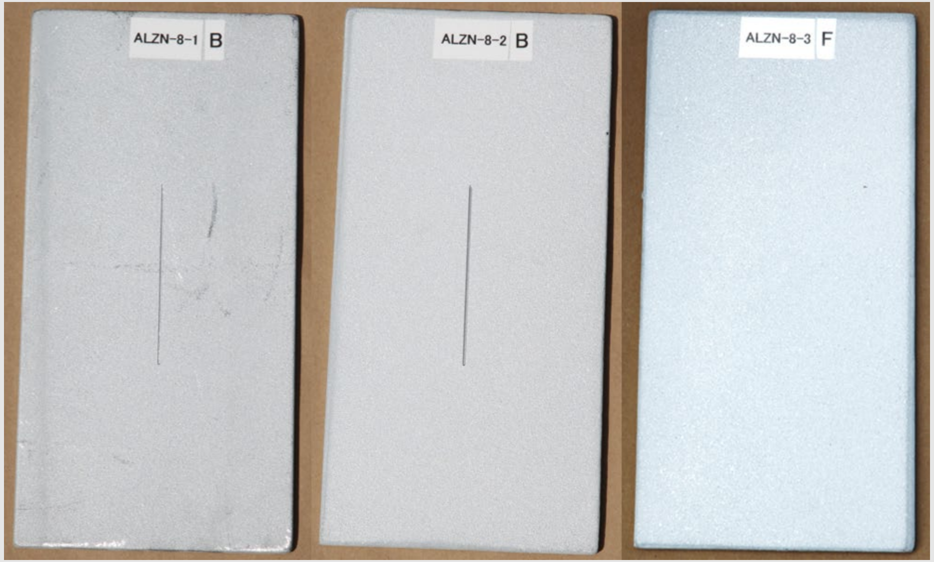


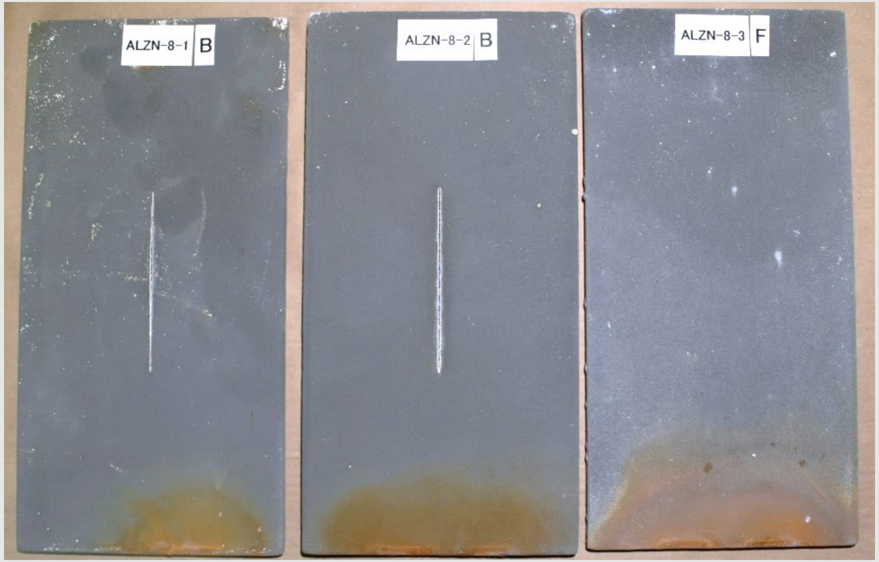
No initial photo of ALZNS-4-1 available

Seal is beginning to delaminate from panels 1 and 2

Photos: Initial and After 4000 hrs (Corrosion Cabinet)

