Sampling Quality

and the Quality of the Sample

The key to good resin management is good sampling

by C.F. "Chubb" Michaud, CWS-VI

In order to properly maintain and service an installed ion exchange bed, one must take periodic samples and test for specific properties, comparing the results to the analysis of the originally installed bed. This creates a trend line for such important properties as capacity and moisture. Oh, you forgot to get that information? Just tell the resin manufacturer the resin grade and lot number and he'll look it up for you. Didn't write that down either? Uh huh. If this describes you or your customer, you are in the majority. I will add, however, it is impossible to plan your journey if you don't know where you started.

The need for sampling

In a previous article on resin oxidation, (C.F. Michaud, "Oxidizers, Age and Softening Resins," *WC&P*, August 2000) it was pointed out that as resins age, they become less productive. They require more regenerant per equivalent of exchanged ions and their selectivity becomes a little weaker. This produces higher average leakages and thus, shorter service runs. At some point, the extra cost of regenerant will exceed the costs of resin replacement and it becomes more cost effective to replace or re-bed the resin rather than continue wasting chemicals and water.

Resin manufacturers generally test every batch of product and retain both the sample and the test data for several years. If you are an end user of ion exchange resin, get this information from your vender on every batch of resin you install. If you are an equipment or service provider, record this information with your instruction manual. If you ever have to troubleshoot or service this equipment in the future, this simple step will save hours of frustration and thousands of dollars in labor and down time. Most resin manufacturers will be more than willing to provide basic resin analyses on major installations on a free-of-charge basis or for a nominal lab fee. At a minimum, periodic determination of resin capacity and moisture plus a visual account of the resin's condition (whole beads, cracked beads and fines) will provide a wealth of information to track the resin's life cycle. To do this you need two things: good records and good sampling techniques.

The information you require should allow you to determine the ongoing operating costs and the point at which rebedding becomes economically advantageous. As a rule of thumb, by the time the operating capacity has dropped 20 percent from the original bed capacity, you have crossed into a point where rebedding would be cost effective.

If we assume that salt costs $0.05/lb, acid costs $0.15/lb. and caustic costs $0.25/lb. and that we are regenerating every day with 10 lbs. of chemical, we can calculate our annual costs and saving as shown in Table 1.

Consuming 75 gallons of water per cu. ft. per regeneration, we will use 27,375 gallons of water/year/cu. ft. At $3.00/1,000 gallons that's an additional $82.13/year/cu. ft. Keep in mind that as the resin swells, the pressure drop will increase and therefore the cost of power. By now, you have no doubt decided that a 20 percent drop-off in capacity is the absolute end of the run. In many cases it could be sooner—much sooner.

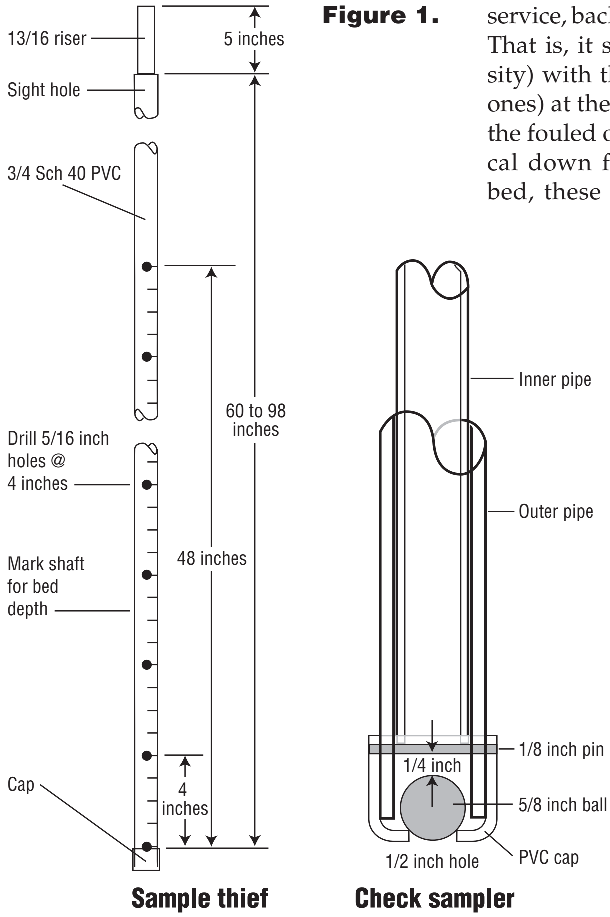
Portable exchange plants are faced with a higher chemical cost per volume of water treated and with a corresponding increase in direct freight and labor. Instead of a 10 day cycle, you drop to an eight day cycle. You can work an extra shift or buy a few more trucks and drivers, build a bigger plant—or upgrade your float.

