

Design and Maintenance for Corrosion Protection



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Program Director | Coatings and Mechanical Integrity





Design and Maintenance for Corrosion Protection

Moderator:

Mike Pampalone, PE, PMP, Alpha Corporation

Speaker:

- Cortney Chalifoux, PhD, PE, PCS, Pond and Company



PRESENTER

Cortney Chalifoux_{PHD, PE, PCS}

Pond and Company

Program Director | Coatings and Mechanical Integrity

- **Sports Teams:** Philadelphia Eagles
- **Vacation Spots:** Disney World and Cancun
- **Did You Know:** I played water polo for 10 years throughout high school, college, and graduate school
- **Hobbies:** Celebrating baseball wins and family golf time. My husband and I celebrate our kindergartener's home runs, school achievements, and little tap-ins (maximum proud-mom energy).
- **Coollest Project(s):** Kings Bay Dry Dock Rehabilitation: QP-5 and Flood Tunnel Coating/MIC Failure Analysis

Learning Objectives

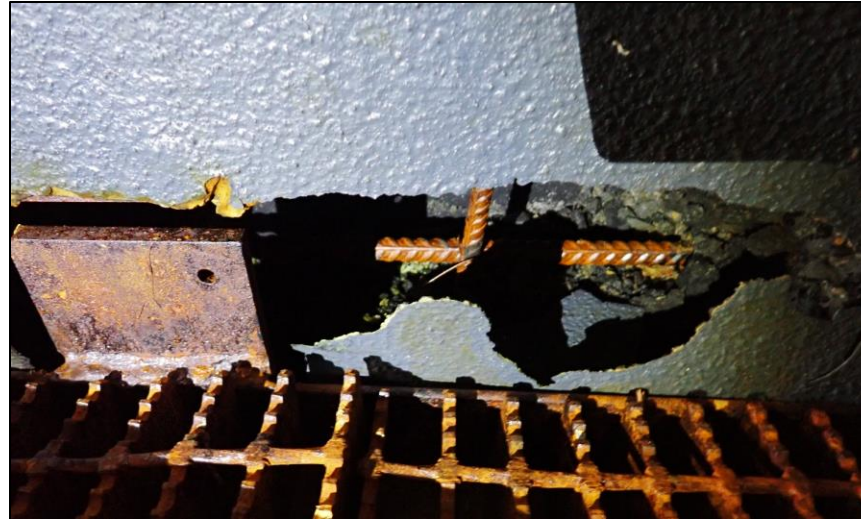
- Understand the **basic elements** in the design of coating and CP systems for corrosion protection.
- Gain insight into **assessments performed during coating condition inspections** and how data informs sustainment strategies.
- Learn how to **prioritize sustainment and maintenance strategies** to extend infrastructure life and provide **cost-effective solutions** to government and industry.





Agenda

- Quick Summary of Corrosion
- Coatings Design and Maintenance
- Cathodic Protection (CP) Design and Maintenance

