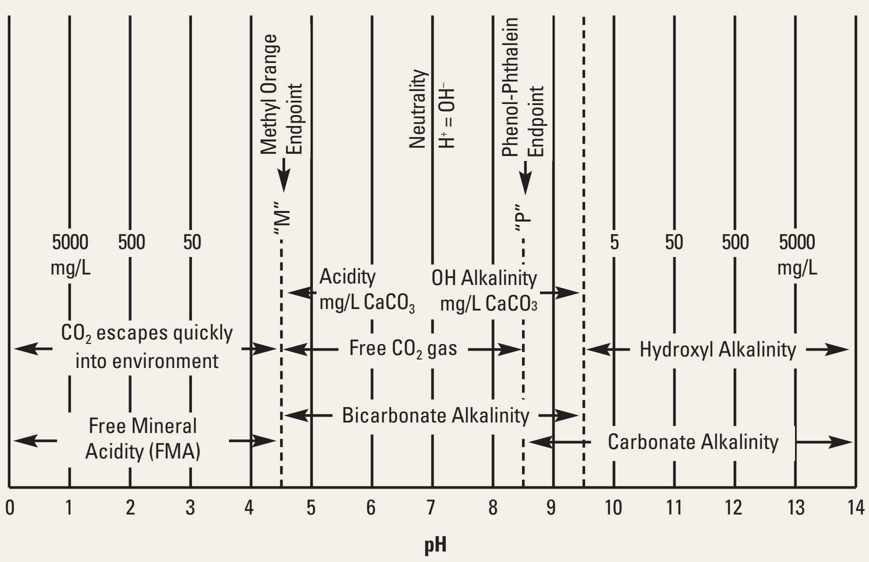
By Wayne E. Bernahl, W. Bernahl Enterprises, Ltd.

Is Dealkalization by Ion Exchange Right for You?

Alkalinity in water is present in four forms: Dissolved carbon dioxide (CO_2), bicarbonate (HCO_3), carbonate (CO_3) and hydroxyl (OH). The bulk of alkalinity in most naturally occurring water sources is bicarbonate alkalinity combined with some CO_2. The form of alkalinity that is found in naturally occurring water is a function of the water's pH. Figure 1 illustrates this relationship.

Figure 1. Alkalinity



Homeowners rarely think about alkalinity. However, the presence of alkalinity in water combined with water hardness might cause a scaling problem in water heaters for the homeowner because calcium carbonate ($CaCO_3$) is inversely soluble as the water temperature increases. The use of a simple water softener usually can eliminate most scaling problems for the homeowner. However, to the industrial water user, alkalinity can be a critical contaminant that must be removed and controlled to prevent scale and corrosion of critical industrial processes and to minimize total operating costs.

Industrial heat exchange equipment usually has higher heat transfer rates than a home water heater, and it usually operates at much higher temperatures. Therefore, the scaling potential is greater. Scaling in industrial applications is well understood and can be prevented by any good water treatment program, but it may require the use of expensive chemical additives and a reduction in the cycles of concentration for the system. In a boiler operation, there is potential for both scaling and corrosion to occur. In a boiler, alkalinity entering with the feedwater will break down with heat and time to CO_2 and OH. The CO_2 will go off with the steam because it is a gas. As the steam cools, the CO_2 dissolves back into the condensate where it forms carbonic acid. This acidic condensate then will corrode the condensate return piping of the system and cause corrosion products (crud) to return to the boiler, which will cause fouling to occur. Amines can be fed to most condensates, which will neutralize the carbonic acid or film out on the condensate piping, but amines increase operating costs. The more alkalinity in the feedwater, the more amine required to neutralize the CO_2.

The other breakdown product (OH) also can be a problem. OH alkalinity in the boiler water can cause caustic gouging or under-deposit corrosion. The potential for the problems associated with alkalinity in a boiler increase with increasing operating pressure. Standard setting bodies such as the American Society of Mechanical Engineers (ASME) or American Boiler Manufacturers Association (ABMA) have published guidelines for boiler and feedwater chemistry. A copy of these should be obtained by anybody operating industrial boilers.

All problems associated with alkalinity increase operating costs to a point where it may become cost effective to remove the alkalinity from the water before its intended industrial use. Alkalinity can be removed from water by either membrane or ion exchange processes. This article will cover the three ion exchange processes used for removing alkalinity.

