

Lecture 16

Cathodic Protection – Principles and Classification

Keywords: Cathodic Protection, Equipotential Surface, Impressed Current, Sacrificial Anode.

Sri Humphrey Davy 's pioneering work (1824) on protecting the copper sheathing on wooden hulls in the British Navy by sacrificial zinc and iron anodes is considered to be the earliest example of application of cathodic protection.

Copper-sheathed ship hulls protected by sacrificial blocks of iron.

Zinc alloy as sacrificial anode. Galvanising – Typical example of sacrificial anode to protect steels.

Various definitions

Reducing or eliminating altogether corrosion by making the metal a cathode by application of either an impressed DC current or attaching the metal to a sacrificial anode.

Corrosion occurs at anodic areas – if all anodic areas can be converted to cathodic areas, the entire structure will become cathode and corrosion is stopped.

Corrosion occurs at the regions where current discharges from metal to environment (soil, water) (anodic areas). There is no corrosion at regions where current enters from the environment to metal (cathodic areas).

Objective should then be to force the entire structure to collect current from the environment (making it cathodic entirely).

Current flow depends on factors such as:

- Resistivity of environment and
- Degree of polarization of anode and cathodic areas.

Cathodic protection is achieved by supplying electrons to the structure being protected.

Driving force for corrosion is the potential difference. Equipotential surface - No driving force (no current flows). In Fig. 16.1, the above principles underlying cathodic protection are illustrated diagrammatically.

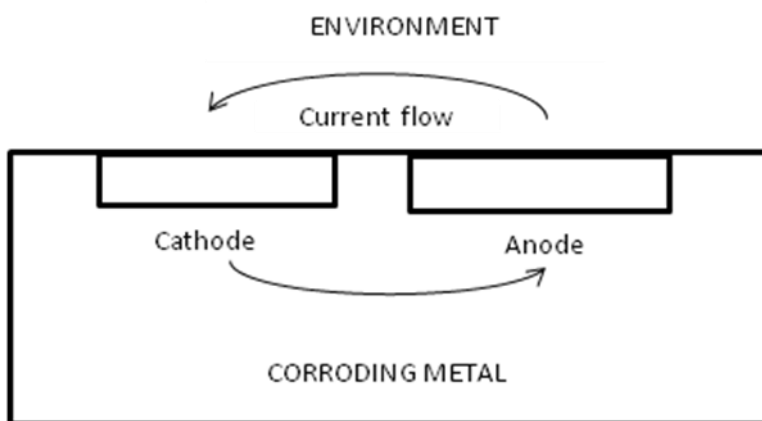
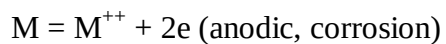


Fig 16.1 Basic concept of cathodic protection.

Reactions



Principles governing cathodic protection are illustrated in Fig. 16.2 below. As per mixed potential theory, the zero current criterion is shown. An equilibrium is established on metal (M) in which anodic oxidation rate is equal to cathodic reduction rate [E_{corr} and $i_{\text{corr}}(A)$]. By cathodic polarization of the metal with an applied DC current (i_{app}), initial corrosion potential is seen shifted to a lower value [$i_{\text{corr}}(B)$]. Complete stoppage of corrosion, requires polarization of the metal to the reversible potential of the metal (E_M^0).

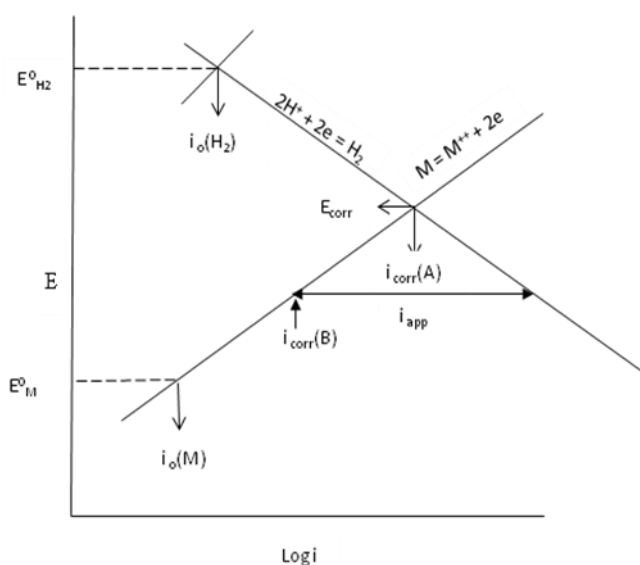


Fig 16.2 Electrochemical principles governing cathodic protection

Principles of cathodic protection of a metal (steel, for example) in neutral aerated water or sea water are shown in Fig. 16.3. Diffusion controlled cathodic oxygen reduction is the cathodic reaction marked by a limiting current. Applied current and corrosion rate are limited by the limiting (diffusion) current density. Current requirements can be further reduced by surface coatings.

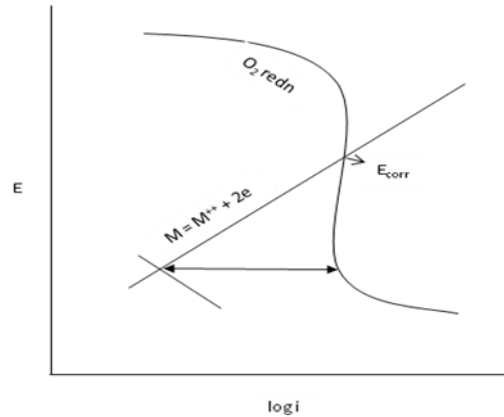


Fig 16.3 Electrochemical aspects of cathodic protection in neutral sea water.