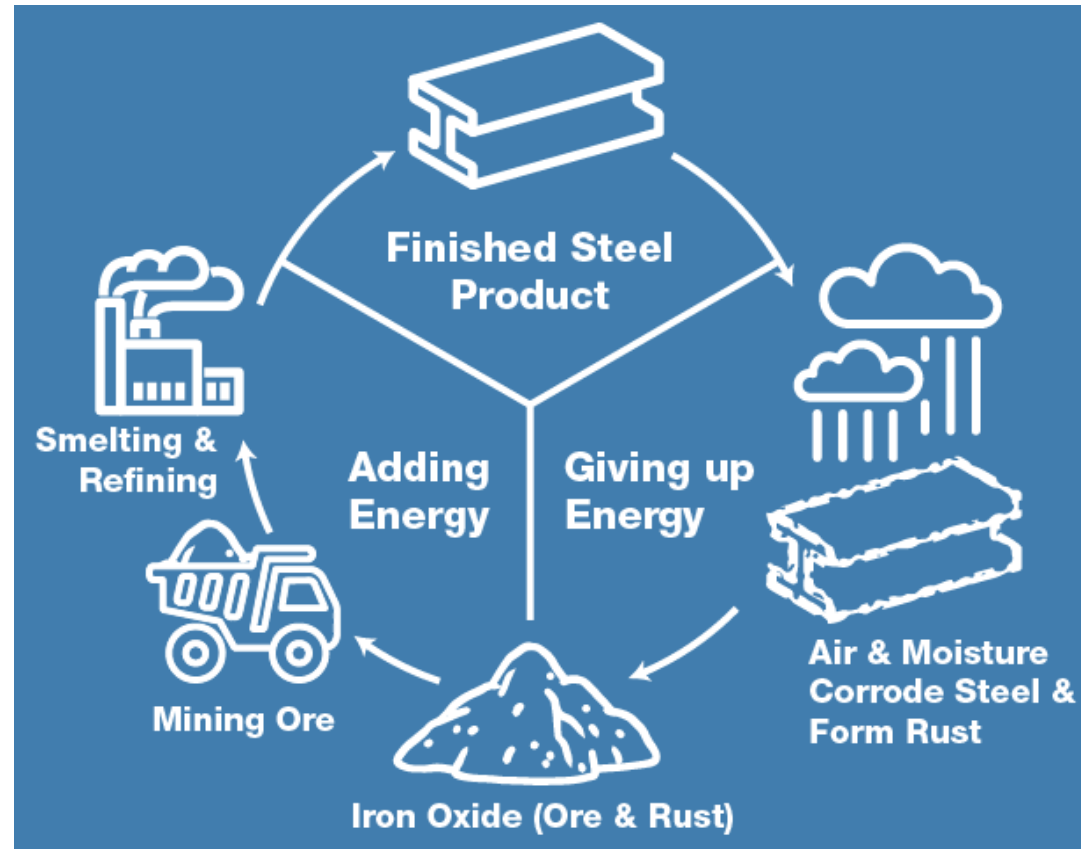


Life Cycle of Steel

In-Service Use



Production



Raw
Materials

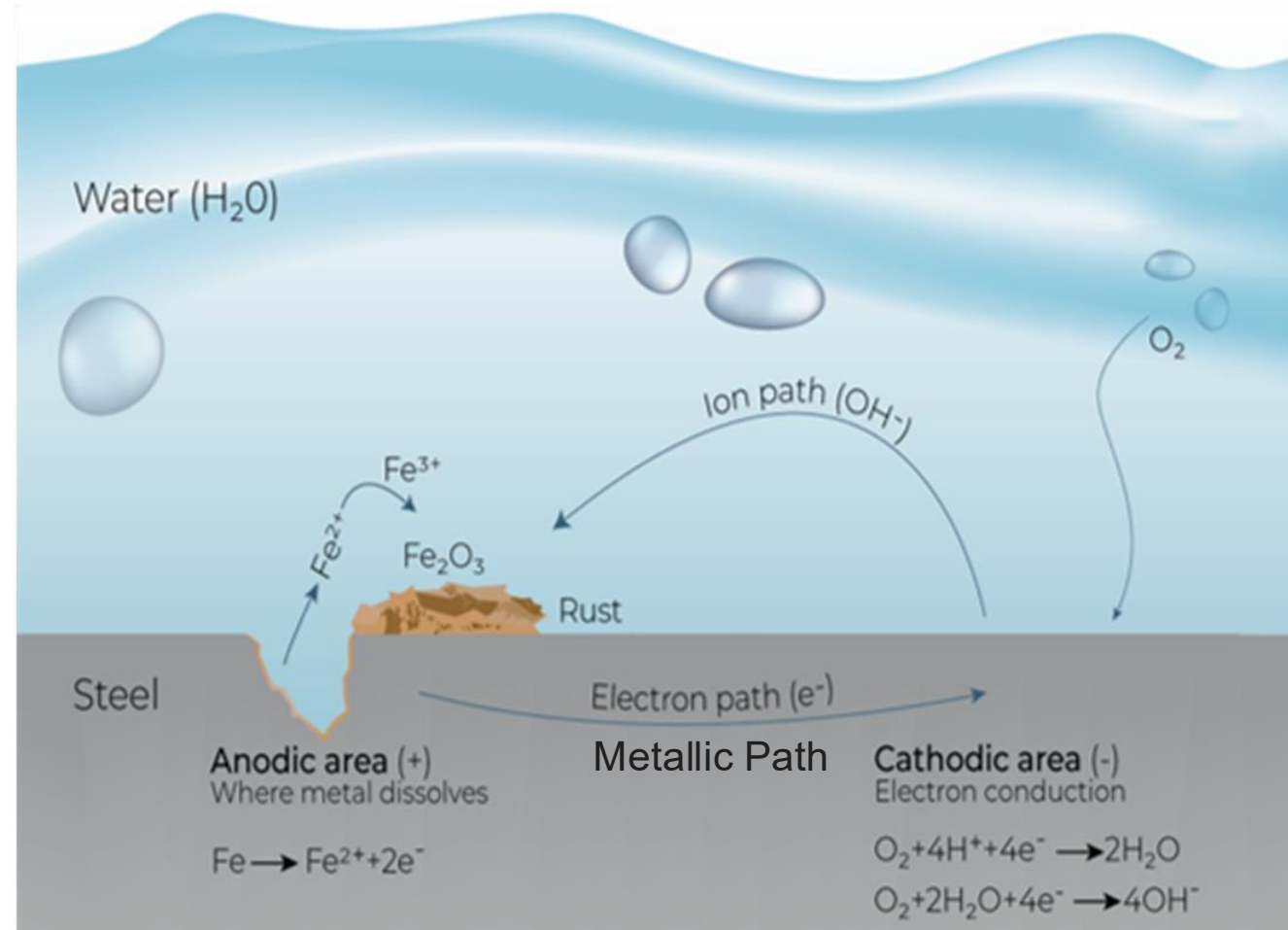
Corrosion

Anode

Cathode

Metallic Path

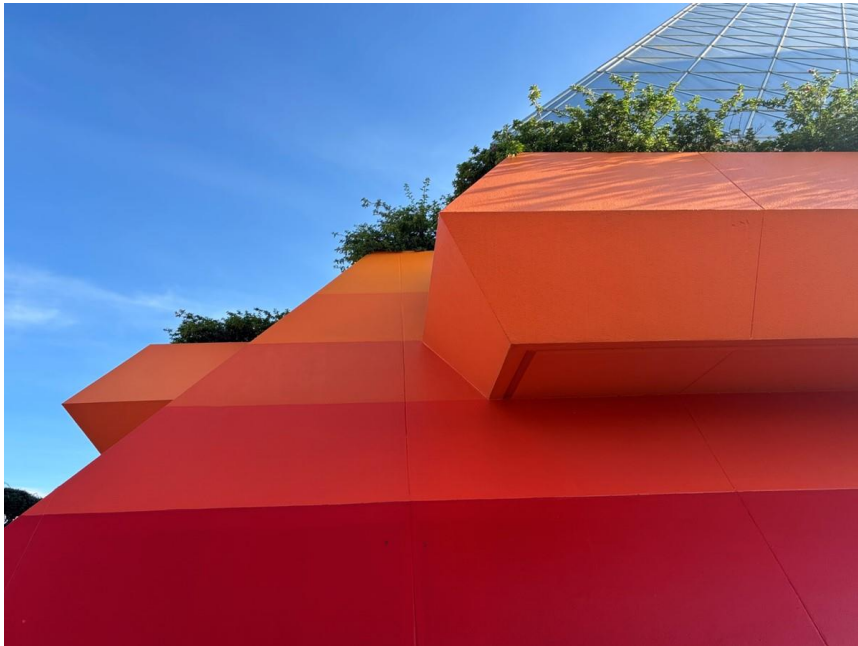
Electrolyte



How to Mitigate Corrosion

Coatings

Atmospheric and Immersion



Cathodic Protection (CP)

Underground/Immersion Only





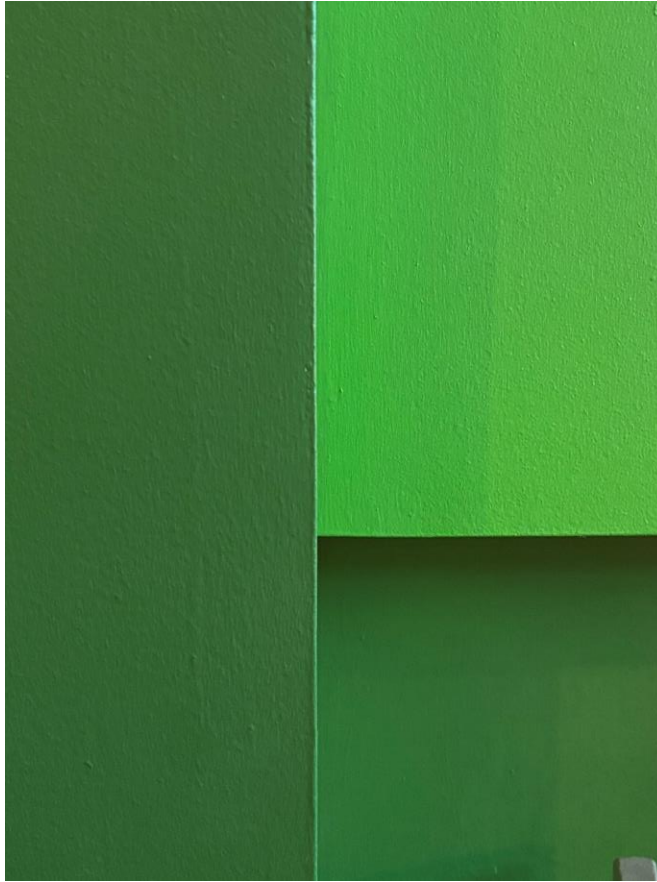
Why Protective Coatings?

