

stroy slime-forming organisms. The others are presumed to poison marine organisms, most of which *recover* when the chemical is not used regularly.

While chlorine is the most generally used chemical, others may occasionally prove to be more practicable. Choice of the chemical is conditioned largely by the design and operation of the system.

Open Recirculating Systems

In spray ponds and cooling towers of the open type, light-loving algae growths are likely to cause blocking of the distribution piping and troughs. These organisms are most troublesome in areas accessible to sunlight. Algae slimes are usually stringy in character.

In open recirculating systems, continuous use of small quantities of chlorine is generally most satisfactory. In once-through systems, where large quantities of water are used, intermittent treatment a few times each day will usually result in satisfactory slime removal and chemical economies.

Neither the phenols nor copper sulphate may be used for the removal of slime already formed. For this purpose, chlorine gas is used. After being cleaned, the other chemicals may be used to prevent the reestablishment of slime in the system. The removal of green algae from a cooling tower should never be used as an indication that the true slime-forming organisms on heat exchanger surfaces have been removed. The more resistant slime formers, which so materially reduce heat transfer efficiency, will often be unaffected by treatment which completely eliminates algae.

Closed Once-Through Systems

In equipment where light is excluded, slime formations are due to fungi. Usually, they predominate on the heat exchange surfaces. Bacteria form thick, soft slime. Yeasts and molds form tough rubbery slimes. Chlorine and hypochlorite solutions, fed intermittently, are used to prevent such slimes.

UNDER-WATER CORROSION

When deleterious substances are present in water, the corrosivity of the solution is increased in proportion to the amount of deleterious substances present, the temperature, and usually the rate of flow of the solution over the metal surfaces. There are other relevant factors, but their influence in general is subordinate to those mentioned. Dissolved oxygen, acid 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 laboratory¹⁴ and field tests¹⁵ have shown that the addition of alkalis 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 effective¹⁶. 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, dextrans, and tannins are sometimes used, but their value is