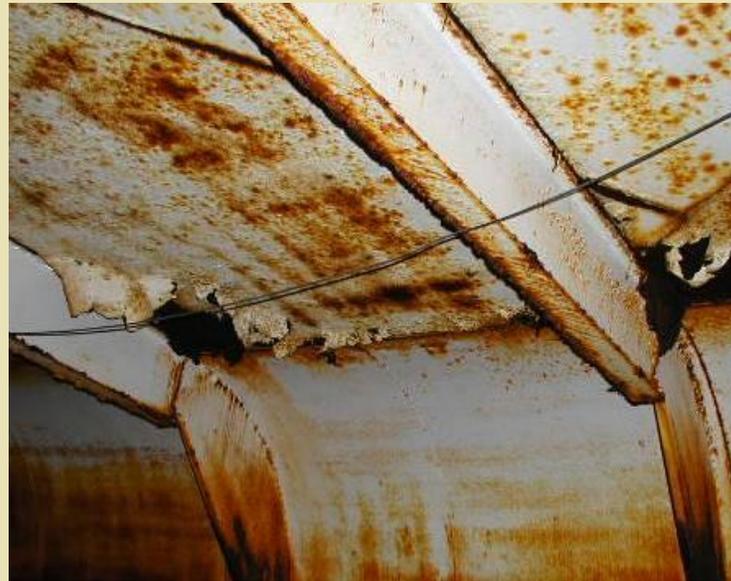


Corrosion Control of Water Storage Reservoirs – Practical Experiences

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**Presented By:
Jeremy A. Hailey, P.E.
Northwest Corrosion Engineering**

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Topics of Discussion

- ◆ Corrosion – Why Should We Care?
- ◆ Corrosion Basics
- ◆ Methods for Controlling Corrosion
- ◆ Typical Corrosion Control Installations

Why Should We Concern Ourselves With Corrosion?

- ◆ Reason #1 – Cost and Replacement Issues



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Why Should We Concern Ourselves With Corrosion?

- ◆ Reason #2 – Good Public Relations

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Why Should We Concern Ourselves With Corrosion?

- ◆ Reason #3 – Public Safety



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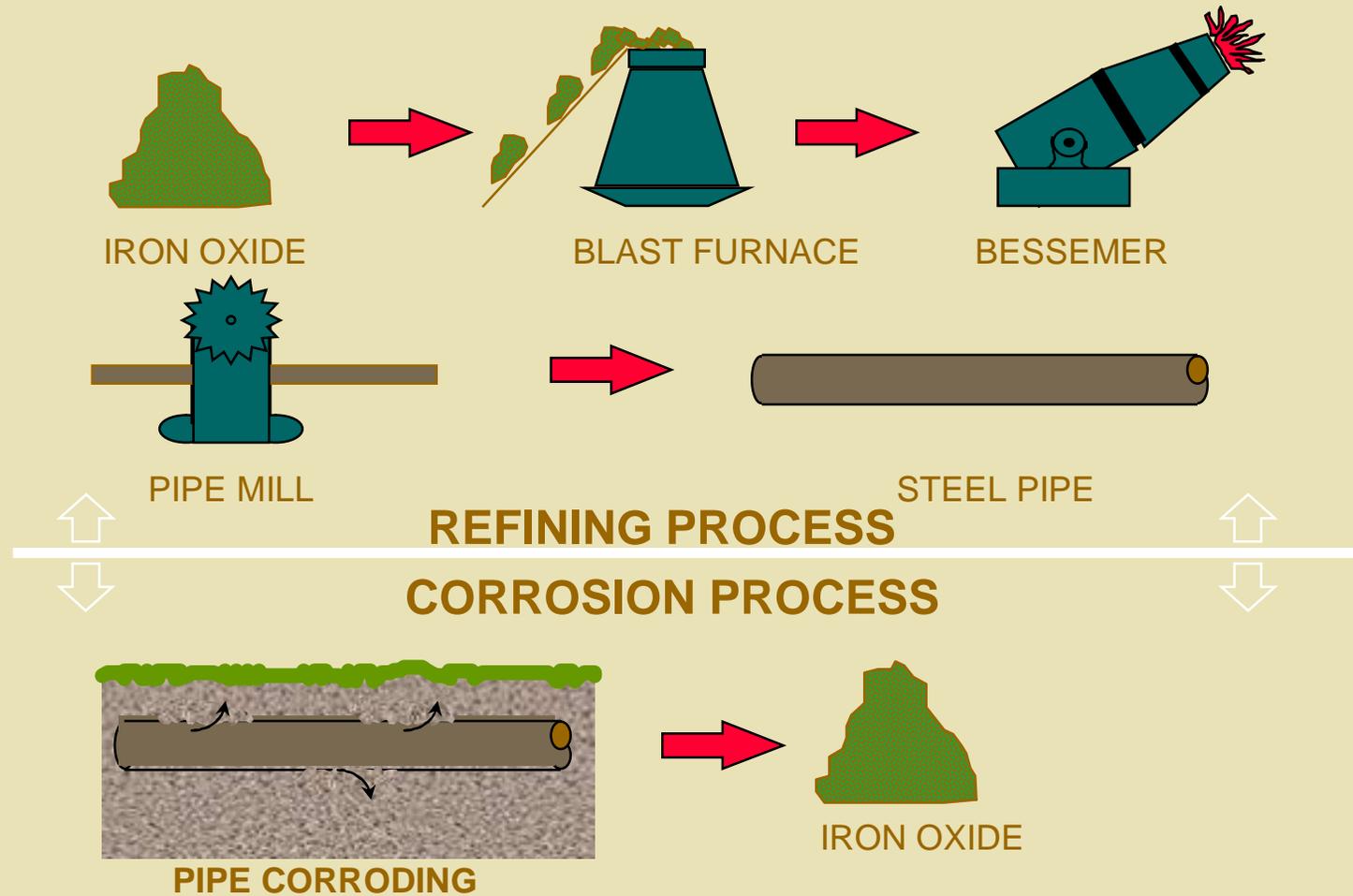
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What is Corrosion Why Does Corrosion Occur?

- ◆ Corrosion is the deterioration of a material, usually a metal, resulting from a reaction with its environment.
 - Metals tend to want to revert back to their ores.

For Example:



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Corrosion Theory

- ◆ All materials have various physical properties
 - Color, hardness, ductility, shear strength, ability to conduct heat, melting point, electrical potential.....
- ◆ Corrosion in metal occurs because of an electrical imbalance, or electrical potential difference.
- ◆ Much like when two beakers of water, each at a different temperature, are poured together the resulting temperature will be somewhere between the two starting temperatures.

