

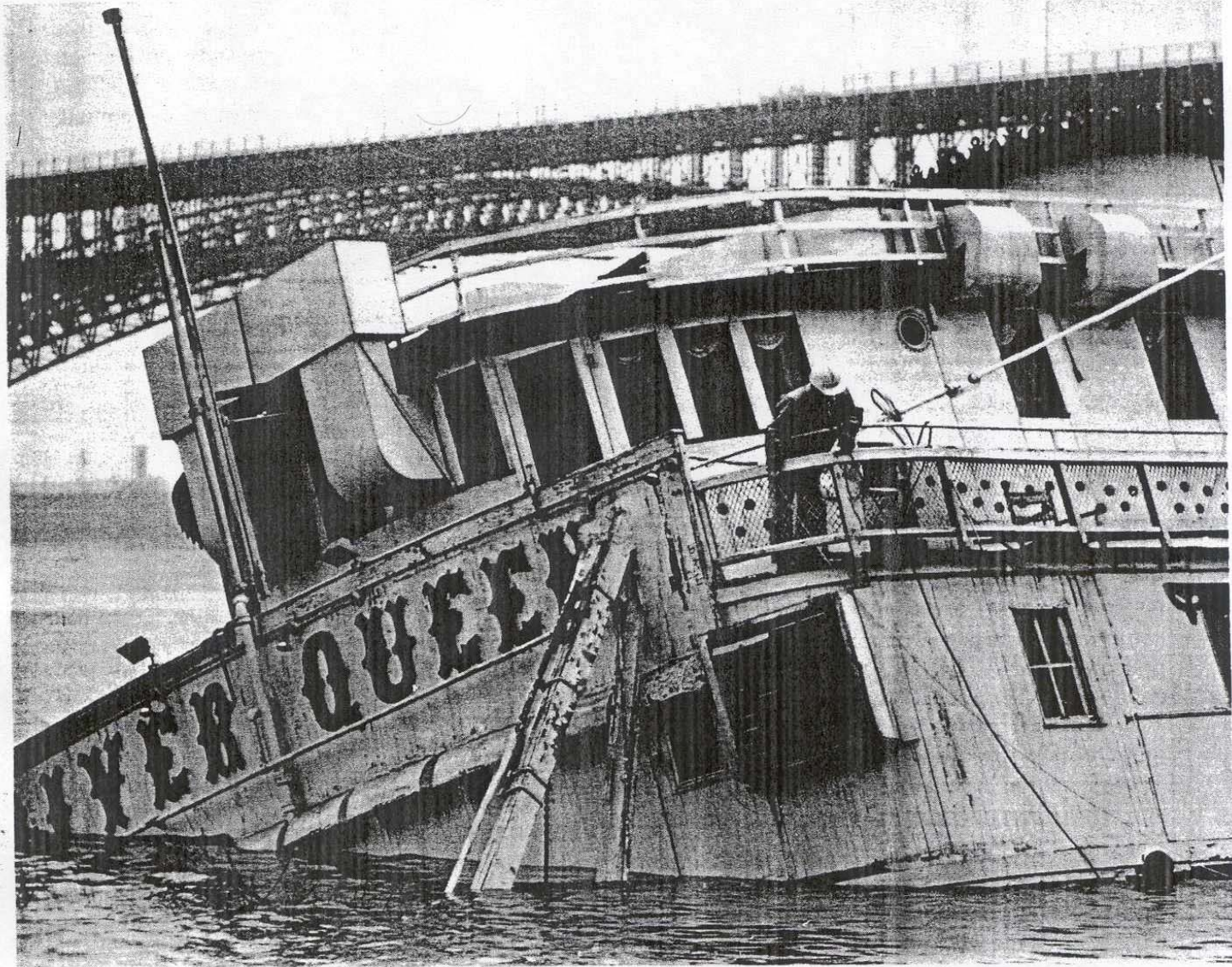
Practical Corrosion Considerations for Small Boat Harbors

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Valdez Alaska

By: John C Daley, P.E.

How Important is Corrosion?

- FHWA 2002 In Depth Study
- Annual Direct Costs of Corrosion= \$276 Billion
- 3.1% of GDP



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What is Corrosion?

