Chapter 51

CORROSION AND WATER FORMED DEPOSITS CAUSES AND PREVENTION

Definitions, Classification and Characteristics of Water, Causes and Prevention of Scales and Sludges, Causes and Prevention of Slimes, Under-Water Corrosion, Atmospheric Corrosion, Buried Pipe Lines, Handling Water Treating Chemicals, Legal Regulations

THE surfaces of heating and ventilating equipment that are in intimate contact with water sometimes are affected by the chemical characteristics of the contacting waters to such extent that prohibitive amounts of insoluble materials are formed or corrosion ensues at an insufferable rate. To avoid or to correct such troubles, it is desirable that heating and ventilating engineers have a general appreciation of industrial water chemistry. The principal purpose of this chapter is to provide those criteria by which the average engineer may judge whether a problem is one that will yield to rather simple remedies or will require the skill of an experienced water technologist.

DEFINITIONS

The following definitions for water-formed deposits, corrosion, and closely allied terms have been proposed:

Water-Formed Deposits. A water-formed deposit [1] is any accumulation of insoluble material derived from water or formed by the reaction of water upon surfaces in contact with water.

Deposits formed from or by water in all of its phases may be further classified as scale, sludge, corrosion products, or biological deposits.

Scale. Scale [1] is a deposit formed from solution directly in place upon a confining surface. It is a deposit which will retain its physical shape when mechanical means are used to remove it from the surface on which it is deposited. Scale, which may or may not adhere to the underlying surface, is usually crystalline and dense, frequently laminated, and occasionally columnar in structure.

Sludge. Sludge [1] is a water-formed sedimentary deposit. It usually does not cohere sufficiently to retain its physical shape when mechanical means are used to remove it from the surface upon which it deposits. Sludge is not always found at the place where it is formed. It may be hard and adherent and baked to the surface on which it has been deposited.

Biological Deposits. Biological deposits [1] are water-formed deposits of biological organisms or the products of their life processes. Biological deposits may be microscopic in nature, such as slimes, or macroscopic, such as barnacles or mussels. Slimes are usually composed of deposits of a gelatinous or filamentous nature.

Corrosion. Corrosion [2] is destruction of a metal by chemical or electrochemical reaction with its environment. In the corrosion process, the reaction products formed may be soluble or insoluble in the contacting environment. Insoluble corrosion products may deposit at or near the attacked area or be carried along and deposited at considerable distance from the attacked area.

Corrosivity. Corrosivity [3] is the capacity of an environment to bring about destruction of a metal by the process of corrosion. Corrosivity is a property of the environment, but it has no significance until the metal in question is specified.

CLASSIFICATION AND CHARACTERISTICS OF WATER

For industrial use there is no accepted conventional classification of water. Rather, each industry usually develops a body of ideas applicable to its own water problems [4]. For heating and ventilating engineers, it is

perhaps most convenient to distinguish between mineralized waters and condensates.

Mineralized Waters

All the waters found in streams, wells, lakes, and the ocean are mineralized. The same is true of all municipal supplies even though they may have been *treated*. For a given area ground waters are likely to be more highly mineralized than are surface waters. Conversely, surface waters are more likely to be contaminated with municipal sewage and trade wastes. Virtually all mineralized waters also contain biological organisms.

Mineralogical Characteristics. The character and amount of extraneous inorganic materials—including deleterious gases—dissolved and suspended therein describe the mineralogical charateristics of any water. Revealing such information is the function of a mineralogical chemical analysis.

TABLE 1. MINERAL ANALYSES TYPIFYING COMPOSITION OF WATERS AVAILABLE AND USED INDUSTRIALLY IN THE USA

SUBSTANCE	UNIT	LOCATION OR AREA[a,b]								
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Silica	SiO_2	2	6	12	37	10	9	22	14	.....
Iron	Fe	0	0	0	1	0	0	0	2	.....
Calcium	Ca	6	5	36	62	92	96	3	155	400
Magnesium	Mg	1	2	8	18	34	27	2	46	1,300
Sodium	Na	2	6	7	44	8	183	215	78	11,000
Potassium	K	1	1	1	.....	1	18	10	3	400
Bicarbonate	HCO_3	14	13	119	202	339	334	549	210	150
Sulphate	SO_4	10	2	22	135	84	121	11	389	2,700
Chloride	Cl	2	10	13	13	10	280	22	117	19,000
Nitrate	NO_3	1	.....	0	2	13	0	1	3	.....
Dissolved Solids	.....	31	66	165	426	434	983	564	948	35,000
Carbonate Hardness	$CaCO_3$	12	11	98	165	287	274	8	172	125
Non-Carbonate Hardness	$CaSO_4$	5	7	18	40	58	54	0	295	5,900

[a] All values are parts per million of the unit cited to nearest whole number (see Reference 5).

[b] Numbers indicate location or area as follows:

(1) Catskill supply—New York City
(2) Swamp Water (Colored) Black Creek, Middleburg, Florida
(3) Niagara River (Filtered) Niagara Falls, New York
(4) Missouri River (Untreated) Average
(5) Well Waters—Public Supply—Dayton, Ohio—30-60 ft.
(6) Well Water—Maywood, Illinois—2090 ft.
(7) Well Water—Smithfield, Va.—330 ft.
(8) Well Water—Rosewell, N. Mexico
(9) Ocean Water—Average

The analyses in Table 1 disclose the composition of the public water supplies used by about 45 per cent of the total population of the cities, in the United States, having more than 20,000 inhabitants [5].

All values recorded are in terms of parts per million *. This is the approved standard terminology for reporting the results of mineral analyses [6]. Values reported in the other terms commonly used may be converted into the standard form by using the conversion factors listed in Table 2.

Data for dissolved gases or pH values have been omitted in Table 1 because even waters of the same mineral contents may vary widely in these respects. Unpolluted natural waters usually have pH values within the range 5 to 8, depending upon their *free* CO_2 contents. Polluted

* Parts per million are hereinafter abbreviated ppm. A part per million signifies a unit weight of material per million unit weights of the solution.