GUIDELINES FOR ANION RESIN REPLACEMENT

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Water purification by ion exchange is an important part of the pretreatment scheme for almost all boiler water applications. Cation resin in the sodium form is used to soften water, and in the hydrogen form to remove all cations including calcium, magnesium, sodium, potassium, and iron. Anion resins in the chloride form are used to remove alkalinity and in the hydroxide form will remove all anions including sulfate, nitrate, chloride, alkalinity, and silica. Resin sampling and cation resin replacement were discussed in a previous article, AWT Analyst October, 1993. This article will focus on strong base anion resins.

Anion resins are always more expensive, less stable, and have a shorter operating life than cation resins. When the anion resin is in a two bed demineralizer configuration, operated in the hydroxide form, it requires a more expensive regenerant than the cation unit. The anion unit is regenerated with sodium hydroxide while the cation unit is regenerated with sulfuric or hydrochloric acid. The anion resin cycle contributes the most to the operating cost of a two bed demineralizer.

Identifying the Problem

Periodic and careful checking of ion exchange equipment can help prevent unexpected downtime and help predict when it will be necessary to change regeneration procedures, introduce techniques to clean resin from fouling substances, or ultimately replace old resin with new. A review of plant operating records and discussions with plant personnel are a very necessary first step to gaining a complete understanding of what is happening in or to the ion exchange unit. Factors that effect the predicted life of an anion exchange resin include: the regeneration level, the regenerant temperature, the operating water temperature, the presence of dissolved oxygen, the presence of fouling substances, and the presence of other oxidizing agents or interferences. Gnerally, type 1 anion resins last 5 to 7 years, type 2 4 to 6.

Loss of Capacity

The aging and deterioration of anion resins is not as straightforward a process as it is in cation resins. With cation resins, the moisture retention of the material can be fairly well correlated with the total capacity. This is not the case with anion resins. The anion resins degrade chemically by two paths. One path results in the complete loss of an amine functional group. The type 1 anion resins degrade chiefly by this route in normal service. The second manner in which anion resins degrade is by a change of functionality, where the strong base sites are converted to weak base sites. The resultant weak base sites are very stable. Type 2 anion resins degrade primarily by this method.

Long Rinses

Anion resins in two bed and mixed bed demineralizers are particularly susceptible to organic fouling. Fouling can cause short runs and extended rinses. The appearance of these symptoms is usually gradual as the accumulation of organic material on the resin happens gradually. Long rinses can also develop from the change in functionality of strong base anion resins as some of the sites degrade from strongly basic to weakly basic. Figure 1 shows the rinse requirements of strongly basic anion resins as a function of the weak to strongly basic sites ratio. This information can be used with the information from anion resin laboratory test results to calculate theoretical rinse requirements and compare this to the actual field conditions. If the actual rinse volumes are greater than the calculated projections, there is probably some organic fouling present.

High Silica Levels in Two Bed Effluents

The effluent from two bed demineralizers should be free of hardness and have only very low levels of sodium and silica present. When rising levels of silica are seen in the effluent of the demineralizer, the anion unit is the most obvious source of the problem. The anion unit can be the culprit from loss of strong base exchange capacity of the resin or from mechanical problems such as channeling or flow bypass. More commonly, though, the problem stems from the cation unit. A poorly operating cation exchanger will leak high levels of sodium during the run. These sodium ions become associated with an hydroxyl ion in the anion bed, forming sodium hydroxide. Although this sodium hydroxide is present in relatively low levels, it can act as a mild regenerant and push previously collected silica ions off of the bed, increasing leakage during the run.

Interpreting Laboratory Test Results

It is important that anion resin samples be tested in the proper ionic form. Usually that is the salt, or chloride form. Anion resins swell considerably from the chloride form to the hydroxide form, with some types of anion resin this can amount to well over 20% swelling. Laboratory test data usually notes the reference form that the resin was tested in.

The ionic form and its corresponding swelling or shrinking of the bed can have a profound impact on the bed depth of the ion exchange unit. It is extremely important in anion units that the bed be in the correct ionic form before measuring the bed height. Most anion resins are purchased and loaded in the salt or chloride form.

Moisture Analysis

The specification values for the moisture content of new anion resins are stated as a range. Typical ranges are found below, all measured in the chloride form:

Name	Type	Moisture %
ResinTech SBG1P	Type 1 porous	51 - 57
ResinTech SBG1	Type 1 standard	43 - 47
ResinTech SBG2	Type 2	38 - 44
ResinTech SBACR	Type 1 acrylic	57 - 62
ResinTech SBMP1	Type 1 macroporous	50 - 60

When the moisture content is about 10% below or above the stated ranges, the other laboratory test data needs to be checked to see if the resin has been fouled or has lost capacity. Either one can skew the numbers of the moisture test.

Whole Bead Count

A high degree of broken beads can lead to hydraulic problems, such as high pressure drop or channeling. When small, the broken particles, or fines, are more susceptible to loss during backwash. If broken beads constitute more than 25% of the resin sample, and the unit is experiencing hydraulic problems, resin replacement should be considered as well as an investigation into what caused the breakage.

Capacity Tests

The capacity test results will report the amount of capacity lost and also indicate the degree of mixed functionality that the resin has attained. For instance, a four year old type 2 anion resin may have lost 50% of its strong base capacity but gained a significant amount of weak base capacity as it has aged. A rule of thumb that is often referred to is that an anion resin is a candidate for replacement when it has lost 50% of its strong base capacity. This rule of thumb, however, does not take into account the nature of the water that the resin is treating.