Aesthetics

Chemical
Resistance

Wear
Resistance

UV
Protection



Corrosion

Slip
Resistance

Anti-Microbial
Protection

Heat
Resistance



Why Coatings Fail



Improper Surface Preparation



Improper Coating Selection/Design



Improper Application



Improper Drying, Curing,
Overcoating



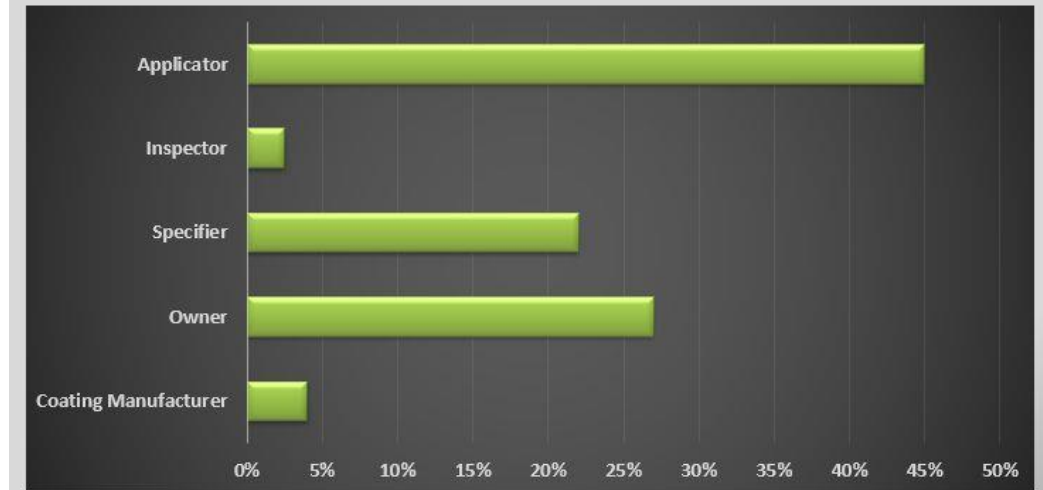
Lack of Protection Against
Environment



Mechanical Damage

Responsible Party

Coating Failure Breakdown, 2000 to 2023



Presentation by Nicole de Varennes, P.L. (Eng.), CIP3

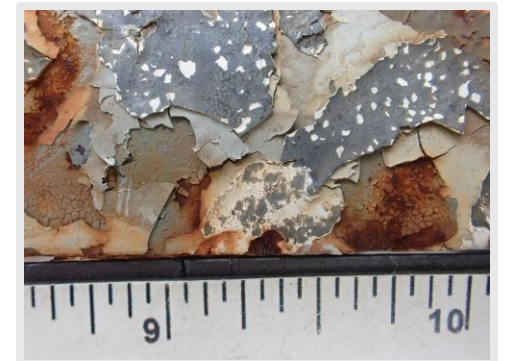
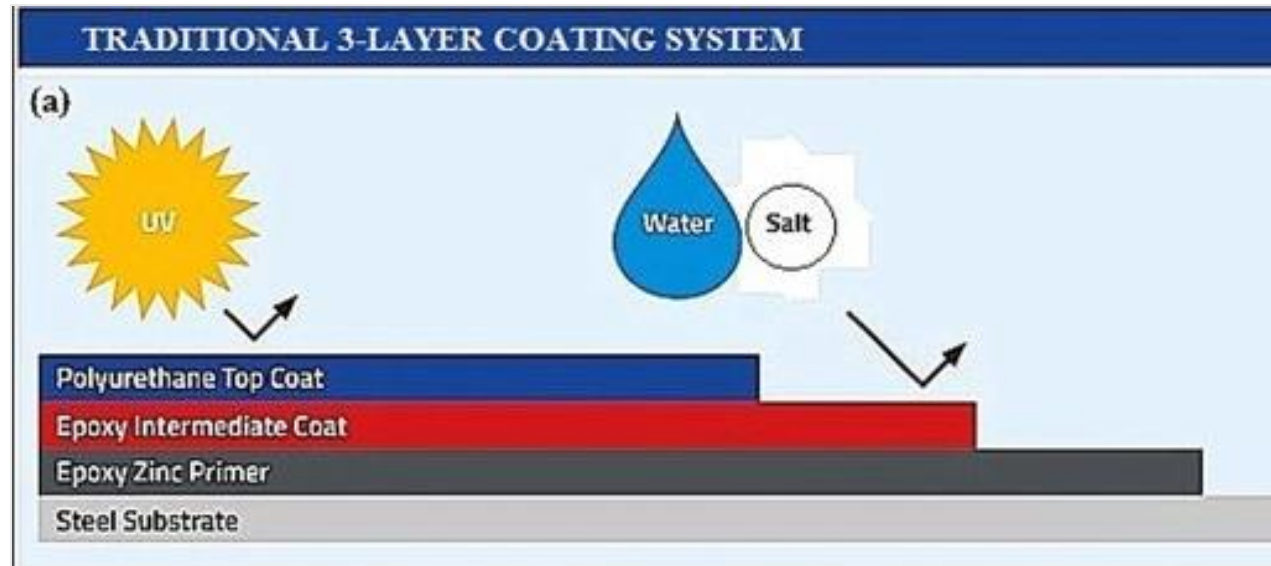
Choosing the Right Coating System

Coatings for Atmospheric Environment

Industry standard for
structural steel

Heavy-duty corrosion
protection

Decades of proven
performance



Atmospheric-Corrosivity Categories

C1 – Very Low
(Climate Controlled)



C2 – Low
(Rural)



C3 – Medium
Urban



C4 – High
(Industrial/Coastal)



C5-I – Very High
(Industrial)



C5-M – Very High
(Marine)

Coating Life Expectation

"Practical Life" of Zinc-Epoxy-Urethane System

C1 – Very Low
(Climate Controlled)



C2 – Low
(Rural)



C3 – Medium
(Urban)



C4 – High
(Industrial/Coastal)



C5-I – Very High
(Industrial)



C5-M – Very High
(Marine)

Assessing Coating Condition: Existing Systems

Coating
Thickness

Adhesion

Chalking

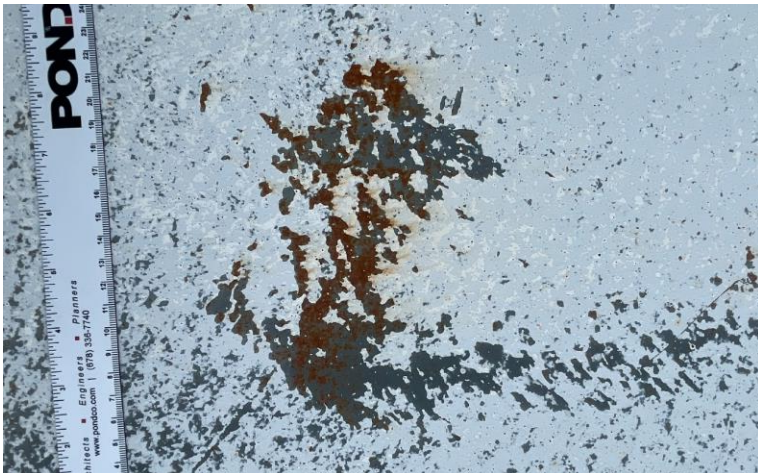
Blistering

Condition of
Substrate

Percentage of
Corrosion

Type of
Corrosion

Pattern of
Corrosion



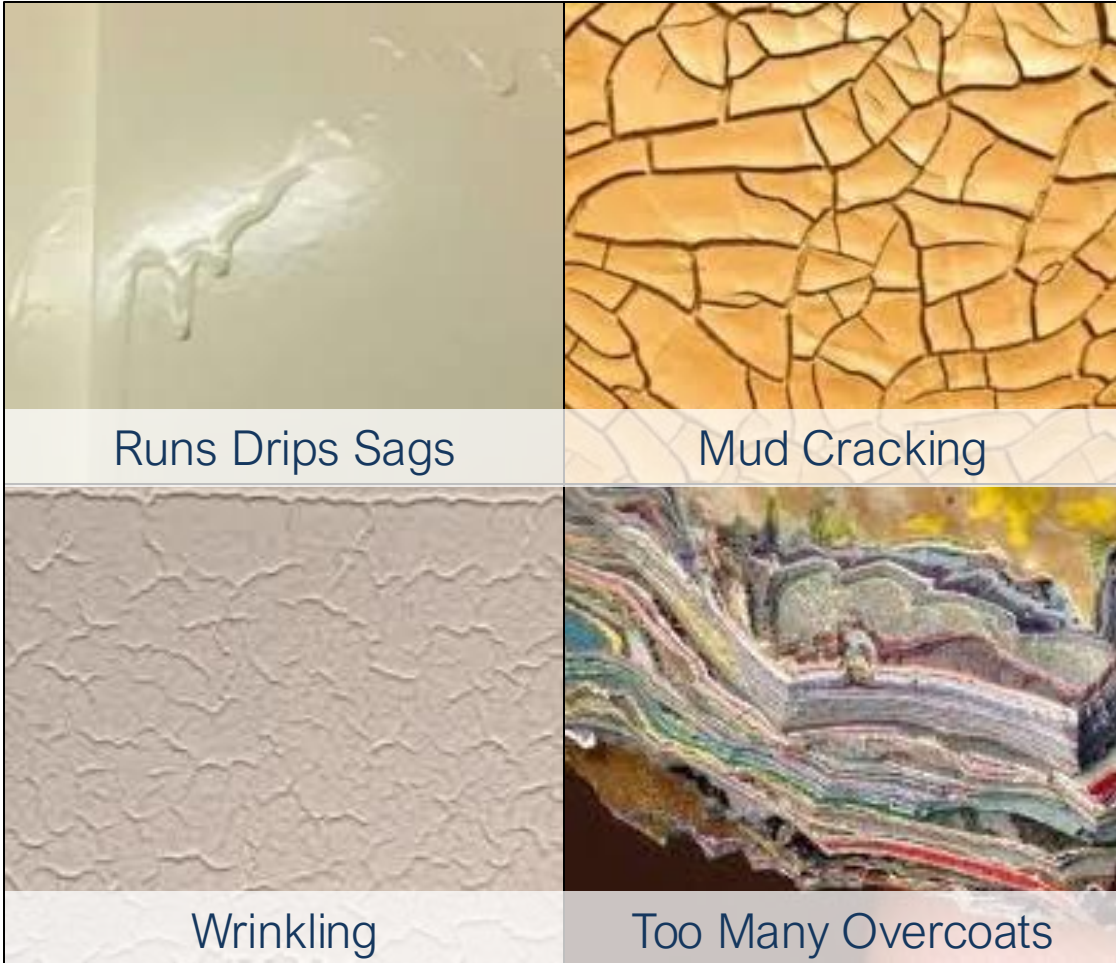
History of
System

Access to
Structure



Coating Film Thickness (Dry Film Thickness – DFT)

