Adverse Effects
Background Information

Corrosion

Corrosion is defined as the destruction of a metal by chemical or electrochemical reaction with its environment. Corrosion involves the oxidation of metal atoms to cations, which in turn can react to form oxides, hydroxides, and other species on the metal surface. In these scenarios, the metal cations may not directly be released into the water and could form precipitates or films. If corrosion occurs rapidly enough that the formation of these films is not possible or if the films that form are insufficiently protective, the release of metal cations into the water will occur. At this point, other chemical processes such as precipitation and dissolution of other metal compounds, such as carbonates, silicates, and other scales, then control the quantity and form of metal released into the water.

The extent, rate, and mechanisms of corrosion that occur all depend on numerous factors. Such factors include the pH, temperature, and chemistry of the water such as hardness and chloride content. Water quality analysis is complex and involves the interaction between multiple species and different chemical additions. Each of these factors plays a role in the corrosion mechanism which is also dependant on the material of construction with which the water is in contact.

In industry, corrosion can cause numerous problems. This includes the failure of equipment which has the added cost of replacement and plant downtime. Furthermore, in cooling or heating systems, this can lead to decreased plant efficiency as a loss of heat transfer is observed caused by the accumulation of corrosion products. Corrosion is specific to the water quality and material of construction as discussed below. The general corrosive affects are shown below.

Water Properties and Effect on Corrosion

Water Properties	Corrosivity
Hardness	As hardness increases, corrosion decreases.
Alkalinity	Increase in alkalinity causes a decrease in corrosion.
pH	Corrosion depends on its value – Corrosive at low pHs, as pH increases up to 8.5, corrosion decreases.
Temperature	Increase in temperature, corrosion increases
Chloride	Higher chloride concentration increases water corrosivity
Sulphate	Higher sulphate concentration increases water corrosivity
Temperature	Pitting corrosion is accelerated by temperature

Scaling

Scaling is described as precipitation or crystallization of inorganic salts, such as calcium, magnesium, carbonate, sulphate, phosphate, and silica that allow depositing minerals on the surface. Scaling is a major problem wherever heating of water or heat exchange takes place. Scale accumulates on the surface of the heat exchange surfaces, insulating them, and thus reduces the heat exchange efficiency. Scaling of internal passageways of heat exchangers and pipelines decreases working volume and restricts flow. Scaling may also lead to problems in other items of industrial equipment, such as screens, vacuum pumps, heating baths, steam-heated drying drums and tanks. Scale can also form on paper machine wires and felts, necessitating special cleaning procedures that can reduce their active life.

Water Properties and Effect on Scaling

Water Properties	Scaling
Hardness	As hardness increases, scaling increases
Alkalinity	As alkalinity increases, scaling increases
pH	Mild scaling at high pHs
TDS	High TDS accelerates scaling

Fouling

Fouling occurs when insoluble particulates suspended in a water system form deposits on a surface. Fouling mechanisms are dominated by particle-particle interactions that lead to the formation of agglomerates. Fouling is typically experienced in membrane systems through precipitation and deposition of molecules or particulates on the membrane surface or membrane pores. The consequences of membrane fouling are increased membrane separation resistances, reduced productivity, and/or altered membrane selectivity.

Particulate fouling is caused by suspended solids (foulants) such as mud, silt, sand or other particles in the water. Fouling can occur due to inorganic mechanisms such as silt deposition or organic mechanisms such as in the case of microbial sludge deposition. Biofouling occurs when living matter grows on the equipment. In many cases, re-circulating cooling systems are ideal for promoting the life of microorganisms thus promoting biofouling. In cases whereby fouling occurs, under deposit corrosion may be a concern as the deposits create a favourable environment for this type of corrosion. Fouling typically occurs in membranes as well as different types of equipment and in pipelines. .

Other types of fouling include corrosion fouling which occurs when corrosion products accumulate and adhere to the surface of the equipment. Biological fouling which occurs when living organisms such as macroorganisms and /or microorganism grow and are deposited onto the walls of the equipment. These deposited biofilms are of concern as they can accumulate debris that may impede or completely block flow through the equipment.

The fouling tendency is dependent on the size of the particles requiring removal and the type of membrane technology. In general, the fouling layer is formed by particles having a dimension up to 10 times the pore size.