Galvanic Series

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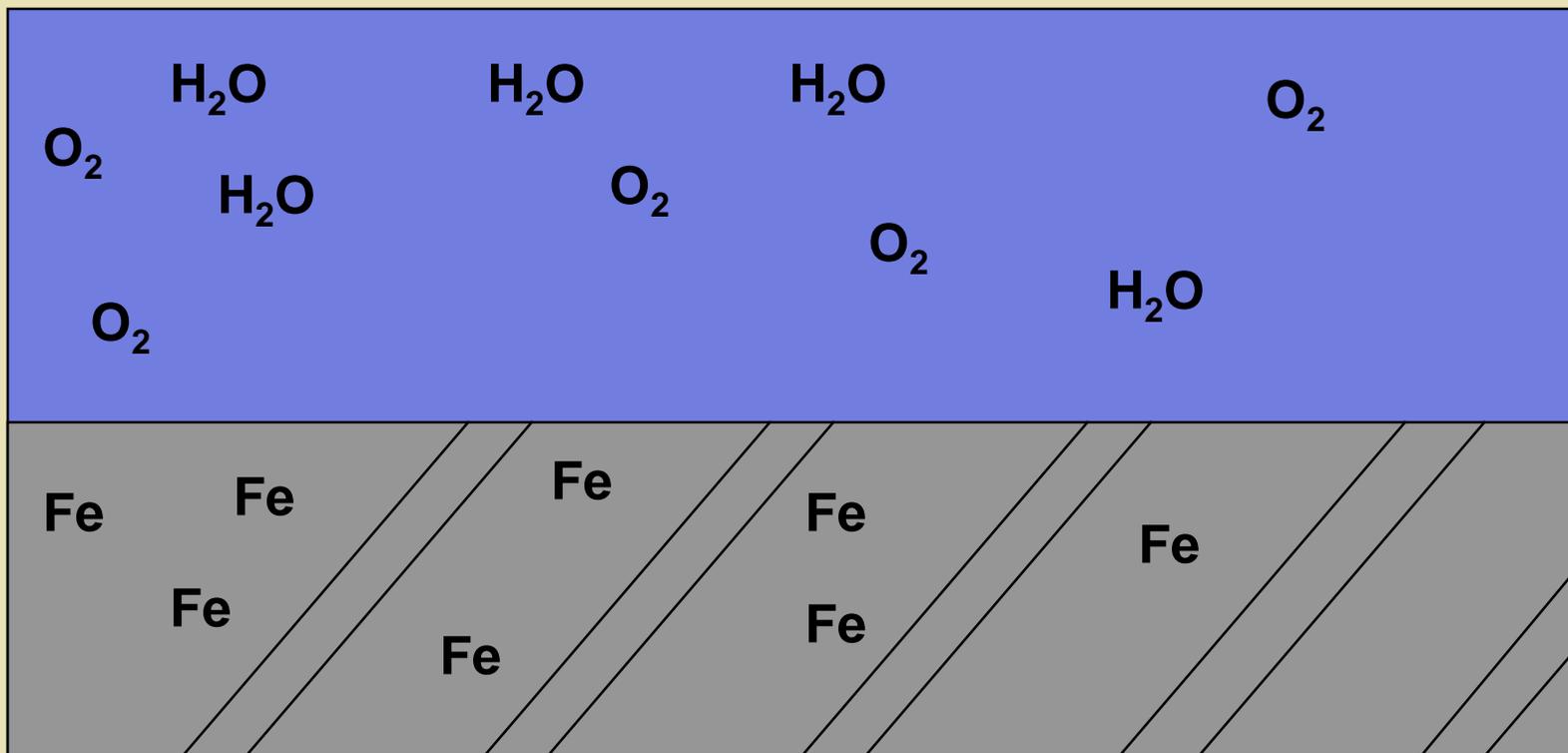
| Material | Potential (mV) |
|--------------------------|-----------------------|
| Magnesium | -1750 |
| Zinc | -1100 |
| Aluminum | -1050 |
| New Carbon Steel | -500 to -800 |
| Ductile/Cast Iron | -350 to -500 |
| Carbon Steel | -350 to -500 |
| Stainless Steel | -300 |
| Copper | -200 |

Corrosion Cell

- ◆ The amount of corrosion is a function of the materials consumption rate. For example, 1 ampere of current flowing off a ductile iron pipe for one year will result in 20 pounds of metal loss.

Oxygen Concentration Schematic

Steel and Electrolyte



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Oxygen Concentration Schematic

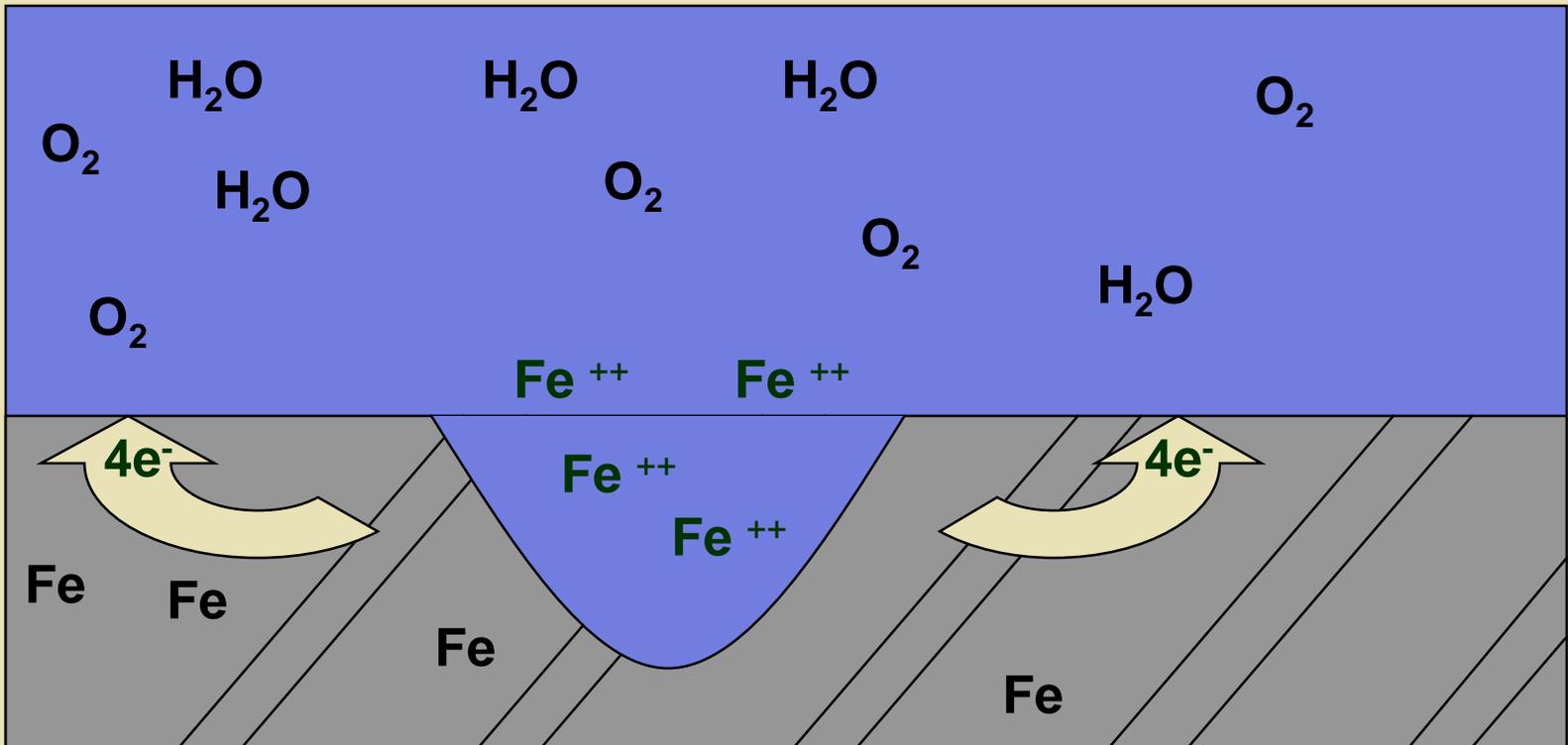
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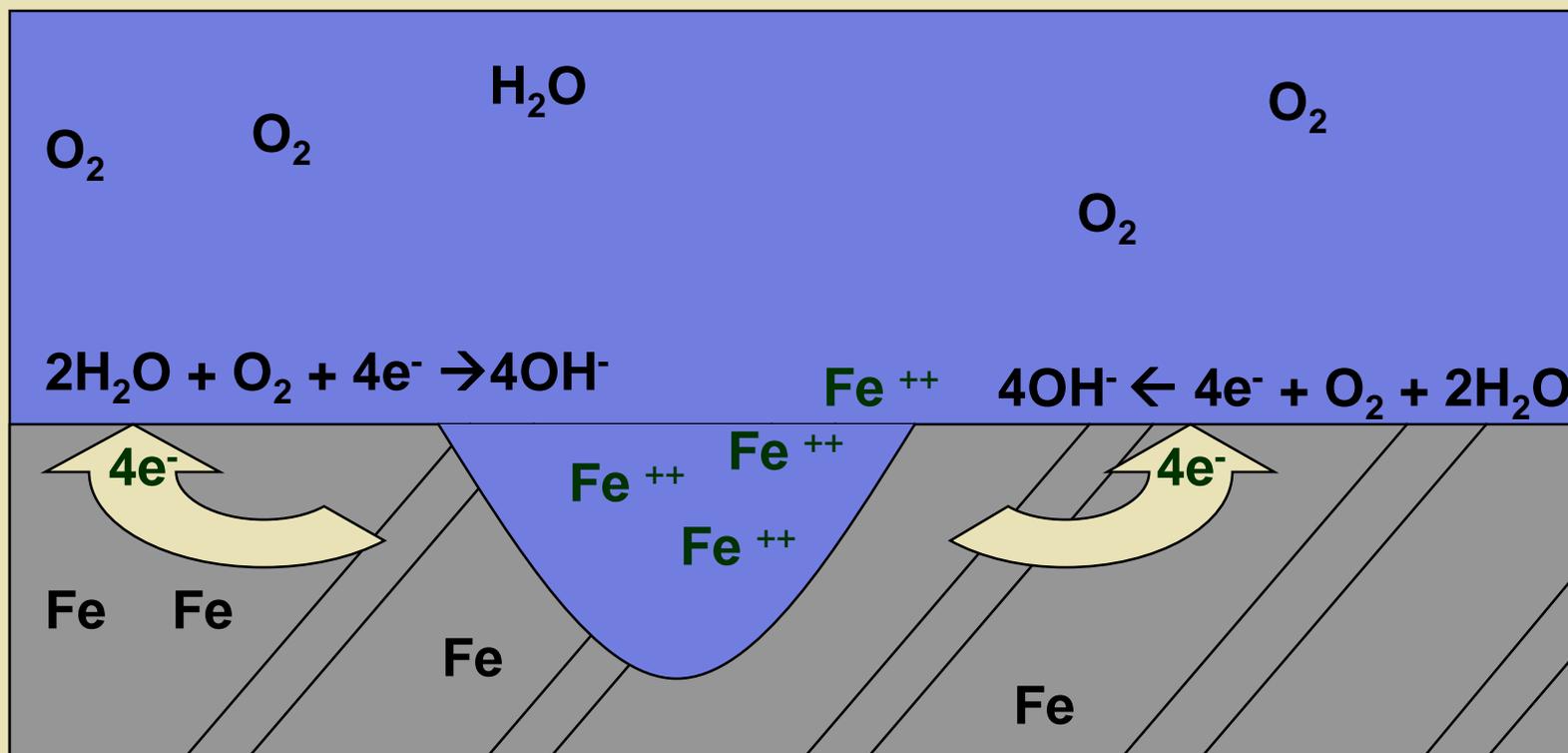