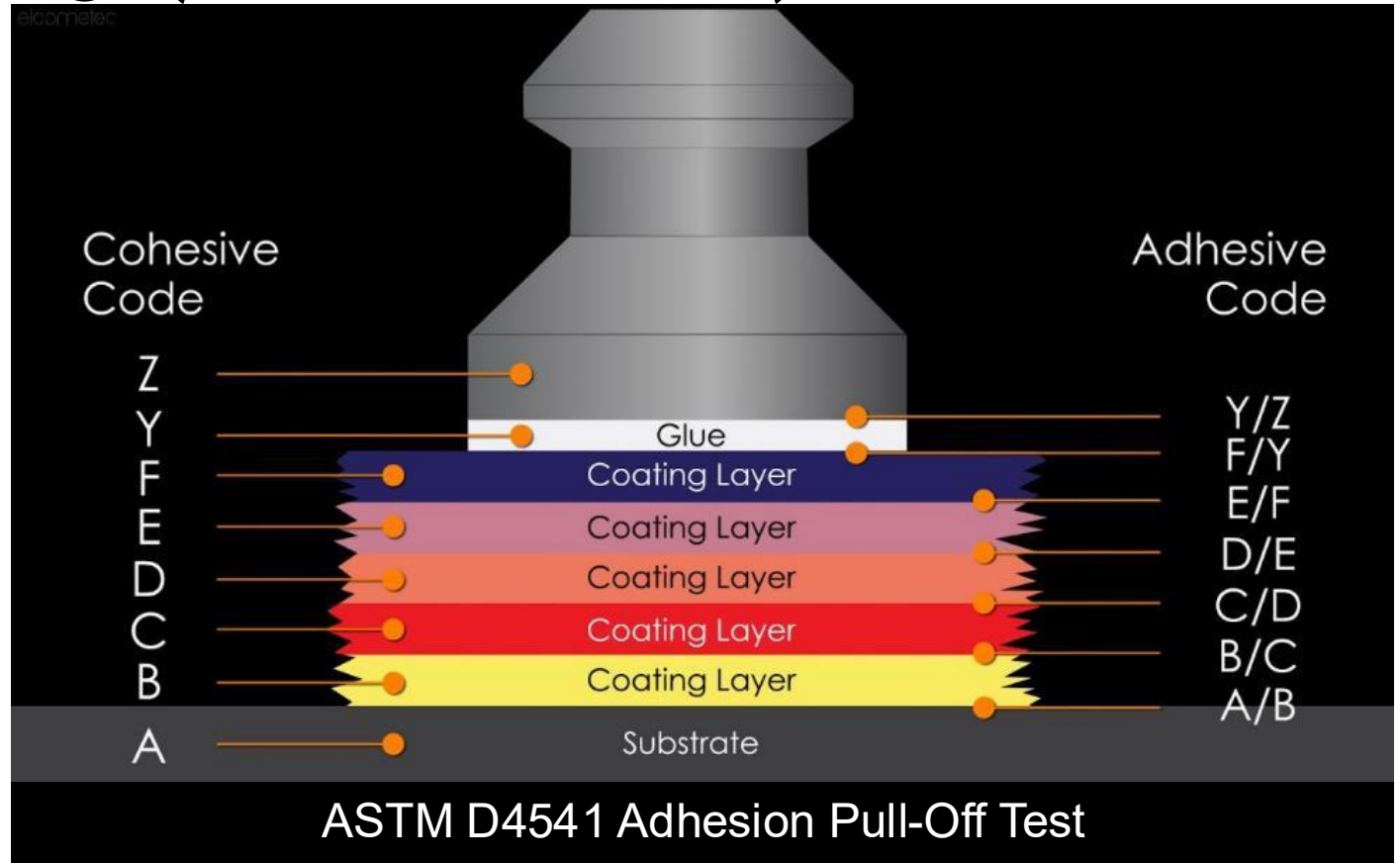
Thick Coating Failures



Thin Coating Failures

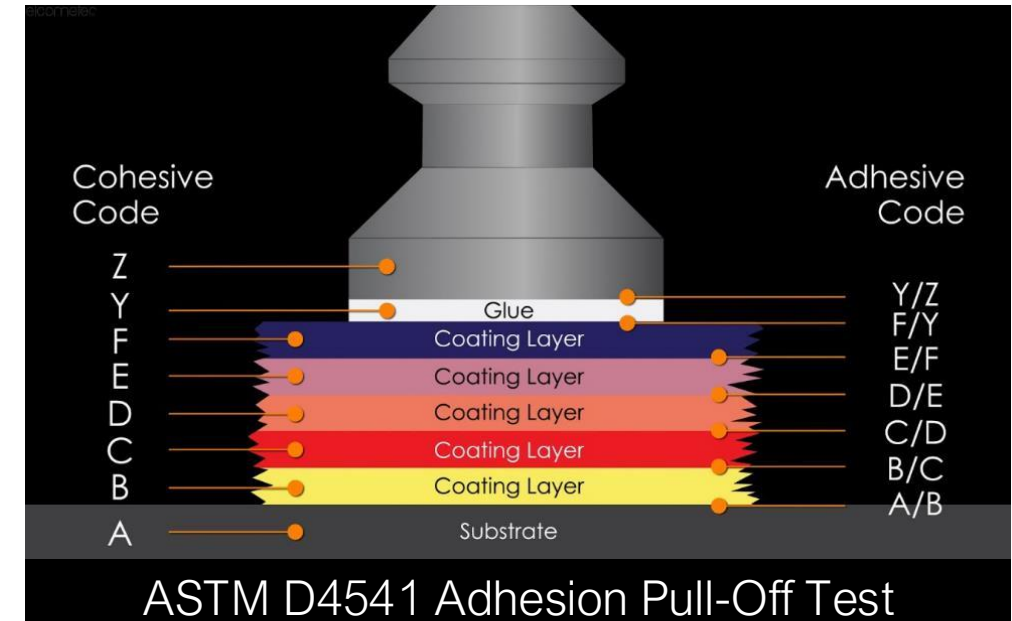


Adhesion Testing (Destructive)



ASTM D4541 Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers

Adhesion Testing (Destructive)



ASTM D4541 Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers

Maintenance Plans: Repair Strategies

Monitor and
Reinspect

Full Overcoat

Spot Repair

Full
Removal/Replace

Spot Repair and
Full Overcoat

Mechanical
Repairs



Why Cathodic Protection?