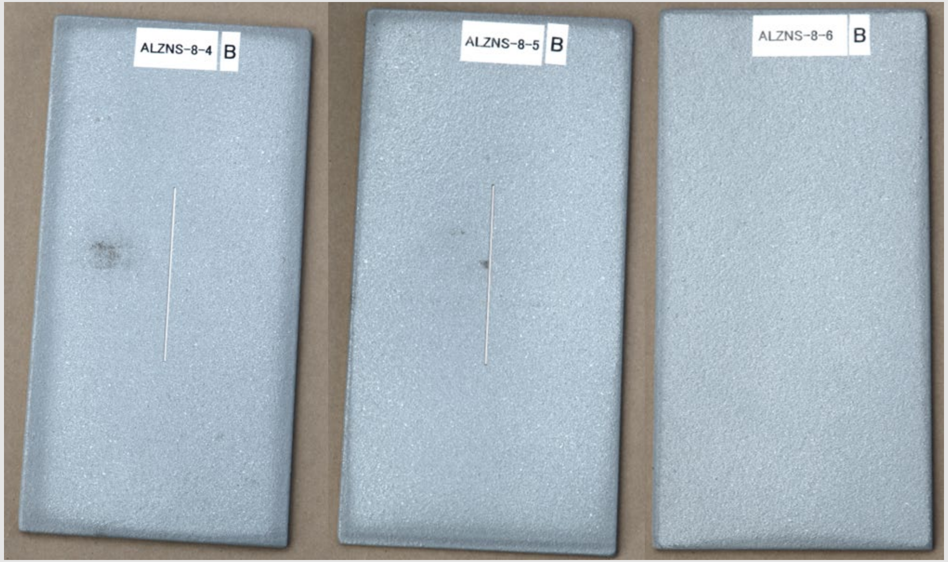
- 8 mil 85/15 Zinc/Aluminum, unsealed

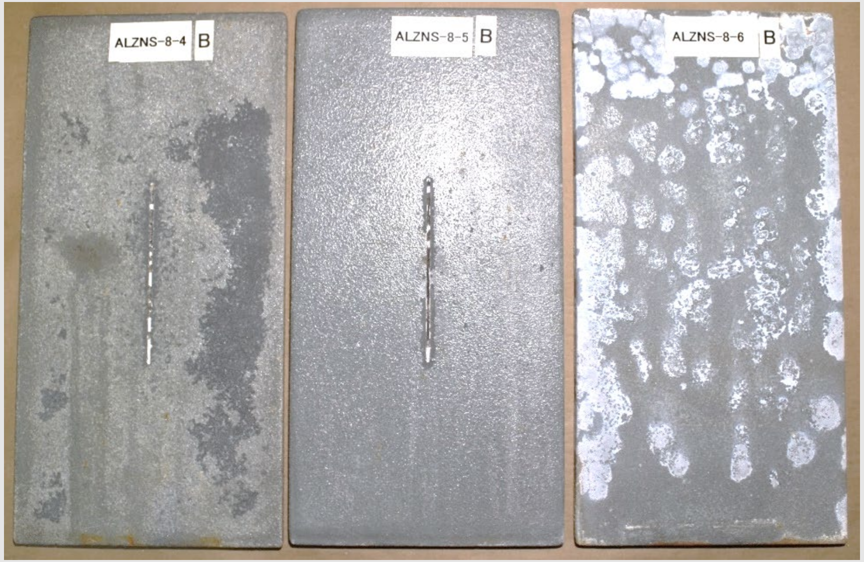




Photos: Initial and After 4000 hrs (Corrosion Cabinet)