Salt Splitting Dealkalization

This method of dealkalization (see Figure 2) probably is the most prevalent in commercial and light industrial applications and where low-pressure boiler systems are involved. It utilizes the use of a Type II anion resin bed regenerated with salt (NaCl) or more often salt with a small amount of caustic (NaOH) added. The anion bed follows a softener since the anion resin would

Figure 2. Salt Splitting Dealkalization

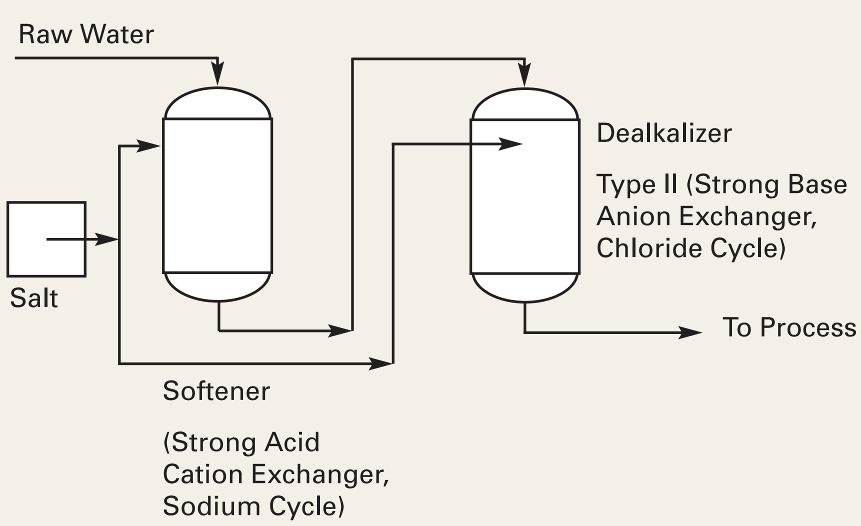


Figure 3. Split Stream Dealkalization

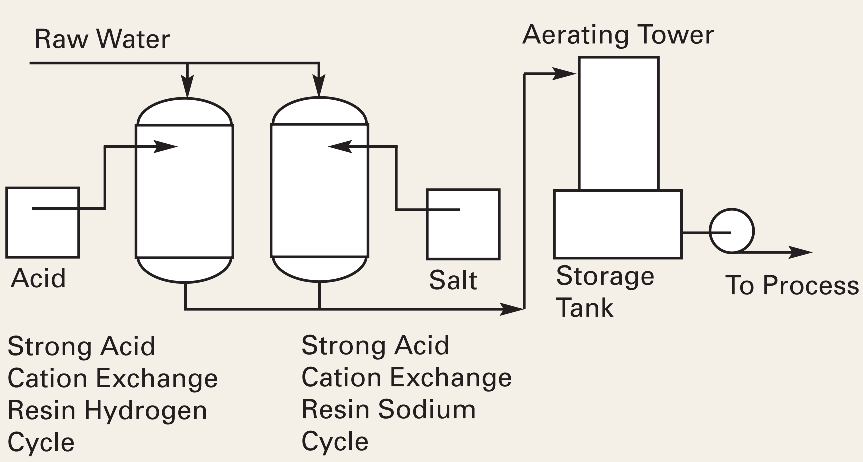
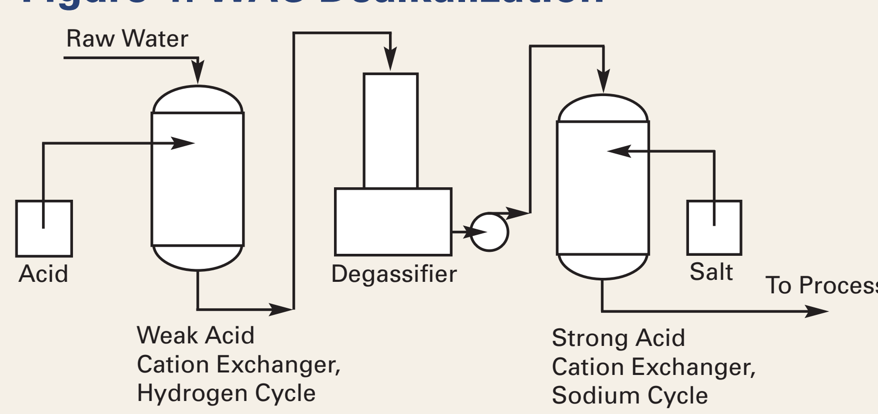


Figure 4. WAC Dealkalization



About the Author
Wayne Bernahl is president of W. Bernahl Enterprises, Ltd. He has worked in the industrial water treatment marketplace for 38 years. He spent most of this time in technical marketing and consulting positions dealing with ion exchange and reverse osmosis applications.

