

The dosage of barium carbonate, in pounds per 1000 gallons per 1 ppm of sulfate hardness, expressed as CaCO_3 , and allowing 10 per cent excess, is 0.0181.

NOTE: Although barium carbonate will react with sodium sulfate, an equivalent amount of sodium carbonate will be left in the effluent, so that this process is of value only in removing calcium sulfate and magnesium sulfate.

Two-Stage Cold Lime and Sodium Cation Exchange Process. In this process the bicarbonate hardness is first reduced by treatment with lime plus a small dosage of a coagulant in a cold lime water softener. The pH of the effluent is then usually reduced somewhat by (1) recarbonation or (2) treatment with a small dosage of sulfuric acid and filtered. It is then passed through sodium cation exchanger water softener(s) which remove both the noncarbonate and residual carbonate hardness.

The quality of the effluent is excellent because (1) the total solids have been reduced by the lime treatment and (2) the effluent is practically zero in hardness instead of the 50 to 68 ppm (3 to 4 gpg) of hardness that would have resulted from "complete" treatment by the cold lime soda process. Also, with waters high in both bicarbonate and non-carbonate hardness, the operating costs are low because it is usually cheaper to remove bicarbonate hardness by lime treatment than by the sodium cation exchange process, and it is cheaper to remove noncarbonate hardness by the sodium cation exchange process than by the lime soda process. The cost for the equipment, however, is high, roughly in the neighborhood of twice as much as that for either plant by itself when a clear ground water is to be treated (not when a hard turbid surface water is to be treated since the lime treatment can then be carried out simultaneously in the same equipment used to remove the turbidity).

Iron and Manganese Removal. Iron and manganese, if present as the divalent bicarbonates, may readily be removed in the cold lime-soda processes by aeration, since they are speedily oxidized to the insoluble, hydrated higher oxides at the high pH values prevailing in the cold lime-soda process. Organic iron and/or manganese may be removed by coagulation. See Chapter 14 for iron and manganese removal by the cold lime-soda processes.

Silica Removal by the Cold Lime-Soda-Magnesia Process. In the removal of silica by the cold lime-soda-magnesia process, it has been found that magnesium hydroxide precipitated in situ is more effective than magnesium oxide and also that magnesium oxide hydrates very slowly at ordinary temperatures. Obviously, the magnesium hardness of the raw water, since it is precipitated in situ as magnesium hydroxide, is of value in reducing the silica content. With most waters, however, an additional