
CATHODIC PROTECTION

BASIC PRINCIPLES

The presence of anodes and cathodes in a structure can be caused by micro or macro influences.

On the micro scale, they may be due to:-

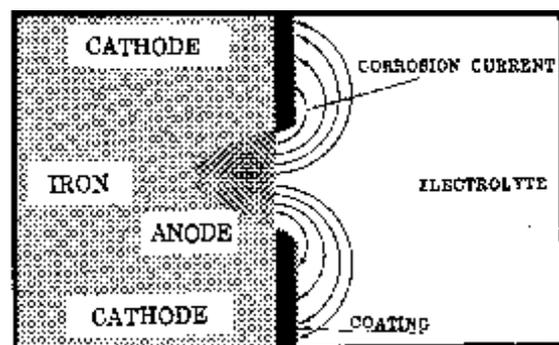
- ❑ *Heterogeneities in alloy structure*
- ❑ *Oxide layer*
- ❑ *Difference in stress level*
- ❑ *Micro segregation, etc*

On the macro scale, anodes and cathodes may be caused by:-

- ❑ *Variation in oxygen availability*
- ❑ *Water composition*
- ❑ *Soil resistivity*
- ❑ *Bimetallic couples*
- ❑ *Presence or otherwise of protective coating, etc*

Corrosion results from an electrochemical reaction. It requires an anode, a cathode, a common electrolyte and an electrical connection between the two zones. The corrosion process results in the flow of a small electric current from the anode to the cathode through the electrolyte. The magnitude of the current, which is due to a number of factors, is directly proportional to the metal lost due to corrosion. One ampere flowing for one year would result in the loss of 9kg of steel from a corroding surface.

Freely flowing corrosion current
from Anode to Cathode



In recent years, cathodic protection has found a general acceptance amongst engineers and structure owners as being a truly effective method of preventing corrosion under the ground or under the sea. It is now more common than not to find cathodic protection used on marine structures and on buried pipelines.

The concept of cathodic protection is straightforward. Corrosion occurs as the result of electrochemical reactions between zones of differing potential on a metal surface. Oxidation (corrosion) occurs at the

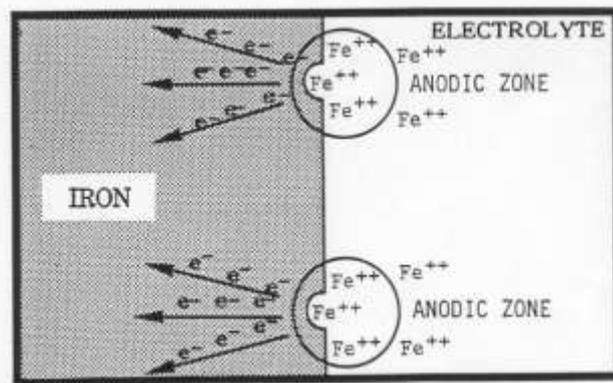
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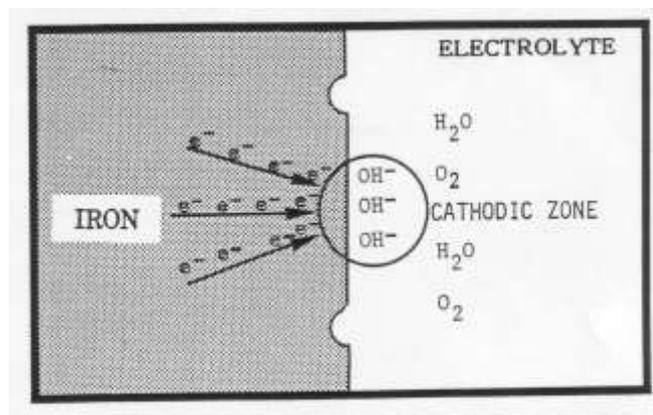
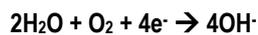
anodic zone and reduction (no corrosion) occurs on the cathodic zone. Cathodic protection is achieved when an entire metal surface is converted to a cathodic zone.

