of brines. Ammonia precipitates calcium and magnesium salts, thus clogging the system at restricted points.

The addition of caustic soda and sodium dichromate to brine solutions to inhibit corrosion of iron, is a more or less general practice. Sodium silicate and sodium phosphate are also used at times, but tests indicate they are not as effective as is sodium dichromate. It has been suggested[20] that 125 lb of sodium bichromate per 1000 cubic feet of calcium chloride brine, and 200 lb per 1000 cubic feet of sodium chloride brine, be added to inhibit brines; that when salt or calcium chloride is added to "strengthen" brine, sodium dichromate also be added in the amounts shown in Table 7.

Refrigerants. The common refrigerants, except those of the hydrocarbon type, will attack the common metals and alloys if *moisture is present.* Even a very small amount of water may cause severe corrosion

TABLE 7. QUANTITIES OF SODIUM DICHROMATE TO BE ADDED TO MAINTAIN INITIAL CONCENTRATION

Specific Gravity of Brine to be Strengthened	Lb Sodium Dichromate per 100 lb $CaCl_2$ Added
1.16	0.695
1.18	0.621
1.20	0.556
1.22	0.502
1.24	0.455
	Lb of Sodium Dichromate per 100 lb NaCl Added
1.12	1.79
1.14	1.47
1.16	1.32
1.175	1.18

with certain refrigerants. The amount required need only be sufficient to produce a water film on the metal surface.

With the halogenated hydrocarbons, complete elimination of water is much to be desired. Where ammonia is used, copper and its alloys, aluminum and zinc, are attacked especially at elevated temperatures. When sulphur dioxide is used, more than 50 ppm (0.005 percent) of water will cause appreciable corrosion of virtually all the common materials.

Minimizing Condensate Corrosiveness

There are four expedients that may be utilized to minimize corrosion in steam condensate systems: (1) treatment of the boiler feedwater so as to eliminate deleterious gases entrained with the steam, (2) design of the condensing equipment to minimize dissolution in the condensate of the deleterious gases entrained with the steam, (3) chemical treatment of the condensate, (4) use of resistant metals.

Boiler Feedwater Treatment. Elimination of oxygen from boiler feedwater and, therefore, from the steam developed, can be accomplished either mechanically or chemically. In some steam generating stations, both expedients are employed.

Tests[21] have indicated that in small low-pressure heating boilers, where the boiler input contains less than about 50 ppm of carbonate hardness,

the CO_2 in the steam can be controlled by adding calcium hydroxide to the boiler. In Fig. 5 are shown the equilibria conditions proposed for boilers operating at pressures up to about 5 psi gage. This expedient may *not* be used in higher pressure boilers, because of the possibilities of scale and sludge formations. In the latter, the only method used to date for treating the feedwater consists of removing the alkaline earth salts, *i.e.*, softening, and subsequent acidulation followed by deaeration at temperatures near the atmospheric boiling point of water.[22]

Design of Condensing Equipment. In the design of water heaters and comparable types of condensing equipment,[23] it is possible to shift the accumulation of non-condensible gases to a location away from the condensate level and, subsequently, vent these gases to the atmosphere.

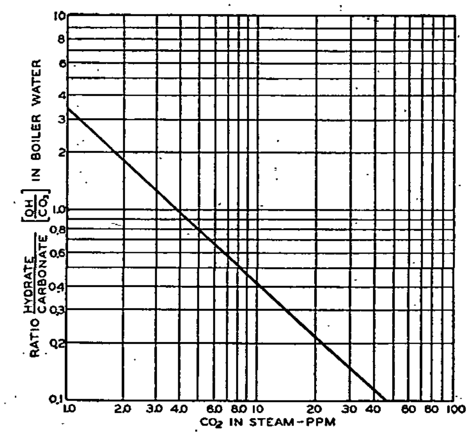

FIG. 5. RELATION OF HYDRATE/CARBONATE CONTENT IN *Hard* BOILER WATER AND CO_2 IN STEAM AT ABOUT 5 PSI OPERATING PRESSURE

(All analytical values are ppm by weight)

Venting an amount of steam equal to about one-half percent of the total steam entering the condenser is the optimum vent rate.

Venting is of little practical value when the CO_2 content of the incoming steam is below about 5 ppm. When the steam contains more than 5 ppm, venting provides a means of producing a condensate containing a minimum of about 3 ppm. However, even as little as 3 ppm of dissolved CO_2 can produce active corrosion if large amounts of condensate are flowing.

Chemical Treatment of Condensate. Condensates containing comparatively large amounts of oil, are practically non-corrosive, due to the protective film provided by the oil. When oil is intentionally added to condensate,[24] inadequate quantities may accelerate rather than decelerate corrosion on those surfaces not covered by the oil. Sodium silicate added to CO_2-bearing condensate has been shown to decrease, but not entirely prevent, corrosive action. It is not definite whether the protection afforded by silicate solutions is due to the establishment of a protective