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CORROSION PREVENTION AND CONTROL

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Corrosion Prevention and Control

Four primary techniques are used for limiting corrosion rates to practical levels:

1. Material Selection
2. Coatings
3. Cathodic Protection
4. Chemical Corrosion Inhibitors

1. Material selection

- Entails picking an engineering material – either metal alloy or non-metal – that is inherently resistant to the particular corrosive environment and also meets other criteria.
- Variables that will affect corrosion are established along with materials that may provide suitable resistance for those conditions.

1. Material selection

- Obviously other requirements such as cost and mechanical properties of the potential materials must be considered.
- Data needed to thoroughly define the corrosive environment include many of its chemical and physical characteristics plus application variables such as its velocity (or is it ever stagnant?) and possible extremes caused by upset conditions.
- Corrosion tables may be helpful tools for material selection in different environments. These tables are available in handbooks and internet.

Sulphuric acid

H₂SO₄

H ₂ SO ₄ conc % ▶	0.1%	0.5%	0.5%	0.5%	1%	1%	1%	1%	1%	2%	2%	2%	3%	3%	3%	3%	3%	5%
Temp °C	100=BP	20	50	100=BP	20	50	70	85	100=BP	20	50	60	20	35	50	85	100=BP	20
Carbon steel	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Moda 410S/4000	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Moda 430/4016	×	●	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Core 304L/4307	×	○	●	×	○	●	●	×	×	○	●	●	○	●	●	×	×	●
Supra 444/4521	×	○	×	×	○	×	×	×	×	○	×	×	○	×	×	×	×	×



The material is corrosion resistant. Corrosion rate less than 0.1 mm/year.



The material is not corrosion resistant, but useful in certain cases. Corrosion rate 0.1 - 1.0 mm/year.



Serious corrosion. The material is not usable. Corrosion rate over 1.0 mm/year.



Boiling point of the solution.



Risk (Severe risk) of pitting and crevice corrosion.



Risk (severe risk) of stress corrosion cracking.



Risk (severe risk) of crevice corrosion. Used when there is a risk of localised corrosion only if crevices are present. Under more severe conditions, when there is also a risk of pitting corrosion, the symbols p or P are used instead.



Risk of intergranular corrosion.

2. Coatings

- Are the most widely used method for controlling corrosion.
- The possibilities cover a wide range and include such things as paints of many types, electroplating, weld overlays and bonding a thin, corrosion-resistant metal or non-metal onto a stronger substrate metal that is susceptible to corrosion.
- The coating selection, surface preparation, application and proper quality control throughout the process to attain an optimal coating for the given application requires special experience.

2. Coatings

- In many cases the coating simply acts as a barrier between the corrosive environment and the substrate material. In some cases such as in galvanized steel the coating (zinc in this case) provides a barrier but it also acts as a sacrificial anodic material to protect the steel below by preferentially corroding instead of the steel. This effect is cathodic protection.

3. Cathodic protection

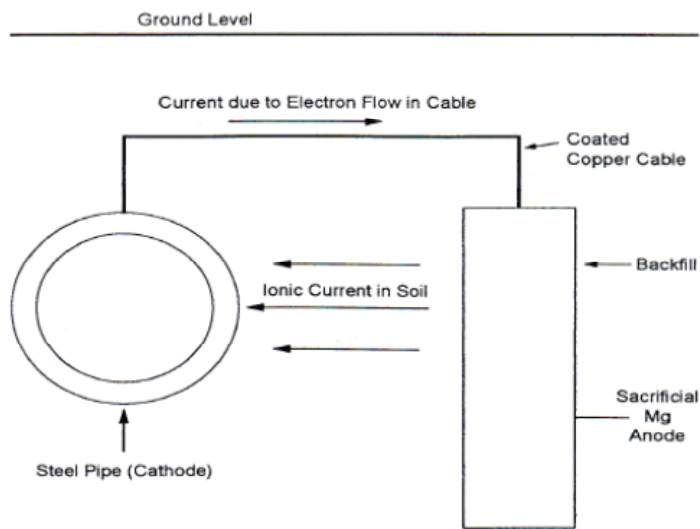
- Cathodic protection is a corrosion control technology with a long history. It functions due to a fundamental characteristic of corrosion, i.e., when the electrochemical process of corrosion occurs there is a flow of DC electric current from the surface being attacked.
- The second type of CP is *impressed current CP*. Here an electric power rectifier is used to lower the voltage of AC line voltage feed to it while changing the AC to DC current. The rectifier is connected to non-consumable anodes that supply DC current to the metal surface to be protected.