- Corrosion is the deterioration of a substance or its properties because of a reaction with the environment
- Corrosion is an electro-chemical process. It includes the transfer of ions and electrons.
- Rust is a common form of corrosion

A Corrosion Cell

- Anode and Cathode
- Electrolyte
- Metallic Path

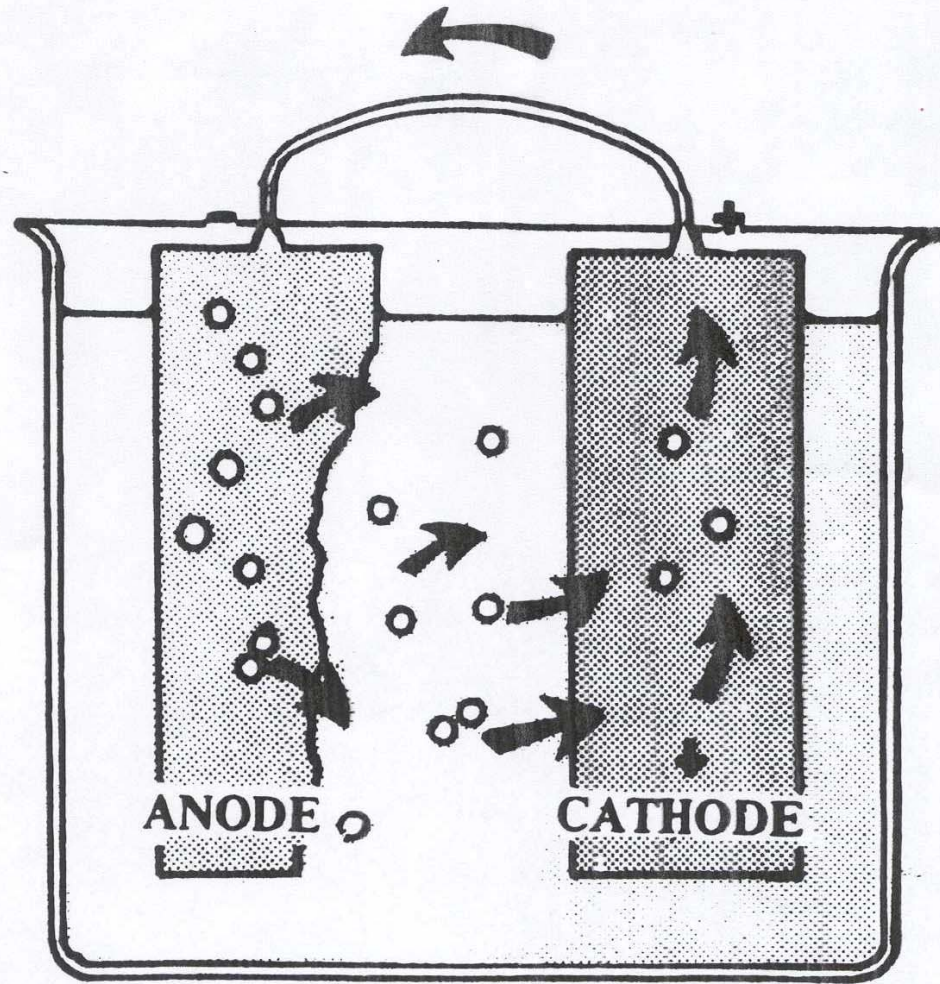


FIGURE 2.4 — Sketch showing flow of current between an anode and a cathode in a corrosion cell.

Anode and Cathode

- Dissimilar Metals (Battery)
- Differing grain structure in same base metal (Heat Affected Zone)

