Protecting Ion Exchange Resins from Suspended Solids

By Frank DeSilva

Cleaning and prevention to avoid fouling

Ion exchange resins used in softening, anion or deionization applications are designed to remove certain ionized substances from water. The resin beads typically range in size from 16 to 50 mesh (1.2 to 0.3 mm) and although they are designed for the removal of dissolved ions, they can become a very effective filter media.

In some specialty applications (e.g., condensate polishing) resins are used as much for their filtration properties as for their ion exchange characteristics. For the most part, however, it is a good idea to keep the resin bed free of suspended particles.

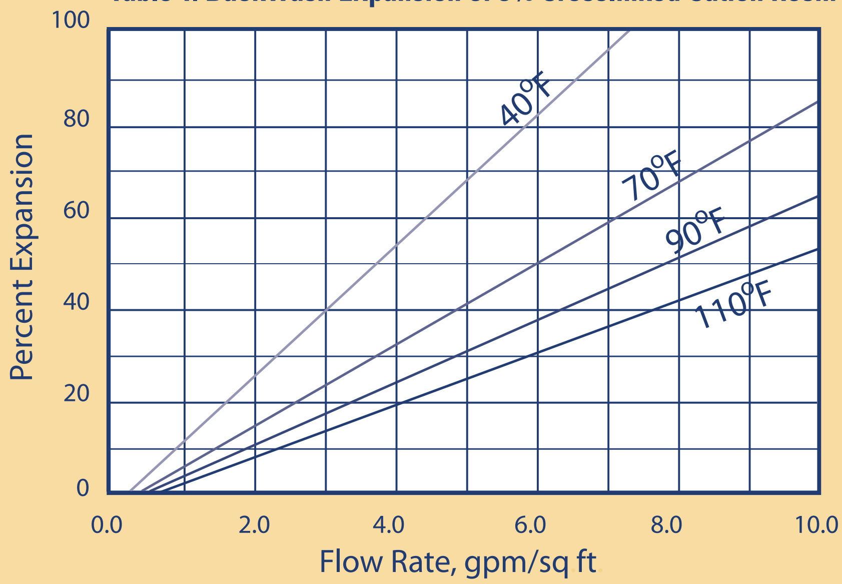
Ion exchange resins have properties relating to their surface properties that cause certain types of materials to coagulate, coalesce, precipitate or just plain stick to the resin beads. This can result in physical fouling of the resin. The foulants can be trapped in the resin bed, coated onto the surface of the resin or a combination of both.

Nonionic and undissolved contaminants include turbidity, silt, mud and dirt, color, organic matter, colloidal silica, microorganisms, bacteria and oil.

Water develops turbidity from the presence of these suspended particles. The higher the turbidity, the cloudier the water. A turbidimeter measures turbidity in nephelometric turbidity units (NTU), which measures the light-scattering effect of suspended particles.

Water with an NTU reading below 0.3 generally has no problem with long-term fouling of ion exchange resins due to a build-up of dirt. In the range of 0.3 to 1 or 2 NTU, there are minimal problems, probably not sufficient to justify pretreatment. Anything more than approximately 2 NTU is cause for concern and may affect long-term operation. Anything more than 10 NTU will rapidly foul ion exchange resin, and some form of solids removal pretreatment should be placed in front of the unit. There is no exact correlation between NTU level and fouling potential because different forms of turbidity have different characteristics.

Table 1. Backwash Expansion of 8% Crosslinked Cation Resin



Lowering TSS

Accepted methods of lowering the total suspended solids (TSS), and subsequently the NTU, include physical filtering with sand, multimedia filters (MMF), zeolites or granular activated carbon (GAC). Some filtration systems employ coagulation aids to help agglomerate and filter out TSS. Table 2 on page 14 shows the nominal micron rating of several filter medias.

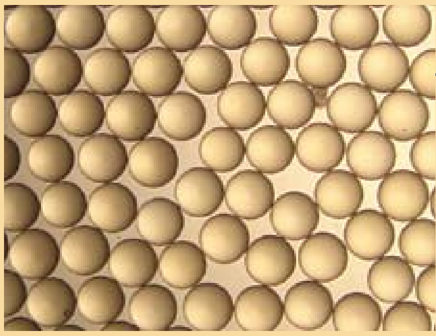
Sand and MMF are relatively heavy, dense medias that require significant backwash flows to periodically clean the media. The equipment design and available flow must accommodate this requirement, which can be cumbersome at times. However, the high flow rate required for the filter media backwash is usually sufficient to clean accumulated dirt out of the filter and provide a good scrubbing action.

The lighter zeolites and carbons are less dense medias and require less of a backwash flow. They are good for systems that do not have a substantial water flow available for a high backwash flow rate, but not as good if one needs to backwash out the heavy dirt or silt collected during service. Also, the use of these media for the removal of suspended solids may impair their absorptive and ion exchange characteristics because of the potential for blinding the media surface area.