3. Cathodic protection

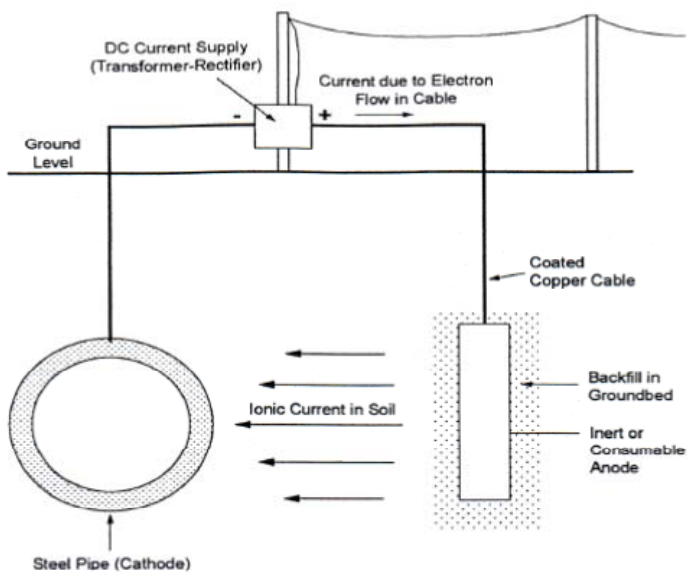
- Cathodic protection (often known as CP) provides a flow of DC current onto the protected surface to counteract corrosion current flow. The resulting rate of corrosion is greatly reduced to allow practical, long-term use of the protected metal, e.g., for 10 to 20 years or more, although corrosion is not stopped. The amount of current necessary to be supplied to the surface to control the rate to practical levels depends on the area exposed. Thus CP is most often used in conjunction with some type of coating. This greatly lowers the current needed for protection. No coating is 100% free of small areas where the substrate is exposed. Using CP with a coating means current is only needed at these bare spots.

3. Cathodic protection

- There are two types of CP. One is the *sacrificial anode* (also called galvanic) type in which a metal more susceptible to corrosion in the given electrolyte is electrically connected to a less susceptible metal to be protected. The former metal becomes the anode and is consumed over time while the latter metal becomes the cathode in a galvanic corrosion cell. Thus the zinc on galvanized steel is the anode while the steel substrate – as the cathode – is protected.
- Each type of CP has its separate advantages and disadvantages.



Principle of cathodic protection with sacrificial anodes



Principle of cathodic protection with impressed current

4. Chemical Corrosion Inhibitors

- Corrosion is an electrochemical process that consists of an oxidation reaction on the anodic site (or sites) of the metal plus one or more reduction reactions on the cathodic site (or sites). These two types of reactions must always occur at the same rate. An effective inhibitor functions by chemically changing one or both of the two reactions so as to slow their rates. Thus the rate of the overall corrosion reaction is reduced to practical levels when a proper inhibitor is applied.

4. Chemical Corrosion Inhibitors

- Using too much or too little can each have negative consequences.
- Inhibitors are most often used in circulating cooling water systems or to treat steam boiler feed water before usage in a boiler. Also can be used in acidic systems, such as, pickling and oil well acidifications.
- Corrosion inhibitors are solid, liquid or gaseous compounds that are added in small quantities to the given corrosive environment to change its interaction with the metal to be protected.

Types of Corrosion Inhibitors:

Inhibitors can be classified, as described above, as:

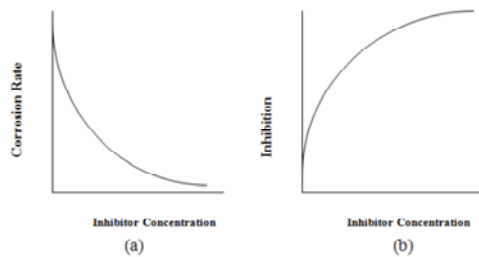
- a. **Adsorption Inhibitors**, which are generally organic compounds, their action is due to blanketing effect over the entire surface of metal, i.e. both anodic and cathodic areas, separating the metal surface from the action of aggressive ions in solution, sometimes cause a considerable reduction in corrosion rate.

Types of Corrosion Inhibitors:

- b. **Filming Forming Inhibitors**, their action are appear to act by causing a barrier, or blocking film to be formed of material other than the actual inhibiting species itself, and as mentioned above, it may sub classified as (a) *Anodic film inhibitors*, their function in neutral or alkaline solution and act by producing a passivating oxide film primarily at those parts of the surface where metal cations are formed, i.e. at the anodic sites. And (b) *Cathodic film inhibitors*, they act by inhibiting the cathodic regions without greatly affecting the anodic sites. They are operating by filming the cathodic areas.

Types of Corrosion Inhibitors:

c. **Vapor Phase Inhibitors**, these are substance of low but significant vapor pressure, the vapor of which has corrosion inhibiting properties. They are used to protect critical machine parts, such as ball bearings or other manufactured steel articles, temporarily against rusting by moisture during shipping or storage. On contact with the metal surface the inhibitor vapor condenses and forms the protective layer.



A- Typical Curves showing drop in corrosion rate as a function of inhibitor concentration.

B- Typical curves showing increased efficiency as a function of inhibitor concentration.