PREVENT corrosion where and when coatings fail

Applied where coating cannot easily be inspected/repaired

Buried
Piping

Underside of
Tank Floors

Buried Tanks

Inside Water
Tanks

Rebar in
Concrete

Sheet Piles
Pipe Piles





Corrosion in Piping

During
Construction

Modifications

Third Party
Damage

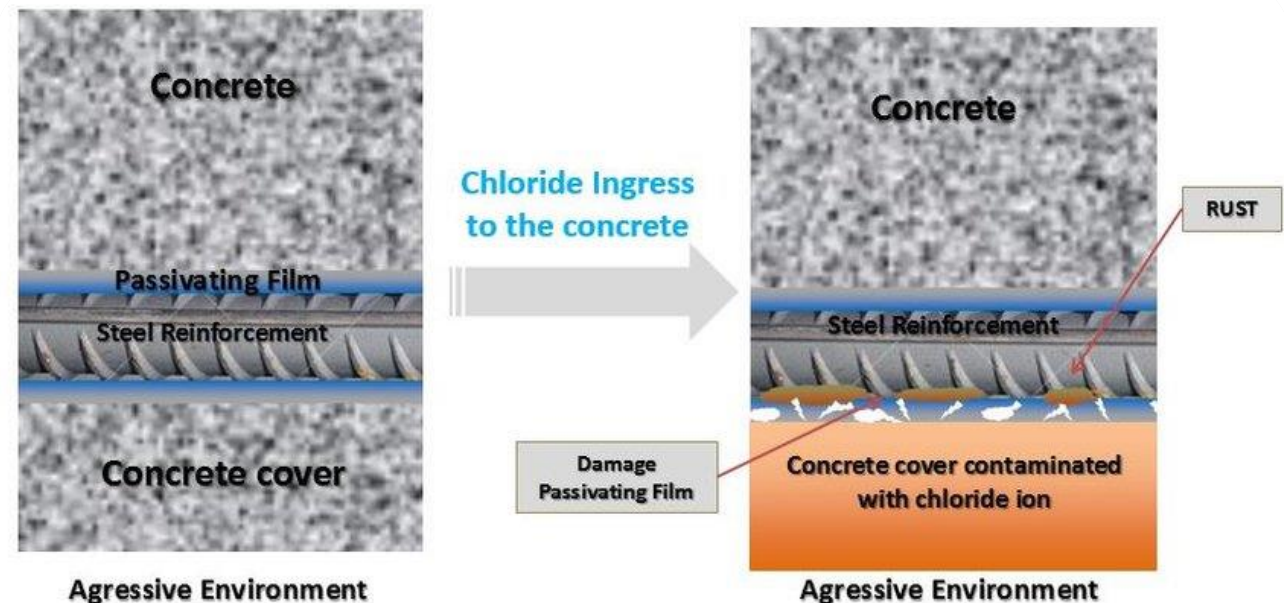
Change of
Electrolyte

Age

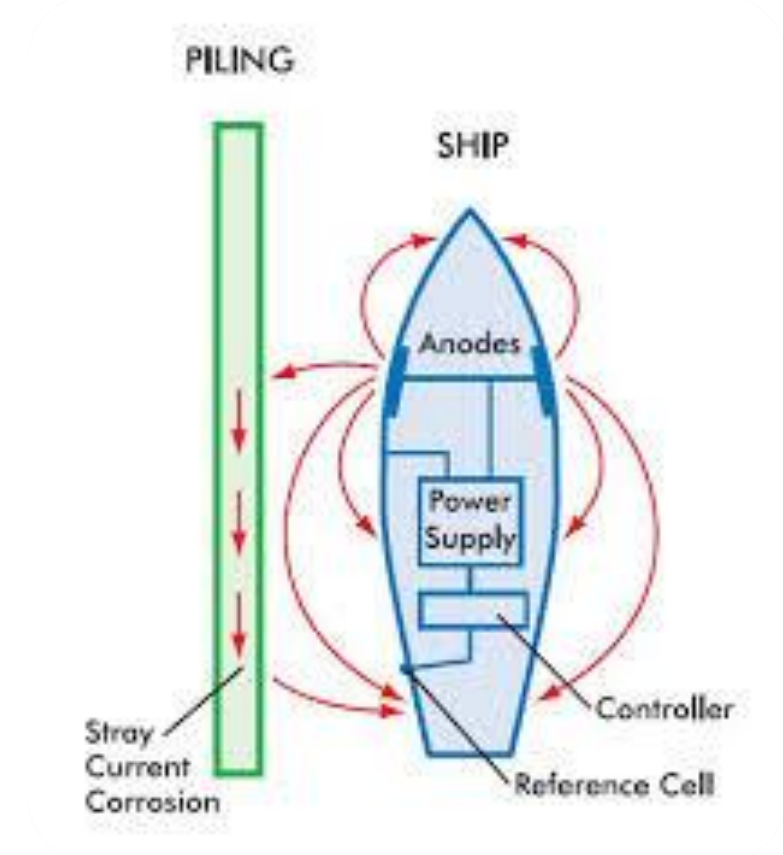
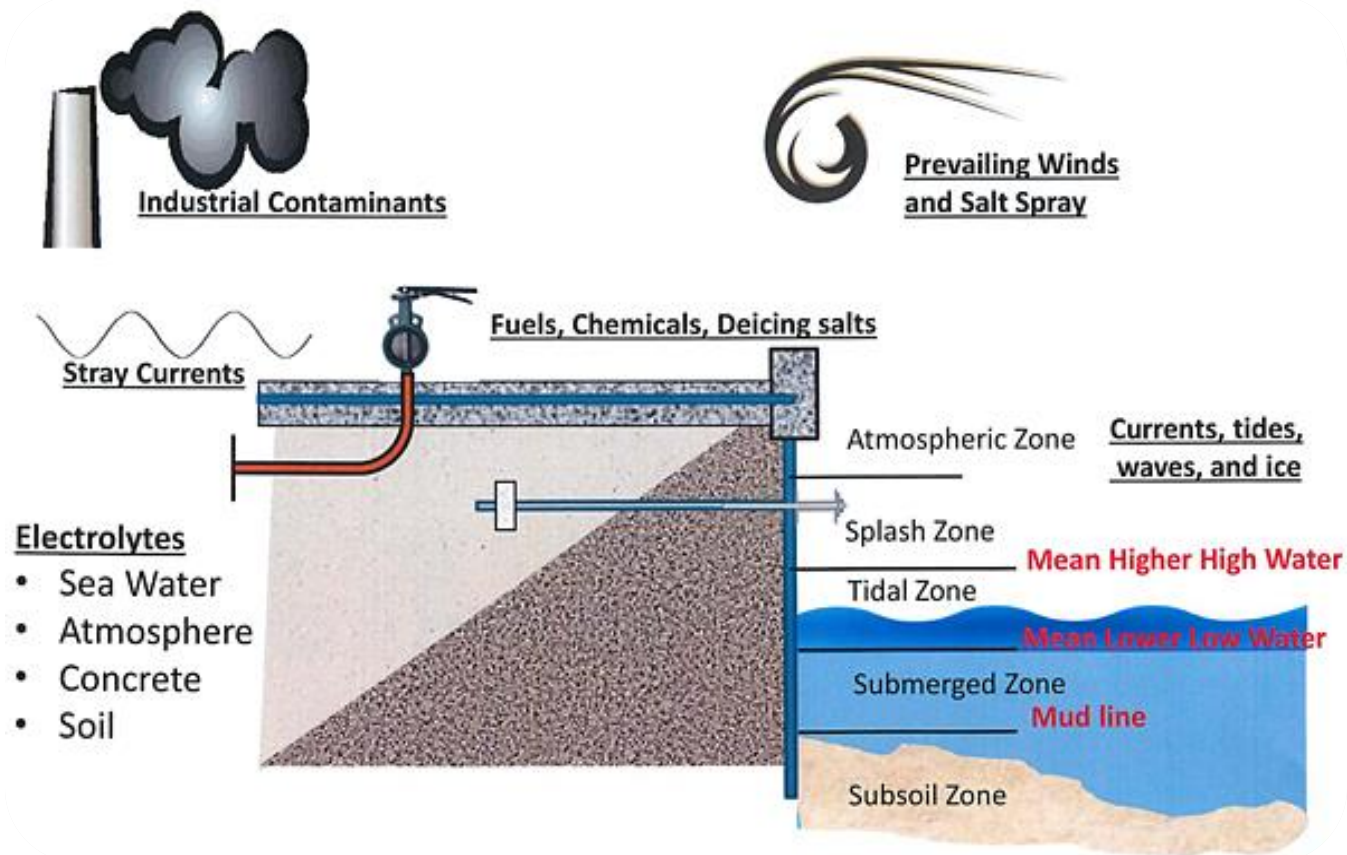


Corrosion in Concrete

- Chloride Induced Corrosion is the main cause of rebar corrosion
- Iron oxide (rust) is more voluminous than steel, causing expansion
- Cracks and spalls form as concrete tensile strength is exceeded



Corrosion in Waterfront Structures



Choosing the Right CP System

Galvanic CP (Sacrificial Anode)



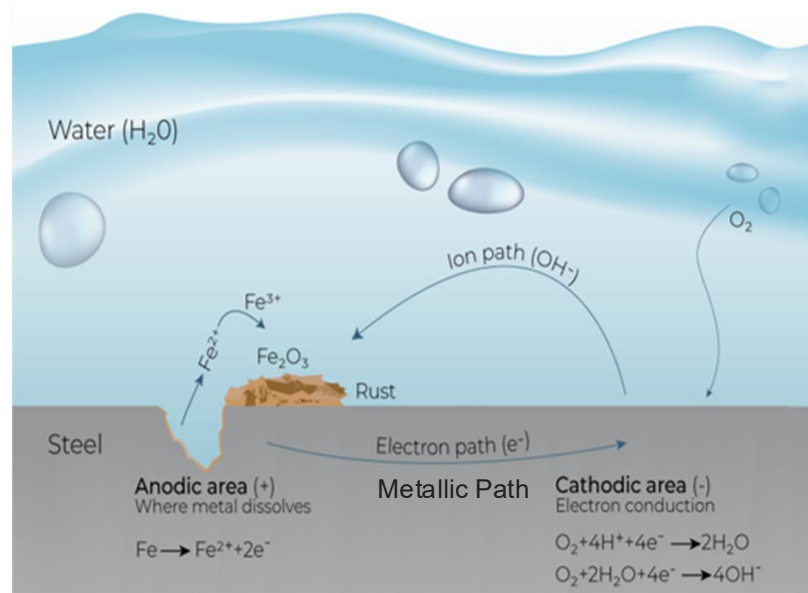
(Photo Courtesy of Cathtech USA)