Oxygen Concentration Schematic

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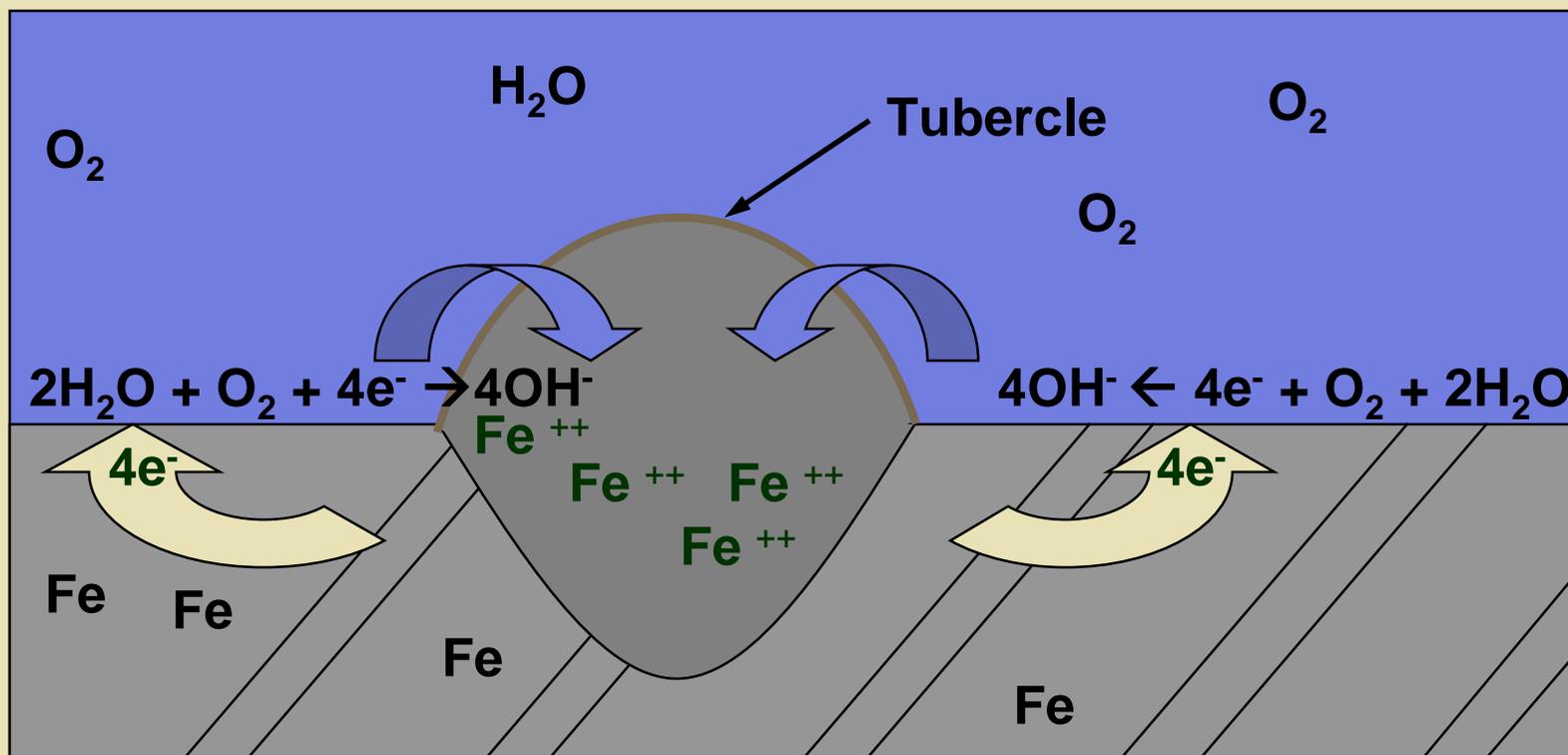


Oxygen Concentration Schematic

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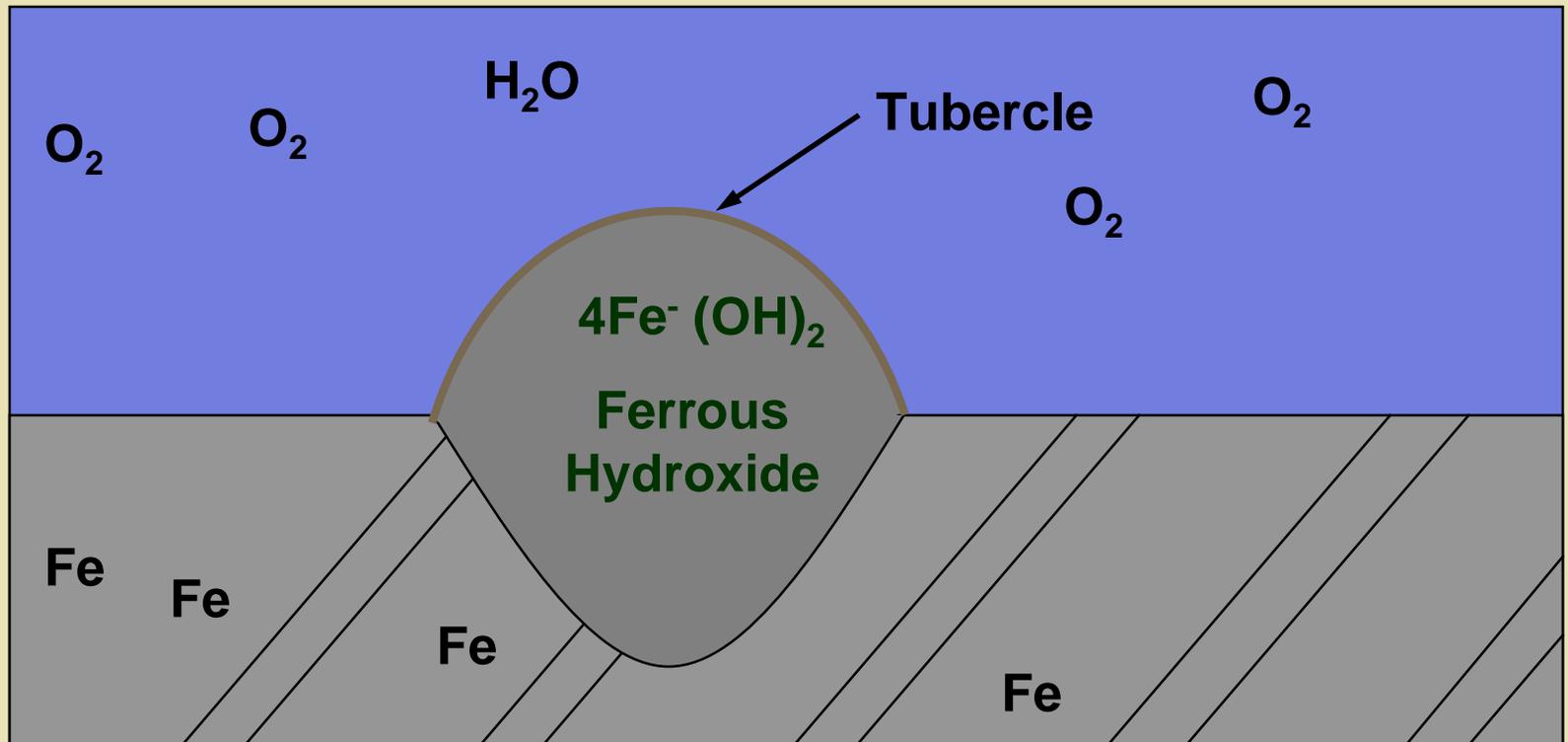