Without well kept records, end users of resin will have to depend upon a spot analysis to determine the bed condition. This will involve sending a sample of your resin out for analysis. Often this report will not show the "dynamic" changes occurring in the resin nor offer useful information for predicting bed life.

Table 1.

	Cost/lb.	Cost/day/cu.ft.	Cost/year/cu.ft.	Water cost	Total $	20% savings
Salt	$ 0.05	$ 0.50	$ 182.50	$ 82.13	$ 265.63	$ 53.13
Acid	$ 0.15	$ 1.50	$ 547.50	$ 82.13	$ 629.63	$ 125.93
Caustic	$ 0.25	$ 2.50	$ 912.50	$ 82.13	$ 994.63	$ 198.93

Figure 1.



You need good information over time for that. Also, the cost of this analysis may run $150 to $300. That cost may make the monitoring of small installation and residential units unaffordable. When all else fails, softener resins will cross over in six to eight years on city water and 12 to 15 on un-chlorinated well water (assuming no iron fouling). Acid regenerated cation exchangers might last five to seven years and anions three to five years. Depending upon the end quality requirements, mixed beds will last one to three years.

There are a number of factors that contribute to the decline of service life of resin. In general, the severity of the service (temperature and pressure) and the frequency of regeneration are the two with the highest impact. Resins do not wear out suddenly but they do fail at an increasing rate with age. About 50 percent of the degradation may occur in the last 20 percent of the resin's service life. If you have decided that resin bed performance monitoring is for you, there are some things you should know about sampling.

There are approximately 175 million beads in a cubic foot of resin. Like snowflakes, they are all different. Normal resin beads range in size from 300 to 1,200 microns and average about 600 microns. In service, backwashing classifies the beads. That is, it sorts them by size (and density) with the smaller ones (and broken ones) at the top and the larger ones (and the fouled ones) at the bottom. In a typical down flow co-current regenerated bed, these beads do not move around much over time. Small beads and fines will accumulate at the top of the bed. Should fouling, such as iron or silica occur, those beads will drop further down in the bed. If there is chlorine in the feed water, it will attack the top of the bed more than the bottom. After a few months of operation, there will be very few "average" beads. Each zone will have aged in a different manner. How then do we determine the characteristics of our resin bed down the road?

Proper sample taking is key

Statistically, the very notion of testing a sample to get a representation of the whole is inherently flawed. If you want to know how much an average chicken weighs, you have to first weigh all the chickens and then do the math. If you want to know the condition of an ion exchange bed, you must test the entire bed. This, of course, is impractical. As an alternative, we can test a representative sample. The significant word here is representative. Anything else will be inaccurate. No matter how exact the analysis, the results will not be reliable if the sample is not reliable.

How much variation can there be in one bed? Consider the case of "premature" resin failure. A grab sample taken from the top six inches of the bed shows excess broken beads, fines and high moisture. These all indicate that the bed should be changed. In addition to unnecessary and costly change outs, there are many problems that go undetected because the sample is pulled from a spot other than where the problem occurred. I have made recommendations to add anion or cation resin to mixed bed float because the ratios were off when indeed, it was the sampling that was off. The spread between the top, middle and bottom of the bed increases with age. A softener that has been in service for two years will show up to two percent difference in moisture and five percent in capacity from top to bottom. This difference continues to grow with age. So what is a proper sample?

Sampling new resin is easy. A cup of resin from each of four random drums or bags before it goes into the tank will suffice. If there are multiple lots, sample each lot and blend them to make a composite sample OR, take a core sample after filling the tanks. Later on, you will have to use the core sampling technique to get a representative sample for analysis.