Anode

Cathode

Metallic
Path

Electrolyte



Impressed Current CP (ICCP)

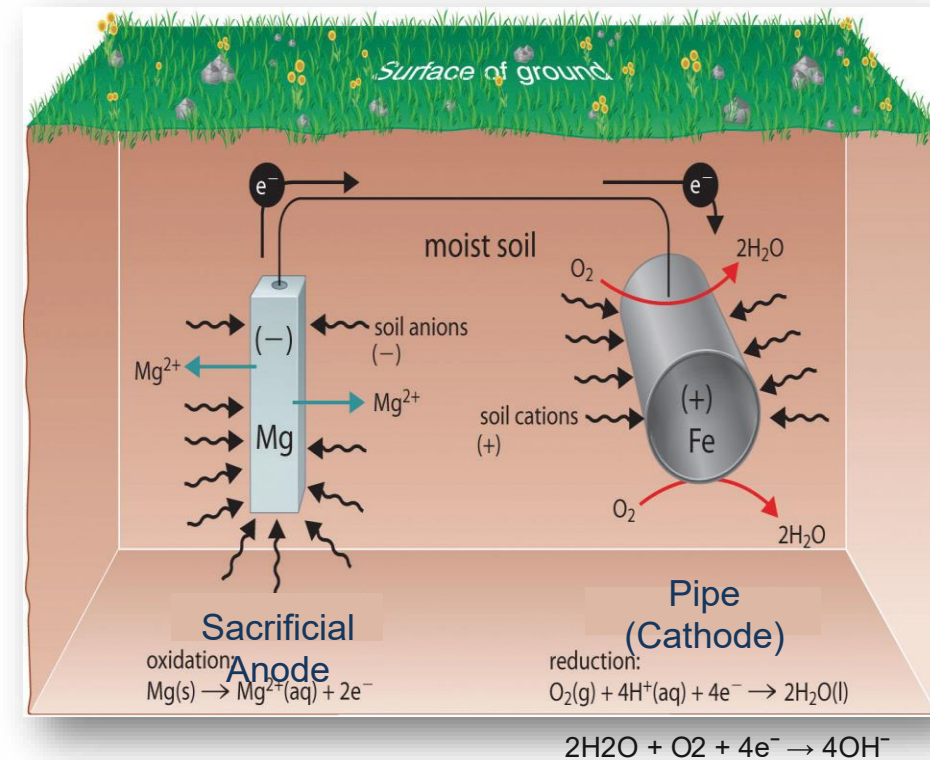


(Photo Courtesy of Jennings Anodes)

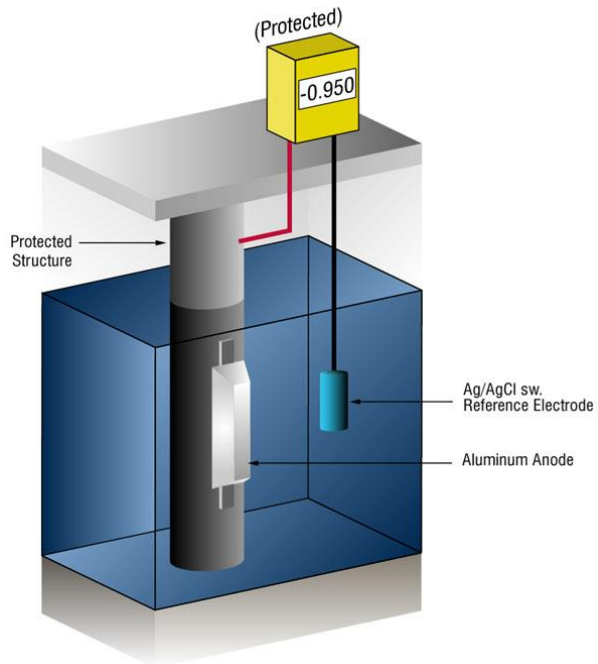
Galvanic Cathodic Protection (CP)

Advantages:

- No external power source required
- Low maintenance requirements
- Small current output = minor stray current interference
- Easy to install
- Provide uniform current distribution



Galvanic Cathodic Protection (CP)



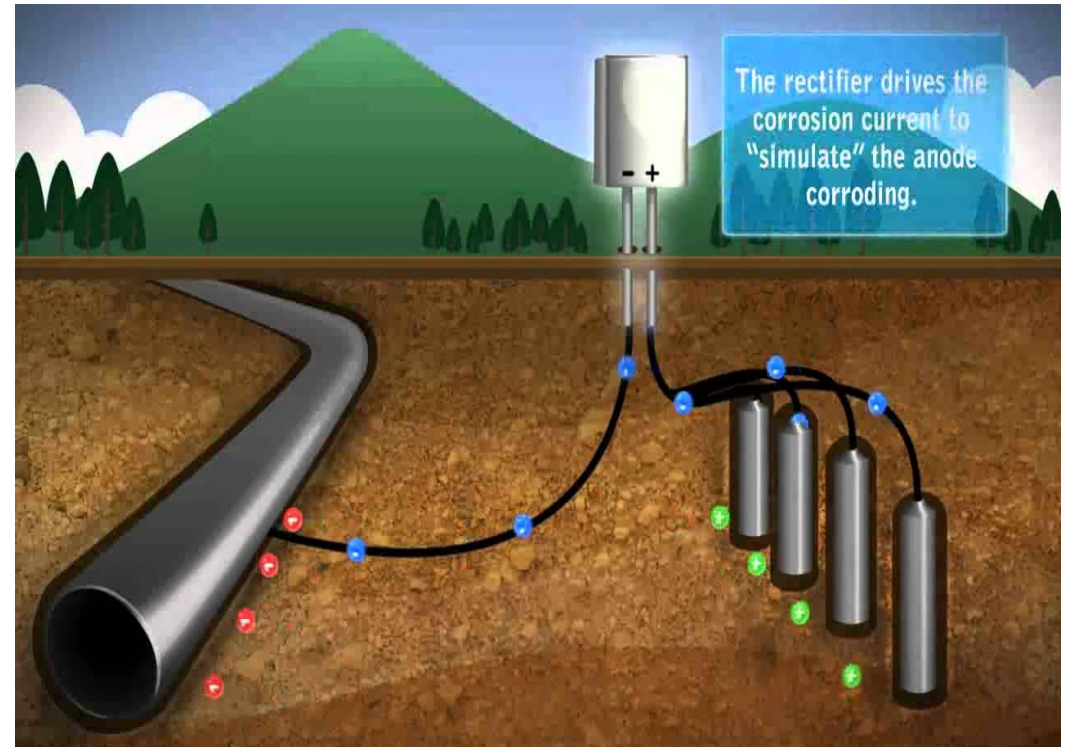
Limitations:

- Low driving voltage/current output
- Susceptible to failure in isolation
- More anodes for poorly coated structures
- May be ineffective in high-resistivity environments