- 8 mil 85/15 Zinc/Aluminum, sealed

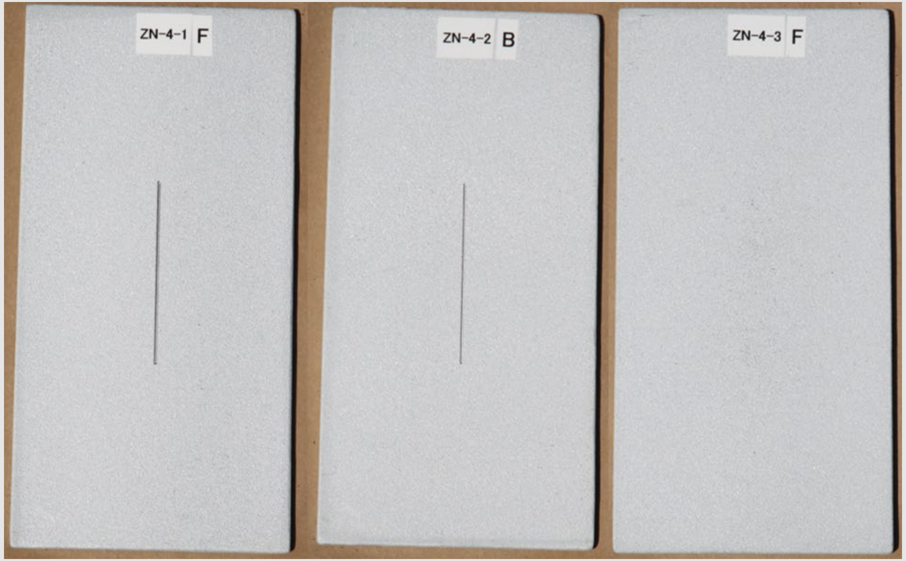


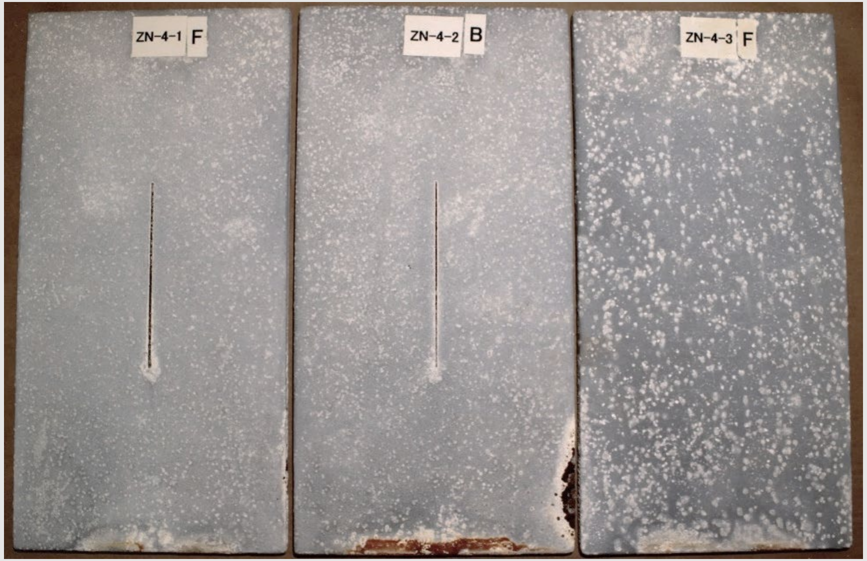


Seal is beginning to degrade from panel 4, intact on 5, and mostly degraded on 6

Photos: Initial and After 4000 hrs (Corrosion Cabinet)

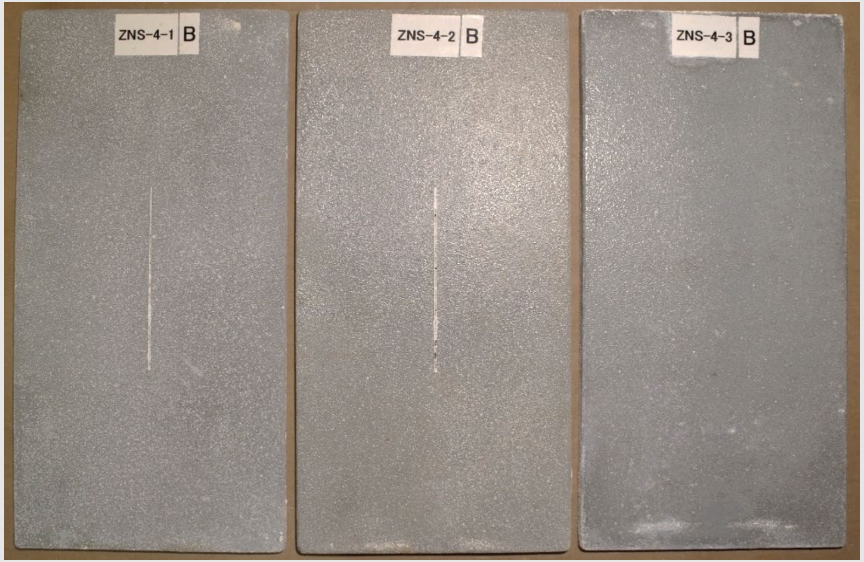
- 4 mil Zinc, unsealed





Photos: Initial and After 4000 hrs (Corrosion Cabinet)

