gases, and chloride salts are the corrosion accelerators most frequently encountered.

Neutral and slightly alkaline waters saturated with air, corrode iron at a rate about triple that for the same water free of air. Hot water containing oxygen will corrode iron at a rate three to four times that for the same water when cold.

Corrosion of iron decreases as the pH of water solutions increases, and practically ceases at a pH of 11. If the metal contains film forming agents, such as chromium, nickel, and silicon, or if the water contains inhibitors such as silicates and chromates, corrosion may in some instances be minimized.

Cold Water Services

Where water from municipal supplies is used industrially in a closed system with little or no increase in temperature, it is seldom necessary or feasible to treat the water to reduce its corrosivity. When it is mandatory, the addition of caustic soda to *maintain* a pH over 11, *plus* the addition of sufficient sodium sulphite to maintain a residual of over 100 ppm (as Na_2SO_3), usually suffices to prevent serious troubles. However, in some cases the cost may be prohibitive.

When the use of sodium sulphite or a comparable chemical for oxygen removal is prohibited, as in potable waters, the addition of small amounts of lime to maintain a Langelier Index (see Fig. 4) of 0.5 or more may prove helpful.

In systems exposed to the atmosphere, as for example air washers or storage tanks, both laboratory[14] and field tests[15] have shown that the addition of alkalies to maintain a pH greater than 8.5, plus the addition of other chemicals that produce protective films on the metal surface, will measurably decrease corrosion. Sodium dichromate, sodium silicate, and tri-sodium orthophosphate have been shown to be effective film formers in the order mentioned.

Caustic soda is usually used to raise the pH value, and sodium dichromate is most often employed as a film former in industrial waters. In old systems, not previously inhibited, about 500 ppm of sodium dichromate are usually maintained at the start. After two or three months, and in new systems, a residual of about 300 ppm of dichromate usually proves effective. When insufficient dichromate is employed, pitting is sometimes accelerated. Aeration does not impair the efficiency of dichromates, but does deplete the caustic soda concentration.

In large industrial systems, the use of vacuum deaeration has been shown to be effective.[16] In small systems, the equipment required can seldom be justified economically.

Soft water, as for example the effluent from zeolite softeners, is likely to be several times more corrosive to iron than hard waters. In small installations, the use of copper or brass pipe usually is a practical expedient. Cement lined pipe and tanks suitably resist attack.

Where the water contains slime-forming organisms, especially those bacteria that thrive on iron, chlorination of the water is imperative to inhibit tuberculation and subsequent pitting.

Bitumastic paints, applied at *regular* intervals upon *well cleaned* surfaces, will measurably prolong the life of equipment handling cold waters.

Hot Water Services

As a usual thing, corrosion does not create important troubles when temperatures are maintained below 140 F.

In closed systems where little fresh water is introduced, such as in a hot water space heating system, corrosion is usually negligible because the oxygen released in heating the water is purged through the vents.

Where large amounts of fresh water are constantly entering and are being heated, the use of mechanical deaeration is the most universally satisfactory expedient to employ. Where the use of such equipment cannot be justified economically, anti-corrosive chemicals, and the use of corrosion resistant metals, are the more practical expedients to be used.

Treating Chemicals. Alkalies, such as lime and caustic soda, silicates of soda (water glass), the poly-phosphates of soda, sodium sulphite, and sodium dichromate are usually used. Organic compounds, such as the glucosates, dextrines, and tannins are sometimes used, but their value is still a controversial matter. When any chemical is used, so many relevant factors are involved that it is always advisable to seek adequate technical counsel in inaugurating the treatment. Very often, where such precaution is not taken, new troubles are created that are more aggravating than the original difficulty.[17]

Silicate of soda is used to protect iron, lead, and brass water pipe.[18] For most waters, a solution of $Na_2O{:}3SiO_2$ is recommended. Sodium silicate, equivalent to about 10 ppm added silica, should be fed to the water for the first month after which it may be reduced to give 5 or 6 ppm added silica. Where careful control of the silicate feed is exercised, the water is not injured for domestic use by this treatment. The rate of corrosion of iron pipe has been reduced by 70 percent, and dezincification of brass pipe practically stopped, by this simple treatment. The amount required and the effect are not the same in all waters.

Pipe Materials. Brasses with 60 to 67 percent copper are dezincified in some corrosive waters, and in certain localities are not much more serviceable than galvanized iron or steel pipe. The zinc in brass pipes is leached out locally, leaving a plug of porous copper. The weakening of such pipe is especially noticeable under the threads. Dezincification is retarded by the use of silicate of soda (8 ppm added silica).[19]

In salt or fresh water, there is no material difference in rate of pitting of wrought iron, steel, low metalloid steels, or copper bearing steels. This is contrary to the relative performance of these metals in atmosphere.

Refrigerating Systems

Corrosion in refrigerating systems is confined to surfaces in contact with brines or those in contact with the refrigerant.

Brines. Refrigerating brines usually are comprised of sodium chloride, calcium chloride, or calcium and magnesium chlorides. The corrosivity of dilute brines is higher than their more concentrated solutions. The corrosivity of sodium brines, other conditions being fixed, is about 1.5 times greater than brines of the alkaline earth metals.

Brines are excellent electrolytes. Contact of dissimilar metals of wide potential differences, when in contact with brines, results in rapid corrosion by galvanic action.

The leakage of air, acid refrigerants, or both, accelerates the corrosivity