

CORROSION MONITORING AND PROTECTION FROM CORROSION OR CORROSION PREVENTION METHODS

[I] Design and Material Selection

The design of the material should be such that corrosion even if it occurs, is uniform and does not result in intense and localized corrosion. Important design principles are :

- (1) The contact of different metals in the presence of a corroding solution should be avoided. In the absence of this principle, corrosion is localized on the more active metal, while the less active metal remains protected.
- (2) If an active metal is used, it should be insulated from more cathodic metals.
- (3) If two metals are to be in contact, they should be so selected that their oxidation potentials are as near as possible.
- (4) When two dissimilar metals are to be in contact, the anodic material should have as large area as possible and the cathodic material should have as small area as possible.
- (5) When contact of dissimilar metals is unavoidable, suitable insulator should be inserted between them to reduce current flow and attack on the anode.
- (6) If two metals have to be in contact, a protective coating over both the metals will reduce the chance of pitting. Special care should be taken to coat the anode completely because any scratch or crack on the anode coating can lead to intense attack at the exposed areas.

- (7) When a structure consists of two dissimilar metals, it is beneficial to use a more active third metal in contact so that the structure is saved from corrosion at the expense of the third metal.
- (8) When the design allows for adequate clearing and flushing of the critical parts (*i.e.*, susceptible to dirt, deposition etc.) of the equipment. Sharp corners and recesses should be avoided, because they favour the formation of stagnant areas and accumulation of solids.
- (9) As far as possible, the equipment should be supported on legs to allow free circulation of air and prevent the formation of stagnant pools or dam areas.
- (10) Uniform flow of a corrosion liquid is desirable, since both stagnant areas and highly turbulent flow and high velocities can cause accelerated corrosion. So, highly impingement conditions of flowing liquid should be avoided as much as practically possible.
- (11) A proper design should prevent condition subjecting some areas of structure to stress (cold worked part). Such an area could set up a galvanic couple with non-stressed (not worked) areas of the metal.
- (12) Noble metals are more immune to corrosion but they cannot be used for general purposes for economical reasons. The next choice is to use the purest possible metal. Even minute iron in magnesium or lead in zinc die casting alloys may be highly detrimental.
- (13) Both corrosion resistance and strength of many metals can be improved by alloying. Several corrosion-resistance alloys have been developed for specific purposes and environments. For example, stainless steel containing chromium produce an exceptionally coherent oxide film which protects the steel from further attack.

[II] Cathodic and Anodic Protection

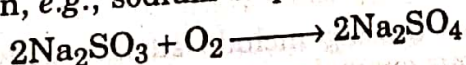
In situation where it is impossible or impractical to change the nature of the corrosion medium, corrosion control may be achieved by cathodic protection or by anodic protection. When electrical current flows between the anodic or cathodic areas on a corroding metal surface, the higher the current, the greater and faster will be the corrosion at the anode. The rate of corrosion can be controlled by imposing additional current on the metal using an external circuit. If an opposing current is applied to nullify corrosion, it is called cathodic protection. If the potential of the metal is so adjusted that the corrosion is appreciably suppressed because the metal is rendered passive, then it is called **anodic protection**. The principle involved in cathodic protection is to force the metal to behave like a cathode. Since there will not be any anodic area on the metal, corrosion will not occur. While in anodic protection, metal is passivated by applying current in a direction that renders it more anodic. The technique is only applicable to such metals and alloys which exhibit active-passive behaviour.

[III] Modifying the Environment

The corrosive nature of the environment can be reduced either by, (i) the removal of harmful constituents or (ii) the addition of specific substances, which neutralize the effect of corrosive constituents of the environment.

(1) **Deaeration** : In oxygen concentration type of corrosion, exclusion of oxygen from aqueous environment reduces metal corrosion. Expulsion of dissolved oxygen is done by adjustment of temperature, together with mechanical agitation. The method also reduces the CO₂ content of water, thereby decreasing the corrosion rate of steel pipelines carrying steam condensates from boilers.

(2) **Deactivation** : It involves the addition of chemicals, capable of combining rapidly with the oxygen in aqueous solution, *e.g.*, sodium sulphite.



(3) **Dehumidification** : It reduces the moisture content of air to such an extent that the amount of water condensed on metal is too small to cause corrosion. Alumina or silica gel which absorbs moisture preferentially on their surfaces, are used only in closed areas like air-conditioning shop.

(4) **Alkaline neutralization** : It consists of preventing the corrosion by neutralizing the acidic character of corrosive environment (due to the presence of HCl, H₂S, SO₂, CO₂ etc.). Such alkaline neutralizers (like NH₃, NaOH, lime, etc.) are generally injected either in vapour or liquid form to the corroding system or to its parts. This method has been widely used in controlling the corrosion of refinery equipments.