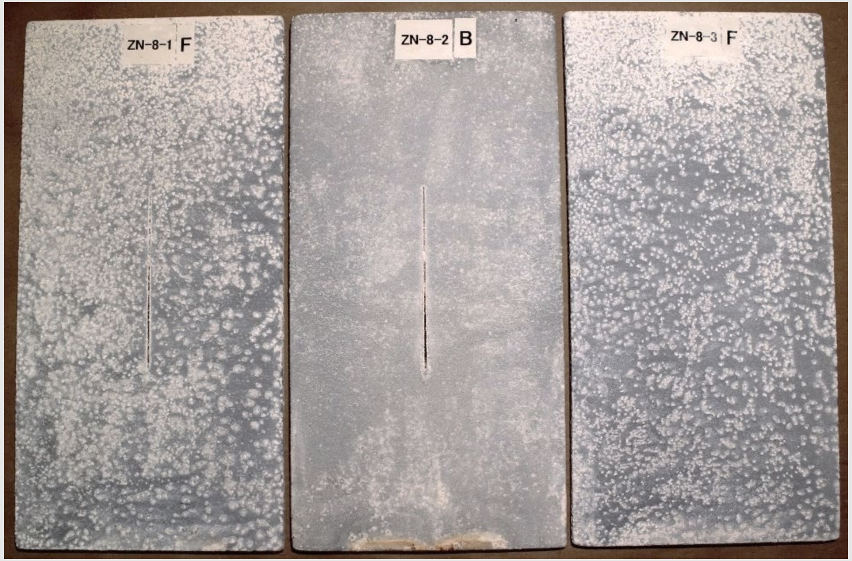
- 4 mil Zinc, sealed



Seal degraded on 1, mostly intact on 2 and 3

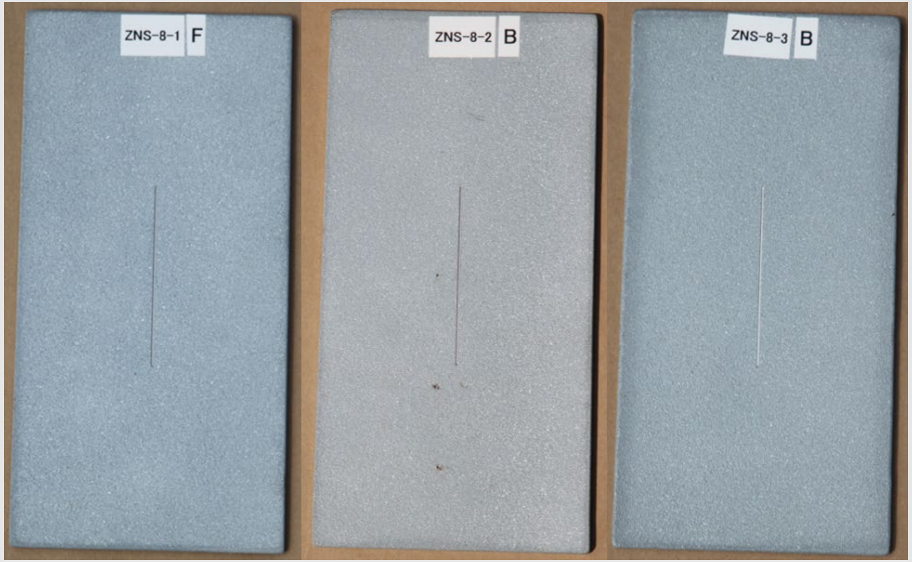
Photos: Initial and After 4000 hrs (Corrosion Cabinet)