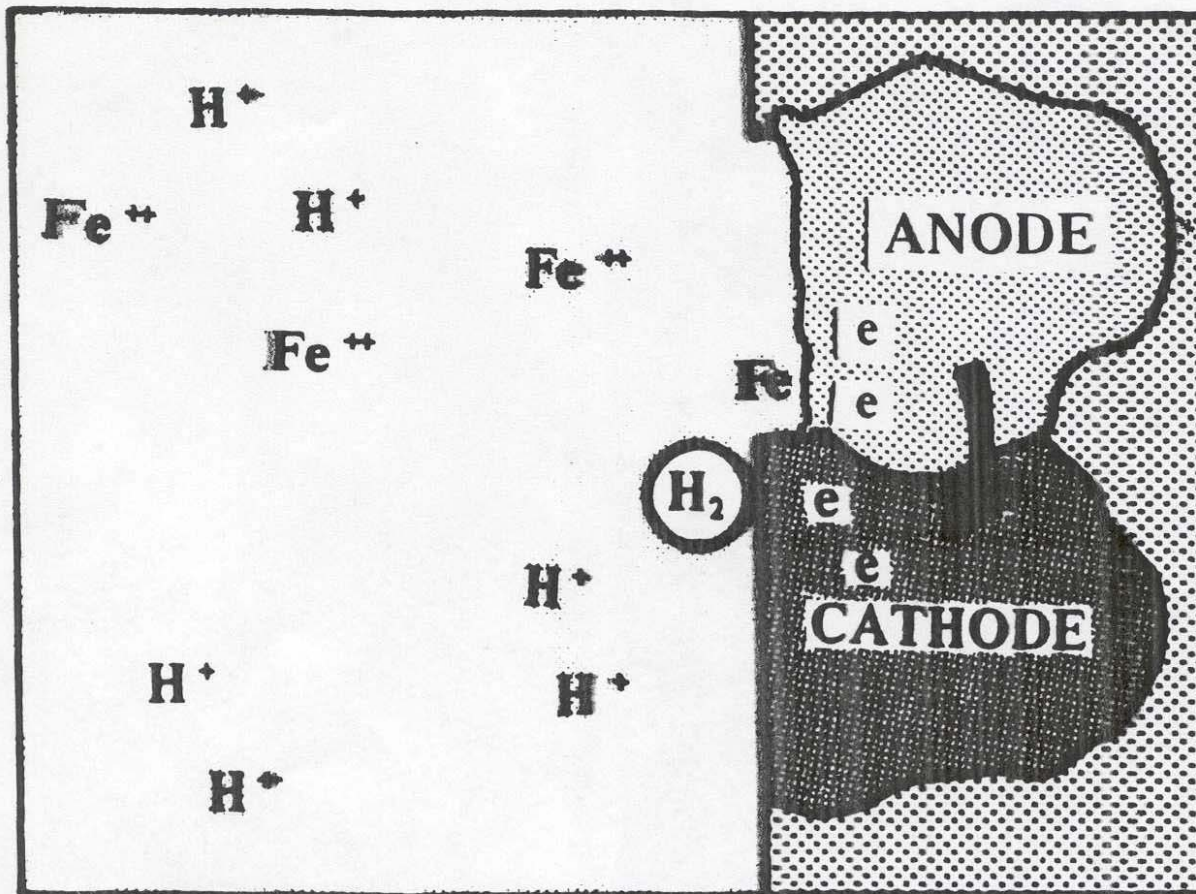


FIGURE 2.10 — Formation of ions at an anodic area and release of hydrogen at a cathodic area in a local cell on an iron surface.

Electrolyte

- Sea Water
- Fresh Water
- Soil

Types of Corrosion

- General or Uniform
- Pitting
- Crevice
- Many Others

General Corrosion Rates

- Typical saltwater 5-10 mils per year. About $\frac{1}{4}$ " in 25 years
- Cook Inlet 20 mils per year. About $\frac{1}{2}$ " in 25 years
- Pitting rates can be much higher!