A core sample is just that. It is taken from all levels of the vessel by inserting a rigid 1/4 or 3/8 inch pipe (copper is fine) through the tank opening. Work it down through the bed with short up and down stokes. Once you reach the bottom of the bed, place your thumb over the open end to plug the top and extract the sample by pulling the pipe quickly out of the bed. Have a container handy to place the bottom end of the pipe into and release your thumb. The resin will run out of the pipe into the container. Repeat until you have at least a pint of resin. This technique works great for PEDI tanks but might prove difficult if you are trying to reach down into an 8-foot high vessel. In those cases you should use a sample thief.

It takes a thief

Sample thieves can be purchased but you can make your own. Use two pieces of PVC pipe approximately 6 to 8 feet long. One should slide snugly inside the other. I use a 13/16 inch thin-walled riser pipe and standard 3/4 inch Sch 40 PVC. Cut the larger pipe about 4 inches shorter than the smaller and glue or slip a cap on one end (of the larger). Slide the smaller pipe all the way inside the larger. The smaller pipe should be snug but still turn or slide freely. Mark the bottom of the outside pipe as close to the cap as possible and every four inches up to 48 inches and drill the marks with 1/4 inch holes. In line and at the top of the larger pipe drill another 1/4 inch hole. This hole serves as a guide for all the others (see Figure 1). This should now resemble a flute. When the inner pipe is slid up or rotated about 1/2 inch, it will blind off the holes.

Using a simple sample thief

To obtain a sample, close off the holes by raising the inner pipe 1/2 inch. Insert the pipe down through the resin bed (this works best when the water level is a few inches above the resin. Align the top guide hole by sliding the inner pipe down again. This opens all of the sample ports. Move the sampler up and down in two to three inch strokes to allow resin to enter. Close the ports by drawing the inner pipe up again and extract the sample. Each lift is about 12 cubic inches and it will take three to four extractions to get sufficient resin. Take the samples from different parts of the tank. A shorter version can be made for PEDI tanks. You can also mark a scale on the sampler by marking between the holes as shown in Figure 1. This way you can get the bed depth measurement at the same time. Should you need to get a sample from a specific part of the bed, you can blind off most of the upper holes with masking tape and use only one or two at the bottom. Using the "yard stick" measuring guide marks, insert the pipe to the level you want to extract the sample from. Then open the ports. Keep your thumb over the top of the inner pipe and draw the sample by pulling up on the inner pipe (like a giant hypodermic syringe).

You can even go "modern" and build a sample thief specifically for a measured level sampling. Use a rounded PVC glue-on cap at the bottom of the 3/4 inch pipe and drill a 1/2 inch hole squarely in the bottom end. Drop a marble (or ball bearing or small rubber ball) inside the pipe. Try to find one that is 5/8th inch (0.625"). Drill an 1/8 inch hole through the top edge of the cap leaving a 1/4 inch gap between the top of the ball. If there is not enough space, you can drill through the bottom of the outer pipe above the cap. Then insert a plastic pin and glue in place (PVC welding rod works here). You now have a check valve. You can now suck in a sample from the top or middle or eight inches off the bottom—wherever you wish—by using the inner pipe as a plunger. The pin will keep the ball from falling out when you dump the sample (See Figure 1). Good luck.

Conclusion

Tracking the capacity and moisture holding of a resin installation will allow timely change outs when it is more economical to do so rather than continuing to waste money on increased frequency of regeneration. Different resins have different aging characteristics and different economic change out points. To properly track, you must properly sample. Factor in the labor cost of re-bedding when doing your economic balance.

About the author

♦ *C.F. "Chubb" Michaud, CWS-VI, holds bachelor's and master's degrees in chemical engineering from the University of Maine and has more than 30 years of professional experience in water and fluid treatment processes. Michaud is technical director for Systematix Inc. of Buena Park, Calif. He is also chairman of the Water Quality Association's Ion Exchange Task Force, sits on the Science Advisory Committee and is a founding member of the WC&P Technical Review Committee. Michaud can be reached at (714) 522-5453, (714) 522-5443 (fax) or email: cmichaud@systematixUSA.com*