- 8 mil Zinc, unsealed

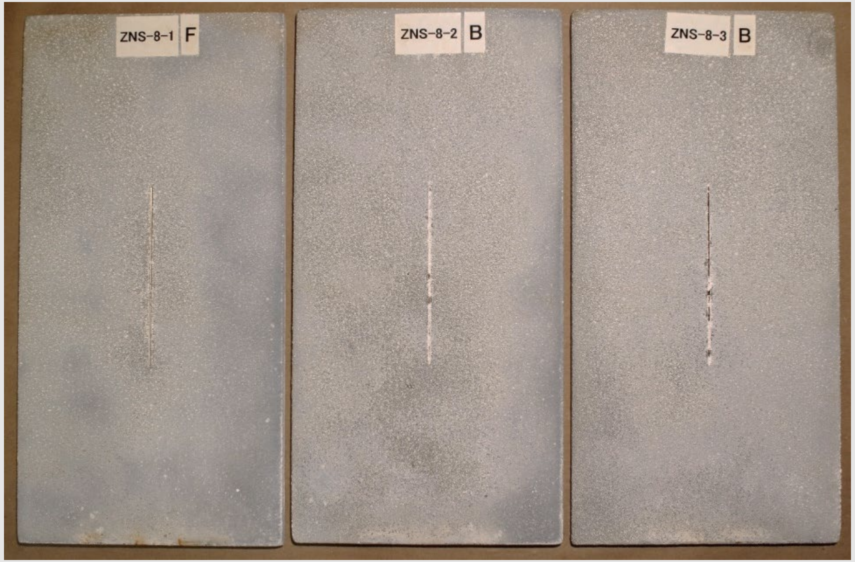


Photos: Initial and After 4000 hrs (Corrosion Cabinet)

- 8 mil Zinc, sealed



All three panels mistakenly scribed. Silicone was used to fill scribe on panel 1.



Seal mostly degraded on all panels

Observations

- Exposure Site Panels
  - All panels are resisting corrosion compared to controls after 29 months
- Corrosion Cabinet Panels
  - All panels are resisting corrosion compared to controls after 4000 hrs
  - Seal layers are partially or totally degraded on many sealed panels
  - Metalized panels containing zinc appear to resist corrosion most similarly to IOZ panels based on visual inspection
  - Metalized panels with aluminum-only show the most corrosion
    - Seal layer on the 4 mil AL panels appear to achieve similar performance as 8 mil AL based on visual inspection
  - Need to measure scribe volume after additional corrosion cycles before conclusions can be made regarding material performance

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Today's Panelists

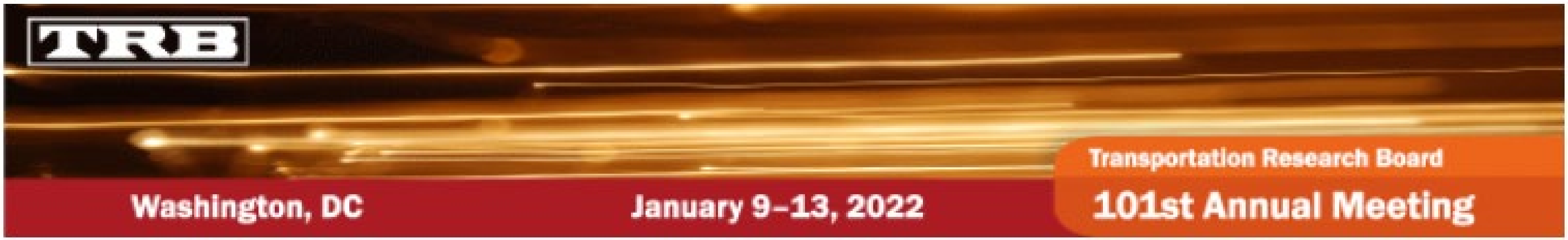
Moderator: Vickie Young,
FDOT

Timothy McCullough,
FDOT

Paul Vinik,
Greenman Pedersen, Inc.

Johnnie Miller,
TX DOT

Register for TRB's Annual Meeting!



Register now for our January meeting! ***There will be no onsite registration this year.***

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