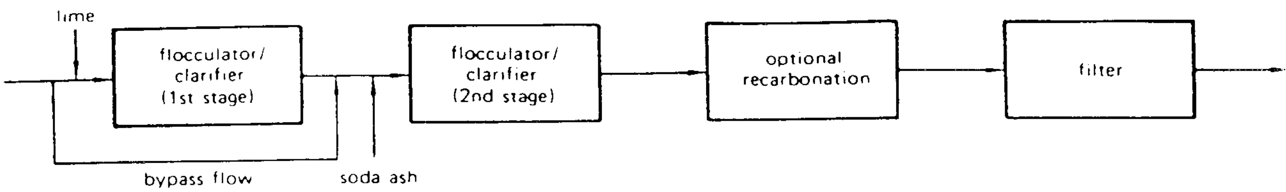

Figure 7.9 A Split (Bypass) Process

Practical limits of *precipitation softening* by the lime process are 30 to 35 mg/l of $CaCO_3$ and 8 to 10 mg/l of $Mg(OH)_2$ as $CaCO_3$ due to intrinsic solubilities. Water softened with this process usually leaves the apparatus with a hardness of between 50 and 80.

Example 7.18

Water contains 130 mg/l as $CaCO_3$ of $Ca(HCO_3)_2$. How much slaked lime ($Ca(OH)_2$) is required to remove the hardness?

Since the $Ca(HCO_3)_2$ is given in $CaCO_3$ equivalents, 130 mg/l of lime (as $CaCO_3$) is implicitly required. It only remains to convert the $CaCO_3$ equivalent to a substance measurement using appendix A.

$$Ca(OH)_2 = \frac{130}{1.35} = 96.3 \text{ mg/l as substance}$$

Example 7.19

How much slaked lime (90% pure), soda ash, and carbon dioxide are required to reduce the hardness of the water evaluated below to zero using the lime-soda ash process? Neglect the fact that this process cannot really produce zero hardness, and base your answer on stoichiometric considerations.

total hardness:	250 mg/l as $CaCO_3$
alkalinity:	150 mg/l as $CaCO_3$
carbon dioxide:	5 mg/l

Using appendix A, the CO_2 is first converted to its $CaCO_3$ equivalent.

$$(2.27)(5) = 11.35 \text{ mg/l as } CaCO_3$$

The alkalinity of 150 mg/l is already in $CaCO_3$ equivalent form. Therefore, the total $CaCO_3$ equivalent from substances requiring lime for neutralization is $11.35 + 150 = 161.35$ mg/l as $CaCO_3$.

From appendix A, the amount of 90% pure slaked lime ($Ca(OH)_2$) is

$$\frac{161.35}{(1.35)(0.90)} = 132.8 \text{ mg/l as substance}$$

50 mg/l of lime is arbitrarily added to raise the pH above 10.8. The total lime requirement is then

$$132.8 + \frac{50}{0.90} = 188.4 \text{ mg/l as substance}$$

The noncarbonate hardness is $250 - 150 = 100$ mg/l as $CaCO_3$. The soda ash (Na_2CO_3, 98% pure) requirement is

$$\frac{100}{(0.94)(0.98)} = 108.6 \text{ mg/l as substance}$$

The first stage recarbonation CO_2 requirement depends on the excess lime added.

$$\frac{(50)(1.35)}{(2.27)} = 29.7 \text{ mg/l as substance}$$

- Ion Exchange Method

In the ion exchange process (also known as *zeolite process*, *resin exchange process*, or *ion exchange method*), water is passed through a filter bed of exchange material. This exchange material is known as *zeolite*. Ions in the insoluble exchange material are displaced by ions in the water. When the exchange material is spent, it is regenerated with a rejuvenating solution such as sodium chloride (salt), or, in the case of common cationic resins, sulfuric and hydrochloric acids are used as *regenerants*. Soda ash is used as a regenerant in weakly-basic exchangers.

The processed water will have a zero hardness. However, since there is no need for water with zero hardness, some water is usually bypassed around the unit.

There are three types of ion exchange materials. *Greensand* (*glauconite*) is a natural substance that is mined and treated with manganese dioxide. *Siliceous-gel zeolite* is an artificial solid used in small volume deionizer columns. *Polystyrene resins* are also synthetic. Polystyrene resins currently dominate the softening field.[15]

[15] Differences in the polymerization step can result in polymers with gel or macroporous structures. *Gel polymers* have low cross linking, high capacity, and fast reaction kinetics. *Macroporous polymers* have high cross linking, reduced capacity, and lower kinetics. Gel resins have historically been used in water softening. However, the chemical resistance of macroporous forms is advantageous in special applications.

5C