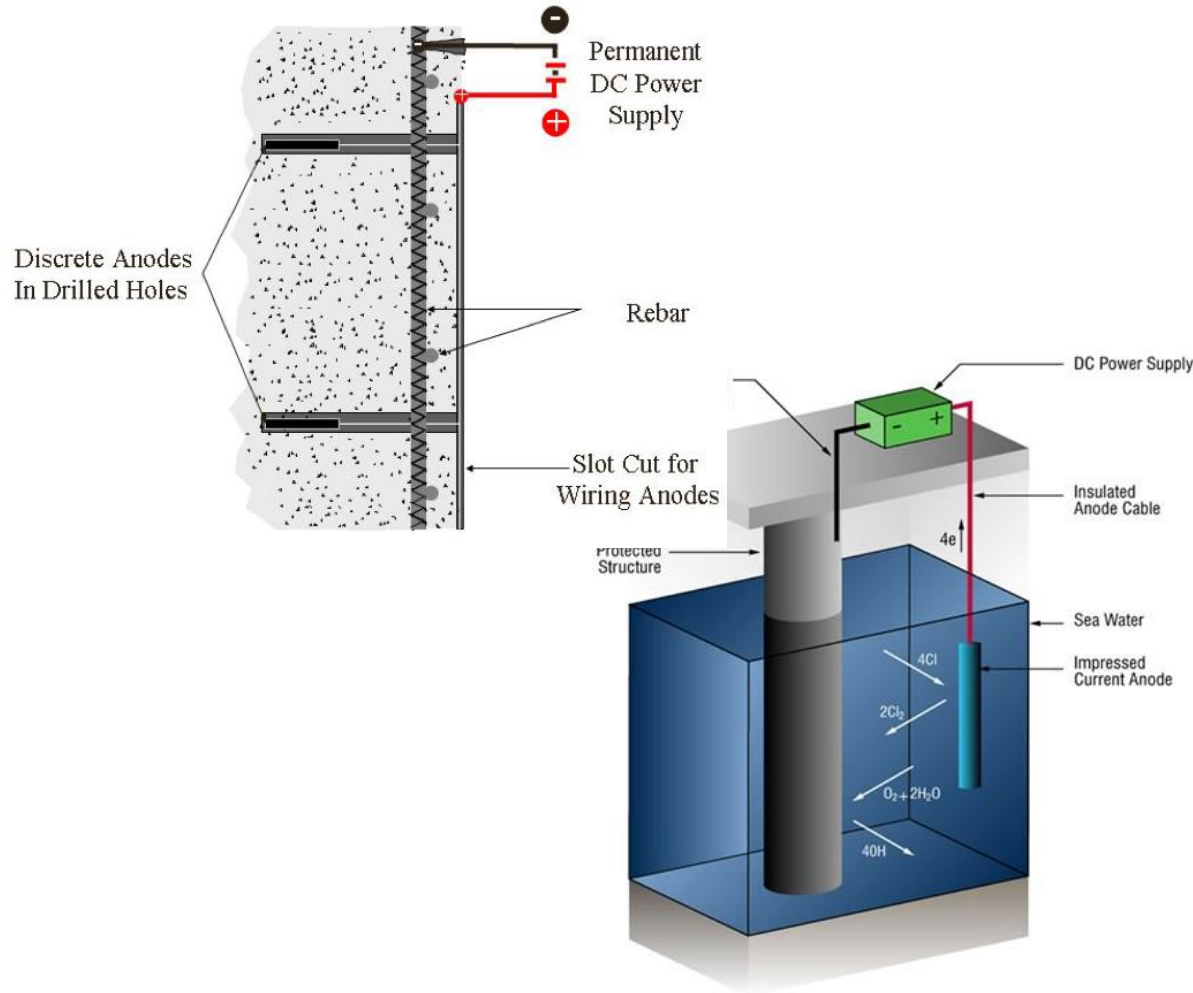
Impressed Current CP (ICCP)

Advantages

- High current output (large/poorly coated structures)
- Adjustable protection levels (control rectifier output)
- Effective when galvanic systems are limited (high-resistivity environments)
- Can protect multiple structures with a single power source



Impressed Current CP (ICCP)



Limitations:

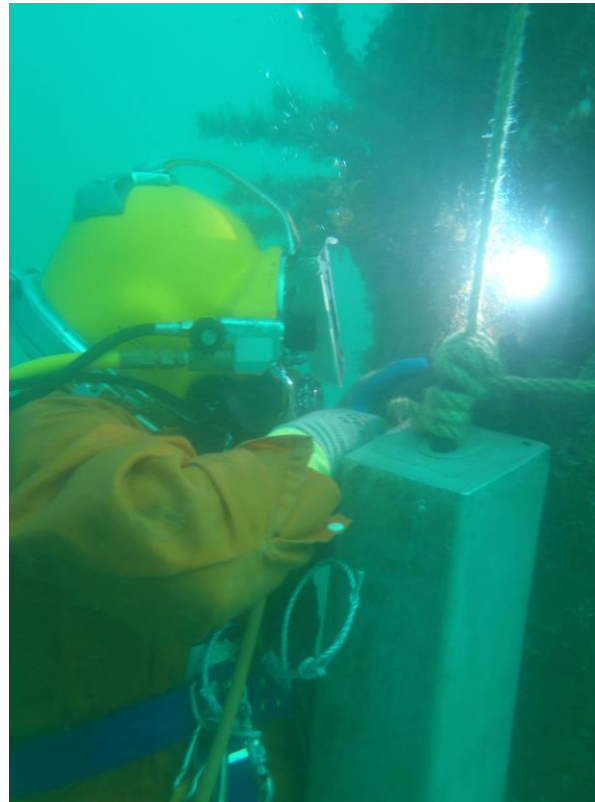
- Requires external power source
- Higher installation and maintenance costs
- Potential for stray current interference affecting nearby buried or submerged assets
- Periodic monitoring and adjustment of necessary
- More complex system components increase failure risk

