



Alkalinity Removal Using a Chloride Cycle Dealkalizer

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Alkalinity

Alkalinity is a measure of water's ability to neutralize an acid. It primarily reflects the concentration of bicarbonate (HCO_3), carbonate (CO_3), and hydroxide (OH) ions.

Alkalinity Removal in Boilers

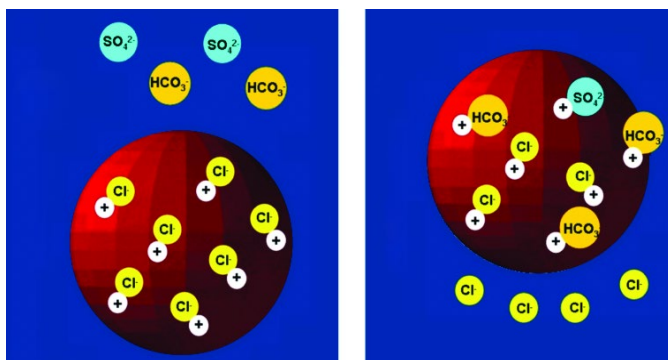
The heat and pressure inside a steam boiler causes the carbonate and bicarbonate alkalinity in the feedwater to break down to form hydroxide ions and carbon dioxide gas. The hydroxide ions remain in the boiler water to concentrate along with other feedwater impurities, while the carbon dioxide flashes off with the steam to become carbonic acid in the condensate. High carbonate and bicarbonate alkalinity in the feedwater is undesirable for two main reasons

1. The more present, the greater the potential for corrosion and the greater the neutralizing amine costs. Reducing the makeup alkalinity can greatly reduce the potential for carbonic acid corrosion in the condensate return system and the associated condensate treatment costs. A dealkalizer should be considered whenever condensate corrosion cannot be adequately or cost effectively controlled using chemicals alone.
2. Although a minimum level of alkalinity is desired in the boiler water for corrosion and deposit control, high levels can cause foaming and carryover. If the feedwater alkalinity is high, a high blowdown rate may be required to keep the boiler alkalinity within the desired range. Reducing the makeup alkalinity can significantly reduce blowdown requirements and lower the fuel, water, and treatment costs.

Chloride Cycle Dealkalization

Dealkalization is the removal of alkalinity ions from water. Chloride cycle dealkalization is perhaps the simplest method and can be cost effective in many situations. Chloride cycle dealkalizers operate similarly to sodium cycle softeners using the principle of ion exchange and regeneration using concentrated sodium chloride (salt) solutions. However, in a chloride cycle dealkalizer, anion resin is used instead of a cation resin. When regenerated with a concentrated solution of sodium chloride, the anion resin becomes charged with chloride ions. When water is passed over the resin

during the service cycle, the carbonate, bicarbonate, and sulfate ions become attached to the exchange sites and an equivalent amount of chloride ions are released. Since this exchange process is considerably slower than in a softener, the service flow rate must be lower (typically 2-3 gpm/ft³), larger tanks are needed, and the minimum bed depth must be greater (30" for a dealkalizer vs. 24" for a softener). A properly operating chloride cycle dealkalizer will reduce the alkalinity of the influent water by about 90% $\pm$ 5%. The chloride level in the effluent will increase by about 1 ppm for every ppm of alkalinity and sulfate removed.



Regeneration

Eventually, the resin will become saturated with the anions being removed and the alkalinity level in the effluent will rapidly increase. A chloride cycle dealkalizer should be removed from service and regenerated whenever the alkalinity in the effluent exceeds 10% of the raw water alkalinity. The regeneration process consists of the same basic steps as used by a sodium cycle softener: backwash, brine draw, slow rinse, and fast rinse.

Backwash: removes suspended solids on the resin bed. This process expands the bed, releases the solids, and prepares the bed for brine draw. The backwash flow rate for a chloride cycle dealkalizer should be 2-3 gpm/ft² of bed area. *Do not backwash a new resin bed during the initial startup.*

Brine Draw: regeneration can be accomplished using either salt (NaCl) alone, or a combination of salt and caustic (NaOH). The normal salt dosage is 5-7 lbs/ft³ of resin.



Higher salt dosages do not appreciably increase exchange capacity. However, the addition of 0.25-0.50 lbs/ft³ of 100% NaOH along with the brine does significantly increase capacity, as well as convert any free CO₂ gas in the water into bicarbonate alkalinity (HCO₃) so it can be exchanged by the resin. The addition of caustic during regeneration also has the benefit of slightly increasing the pH of the effluent. Caustic is typically pumped into the brine tank or brine line during regeneration. During brine draw, an approximately 5% brine solution is directed to the top of the resin bed for a minimum of 30 minutes. As the brine flows downward through the resin bed to the drain, the high concentration of chloride ions causes the anions attached to the resin to be exchanged for chloride ions. The flow rate should be about 0.5 gpm/ft³ of resin for optimum regeneration efficiency. The water fed into the dealkalizer and used for regeneration must be soft (<1 gpg) to prevent resin fouling. Consequently, a softener is almost always installed ahead of a dealkalizer. Clean, high-quality salt must also be used to help avoid resin fouling, which is difficult to detect. Test results will usually reveal poor alkalinity removal, but the cause is not obvious. Fouling is a particular concern where both salt and caustic are used for regeneration.

Slow Rinse: when the brine draw is complete, soft water continues to be directed through the resin bed for about 15 minutes at the same flow rate used for brine draw (at least two bed volumes should be passed through the resin). This slow rinse step completes the ion exchange process and pushes the brine from the resin bed to the drain.

Fast Rinse: when the slow rinse is complete, a fast rinse at the service flow rate is directed to the top of the resin bed and through to the drain. This step lasts about 15-20 minutes and flushes the remaining brine from the resin bed. Afterward the dealkalizer is ready to return to service.

Sizing a Chloride Cycle Dealkalizer

To properly size a dealkalizer, the water analysis must include the following parameters: P- and M-Alkalinity, Chloride (Cl), Sulfate (SO₄), Total Hardness, and Conductivity. This information is required to calculate the exchange capacity of the anion resin. Depending on the regeneration method and the ratio of alkalinity ions to the total anion load, the capacity can range from 5,000-12,000 grains of alkalinity removal per cubic foot of resin. Ideally, the sulfate and chloride concentration should be less than 50% of the total anion concentration to maximize efficiency and avoid leakage. Where caustic is used with salt for regeneration, a minor amount of silica (<10%) may be exchanged during different portions of the service cycle. A dealkalizer system typically includes a softener and must be carefully engineered so sufficient flow is available to meet process and regeneration requirements.

Advantages and Disadvantages

A chloride cycle dealkalizer offers key advantages over other alkalinity removal methods

- Acid is not required
- Regenerants are inexpensive and less hazardous
- Degasifier is not required
- Repressurization is not required

However, there are some disadvantages to using a chloride cycle dealkalizer versus other methods

- The efficiency is relatively low (a large amount of regenerant may be required, especially at high flows or if the ratio of alkalinity ions to total ions is low)
- If the ratio of alkalinity ions to total ions is low, the unit must be larger and more resin must be used
- There is no total dissolved solids (TDS) reduction
- A softener is required

A chloride cycle dealkalizer offers the best payback when the makeup alkalinity is high (>100 ppm) and the percent condensate return is low or when the cycles can be increased. High sulfate and chloride levels reduce regeneration efficiency and the overall cost effectiveness of this method. Regardless of the payback, a dealkalizer should be considered whenever condensate corrosion cannot be adequately controlled using chemicals alone.