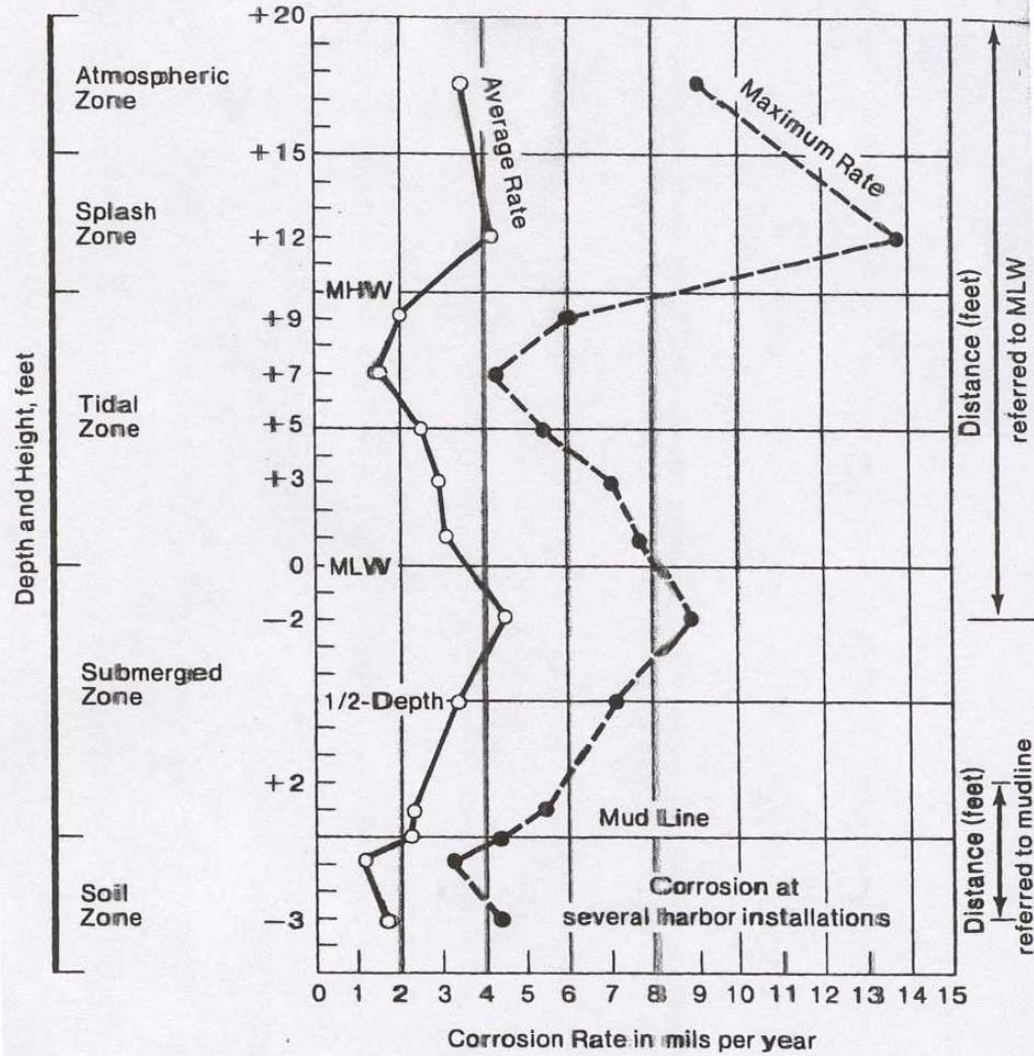


Figure 2.6 Corrosion rate profile of steel sheet piling. [From Edwards, 1963]⁹

What is so special about Cook Inlet?

- Cold water contains more oxygen
- Moving water brings fresh oxygenated water in contact with surface.
- Silt particles "sand blast" corrosion deposit film away
- Fresh water lens on surface forms oxygen concentration cell

Strategies to deal with corrosion

- Materials Selection
- Extra Thickness "Corrosion Allowance"
- Coating
- Galvanizing
- Anodes
- Design Considerations

Materials Selection

- Use Plastic
- Use Concrete
- Use Aluminum
- Use Stainless Steel, Bronze or Brass
- Use Weathering Steel (ASTM A690)

Corrosion Allowance

- Calculate corrosion rate and wastage at design life.
- Consider minimum plate thickness of $\frac{1}{4}$ or $\frac{3}{8}$ inch

Coating

- Perfect coating = no corrosion
- Key is surface prep and QC
- Many examples in automobiles and steel boats
- Many good new coating systems including epoxies and urethanes

Coated Sheet Piling



Coating Failure on Sheet Pile Cell



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Sheet Pile Coating at Mud Line



Galvanizing

- Sacrificial Coating (3 to 6 mils typical)
- Good for 15 to 20 years
- Must be Hot Dip
- No zinc plated items in harbors

Pipe Piling



Pipe Pile With Some Galvanizing



Galvanizing Gone



Sacrificial Anodes

- Simplest system
- Can be zinc, aluminum, or magnesium.
- These have limited current output and will protect a limited area.
- Analogous to a handheld flashlight

Impressed Current Anodes

- High current output / can protect large areas
- Can be mounted on piles or on sleds. Need heavy wires and rectifiers above water.
- More complicated system requires regular maintenance
- Analogous to electric street lights

Anode Sled



Pile Mounted IC Anode



Design Considerations

- Consider minimum plate thickness
- Consider seal welding all fabrications
- Minimize or eliminate overlapping plates
- Eliminate H sections if possible
- Eliminate pile splices in high corrosion zones
- Don't use thin stainless sections or banding

Think Systems and Service Life

- No one item will solve all problems
- Consider several measures,
- Example corrosion allowance and hot dip galvanizing
- Example coating and sacrificial anodes
- Put effort in up front: better to prevent cancer than to try and cure it.

Service Life Example

■ Skyline Steel, LLC

Durability by Design - Options

Section	1 Sacrificial Thickness years	2 A 690 years	3 / 3a Steel Grade Gr 50 to Gr 55 / Gr 60	4 Coating	5 Cathodic Protection	Design Life Options	Life Yrs	Other Option	Life Yrs
AZ 13	32					1	32		
		+ 32				1 + 2	64	1+2+4	79
			+ 3 / + 6			1 + 3 /3a	35- 38		
				+ 15		1 + 4	33		
					+ 20	1 + 5	47		
AZ 18	41					1	41		
		+ 41				1 + 2	82	1+2+4	97
			+ 4 / + 8			1 + 3 /3a	45-49		
				+ 15		1 + 4	56	1+3a+4	64
					+ 20	1 + 5	61		
AZ 26	60					1	60		
		+ 60				1 + 2	120	1+2+4	135
			+ 6 / + 12			1 + 3 /3a	66-72		
				+ 15		1 + 4	75		

Don't

- Put bare steel in salt water
- Use zinc plated fittings, (use hot dip)
- Use thin stainless steel sections
- Let bean counters remove corrosion control from your projects

Questions?