Oxygen Concentration Schematic

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**Tubercle build-up on inside of steel water
reservoir**

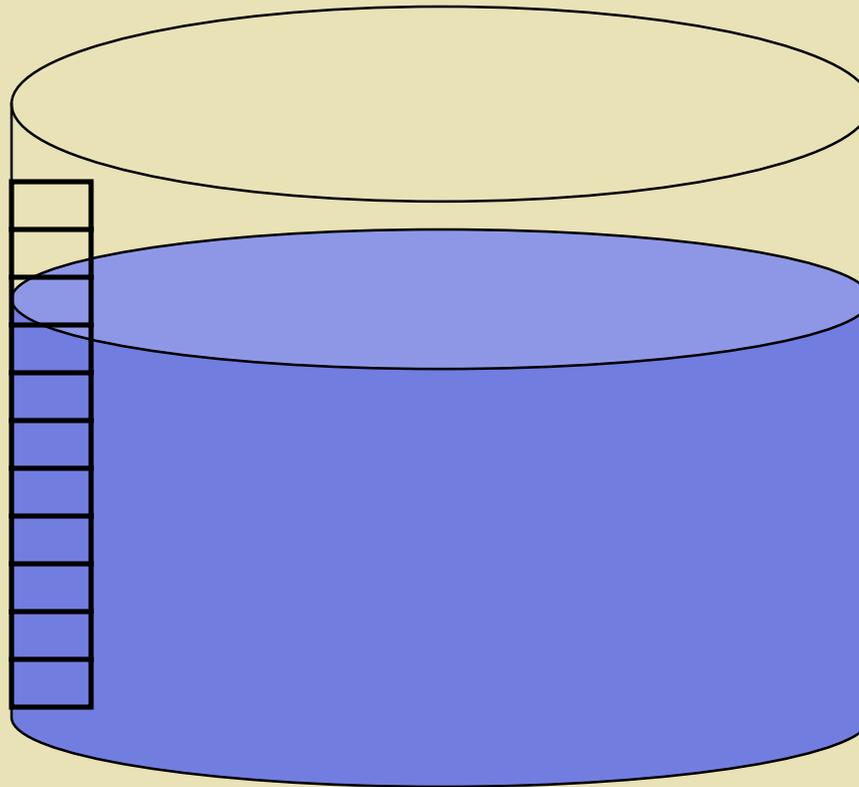
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A Carbon Steel Tank With a Stainless Steel Ladder Welded to It

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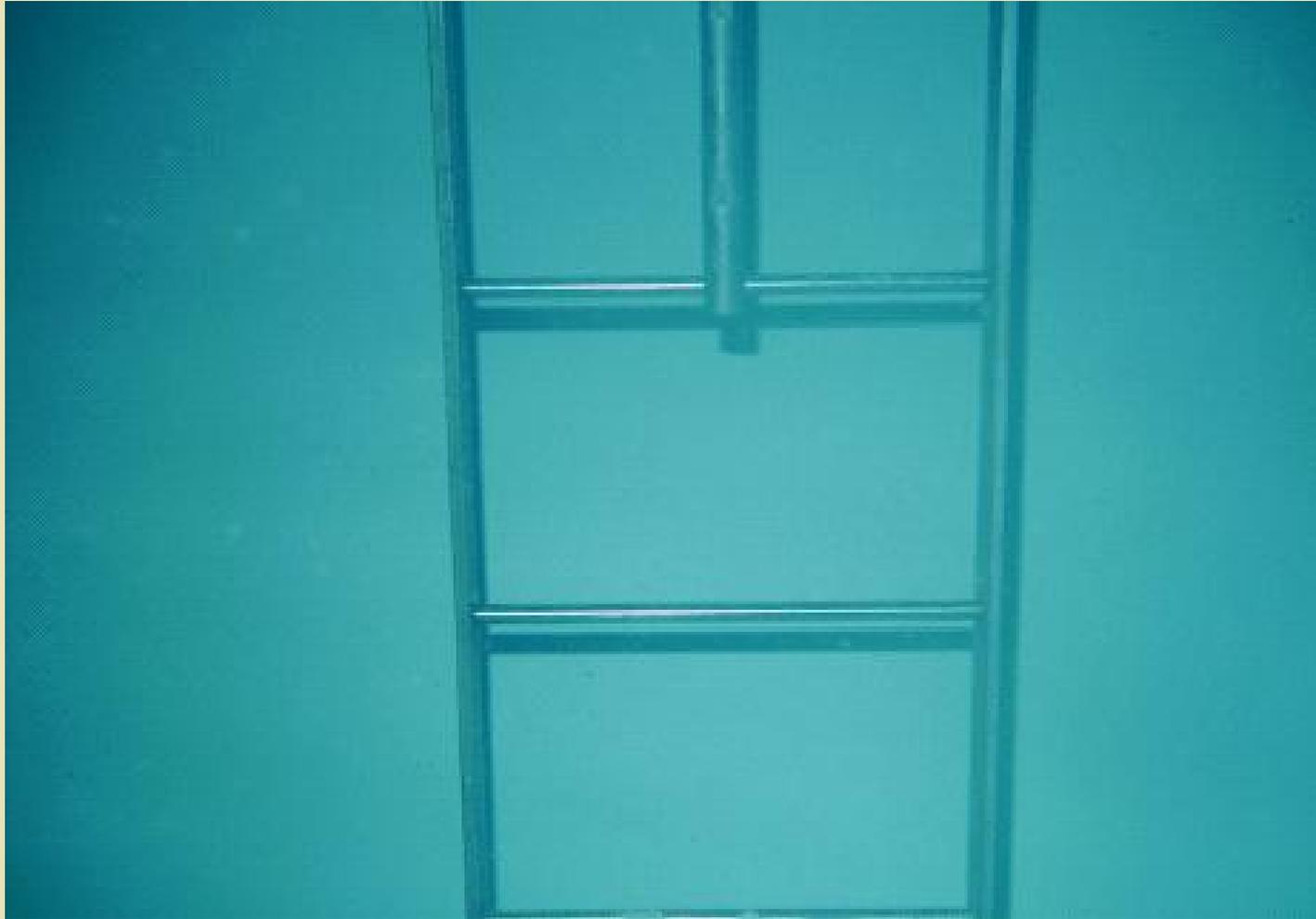
The tank shell will sacrifice itself to protect the ladder.

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Coated carbon steel tank with stainless steel ladder

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Coated carbon steel tank and ladder with stainless steel safety climb equipment.

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What Can We Do About It?

- ◆ Now that we are familiar with how and why corrosion occurs, what techniques are available to slow or stop the process?
 - Repair and Place Back in Service?
 - Material Selection
 - Environment Alteration
 - Coatings
 - Cathodic Protection

Repair & Place Back in Service

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Proper Repair Procedure?

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Proper Repair Procedure?