Corrosion Control Management

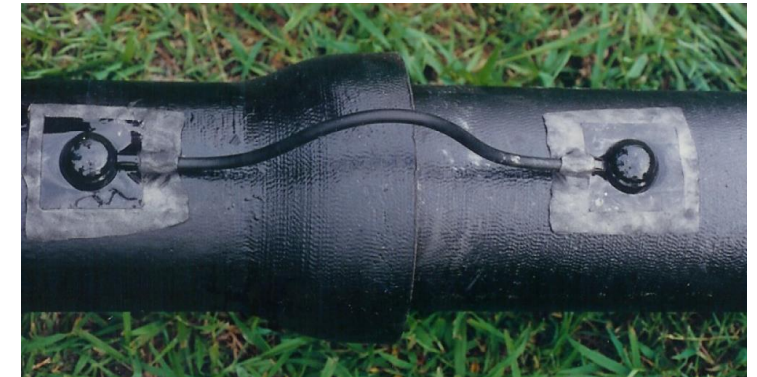
Structural
Evaluations



Environmental
Studies

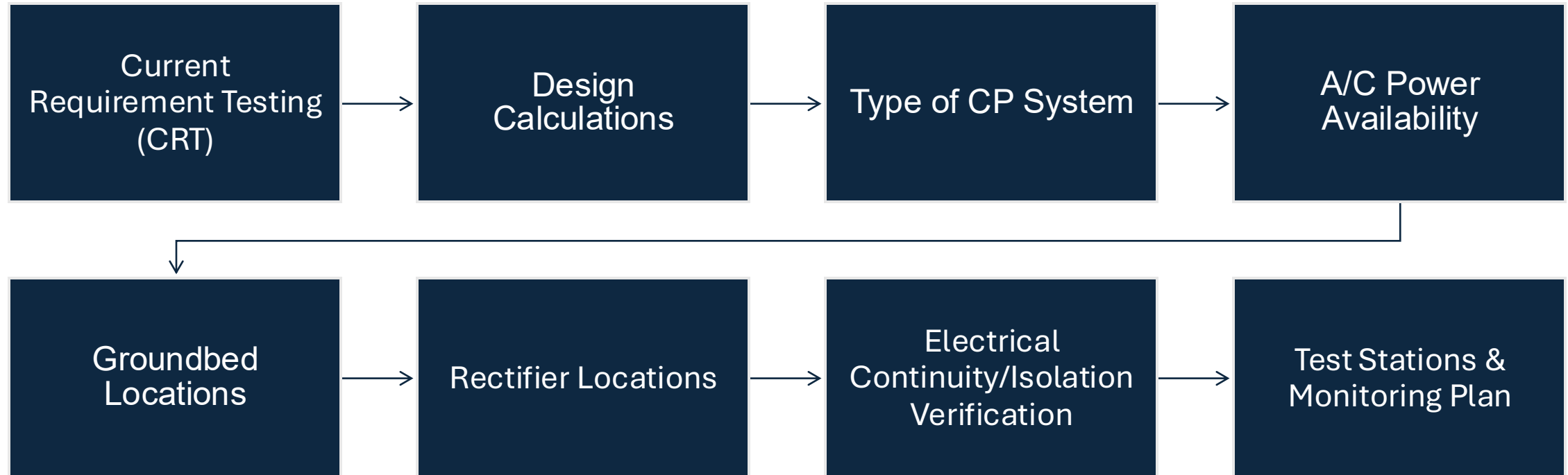


Design
Approach



Monitoring
Program

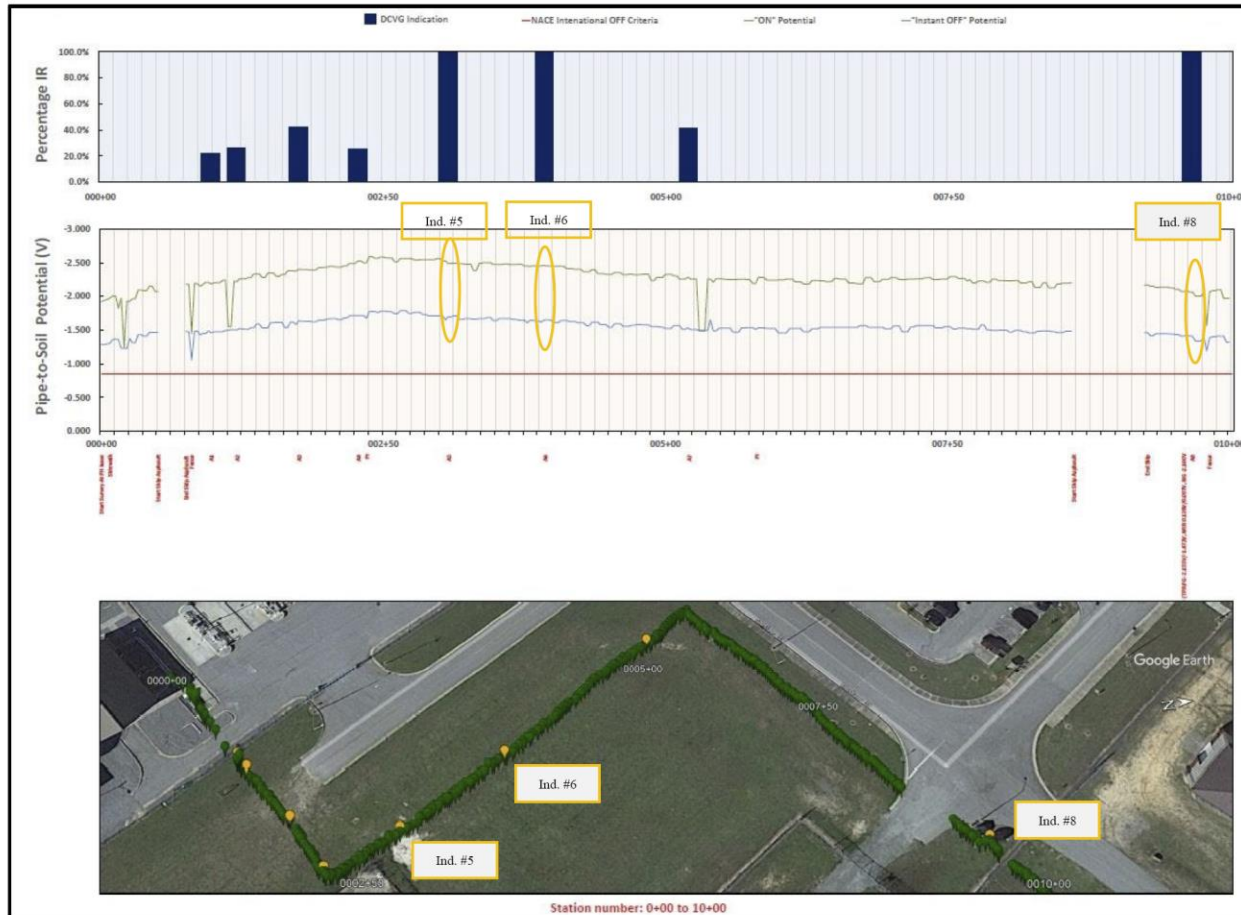
CP Design Process



Importance of Maintenance & Monitoring



External Corrosion Direct Assessment (ECDA)



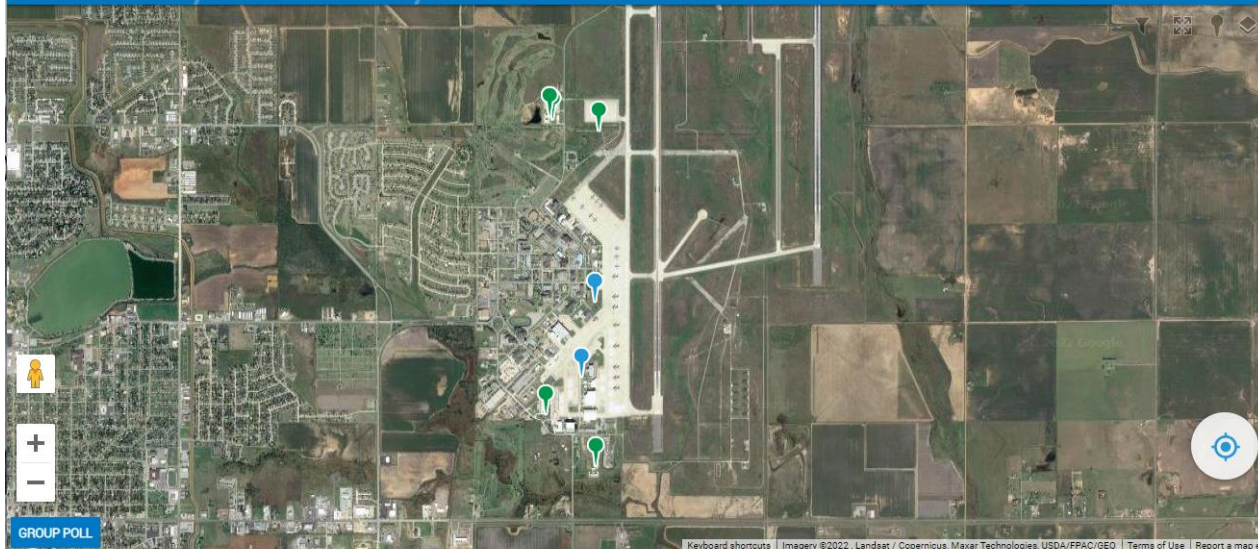
Remote Monitoring

ELECSYS
A LINDSAY COMPANY

Home Devices Reports Favorites Admin

Department of Defense AF ALT: Altus AFB, OK Select Site

NG Nooshin Galati



GROUP POLL

Site	Status	Last Contact	DC Volts	DC Amps	RMU Battery	AC Detect	Digital Input
★ ALT - Rect #01: POL South Fuel Farm Bldg 459 VIP-X	📶 ⚠️ 🔌	17 Apr 2022 20:49	5.17 V	7.16 A	7.40 V	AC Available	
★ ALT - Rect #02: POL C-141 Hydrant System VIPrm	📶 ⚠️ 🔌	07 Jul 2020 11:38	2.65 V	2.50 A	7.80 V	AC Available	
★ ALT - Rect #03: POL C-5 Hydrant Fuel System VIPrm	📶 ⚠️ 🔌	26 Jul 2016 08:54					
★ ALT - Rect #05: POL KC-135 Tanker Line VIP-X	📶 ⚠️ 🔌	10 Apr 2022 23:36	12.50 V	5.48 A	7.90 V	AC Available	Door Closed
★ ALT - Rect #06: POL North Ramp Tank #555 VIP-X	📶 ⚠️ 🔌	11 Apr 2022 03:12	2.70 V	0.99 A	7.90 V	AC Available	Door Closed
★ ALT - Rect #07: POL North Ramp Tank #559 VIP-X	📶 ⚠️ 🔌	16 Apr 2022 01:37	6.52 V	1.43 A	8.20 V	AC Available	Door Closed
★ ALT - Rect #12: POL North to South Transfer Line VIP-X	📶 ⚠️ 🔌	14 Apr 2022 19:10	3.11 V	1.87 A	7.50 V	AC Available	
★ ALT - Rect #15: POL South to North Transfer Line VIP-X	📶 ⚠️ 🔌	14 Apr 2022 01:46	8.64 V	10.79 A	7.90 V	AC Available	Door Closed



Final Thoughts

- Design: Get the fundamentals right
 - Corrosion mitigation is a system: Coating is the barrier and CP is the backup
 - Design for maintenance and inspectability
- Assessments: Drive maintenance decisions
 - Establish baselines
 - Generate actionable scopes
- Prioritize Maintenance: For life extension and value
 - Safety, environment, mission
 - Maximize lifecycle costs



Take Away

Integrate design, evidence-based assessment, and risk-informed maintenance to prolong the life of your structure.

Questions

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- chalifoux@pondco.com