by Francis J. DeSilva

Guidelines for Cation Resin Replacement

A properly operating softener or demineralizer is an essential part of any pretreatment regimen. Influent boiler makeup water that contains impurities such as hardness, alkalinity, or other dissolved minerals can complicate the maintenance and have a negative effect on the economics of a steam-generating boiler system. This article discusses strong acid cation resin typically used in water softeners or as the first unit in a two bed cation-anion demineralizer. Future discussions will focus on the anion resins.

Identifying the Problem

Periodic and careful checking of ion exchange equipment can help prevent unexpected downtime and predict when it will be necessary to change regeneration procedures, introduce techniques to clean resin from fouling substances or replace old resin with new. A review of plant operating records and discussions with plant personnel are necessary first steps to gaining a complete understanding of what is happening in or to the softener, dealkalizer or demineralizer.

When a problem such as high leakage of hardness or sodium or short run lengths develops, a review of properly kept records will reveal whether the problem developed gradually or suddenly. The sudden appearance of a problem usually indicates an equipment-related mechanical problem. A gradual trend indicates something chemical in nature, perhaps the ion exchange resin itself.

In either case, the obvious potential problem sources should be checked first. Look at a recent analysis of the inlet water. Has it increased in TDS? Have the relative ionic ratios changed? The inlet water temperature also can play an important part. Seasonal changes, especially those during fall and winter when the temperature decreases, create a more viscous water is created that causes a greater expansion of resin during the backwash step. This can lead to a loss of resin during the backwash if the flow rate is not adjusted. Lower water temperatures also can cause reduced operating capacities, especially in old and weakly ionized (weak base and weak acid) resins.

Mechanical items also should be inspected. Are the valves and controllers operating as they should? When was the last time the instrumentation was calibrated? Is the regeneration scheme introducing chemicals at the proper concentrations and flow rates? Once the obvious sources have been eliminated as the potential problem, it is time to move on to the ion exchange resin.

Table 1

Type of unit	When to measure bed depths in cation units
Softener	After regeneration
Demineralizer	After regeneration if resin was purchased in hydrogen form
	Before regeneration if resin was purchased in sodium form

Sampling Techniques

An accurate and representative sample of resin from an ion exchanger unit is an indispensable troubleshooting aid. A core sample accomplishes this most effectively. This can be done by inserting a piece of one-in. PVC pipe or thin walled tubing into a resin bed that has been drained of water to just beneath the resin level. The pipe should be long enough to reach to the bottom of the vessel in order to get a true core sample, but care must be taken not to damage the bottom strainers or distributors. After inserting the pipe into the bed, cap the top of the pipe with a stopper (or your hand) and pull it out of the vessel slowly. The sample should be emptied from the tube and mixed, and at least a quart of this mixture should be submitted to the lab for analysis. Two quarts should be used for mixed bed samples.

During the sampling procedure, be sure to check the bed depth of the exhausted resin unless the resin was purchased in the regenerated form. It is normal to lose small amounts of resin over time due to backwashing, but a gross difference between the original bed depth and the depth at time of sampling points to other problems. Make sure the bed depth is measured in the same ionic form as purchased. Any crud or dirt buildup on the top of the resin bed should be noted and sampled to determine its identity (accumulated dirt, polymer carryover, biological growth, etc.). See Table 1. The most important step of the sampling process is labeling the sample. Labels include the date the sample was

taken, the unit from which it was taken, the condition of the resin at the time of sampling (exhausted or regenerated), the type of resin, the age of the resin and the name and phone number of the plant and/or a contact at the plant. Some of this information may not be readily available, especially in older installations, but every piece of data can help to uncover the reason for the resin's poor behavior. Additional information such as a description of the problem, the inlet water analysis, plant operating trends and any other observations also are helpful tools for the laboratory investigation and should be included in a cover letter.

Interpreting Laboratory Test Results

Moisture Analysis

The moisture analysis test places a weighed amount of resin (in a reference ionic form) into an oven to evaporate all the water from the resin. At the end of the drying period, the resin is again weighed. The difference in weight is the moisture that was contained in the resin. The percent moisture of the resin can give a good indication of the remaining physical life of the resin. Resins that are in contact with oxidants such as chlorine will decrosslink. This decrosslinking occurs from the oxidative attack on the divinylbenzene (DVB) links within the resin bead. As the DVB is oxidized, it allows the styrene molecules in the bead to absorb more moisture. A resin with a high moisture content probably has undergone some kind of oxidative attack.

A standard 8 percent strong acid cation resin in the sodium form has a moisture content of 45 to 49 percent when new. When the moisture content increases to a level near 60 percent the resin should be replaced. Oxidized resin is softer, less dense and can be lost through backwash. Also, an increased potential for channeling or high pressure drop exists due to the poor hydraulics.

Capacity Tests

The capacity tests performed in our laboratory measure the total capacity of the resin. This is different from the operating capacity in normal service which is usually only 25 to 75 percent of the total capacity. Cation resin can be a candidate for replacement if the laboratory capacity is less than 75 percent of new values. New cation resin has a capacity of 1.9–2.0 meq/ml. Multiply by 21.85 to convert meq/ml to kilograins per cubic foot.

Whole Bead Count

The bead count is performed under a microscope. It measures the total number of whole perfect beads, whole cracked beads and broken fragments. It presents each of these numbers as a percent of the total count. The ResinTech laboratory uses a conservative approach by counting each one of the broken bead fragments as a single bead. A weighed counting method used by others estimates the fraction of a broken bead that a fragment represents and adds together these fragments until a total bead is created; these fragmented pieces are then counted only as a single broken bead. Using a weighted count leaves too much room for individual error.

A high degree of broken beads could lead to hydraulic problems such as high pressure drop or channeling. When these broken particles are small, they are more prone to loss during backwash. These symptoms may sound very similar to the problems that can occur with an oxidized bead. This is no surprise since oxidation weakens an ion exchange bead and makes it susceptible to breakage. If broken beads constitute more than 25 percent of the resin sample and the unit is experiencing hydraulic problems, rebedding should be considered.

Fouling

Cation exchange resins used in softeners can be fouled with metallic contaminants such as iron, copper, aluminum, barium, strontium and others. Cation resins used in two bed demineralizers are regenerated with acids and the metals usually do not present a problem. Other foulness found in both applications are bacteria, organics, oils, greases and suspended solids.

The microscopic analysis used to determine the whole bead count also can reveal other contaminants that have been filtered out by the resin. These and other observations by the laboratory chemist during the backwash and preconditioning steps of the capacity tests also may detect whether the resin is fouled or other problems exist.

Quantitative tests may be performed to measure the amount of metals on the resin. When the metal content exceeds 100 grams/cubic foot, the resin usually is considered a candidate for a cleaning procedure.

Conclusions

Laboratory results of ion exchange resin testing need to be interpreted as a whole. The rule-of-thumb guidelines presented above must be taken in concert with the expert opinion of the resin manufacturer or laboratory staff before deciding upon remedial action.

About the Author:
Francis DeSilva has worked in the water treatment industry for over 20 years. He is national sales manager for ResinTech, Inc., and currently is the director of the Water Treatment Section of the Liberty Bell Corrosion Course.

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