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Cathodic Protection

- ◆ Cathodic Protection uses the principals of current flow to force a material to consume in preference of another material.
 - In other words, we decide what will corrode.
- ◆ Cathodic Protection is generally provided in two forms:
 - Galvanic Anode
 - Impressed Current

Galvanic Anode Cathodic Protection

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- ◆ Galvanic anode cathodic protection relies upon the potential difference between to materials to provide protective current.
 - Galvanic Chart
- ◆ Common galvanic anode materials include:
 - Magnesium
 - Aluminum
 - Zinc

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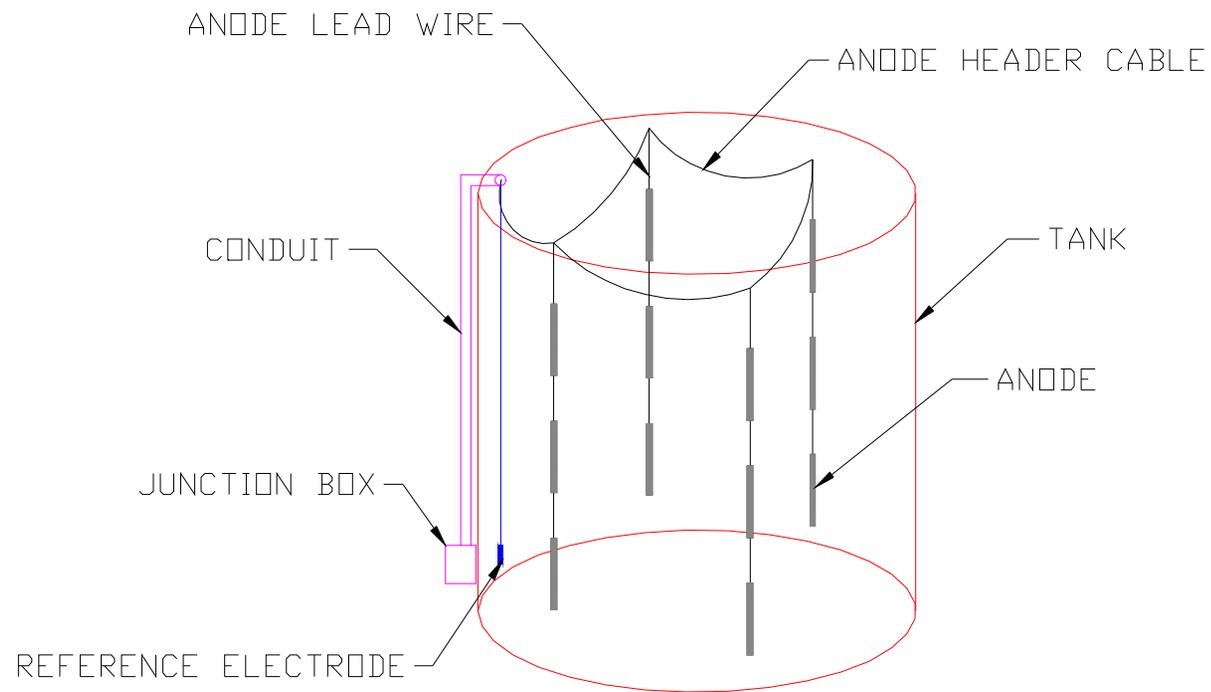
Typical Installation Sequence For a Magnesium Rod Galvanic Anode Cathodic Protection System to Provide Corrosion Control To the Interior of a Steel Water Reservoir

Water Reservoir Schematic

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Semiahmoo Reservoir – City of Blaine

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Equipment Setup

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Drilling Out Anode Handholes

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Stringing Anode Header Cable

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Anode Bundle

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Anode Installation

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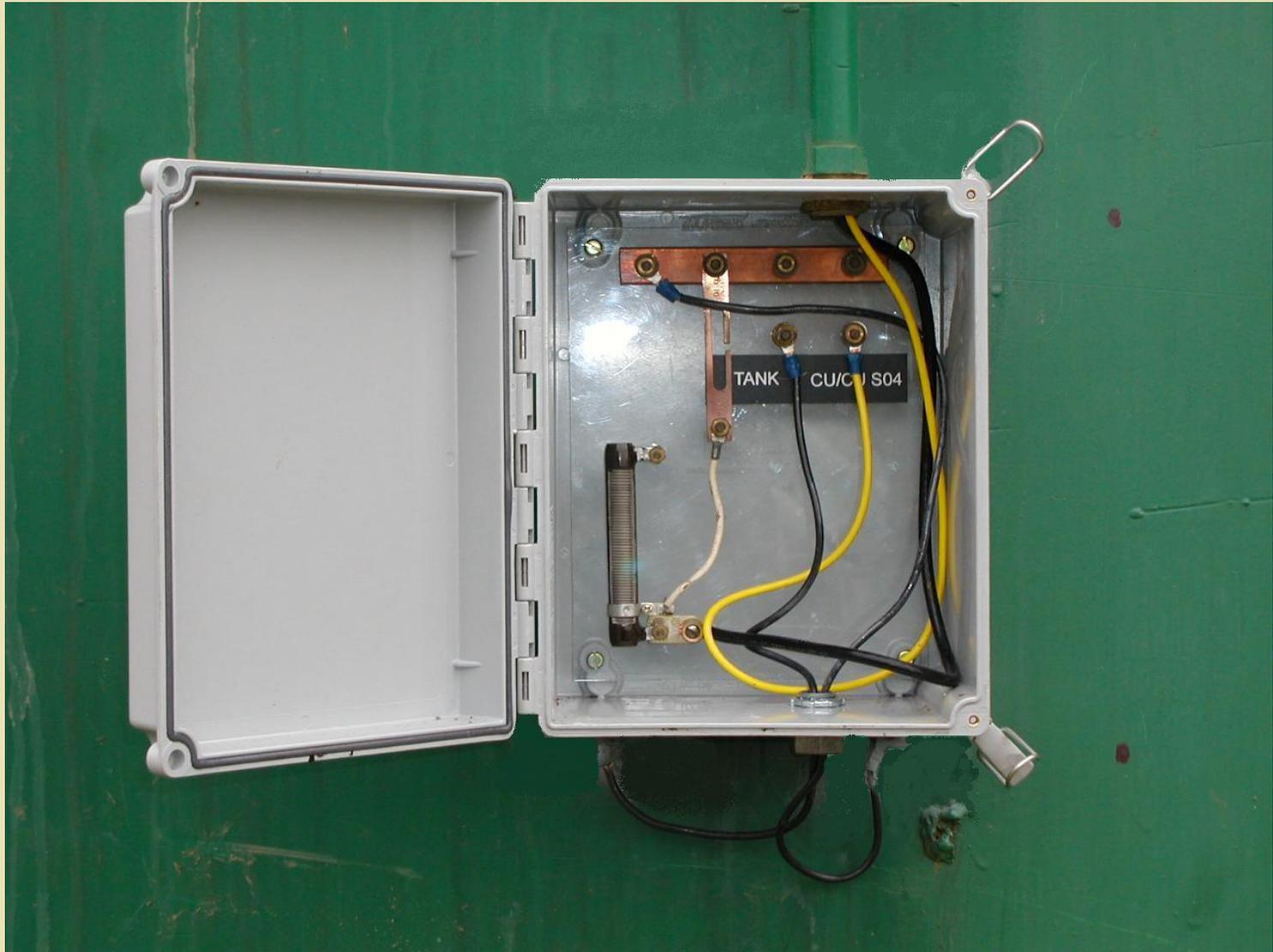
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Anode Junction Box

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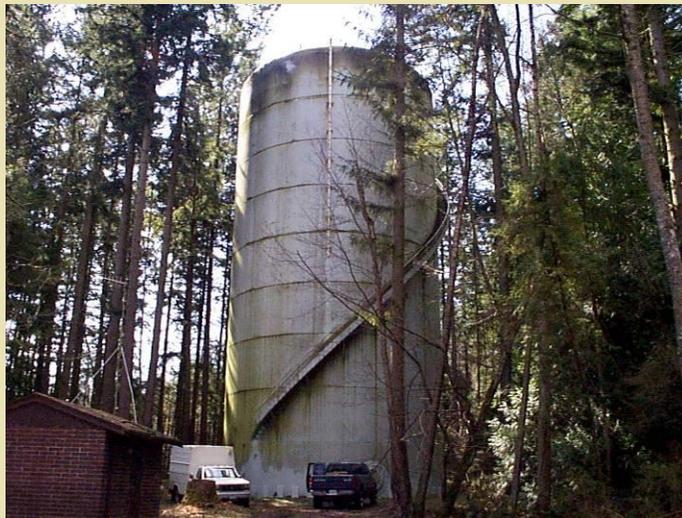
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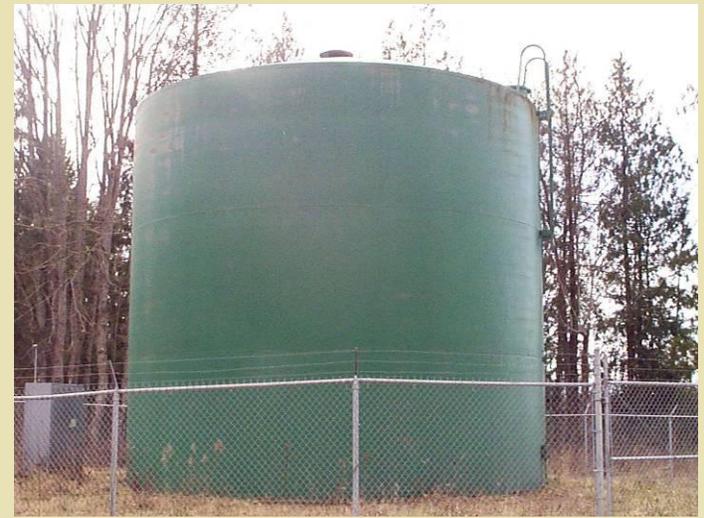
Harvey



