

**PURPOSE**

This section describes the corrosion mechanism of iron and methods used to impede the reaction.

**INTRODUCTION**

Although corrosion technology continues to advance and in recent times has resulted in the development of rust resistant metals, corrosion of iron and steel still remains a major problem. Paint coatings have for centuries been the traditional method of protection against corrosion and today are still among the most effective means available of prevention.

**CORROSION MECHANISM**

Corrosion is usually referred to as the degradation of the metal by chemical or electro-chemical reaction with its environment. When considered broadly, corrosion may be looked upon as the tendency of the metal to revert to its original natural state similar to the oxide from which it was originally smelted.

The actual mechanism in the corrosion of iron and steel is extremely complex and embraces the fields of chemistry and electro-chemistry. Iron will corrode only in the presence of both water and oxygen.

A simplified view of what happens when a piece of iron corrodes is summarised below:



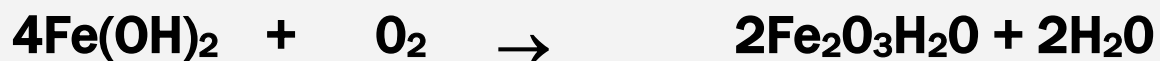
Water and oxygen are also needed for corrosion:



After overall corrosion of the iron is thus a combination of (1) and (2):



The iron hydroxide reacts further with air to form hydrated ferric oxide – rust:



**PROTECTION OF IRON AND STEEL BY PAINTING**

The rate of corrosion of steel depends on current flow between the anodic and cathodic areas. To inhibit corrosion it is therefore necessary to stop or at least reduce this flow of current. This can be done by suppressing either the reaction at the cathode or at the anode or by inserting a high resistance between these electrodes.

Reaction at the cathode. This may be shown as:



For a paint coating to stop this reaction, it must either be impermeable to oxygen and water or impervious to electron flow. Unfortunately, paint coatings do not completely meet these conditions and are sufficiently permeable that they cannot altogether restrain the cathodic reaction.

Reaction at the anode. This may be shown as:



This reaction can be inhibited in either of two ways:

- (1) Make the potential of the iron sufficiently negative so that iron ions are not able to leave the metal surface. This is commonly referred to as cathodic protection.
- (2) Cover the surface of the iron with a film that is impervious to the iron ions - this will prevent the ions from going into solution. This is referred to as anodic passivation.

**Cathodic Protection**

In making the potential to steel more negative, a supply of electrons must be received from another source. Some paints containing metallic pigments are capable of doing this. Certain conditions however have to be met – the metallic particles must be in electrical contact with each other and must be less noble than the iron. The Wattyl range of Galvit Zinc Rich Paints meet these conditions.

**Anodic Passivation**

When a piece of cleaned iron or steel is exposed to air it almost immediately becomes coated with an invisible oxide film. On contact with water or moisture in the atmosphere this film breaks down, allowing corrosion to occur. Specialised anti-corrosive paint coatings may be used to inhibit this corrosion. They act by passivating the surface by means of an inhibitor of limited solubility such as zinc phosphate.

Although we have stated previously that all paint films are to some extent permeable to water and oxygen, and that they cannot protect only by impermeability they do, in spite of this, afford protection to steel by resistance inhibition.

It appears that they protect by virtue of their high ionic resistance which impedes the movement of ions, thereby reducing corrosion current. They therefore act as a barrier coating, significantly restricting corrosive ions from reaching the metal surface.

**DESIGN PRINCIPLES**

Paint coatings certainly play a most important part in the science of corrosion control, however, more can be done to prevent or retard corrosion. Design Engineers can do much to eliminate or at least minimise many of the root causes of corrosion. At the design stage they have the opportunity to assess structural details in the light of a number of well known corrosion control principles, some of which are:

- i. The use of dissimilar metals in contact should be avoided, otherwise where moist conditions are prevalent, galvanic cells will be formed and may cause rapid corrosion. Common examples of this are the use of rivets of dissimilar metal to the main substrate, or copper pipe connections to an iron pipe. Steels of differing compositions can also be the cause of similar problems. Where it is necessary to use different metals, select those close together in the E.M.F. series. Dissimilar metals should be isolated by means of a non-conductor.
- ii. Where anodic and cathodic areas exist or may develop, the anodic area should be as large as possible compared with the cathodic area. This will prevent development of a high current density and rapid attack of a small anode.
- iii. Structural design should provide for adequate drainage, and pockets where moisture can accumulate should be eliminated.

- iv. Avoid moisture retentive materials being placed in contact with metals.
- v. Avoid conditions where differential concentration or aeration cells may develop. These can often occur at unsealed lap joints, at the interface of two coupled pipes, or at threaded connections where the oxygen concentration is lower at the crevice or at the threads than elsewhere. Points of turbulence in liquid flow systems should also be avoided. Differential aeration cells also account for the pitting damage under rust. Less oxygen reaches the metal beneath the rust than at unruined sections, causing corrosion to be concentrated in a small area.
- vi. All edges, joints, welds etc. should be smooth and rounded if possible. This will avoid any possibility of a lack of coating thickness at sharp edges.
- vii. Where possible, avoid designs that may result in formation of differential temperature cells. These commonly occur in heat exchangers, boilers, immersion heaters and similar equipment.
- viii. Design of a structure should allow sufficient space between neighbouring surfaces so that they may be readily coated.
- ix. Consideration should be given to the use of non-corrosive materials.

With adequate planning at the engineering design stage and proper selection and use of anti-corrosive protective coatings, most acute corrosion problems can be avoided.

Control of corrosion is in the main, a problem of economics involving the cost and effectiveness of the control methods, determination of maintenance costs, and the service life of the structure itself.



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