FILMTEC™ Membranes

Water Chemistry and Pretreatment: Scale Control

Softening with a Strong Acid Cation Exchange Resin

In the ion exchange softening process, the scale-forming cations, such as Ca^{2+}, Ba^{2+} and Sr^{2+}, are removed and replaced by sodium cations. The resin is regenerated with NaCl at hardness breakthrough. The pH of the feed water is not changed by this treatment and, therefore, no degasifier is needed. Only a little CO_2 from the raw water is present that can pass into the permeate, creating a conductivity increase there. The permeate conductivity can be lowered by adding some NaOH to the softened feed water (up to pH 8.2) to convert residual carbon dioxide into bicarbonate, which is then rejected by the membrane. The rejection performance of the FILMTEC™ FT30 membrane is optimal at the neutral pH range.

With DOWEX™ ion exchange resins, the removal efficiency for Ca^{2+}, Ba^{2+}, and Sr^{2+} is greater than 99.5%, which usually eliminates any risk of carbonate or sulfate scaling.

Softening with a strong acid cation exchange resin is effective and safe, provided the regeneration is done properly. It is used mainly in small- or medium-size brackish water plants, but not in seawater plants.

A drawback of this process is its relatively high sodium chloride consumption, potentially causing environmental or economic problems. With DOWEX™ MONOSPHERE™ ion exchange resins and a counter-current regeneration technique such as Dow's UPCORE™, it is possible to minimize the sodium chloride consumption to 110% of the stoichiometric value.

Dealkalization with a Weak Acid Cation Exchange Resin

Dealkalization with a weak acid cation exchange resin is used mainly in large brackish water plants for partial softening to minimize the consumption of regeneration chemicals.

In this process, only Ca^{2+}, Ba^{2+}, and Sr^{2+} associated with bicarbonate alkalinity (temporary hardness) are removed and replaced by H^+, thus lowering the effluent pH to 4–5. Because the acidic groups of the resin are carboxylic groups, the ion exchange process stops when the pH reaches 4.2, where the carboxylic groups are no longer dissociated. It is, therefore, only a partial softening. Only those scale-forming cations are removed that are bound to bicarbonate. This process, therefore, is ideal for waters with high bicarbonate content. The bicarbonate is converted into carbon dioxide:

$$HCO_{3^-} + H^+ \leftrightarrow H_2O + CO_2$$

In most cases, carbon dioxide is not desired in the permeate. It can be removed by degassing either in the permeate or in the feed stream.

Degassing the permeate is favored where a potential for biofouling is suspected (e.g., surface waters, high TOC, high bacteria counts). A high CO_2 concentration on the membranes helps to keep bacteria growth low. Degassing the feed is preferred when optimum salt rejection is the priority. Removing CO_2 also leads to an increase in pH (see equation above), and at pH >6 the rejection is better than at pH <5.

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Dealkalization with a Weak Acid Cation Exchange Resin (cont.)

The advantages of dealkalizing with a weak acid cation exchange resin are:

- For regeneration, acid of not more than 105% of the stoichiometric value is needed. This minimizes operating costs and environmental impact.
- The TDS value of the water is reduced (by the removal of bicarbonate salts) by either the amount of hardness or alkalinity, whichever is lower. Accordingly, the permeate TDS value is also lower.

The disadvantages are:

- Residual hardness.
  If complete softening is required, a sodium exchange process with a strong acid cation exchange resin can be added, even in one vessel (layered bed). The overall consumption of regenerant chemicals via thoroughfare regeneration is still lower than softening with a strong acid cation exchange resin alone. Due to the higher investment costs, however, this combination will only be attractive for plants with high capacity. Another possibility to overcome this drawback of incomplete softening is to dose an antiscalant into the dealkalized water.
- Variable pH of the treated water.
  The pH of the dealkalized water ranges from 3.5–6.5 depending on the degree of exhaustion of the resin. This cyclic pH variation makes it difficult to control the salt rejection of the plant. At pH < 4.2, the passage of mineral acid may increase the permeate TDS content. It is therefore recommended that more than one filter be used in parallel and regenerated at different times to minimize the variability in pH. Other possibilities to avoid extremely low pH values are CO_2 removal or pH adjustment by NaOH afterwards.

FILMTEC™ Membranes
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