Table 7.23
Iron/Manganese Removal Processes

processes	iron and/or manganese removed	pH required	remarks
aeration, settling, and filtration	ferrous bicarbonate	7.5	provide aeration unless incoming water contains adequate dissolved oxygen
	ferrous sulfate	8.0	
	manganous bicarbonate	10.3	
	manganous sulfate	10.0	
aeration, free residual chlorination, settling, and filtration	ferrous bicarbonate	5.0	provide aeration unless incoming water contains adequate dissolved oxygen
	manganous bicarbonate	9.0	
aeration, lime softening, settling, and filtration	ferrous bicarbonate	8.5–9.6	
	manganous bicarbonate		
aeration, coagulation, lime softening, settling, and filtration	colloidal or organic iron	8.5–9.6	require lime, and alum or iron coagulant
	colloidal or organic manganese	10.0	
ion exchange	ferrous bicarbonate	6.5±	water must be devoid of oxygen
	manganous bicarbonate		iron and manganese in raw water not to exceed 2.0 mg/l
			consult manufacturers for type of ion exchange resin to be used

FIRST STAGE RECARBONATION: Lime added to precipitate hardness removes itself. This is desirable because any calcium that remains in the water has the potential for forming scale. Further stabilization can be achieved by *recarbonation* (treatment with carbon dioxide).

$$Ca(OH)_2 + CO_2 \rightarrow CaCO_3 \downarrow + H_2O \qquad 7.61$$

Excess recarbonation should be avoided. If the pH is allowed to drop below 9.5, then carbonate hardness reappears.

$$CaCO_3 + CO_2 + H_2O \rightarrow Ca(HCO_3)_2 \qquad 7.62$$

At this time, any unsettled $Mg(OH)_2$ can be returned to a soluble state.

$$2Mg(OH)_2 + 2CO_2 \rightarrow 2MgCO_3 + 2H_2O \qquad 7.63$$

SECOND STAGE TREATMENT: The second stage treatment removes calcium noncarbonate hardness (sulfates and chlorides) which needs soda ash for precipitation.

$$CaSO_4 + Na_2CO_3 \rightarrow CaCO_3 \downarrow + Na_2SO_4 \qquad 7.64$$

Magnesium noncarbonate hardness needs both lime and soda ash.

$$MgSO_4 + Ca(OH)_2 \rightarrow Mg(OH)_2 \downarrow + CaSO_4 \qquad 7.65$$

$$CaSO_4 + Na_2CO_3 \rightarrow CaCO_3 \downarrow + Na_2SO_4 \qquad 7.66$$

Excess soda ash leaves sodium ions in the water. However, noncarbonate hardness is a small part of total hardness. Soda ash is also costly, so the actual dose might be slightly reduced from what is needed.

SECOND STAGE RECARBONATION: Second stage recarbonation is needed to remove $CaCO_3$. CO_2 is added until the pH is about 8.6, at which time no further precipitation will occur because $[Ca^{++}][CO_3^{--}] < K_{sp}$ of $CaCO_3$.

Sodium polyphosphate can be added at this time to inhibit crusting on filter sand and scale formation in pipes.

A *split process* can be used to reduce the amount of lime that is neutralized by recarbonation (and is wasted). Excess lime is added in the first stage. This forces precipitation of magnesium in the first stage instead of in the second stage. Excess lime reacts with calcium hardness in the second stage. The amount of bypass depends on the allowable hardness of water leaving the plant. A typical split process is shown in figure 7.9.