Lincoln Park



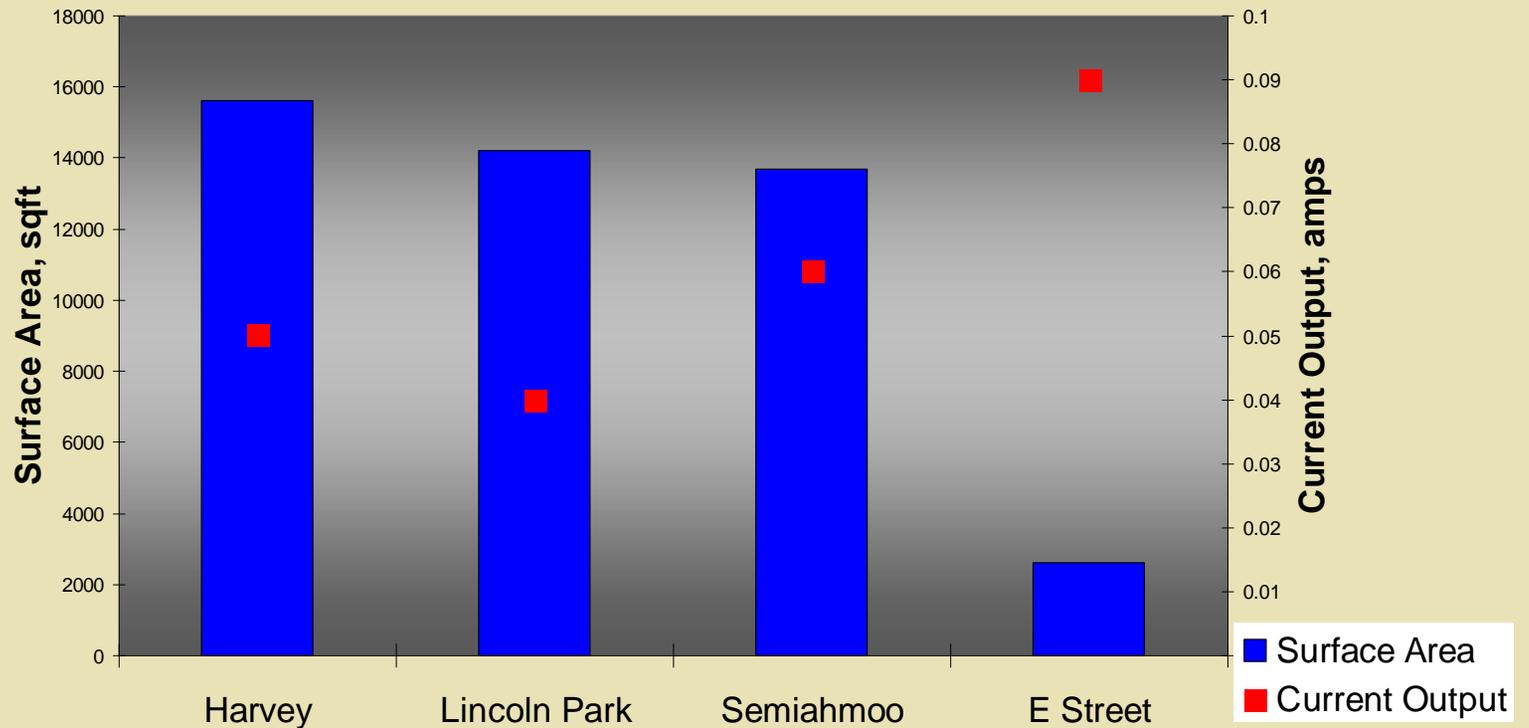
Semiahmoo



E Street

Effects of Internal Coating

Current Densities for Corrosion Control



← Coated → Uncoated

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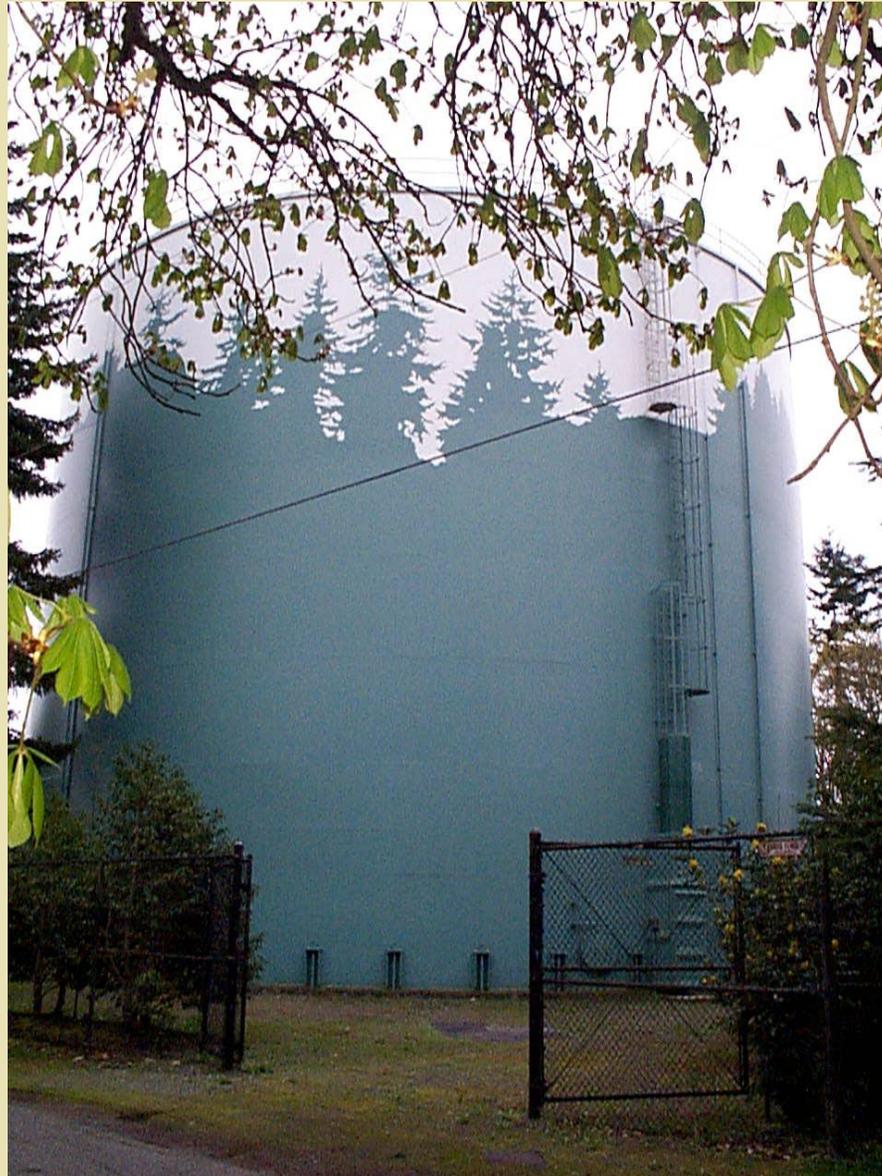
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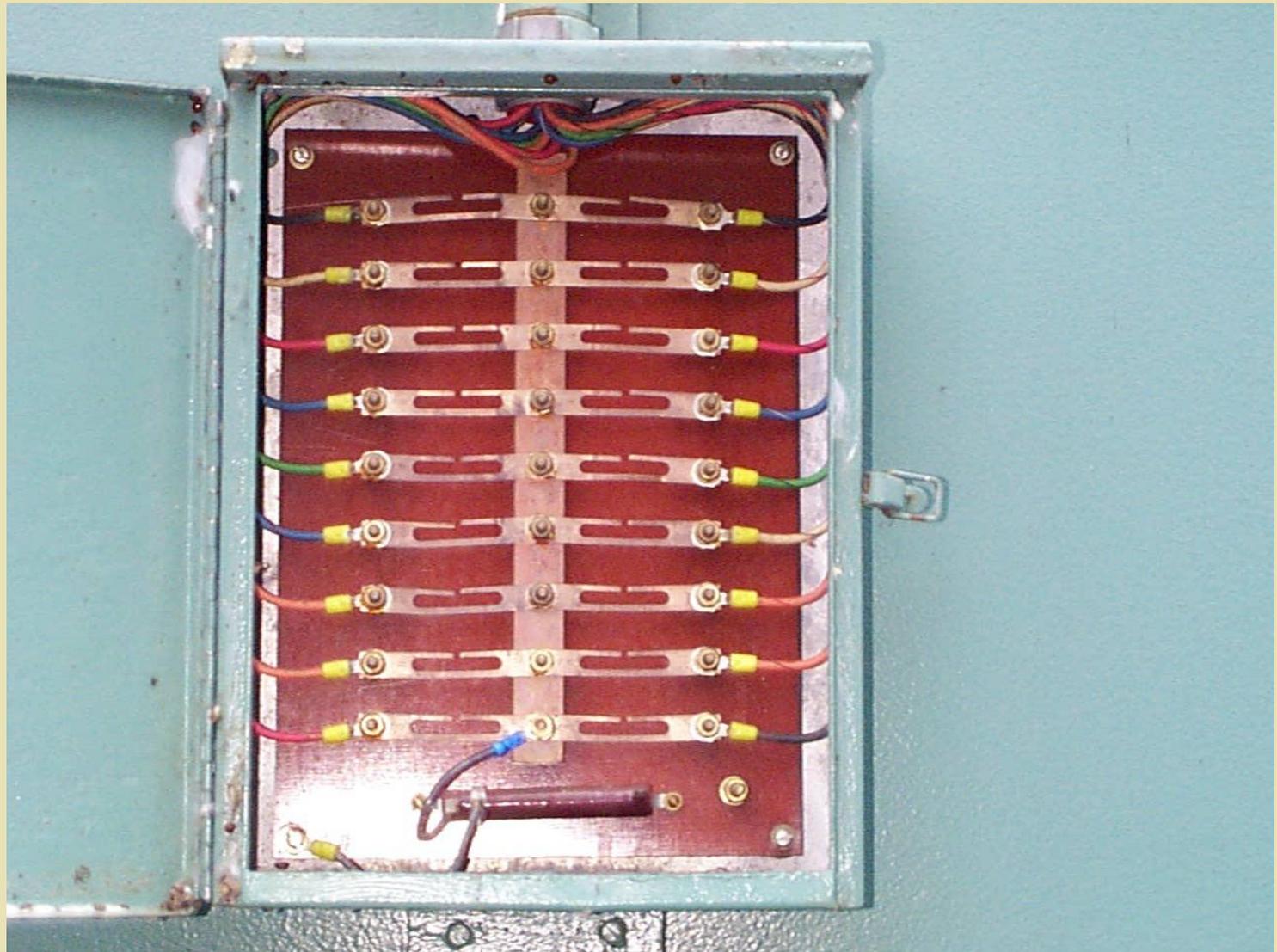


