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CHAPTER 15

CORROSION AND DEPOSITS

Definitions, Basic Theory-Mechanism, Accelerating or Intensifying Factors, Preventive and Protective Measures, Waterside Corrosion and Deposits, Fire-Side and High Temperature Corrosion, Refrigerant Side Corrosion

THIS chapter discusses the fundamentals of corrosion, its prevention and control, with particular reference to some of the common problems arising from corrosion in heating and air-conditioning equipment. It includes discussion of the problems of formation and control of scale and biological growths, which are virtually inseparable from corrosion problems in cooling and heating water systems.

Only a broad general survey of corrosion and deposits can be covered in this chapter. Further information about these topics may be obtained from References 1 to 8 and periodicals and other publications of technical societies, such as the National Association of Corrosion Engineers and the American Water Works Association.

DEFINITIONS

Some terms commonly used in the field of corrosion and water treatment are defined as follows:

Alkalinity. The sum of the bicarbonate, carbonate, and hydroxide ions in water. Other ions, such as phosphate or silicate, may also contribute to alkalinity.

Anode. In corrosion processes, the electrode having the greater tendency to go into solution.

Biological Deposits. Water-formed deposits of biological organisms or the products of their life processes, such as barnacles, algae, or slimes.

Cathode. In corrosion processes, the electrode having the lesser tendency to go into solution.

Corrosion. Destruction of a metal by electrochemical reaction with its environment.

Corrosivity. The capacity of an environment to bring about destruction of a specific metal by the process of corrosion.

Electrolyte. A solution through which an electric current can be made to flow.

Galvanic Corrosion. Corrosion resulting from the contact of two dissimilar metals in an electrolyte or from the contact of two similar metals in an electrolyte of nonuniform concentration.

Hardness. The sum of the calcium and magnesium ions in water.

Inhibitor. A chemical substance which reduces the rate of corrosion or of scale formation.

Ion. An electrically charged atom or group of atoms.

Passivity. The tendency of a metal to become inactive in a given environment.

pH. The logarithm of the reciprocal of the hydrogen ion concentration of a solution. *pH* values below 7 are increasingly acid, and those above 7 are increasingly alkaline.

Polarization. Resistance to current flow at an electrode produced by the product formed by the passage of current.

Ppm. Parts per million by weight. In water, ppm are essentially the same as milligrams per liter (mg/L). 10,000 ppm = 1%.

Scale. A deposit formed by precipitation of a chemical from solution directly in place on a confining surface.

Sludge. A sedimentary water-formed deposit.

Water-formed Deposit. Any accumulation of insoluble material derived from water or formed by the reaction of water upon surfaces in contact with it.

The general responsibility for this chapter is assigned to TC 1.10, Corrosion and Water Treatment.

BASIC THEORY—MECHANISM

Corrosion is defined as *destruction of a metal, or alloy, by chemical or electrochemical reaction with its environment.*[8] In most instances this reaction is electrochemical in nature, much like that in an electric dry cell.

The basic nature of corrosion is almost always the same, a flow of electricity between certain areas of a metal surface through a solution capable of conducting an electric current. This electrochemical action causes destructive alteration (eating away) of a metal at areas which are called anodes where the electric current enters the solution. It is the critical step in a series of reactions associated with corrosion.

An electrolyte must be present as a primary requirement of corrosion. An electrolyte is any liquid that contains ions—electrically charged atoms, or groups of atoms, in solution. For example, pure water is an electrolyte, containing positively charged hydrogen ions and negatively charged hydroxyl ions in equal concentration. A corrosive environment may be any form of moisture, ranging from plain water to the strongest acid or the strongest alkali.

In any environment, regardless of its nature, the basic mechanism of corrosion is, in principle, the same as the electrochemical action of an electric dry cell. There is always an electrolyte present, and two electrodes (an anode and a cathode). These electrodes may be two different metals, or different areas on the same piece of metal. There must be a potential difference between the two electrodes so that electricity will flow between them. A metallic path must exist to complete the circuit for flow of electrons (negatively charged particles) from the anode area to the cathode area.

At the anode, positively charged atoms of metal detach themselves from the metal surface, going into solution as positively charged ions. The released electrons travel through the metal to the cathode area, where one or more cathode reactions may occur. The electrons reaching the surface at the cathode may neutralize some positively charged hydrogen ions which have reached the cathode surface. In losing their charge, the positive ions become neutral atoms again and may combine to form hydrogen gas. The release of hydrogen ions results in the accumulation of a relatively high concentration of hydroxyl ions which are left behind and increase the alkalinity at the cathode surface.

In summation, for corrosion to occur, there must be a release of electrons at the anode and a formation of metal ions through oxidation and disintegration of the metal. At the cathode, there must be a simultaneous acceptance of ions or formation of negative ions. Action at either electrode cannot go on independently. According to Faraday's law, the two reactions must go on at the same time at equivalent rates. Corrosion, or disintegration of the metal, occurs only at the