The total capacity number is the sum of the strong base (or salt splitting) capacity and the weak base capacity. The strong base sites are able to remove all common anions; silica, alkalinity, chloride, nitrate, and sulfate. The weak base sites do not remove those anions that form weak acids, namely, silica and alkalinity. The weak base sites only remove the anions that form strong acids in the cation effluent, most commonly chlorides and sulfates, in the form of hydrochloric acid and sulfuric acid. The total capacity of new strong base anion resins is almost totally strong base functionality. As the resin ages, it will lose capacity and also have some of its strong base capacity converted to weak base. New resin capacity figures, reported in the chloride form, are shown below:

Name	Type	Total Capacity
ResinTech SBG1P	Type 1 porous	1.25 meq/mL
ResinTech SBG1	Type 1 standard	1.4 meq/mL
ResinTech SBG2	Type 2	1.45 meq/mL
ResinTech SBACR	Type 1 acrylic	1.2 meq/mL
ResinTech SBMP1	Type 1 macroporous	1.15 meq/mL

Capacities are usually reported as milliequivalents per milliliter (meq/mL). To convert to kilograins per cubic foot (kgr/cu.ft.), multiply by 21.85.

To accurately determine the condition of the anion resin based on its capacity, the water analysis must be considered. Referring back to the example of the four year old type 2 anion resin that has lost 50% of its strong base capacity but has a significant amount of weak base capacity, we would expect the resin to still behave well on a water with a high percent of chlorides and sulfates and corresponding low percent alkalinity and silica. This would be typical of water that has been treated by a cation unit and forced draft degasifier. If however, the anion resin is used to treat a water relatively high in alkalinity, the capacity would be limited. That is why type 2 anion resins are not recommended to treat waters with more than 25 to 35 percent weak acids.

ResinTech has developed software that uses the laboratory test results as inputs to predict the performance of the resin that was sampled and tested. This program can predict the capacity, leakage, and throughputs of used anion resin on a specific water analysis or on a range of different operating conditions. Figure 2 compares new type 2 anion resin capacity on a water with 32% alkalinity with a 4 year old sample that has lost about half of its strong base capacity. The capacities are shown over a caustic dosage range of 3 to 10 pounds per cubic foot.

This information is very useful for plants that are trying to economize caustic usage. Operators of two bed demineralizers may tend to increase caustic dosages to compensate for capacity losses as the resin ages. The computer program can assist in the adjustment of caustic dosages, especially in determining the upper limits. Consulting Figure 2 we see that the capacity curve for the older resin is somewhat "flatter" than the curve for the new resin, there is not much more capacity gained by dosing the older resin at the high end of the scale, so the operator may want to limit the caustic dose to around 6 lbs/cu.ft.

Organic Fouling

The products of vegetative decay are present in most all water supplies as tannic and humic acids. These organic substances are collected quite readily by anion exchange resins but are difficult to remove during normal caustic regeneration. As organics are collected on the resin, the rinse water requirements gradually increase, and capacity and effluent pH can decrease.

The laboratory can detect organic matter on a resin quantitatively or qualitatively. The resin to be tested for organic fouling should be regenerated before sampling so that any organics removable by the normal regeneration are not present on the resin sample. The ResinTech laboratory utilizes a qualitative technique for testing anion resins that measures the capacity of the resin as received and then again after a treatment to remove organic foulants. The treated or cleaned resin usually exhibits an improvement in laboratory capacity.

It is not always easy to correlate the improvement of capacity in the lab sample to the anticipated improvement of operating capacity in the field. This is because of an inability to determine how the resin is fouled. The organic molecules can be situated mostly near the perimeter of the bead where they not only occupy exchange sites but also impair the kinetics of the exchange sites in the interior of the bead. Therefore, a cleanup performed in the field may yield a percent improvement in capacity greater than what the lab cleanup did.

Fouled anion resins that can be successfully cleaned up generally exhibit capacities higher than what is expected for resins of their age. This is because the collected organics tend to protect the beads from oxygen. Strong base anion resins lose capacity faster when in contact with oxygenated water supplies.

Conclusions

The interpretation of laboratory test results of strong base anion resins is not as easy as it is for cation resins. As the anion resins age they suffer a degradation of capacity, almost always contain some degree of organic fouling, and can also be impacted by the condition and performance of the preceding cation unit. The most common malady afflicting the anion resins in two bed demineralizers manifests itself in the form of extended rinses, either from organic fouling or from a change in functionality. The operator notes this as an inconvenience of time and also as an increase in the consumption of water.

The cost of replacing a bed of anion resin certainly justifies the relatively small amount of time and effort it takes to sample and test the resin.

Is the anion resin the source of the problem? To be sure you may want to get the cation resin checked at the same time.

Can the resin be cleaned up? The performance of a single cleanup procedure may not be enough to bring back the resin to acceptable condition. Organic foulants are slow moving and may require repeated soaks or cleanups before an improvement in operating capacity is found.

Always observe the current state of operating conditions before rebedding a unit with new resin. Has the inlet water analysis changed? If it has, is the right anion resin in use? Consider other types of anion resins: Would a type 2 anion resin give better capacity for your application? Would an acrylic anion resin offer longer life because of its resistance to organic fouling? Should a macroporous resin be considered to handle harsh operating conditions?

It is always a good idea to review the water analysis and laboratory resin report together and to get expert recommendations from your resin supplier.