Corrosion and Cathodic Protection

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Overview

- Oxidation and Reduction
- Passive and Active Metals
- Passivation
- Electrochemical Cell
- Cathodic Protection

Oxidation and Reduction

- Oxidation
  - Textbook Definition: An atom or molcule loses electrons
  - What it means to you: A metal turns to a metal oxide or salt.
  - Example: Iron turns to rust (e.g. Iron Oxide)
    - **Oxidation is the chemical reaction which leads to corrosions.**
- Reduction
  - Textbook Definition: An atom of molecule gains electrons.
  - What it means to you: The opposite of oxidation.

Passive and Active Metals

- Passive metals have a thin (microscopic) layer of metal oxide on their surface.
  - This suppresses their reactivity with other metals.
  - Most metals become passive upon exposure to air.
    - (Exceptions are precious metals like Platinum and Gold)
  - Active metals are metals where this passive layer has been removed.
    - Much more active.

Example: Aluminum is a very reactive metal which goes passive quickly. Place it in a sodium hydroxide solution, which removes the passive layer, and it causes an explosive reaction.

Passive Metals and Corrosion

- Passive Layer protects the metal to varying degress.
  - Can still dissolve or erode.
  - May be porous.

- Stainless Steel gets its name because of the passive film it develops.
  - Thin, uniform layer of “rust” protects against corrosion.

Passivation

- Passivation is the process of creating a uniform passive layer.

- Done with materials like Stainless Steel to provide a more resilient passive layer.

- Most commonly done with an acid dip (pickling) process.
  - Tends to make the stainless steel shinier, reducing emissivity.
  - Other ways to do this, but they aren’t practical for this scale.

Electrochemical Cells

- Electrochemical Cells - an over-glorified battery.
  - **Cathode -** Electrode where reduction occurs.
  - **Anode -** electrode where oxidation occurs.
    - This is the electrode which corrodes.

- Cathodic Protection - protecting a structure from corrosion by making it the cathode of an electrochemical cell.
  - Done by using sacrificial anodes which corrode more readily than vault materials.
  - Common Anodes include: Magnesium, Zinc, and Aluminum.

Cathodic Protection

Corrosion Reaction	Electrode	Standard Potential
Iron(II) + $2e^-$ → Iron	Cathode	0.44 V
Iron (III) Oxide + 2 H_2 → Iron + 1.5 H_2O	Cathode	0.59 V (calculated)
Aluminum → Aluminum (III) + 3 e^-	Anode	1.68 V
Magnesium → Magnesium (II) + 2 e^-	Anode	2.36 V
Zinc → Zinc (II) + 2 e^-	Anode	0.76 V

- Corrosion Reactions of the Anode must have greater protection than the Cathode.
- Cathodic Protection will reverse the oxidation on the cathode, which can make it active.
  - This is significant when sacrificial anodes wear out.
    - Passive layer no longere there to protect the tank.
  - During a dry season, both electrodes may go passive.
    - Cathodic protection only works if the anodes are active.

Questions?