The corrosion reactions at each surface may be described as:-

At the Anodic Zone



At the Cathodic Zone



Cathodic protection is achieved by supplying a current from an external source so that it reverses the natural corrosion currents and ensures that current is flowing through the electrolyte onto all of the metal surface requiring protection. This current flow causes a change in potential.

Freely corroding mild steel in seawater has a resultant potential between anode and cathode of approximately -0.50 to -0.60 volts compared to a silver/silver chloride reference electrode. When cathodic protection is applied, it will be noted that the surface potential of steel will change to more negative than -0.80 volts when measured relative to a silver/silver chloride reference cell. Thus by using this simple practical measurement, it is possible to determine whether corrosion has been completely eliminated or not.

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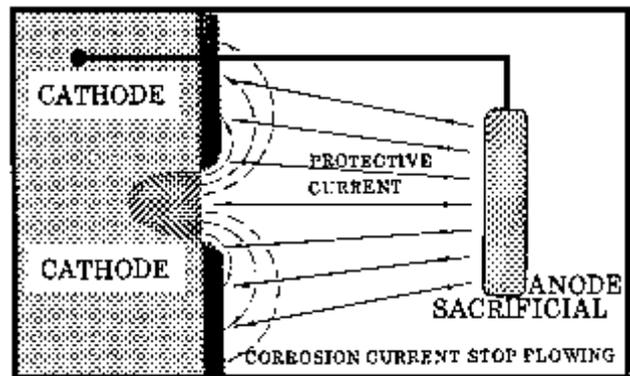
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The external current applied in cathodic protection may be generated from either of two methods, sacrificial anodes or impressed current systems.

Sacrificial Anodes

Sacrificial or galvanic anodes rely on the galvanic corrosion of a more reactive metal to produce current, eg Aluminium anodes, Zinc anodes, or Magnesium anodes.

Flow of corrosion current suppressed by protective current discharged from sacrificial anodes



Sacrificial anodes are most commonly used to protect metallic structures in electrolytes because of their simplicity of installation and maintenance free operation. Of the alloys available for sacrificial anodes, alloys of aluminium have proven to be the most economical in seawater or very low resistivity muds.

Knowing the total submerged and buried steel areas, the water resistivity and the required system life, a Corrosion Engineer can determine precisely what energy will be required to protect a structure and can design a galvanic system to suit the environmental requirements.

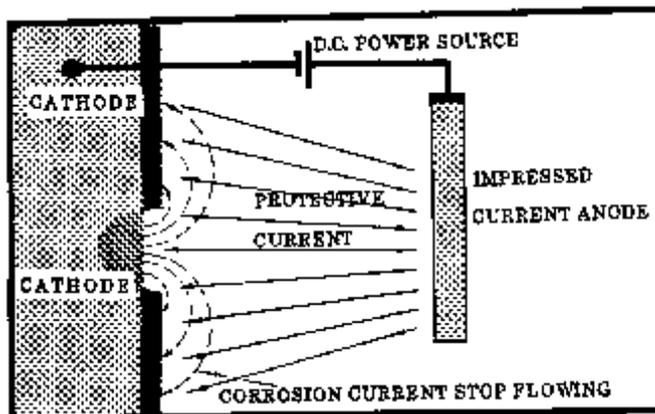
Impressed Current Systems

Impressed current systems provide the same electric current as galvanic anodes by the discharge of DC current from a relatively inert anode energised from an external DC power source, such as a transformer rectifier or thermo electric generator. Impressed current system anodes include materials such as graphite, silicon iron, platinised precious metals and lead alloys.

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Flow of corrosion current suppressed by protective current discharged from impressed current system



Effective cathodic protection guarantees corrosion free existence. Providing the structure is maintained at a potential of -0.8 volts (or more negative) no loss of metal will occur at all during the life of the structure. As cathodic protection can be renewed or added to during the life of the structure, the maintenance of the desired potential is readily achievable. The efficacy of the system can be monitored by simple electrical measurements.

Cathodic protection apart from overcoming the more 'normal' causes of corrosion, may be used to counter accelerated corrosion resulting from contact between different metals, from impingement by high velocity water, from the effects of sulphate reducing bacteria and from the effects of stray DC currents.