Galvanic Anode Junction Box

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Galvanic Anode Lead Wires

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Typical Installation Sequence For a Magnesium Ribbon Galvanic Anode Cathodic Protection System to Provide Corrosion Control To the Interior of a Steel Water Reservoir

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McNeil Island Reservoir

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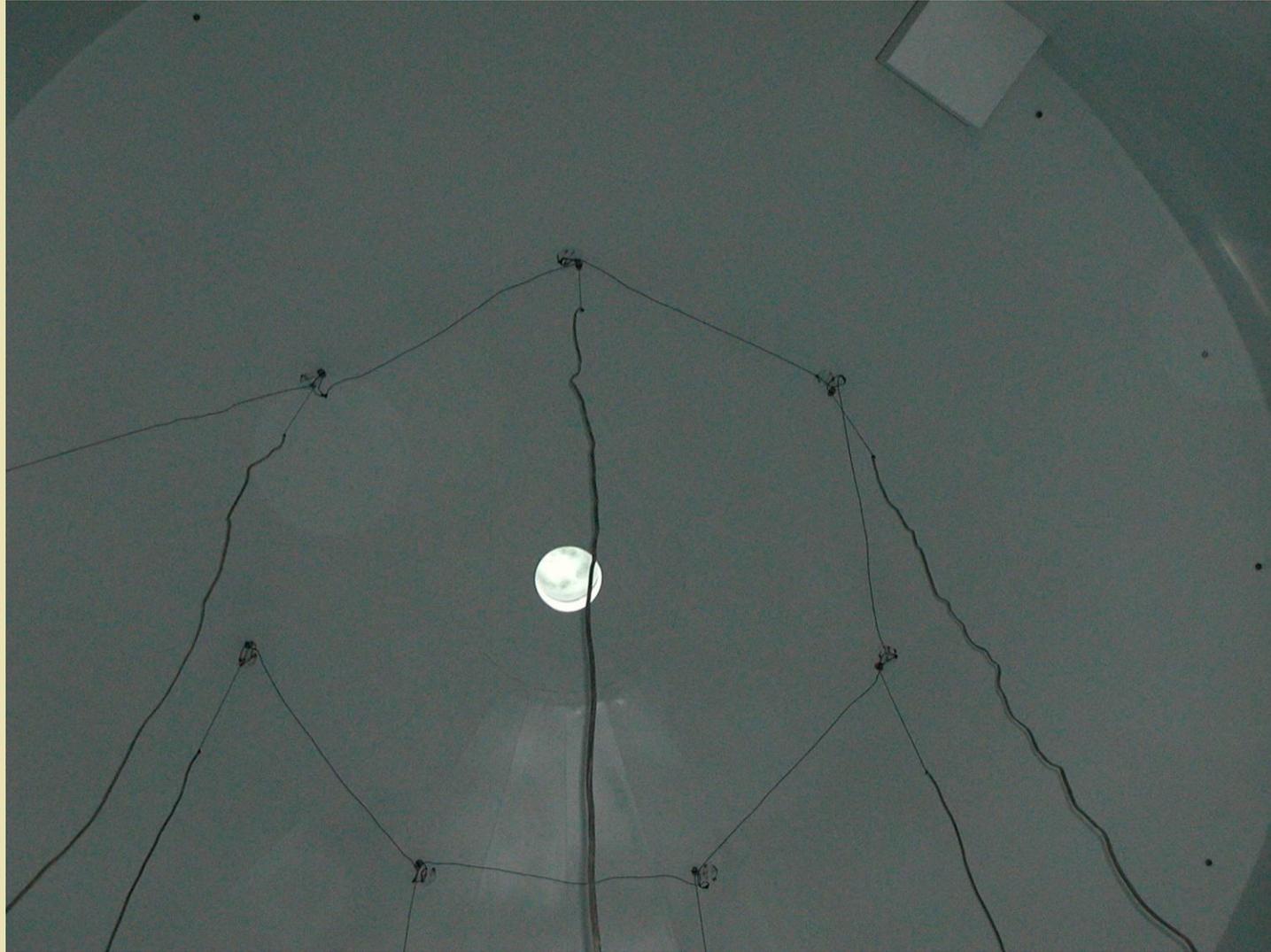
Magnesium Anode Ribbons