Four Forms of Alkalinity in Water

- Dissolved Carbon Dioxide (CO_2)
- Bicarbonate (HCO_3)
- Carbonate (CO_3)
- Hydroxyl (OH)

foul if any hardness (calcium and magnesium) found its way onto the resin. While alkalinity is removed, the total dissolved solids (TDS) of the water are not changed. Therefore, levels of CO_2 in a boiler's condensate would decrease, resulting in lower amine usage. However, there may be no ability to increase the boiler's cycles of concentration because the TDS in the feedwater has not changed. In fact, the conductivity of the feedwater actually may increase slightly. Salt splitting dealkalization has the following advantages.

- Salt is a non-hazardous material and, therefore, is used to regenerate the resin.
- Often, excess softener capacity can be converted to use as a dealkalizer.

However, this process also has the following disadvantages.

- Relatively low dealkalizer operating capacities (8–10 Kg/ft^3) are achieved. Therefore, larger vessels using more resin and regenerants are required.
- The process does not remove any TDS.
- Anion resins are susceptible to fouling from organics and hardness getting through the softener.
- High-quality, evaporated grades of salt are required for regeneration.

Split Stream Dealkalization

Split stream dealkalization (see Figure 3) utilizes two beds of strong acid cation (SAC) resin operated in parallel. One of the beds is operated in the sodium form as a softener and the other bed is operated in the hydrogen form such as the cation vessel of a demineralizer. This bed is normally regenerated with sulfuric acid (H_2SO_4). The feedwater flow is then split between the two vessels. This yields one soft water source containing 100 percent of the influent alkalinity and one acidified water source containing zero alkalinity. In fact, this source has free mineral acidity (FMA). The two streams are then blended together and put over a degassifier, which removes the CO_2 that is created by the FMA of the acidified water source and the alkalinity from the softened water source. Controlling the percentage of each flow in the blended water can control the amount of alkalinity in the final effluent. The split stream dealkalization process has the following advantages.

- Alkalinity in the final blend can be controlled to a desired level.
- TDS is removed to the extent that the alkalinity is removed.
- The operating capacity of the SAC resins are higher than those of the Type II anion resin used in the salt-splitting process requiring smaller resin volumes.

The disadvantages include

- The use of hazardous acid in the regeneration process is required.
- The capital and operating cost of a degassifier is required.
- The feed of small amounts of caustic may be required to raise the pH of the final effluent to acceptable levels.

Weak Acid Cation Dealkalization

When the influent water is both high in hardness and alkalinity and has hardness to alkalinity ratios of 1 or more, dealkalization using a weak acid cation (WAC) resin (Figure 4) becomes extremely efficient and cost effective. The process involves using an extremely efficient WAC resin to exchange hydrogen for hardness that is associated with alkalinity. The water is then put over a degassifier to remove the resulting CO_2, which removes TDS. A conventional softener then removes any permanent hardness remaining in the effluent of the degassifier. Again, a very small amount of caustic may have to be fed to raise the final effluent pH to desired levels.

The advantages of the WAC dealkalization process include the following.

- Very high operating capacities can be obtained.
- Automation can be achieved through the use of a simple online pH meter.
- TDS reduction allows for increased cycles of concentration in downstream industrial processes.
- Softener capacity is minimized because the WAC resin removes the bulk of the hardness in the dealkalization process.
- WAC resin operating efficiencies minimize acidic regenerant waste.

The disadvantages of the WAC dealkalization process include the following.

- The WAC process is not efficient on all water chemistries, especially those with high levels of sodium alkalinity.
- The use of hazardous acid in the regeneration process.
- The capital and operating cost of a degassifier is required.
- The feed of small amounts of caustic may be required to raise the pH of the final effluent to acceptable levels.

If a water source is high in alkalinity, some form of dealkalization should be considered by most industrial and commercial users of the water as a way to prevent operating problems and reduce total operating costs. Do your homework, educate yourself and make sure all costs and available processes are considered in your evaluation.

Increasing cycles of concentration reduce water usage and waste effluents. In boiler operations, the energy cost must be taken into account. Increased cycles of concentration, reduced blowdown, increases in condensate return and heat recovery processes all save energy and have large paybacks to the overall operation. The use of chemical additives may be reduced and estimates for reduced maintenance costs need to be included.

You may find that a dealkalization process is a cost-effective addition to your water treatment process that has a very short payback period. WQP

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