

Alex Sinclair – Marine Consultant

Technical Note – January 2006 - ‘Corrosion’

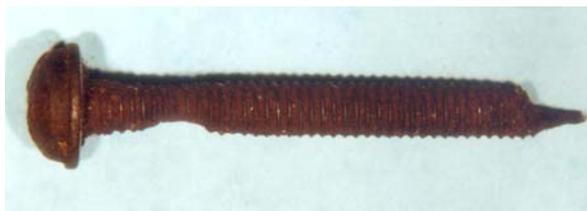
Many technical investigations involve some aspect of corrosion and in dealing with them I am often asked to explain the corrosion process. This note is not concerned with the various forms of corrosion which may be encountered in the field but attempts to provide a plain jargon-free understanding of what corrosion is and what hidden forces so often cause simple and sophisticated metal components to lose their strong and reliable character.

In its broadest sense, corrosion is the decomposition of a metal reacting with its environment. But what drives the reaction?



Danger, electrons on the move!

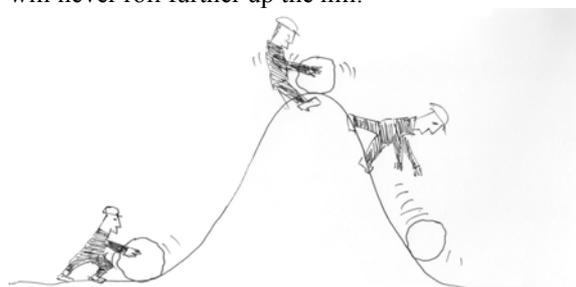
Metals, such as iron (Fe), copper (Cu), zinc (Zn) tin (Sn) and aluminium (Al) are elements. But in nature they do not occur in elemental form, they are found as chemical compounds, principally metal oxides. To be useful in engineering terms, metals must be separated from their rocky oxides (ores) and separation necessitates expending a great deal of thermal, chemical or electrical energy. For example, to smelt iron in a blast furnace the temperature of the furnace is raised to about 1,900°C. To make carbon steel, the pig iron tapped from the blast furnace must be reheated and refined. Similarly, before it can be recovered from its ore (bauxite), aluminium undergoes a complex process involving heating to 1,200°C and then electrolysis in a powerful electrical cell. This type of thermal activity produces basic metals. But before they can be employed in manufacture or construction, additional energy demanding processes are required for alloying, casting, machining, rolling etc.



For want of this corroded screw a ship was lost!

A mild steel plate ready to be incorporated into a ship's hull represents the culmination of a long chain of energy hungry production steps. During its extended manufacture, iron, the main constituent of steel, is thermodynamically elevated from its natural, lazy, low energy ‘oxidised’ form to an energetic ‘reduced’ form – reduction being the opposite of oxidation.

An atom of metallic iron, symbol Fe, possesses its full complement of electrons. But when electrons (negative charges) are lost the metal is said to be oxidised and the ‘ions’ thus formed are represented by Fe²⁺ or Fe³⁺ according to whether two or three electrons have been shed per atom. As reduction from an ore bearing Fe²⁺ or Fe³⁺ to metallic Fe involves imparting so much energy, each atom of smelted iron is effectively a store of energy. Energy is bound up in the metallic product in a manner analogous to rolling a heavy stone up a hill. A great deal of energy is needed to get the stone to an elevated position but much less is needed to encourage it to roll back down the hill. With slight inducement the stone will roll downhill into the valley and thereby shed energy to return to its initial low energy state. Unless energy is positively expended by an outside agency the stone will never roll further up the hill.



Tottering on the corrosion hill.

In other words iron and other metals will not spontaneously reduce (roll up hill) from their oxidised ores to form useful metallic solids. But like the stone, iron, or any other engineering metal, requires little outside help to fall back from an elevated energetic condition to a state of decay. What we term corrosion is in fact the natural process by which a metal divests itself of chemical energy artificially imparted by refining – to return as near as possible to the ore from whence it originated.

Alex Sinclair has a Diploma and MSc. in the Science of Corrosion from Imperial College London and is an independent consulting marine engineer with over 25 years experience of casualty investigation, arbitration and litigation. A full CV is available at www.ajsinclair.com.