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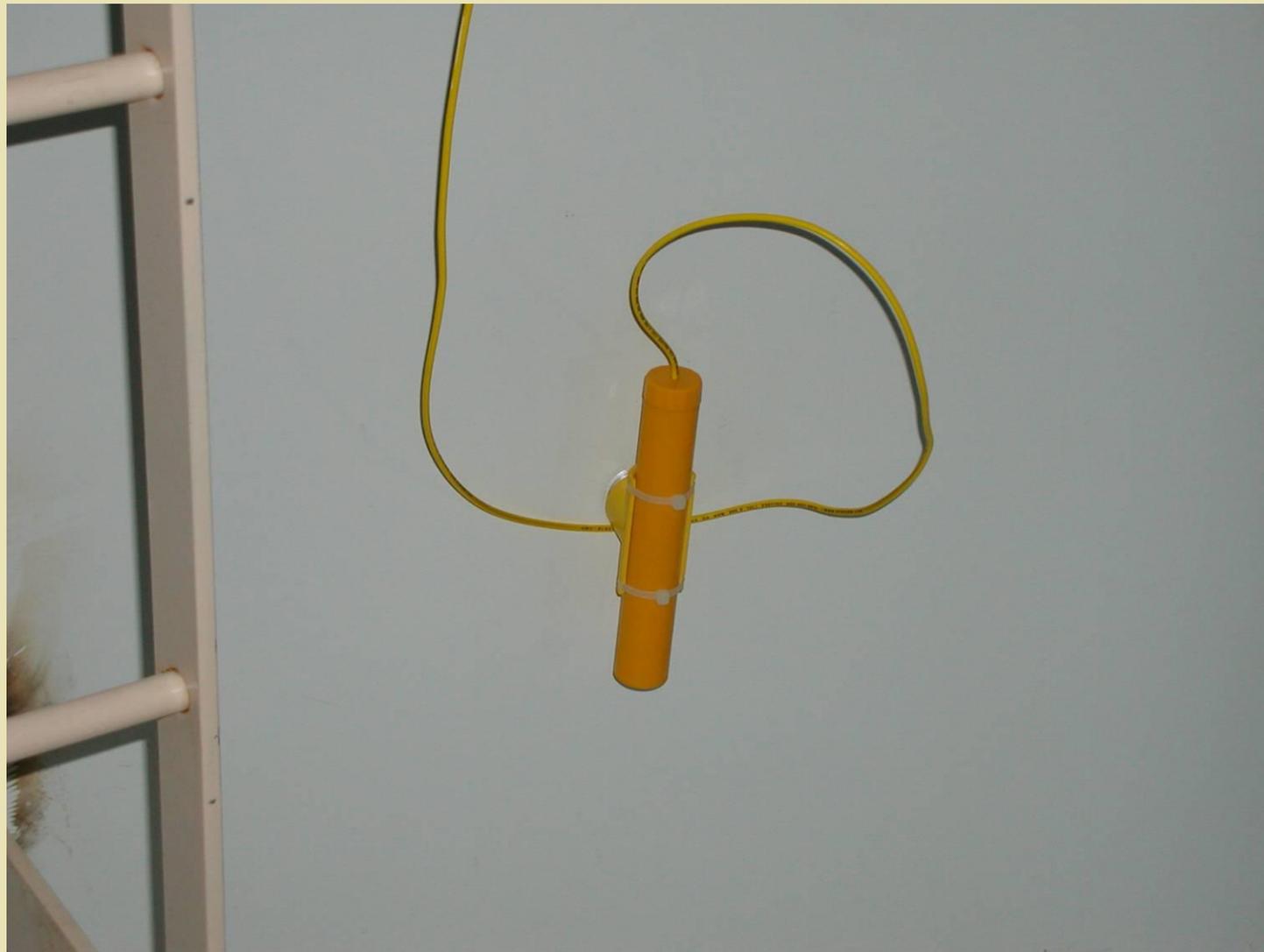
Anodes Suspended From Roof

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Reference Electrode

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Anode Handhole

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3/16" Pit on Tank Floor

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Internal Floor Pitting

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Pitting on Tank Bottom Shell

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Galvanic Anode Cathodic Protection

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- ◆ Advantages Include:
 - Easy to install
 - Generally trouble-free operation
 - Does not require an external power source
 - Require very little maintenance

Galvanic Anode Cathodic Protection

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◆ Disadvantages:

- Limited “throwing” capacity.
- May not provide adequate corrosion control for bare or poorly coated structures.
- Generally have a shorter design life than impressed current systems.

Impressed Current Cathodic Protection (ICCP)

- ◆ ICCP relies upon a transformer rectifier to supply the driving voltage to the anodes.
- ◆ ICCP anodes are generally inert materials with very low consumption rates (typically 1-2 pounds per amp-year as opposed to upwards of 17 pounds per amp-year for some galvanic anodes).

Impressed Current Cathodic Protection (ICCP)

- ◆ ICCP systems are used where a large amount of current is required, such as bare or poorly coated pipelines and water reservoirs.
- ◆ Advantages of ICCP:
 - Can be used to provide current a significant distance
Typical system design life is a minimum of 20 years.
 - Generally operate trouble-free.

Impressed Current Cathodic Protection (ICCP)

- ◆ Disadvantages of ICCP:
 - Requires an external AC power source to operate rectifier.
 - Generally a higher initial cost.

Be Aware of Dangers

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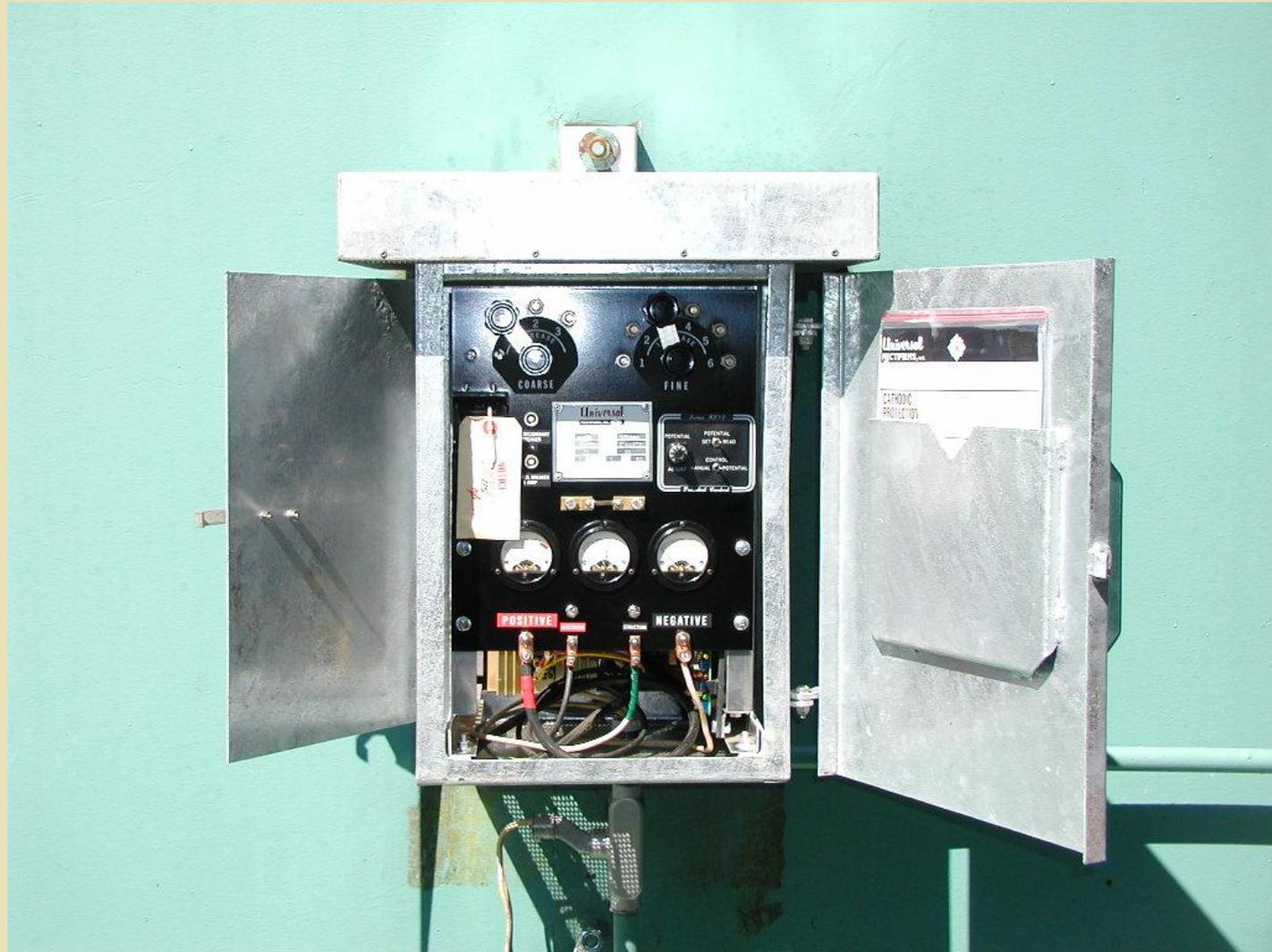
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Water Reservoir Rectifier

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Impressed Current Anodes

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ICCP Hoop System

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Roof Conduit System

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