Two methods of cathodic protection

- a) Use of sacrificial anodes.
- b) Impressed current method.

Fig. 16.4 and Fig. 16.5 illustrate the two types of cathodic protection, namely, sacrificial anode and impressed current methods.

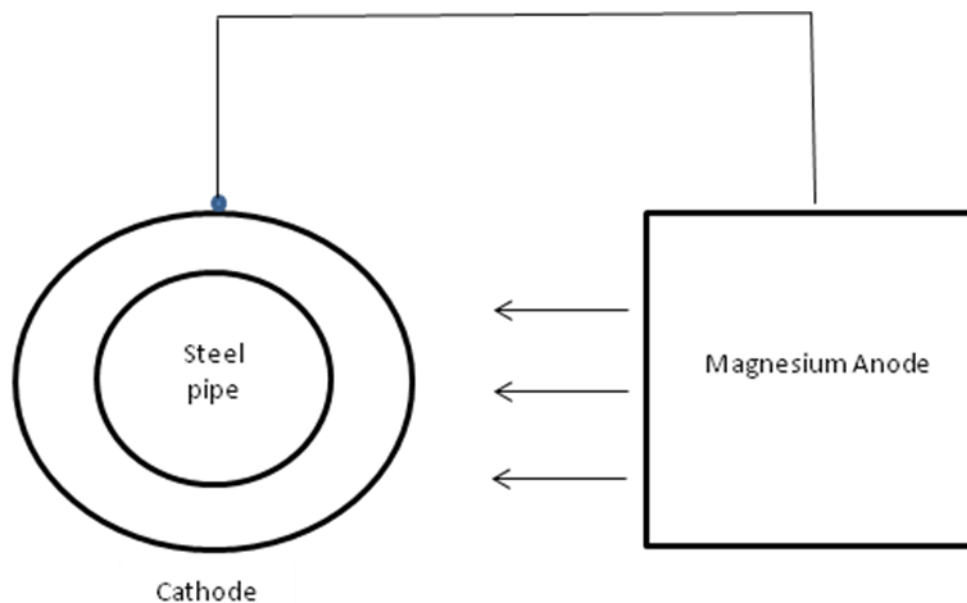


Fig 16.4 Sacrificial anode method

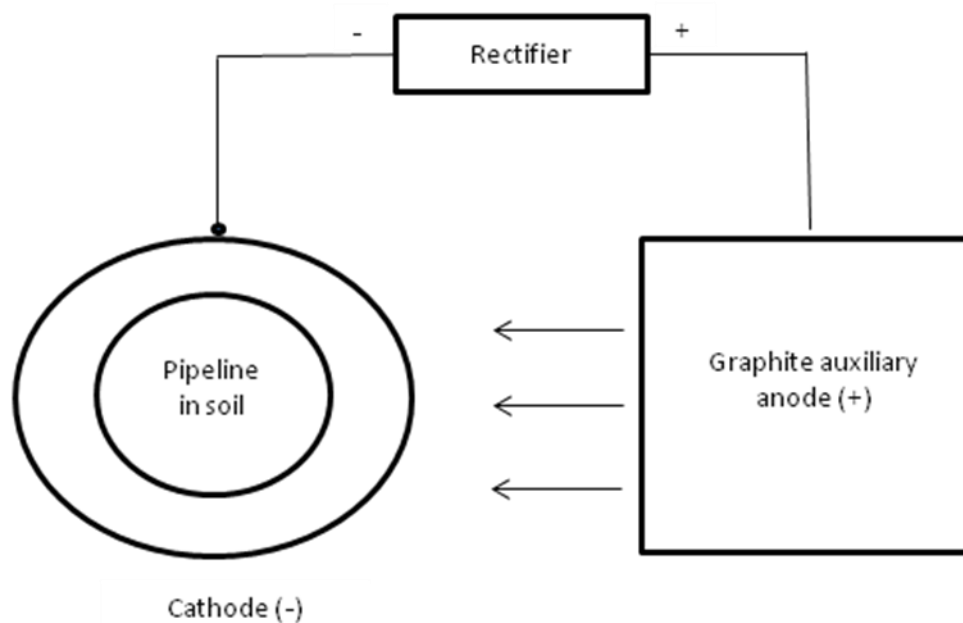


Fig 16.5 Impressed current method

Factors to be considered in the design and execution of cathodic protection installations.

Impressed current system

- a) How much current necessary for complete protection?
- b) Source of DC Current.
- c) Installation, Design, erection and maintenance.
- d) Auxiliary anodes – choice, size, number, installation.
- e) How to assess elimination of corrosion through entire structure?

There are a few limitations based on current flow reaching all through protected conducting structure. For example, in a pile-up of pipes, current may not efficiently reach pipe surfaces placed in between. Internal pipe surface may not receive protection. Similarly, portions of pipe lines above ground, valves etc, cannot receive complete protection.

The above conditions are generally referred to as '**electrical shielding**'.

Current necessary for protection need be just sufficient; neither less nor excess.

Excess current may do harm!

Lower current do not protect!

Requirements of galvanic sacrificial anodes

- a. Potential between the anode and the corroding metal structure should be large enough to overcome the anode-cathode cells.
- b. Sacrificial anode to have sufficient Electrical Energy Content (EEC) which predicts its life.
- c. Good current efficiency relevant to anodic corrosion.

EEC can be estimated and expressed as ampere hours/weight (kg or lb)

Eg: Pure Zinc that possesses high EEC of 372 ampere hour / pound.

This means if the zinc sacrificial anode has to discharge continuously one ampere, on pound of its weight would be consumed in 372 hours. Lower current discharge will prolong its life further.