

PREVENT CORROSION

Some rules on how avoiding and solving these phenomena

Metal corrosion is too often underestimated though it is sometimes really damaging to heat systems.

It is a chemical and electrochemical phenomenon which can occur whenever one or more metals are in a wet environment or in contact with a liquid (as in the case of the pipes of a system or of a heat exchanger) or even in a dry environment.

HOW DOES IT OCCUR: First of all we must consider the tendency of some metals to oxidize more easily than others as specified by the classification hereunder defining the oxidation-reduction potential according to which higher and positive values indicate a higher stability of metal to the detriment of other metals having lower potential values.

Inclination to oxidation of some metals:

COPPER > NICKEL > TIN > LEAD > CHROMIUM (nobler metals)

IRON > ALUMINIUM > CADMIUM > ZINC > MAGNESIUM (less noble metals)

Let's take the example of Iron (one of most easily oxidized metals). If Fe is placed in a wet environment or in contact with water, as in a real pile, it turns into $Fe^{++} + 2e^-$ (i.e. each iron atom frees two electrons). Electrons "run" through the metal attracted by the positive pole (cathode) and combining with hydrogen positive ions in water they produce gaseous hydrogen H_2 (flammable hence dangerous). Another consequence of these simple chemical reactions occurring in the negative zones of metal called "anode" is the dissolution of metal Iron which turns into $Fe(OH)_2$ ferrous hydroxide, an unstable compound depositing in the anodic area and subsequently turning into oxide. The cathodic zone is instead protected. This happens in theory, because actually in the case of Iron, corrosion is "autocatalytic" often proceeding with irremediable consequences.

Other metals such as Aluminium (within a pH range 4 to 8.5) or Copper form a thin film of "stable" surface oxides protecting the metal surface against advancing corrosion. Outside the range above mentioned and if not properly protected, Aluminium corrodes as well as Stainless steel iron; in fact the latter is not actually stainless but, since it consists of an alloy of iron with nobler metals such as Chromium and Nickel, iron is protected by an imperceptible film of "stable" surface oxides formed by Chromium and Nickel. Being a water system made from different metals (hence having different degrees of nobility) the weakest metal "sacrifices" oxidizing to the advantage of nobler ones. This nearly always happens to iron, but be also careful to aluminium.

MAIN CAUSES:

- Presence of different types of metals (pile effect)
- Stray currents (earthed)
- Little non-uniformities of metals
- Difference in temperature and internal stress
- Different concentrations of salts and gases inside water.

Sometimes corrosion can stop or slow down very much since the difference in potential between the cathodic and the anodic zones decreases with the passing of time. Other causes could make it proceed:

- Acid pH (lower than 7)
- The presence of oxygen dissolved in water, i.e. "open" circuits, such as those continuously fed, for example steam boilers where phenomena are exasperated or open cup systems or radiant floors (insufficient oxygen barrier), are more subjected to corrosion.
- The presence of carbon dioxide which, dissolved into water, forms carbonic

acid lowering pH.

- Temperature

When not protected iron oxidizes in different way like $Fe(OH)_2$ ferrous hydroxide, $Fe(OH)_3$ ferric hydroxide, $Fe_2O_3 \cdot H_2O$ oxide hydrate or rust, Fe_3O_4 magnetite, FeO ferrous oxide. On the contrary iron would find its stable equilibrium in a clearly alkaline environment, i.e. with a pH 9.7. Nevertheless, according to "Nerst's theory" the deposit of $Fe(OH)_2$ produced by corrosion would not resist to the high speed of water flow in pipes. Other phenomena are in "favour" of who use iron exchangers; in fact, within a temperature range from 200°C to 570°, a protective and magnetic oxide strictly adhering to the iron surface like magnetite, Fe_3O_4 appears.

However, when temperatures above mentioned are exceeded, magnetite decomposes in ferrous oxide (FeO) of powdery nature which often clogs exchangers and the pump elements.

The main causes of **magnetite dissolution** are:

- Film boiling which becomes manifest at high temperatures & pressures and causes local wall overheating;
- Flame impingement, instability of flames which can cause local overheating of pipes with the consequent detachment of magnetite flakes.
- Local thickening of the oxide film, contributes to increase the metal surface temperature.
- Local deposition of limestone causing a non-uniform diffusion of heat.

Other phenomena can worsen the state of systems, in particular

DEPOSITION PHENOMENA (SLUDGE AND MUD): Sludge and mud, are often present and cause malfunction. Independently of their nature, our prevention program represents one of the main objectives of our treatments.

A "filthy system" jeopardizes not only the efficiency of the heat exchange, but also the effectiveness of anti-corrosive treatment.

In fact, if a surface is clean, i.e. free of any deposits, any possible corrosion phenomena will be of a uniform type and will therefore be less dangerous (if compared to the effects caused by localized corrosion); deposition phenomena can be identified as follows:

- Incrustations
- Fouling
- Biofouling

Incrustations occur for the crystal growth of an adhering layer of insoluble salt (limestone) or oxide (silica) on surfaces where the heat exchange occurs. Water hardness can to a certain extent contribute to protect metals against corrosion, although the opposite problem causing limestone deposition shall not be incurred, too.

Fouling is better known as the deposition of substances such as sludge or iron suspended in make-up water or of organic substances naturally present, particles introduced by the atmosphere, slash disposals such as: hemp, low quality sealing paste, gaskets, cutting oils, incoherent oxides formed in the yard due to the prolonged stops, leaks of softening resins, etc.

Biofouling. Microorganism causing biofouling can penetrate the system through different ways. They can be present in make-up water or in air (insufficient oxygen barrier). Other bacterial species such as spores, iron bacteria, etc. besides moulds and yeasts (the latter remarkably complicate things since they produce abundant amounts of silt).