Reducing Regeneration Waste

Reduce waste volume and save money by eliminating treating/hauling fees

by Charles F. "Chubb" Michaud

Demineralization by ion exchange is not only an effective way to purify water, it is also an effective way of concentrating waste streams to reduce the volume of liquid that has to be treated. Large volumes of water can be processed between regenerations. However, with tighter laws governing waste discharge, ion exchange "efficiencies" must also keep an eye on the quantities of wastes produced. This article pertains to various considerations for regeneration and their relative roles in waste volume generation. It includes softening, clean water DI and wastewater DI.

The regeneration of an ion exchange bed consists of backwashing, chemical draw, displacement rinse and fast rinse or quality rinse. Most literature calls for backwashes as long as 30 minutes, chemical draws of 30 to 60 minutes, displacement of 30 to 60 minutes and a service rinse of 20 minutes at full flow. Using a "typical" resin system in "typical" co-current regeneration conditions, one can consume 100 gallons of water in regenerating a single cubic foot of resin with over 70% of it in the backwash and final rinses.

Commercial softeners and cation demineralizers may routinely use 120 to 140 gallons of water per foot of resin to regenerate. Anions will use up to 80 gallons per cubic foot. *The main difference between cation and anion volumes is in the backwash requirements.*

Assuming 20 grain water with 10 grains of hardness, softener regeneration produces one gallon of wastewater for every 19.2 gallons of soft water. Hydrogen from cation produces only 9.6 gallons and anion yields 8.75 gallons for each gallon of waste produced. A two-bed demineralizer can therefore produce 225 gallons of wastewater for each 1000 gallons of DI water it produces. That's an 81.6% yield! This relatively low efficiency in water use by ion exchange is barely comparable to that of an RO (which is often thought of as a water waster). When loading above 350 ppm (as $CaCO_3$), the demineralizer system becomes less efficient in water usage than a two stage RO. Better system designs will be required to reduce this waste in the future.

Since most of the water used for ion echange regeneration is in backwashing and final rinse, reducing these volumes has the largest impact on water utilization. Softener backwash water can be almost eliminated by recycling. Recycling uses may include irrigation or plant utility water, or it can be reused over and over by filtering out the dirt, disinfecting with chlorine and backwashing with it again. This can amount to a savings of 40 gallons or more per cubic foot.

Brine can be bumped up in concentration from 10% to the 12.5% level which can trim an additional 5 gallons from the draw and slow rinse steps. By recycling 50% of the brine and displacement rinse water — the first half of the displacement rinse is used to make up fresh brine — 10 more gallons can be saved.

Interrupting the end of the displacement rinse by "holding" the bed for 30 minutes can reduce fast rinse requirements by one BV (bed volume = 7.5 gallons). Putting the unit back in service before the final rinse is completed can save an additional BV and the slightly elevated TDS (which is pretty much free of hardness) can generally be tolerated at the point of use. Redirecting the rinse water to a holding tank for other uses such as utility room sinks and toilets is also a possibility.

Combining our efforts in backwash recycle, brine and rinse reclaim and final rinse utilization can therefore reduce the water requirements of the softener from the 120 to 140 gallon range to a very reasonable 25 to 30 gallons.

Many of the same techniques can be utilized in dealkalizers and nitrate removal systems which also use brine for regeneration. Wastewater can readily be reduced by at least 75%. That would put a softener's water usage efficiency up in the 98+% area.

Demineralizers used on municipal water can reduce their backwash requirements by utilizing adequate prefiltration to keep dirt out of the resin bed. The beds then need only be "bumped" to loosen them and redistribute the resin. Freeboard above the resin can be reduced, which will have an additional waste reduction benefit since there will be less dilution of the regenerant in the head space. Fast rinses can be recirculated provided the displacement rinse is extended to about 3 BV's. Combining these designs can increase the water utility in our earlier example from its 81.6% yield up to a 92+% level even without the regenerant and slow rinses being recycled. An overall efficiency of 90% from a two-bed demineralizer is difficult to achieve.

Wastewater presents an additional incentive for its needs for reduced waste regeneration volumes. This lies in the fact that most wastewaters would produce a hazardous or toxic waste that would have to get treated and/or hauled. Minimizing the waste volume carries a real final savings as well.

There are additional sources of wastewater volumes to be dealt with when treating waste streams. For one thing, the water contained in the pipes, headspace and void volume of the resin is already wastewater. On top of that, we're going to add chemicals to strip whatever is on the resins and the rinse waters will more than likely be hazardous as well — even though they contain only a few parts per million of dissolved minerals (usually heavy metals).

If raw water is used in the process, there is the added injury of having to treat all the original TDS (calcium, sodium, etc.) as hazardous wastes since they will be combined with metals in the regenerant waste. The final insult is that these non-hazardous components may take away up to 90% of the capacity of the resin by occupying sites needed for metal removal. There are people out there who demineralize their water after it has been contaminated with hazardous chemicals — then they throw it away!

Wastewater treatment is an entire science and can't be done justice in the space allowed. Nonetheless, we can offer advice.

The first rule of wastewater treatment is to design your demineralizer system to be effective. It should produce a good quality effluent (often requiring a polisher). Then reuse it as rinsewater in your process. This is particularly applicable to plating shops. Next, use raw water for regenerating your DI system, not DI water. Regenerate the cation first and then use decationized water to regenerate the anion. This saves on DI water and makes the system less complicated. Acid and caustic solution make up can be done with water saved from the first part of the slow rinse volume, and the end of the slow rinse can be saved and used as the first of the next regeneration cycle.

Most wastewater treatment systems utilize a central collection sump to store water. Install prefiltration and backwash to the collection sump. Essentially, the backwash is done with the wastewater stream to be treated. Use a recirculating fast rinse from the collection sump — back to the collection sump. This will use a little capacity but it greatly reduces the waste volume.

Plating waste demineralizer regenerate will contain heavy metals and have to be batch treated or hauled. The suggestions offered here will reduce the volume to be treated to 10 to 15 gallons per cubic foot. As such, the batch treatment plant handling the regenerate waste can be very small, very slow and designed to do a very good job.

Minimizing the waste volumes from ion exchange regenerations can save water and money by reducing the need for make up as well as reducing the cost of disposal. The by-product of a wastewater treatment DI system is DI water and can be reused for rinsing and cleaning.

Laying out a schematic of the DI regeneration system and following the flows in and out of the tanks helps direct the effluent waters away from the batch waste treatment plant. Reuse the effluent for whatever use its purity permits. In addition to recirculating and reclaiming backwash water, regenerants and rinses, the following design selections can bring added volume reductions:

1. Use uniform sized resins
2. Use more concentrated regenerant solutions
3. Use counter-current regenerations
4. Use regenerant take-off headers to reduce the head space dilution *OR*
5. Use packed beds
6. Incorporate interrupted rinses
7. Use Type II anion resins instead of Type I. ❑

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