[IV] Metallic Coatings

Metallic coatings are mostly applied on iron and steel because they are the cheap and most commonly used construction materials and are also the most susceptible ones for corrosion. The metallic coatings often used are of Zn, Sn, Ni, Cu, Cr, Al and Pb. Generally, the following methods are used for metallic coatings.

(1) **Electroplating** : Noble metals such as Au, Ag, W, Pb etc and base metal, it protects the base metal by virtue of its noble character. Tin plating and nickel plating are generally used. The electroplating of zinc is called *galvanising*. In electroplating, the object to be plated is made the cathode of the cell. The electrolyte is a salt of the metal to be deposited. The anode may be of the metal to be deposited or it may be an inert electrode such as graphite. When the anode is that of the metal to be deposited, the anode dissolves to replenish the metal in the solution. Using this method metals like Au, Ag, Cr, Ni, Cu, Zn, Sn etc. may be electroplated.

(2) **Hot dipping** : Hot dipping is used for coating metals with films of metals having low melting point such as Zn, Sn, Pb etc. In this process, the metal to be coated is dipped in the molten bath of the coating metal for sufficient time and then removed out along with the adhering film. The process of providing a zinc coating is called *galvanising* and the one providing a tin coating is called *tinning*.

(3) **Vapourising** : Some metals can also be deposited as surface layers by allowing their vapours to strike metallic surfaces with which they undergo alloying. Zn and Al can be plated by vapourisation. The deposition of zinc by vapourisation is known as *sherardising* or *dry galvanising* and deposition of Al is called *calorising*.

(4) **Metal spraying** : In this method, the molten metal is sprayed on the cleaned base metal with the help of a spraying gun or pistol which can be held in hand to direct the molten metal stream as required. This process is only used when hot dipping is not possible. Metal spraying is utilized for huge structures such as bridges.

(5) **Cementation** : In this method, the base metal articles are packed in the powdered coating metal, or a mixture of the powdered metal and a filler and are heated to a temperature just below the melting point of the more fusible metal. Generally, an inert or reducing atmosphere is usually maintained during the process. This method is used for producing alloy layer on iron and steel surfaces with Zn, Al, Cr, Si etc. Steel may be case-hardened by cementation with carbonaceous materials in the pack carburizing process.

(6) **Metal cladding** : Many processes for cladding a base metal with another metal or alloy have been developed recently to impart corrosion and wear resistance. In one of the methods, a duplex ingot is cast with the coating material on the outside and subsequently the ingot is rolled into a plate, sheet or bar or drawn into a wire form. Steel sheets clad with stainless steels, copper covered steel articles and tin-cladded lead foils are prepared by this method. Other methods of cladding include :

- (a) Rolling the clean sheets or plates of the two materials together.
- (b) Applying the coating sheet by spot welding or resistance welding.
- (c) Fusing the cladding material over the surface of the base metal.

[V] Inorganic Non-Metallic Coatings

The inorganic non-metallic protective coating include surface conversion or chemical dip coating, anodized oxide coating and vitreous enamel coating.

(1) **Chemical dip coating or surface conversion** : These coatings are produced by covering the surface of a metal or alloy by chemical or electrochemical methods. The metal is immersed in a solution of a suitable chemical which reacts with the metal surface producing an adherent coating. These coating afford good protection of the base metal from corrosion in some environments and sometimes are of decorative value. The most commonly used surface conversion coatings are chromate coatings, phosphate coatings and oxide coatings.

(2) **Anodized oxide coatings** : Protective oxide films are produced on Al and its alloys in air spontaneously. A more protective, thicker and stronger oxide film can be produced by making Al as the anode in an electrolytic bath containing chromic acid or oxalic acid or sulphuric acid. After anodizing, the oxide coating is sealed by immersing in boiling water. This treatment decreases the porosity and increases corrosion resistance of the film.

(3) **Vitreous enamel coatings** : Vitreous or porcelain enamels are modified glass-like materials having different compositions which are usually applied on steel and cast iron equipment. The metal part to be enamelled is first cleaned carefully to remove grease and oxide scale. The vitreous material for the enamel, called *frit* is prepared by fusing together refractory acidic substances, e.g., quartz and felspar, with basic fluxes e.g., borax, cryolite, fluorspar, soda ash, litharge, sodium nitrate and this frit is applied to the metal.

These coatings are widely applied for ferrous materials used for equipments in the pharmaceutical, chemical, dairy food and beverage industries.

[VI] Organic Coatings

Protection of a metal surface from corrosion by using organic protective coatings is an established practice. Important organic protective coatings include paints, varnishes, enamels and lacquers. When applied on cleaned metal surfaces, they act as effective inert barriers which not only protect the metal from corrosion but also afford decorative and aesthetic appeal.

EXERCISES