It is hard to say which micron rating is best as a pretreatment for ion exchange units. Experience is the best guideline, and differences in local hydrogeology will weigh heavily in the decision. Once a filtration system is selected, care must be taken to prevent the escape of any collected solids to downstream units. If the systems will see variable flow, attempt to make the change in flow gradual so as not to upset the bed. If flow is intermittent, incorporate a one-bed volume rinse step before returning back to service, because every stop-and-go operation can force solids through the bed, and in the case of softer filter media, cause attrition and fines formation.

Fouling Concerns

If the physical units upstream of the ion exchange system fail or are not present, and the downstream resin bed becomes contaminated with suspended solids, problems can develop. The physical foulants cause problems with operation both by blocking the flow passages between the beads and by interfering with the exchange of ions into and out of the beads. The symptoms can include increased pressure loss, flow channeling (bypass of service water or regenerant chemicals), reduced filtration capability, short runs, long rinses and poor water quality. Many



Chemical cleaners, backwashing and air mixing can remedy physical foulants.

Dirty resin can often be identified using a 40-power microscope or even a magnifying glass.

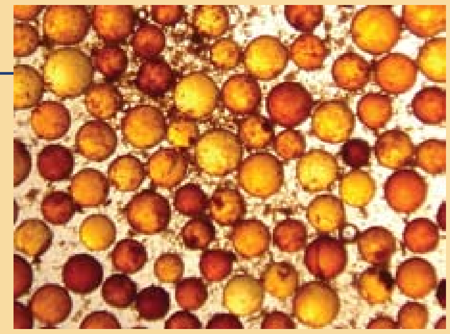


Table 2. Filter Media Nominal Micron Rating

Filter Media	Filtration Efficiency (Nominal)
Sand	25-30 micron
MMF	12-15 micron
Zeolites	3-5 micron
GAC	2-5 micron

of these symptoms are similar to those found with other types of fouling.

Physical fouling is easily identified by visual examination of a sample of resin. A 40-power microscope or even a magnifying glass can be used to examine the resin. If the resin looks dirty, it is dirty.

Physical fouling usually affects the lead bed in a series of ion exchange vessels to a greater extent than downstream beds. Where more than one kind of fouling is present, the physical fouling should be addressed first. Otherwise, any chemical cleaners may be unable to effectively reach the resin.

Cleaning & Backwashing

In many cases, chemical cleaners will loosen or dislodge additional physical foulants. It is often best to physically clean the resin before and after a chemical cleaning. Most co-flow ion exchange systems employ some type of backwash as part of the regeneration cycle. Since backwashing is one method of physically cleaning resin, it is often assumed that the standard backwash is sufficient to keep the resin clean. This is seldom the case.

At 5 gal per minute (gpm) per sq ft backwash flow (typically used for cation resin, see Table 1 on page 12), it takes at least five minutes for water at the top of the resin bed to reach the upper distributor and exit the unit. Any dirt trapped below the surface will not reach the backwash outlet by the time the usual ten-minute backwash ends.

The situation with anion exchangers is worse because the backwash flow rates are almost half those of cation resins. Ten minutes is not long enough to raise the dirt to the backwash outlet. A typical backwash may be completely ineffective to physically clean the resin. Other purposes of backwashing, such as relieving hydraulic compaction and classifying the resin beds, are achieved by the typical backwash step. It is not usually advisable to eliminate the backwash step from a normal regeneration of a co-flow type of ion exchange system.

Most counter-currently regenerated systems do not employ a backwash step as part of the normal regeneration cycle. Some systems have no provisions for backwash at all. Unless the feedwater has very low turbidity, these resins beds will become physically fouled. Despite some claims about the ability of packed bed designs to avoid this concern, it is a fact that if the feedwater contains suspended solids, a portion of these solids will become trapped in the resin bed.

Effective backwashing requires that the resin bed be expanded to a level close to the backwash outlet collector. This introduces a risk of washing the resin out of the exchange tank. Variations of flow or temperature during backwashing increase this risk. One of the most common ways that loss of resin occurs is backwashing at too high a flow rate. The resin bed expansion is sensitive to temperature. Water is denser at colder temperatures and will cause the bed to expand more than it would at warmer temperatures. This means that automatic backwashes probably are not the best way to try to physically clean resin beds. Careful, manually controlled, extended backwashes, performed occasionally as a scheduled maintenance procedure, can be an effective way to keep resin beds from becoming physically fouled.

Air Mixing

When the foulants have had time to harden or have formed a crust on the resin beads, backwashing may be ineffective to remove the dirt. Air mixing the resin bed often creates sufficient turbulence to loosen the foulants and to break up clumps of resin, permitting the subsequent backwash to clean the resin.

The best method to air mix is to introduce air through the underdrain of the exchange tank and let it bubble up through the resin and out the vent. This is assuming that the underdrain is suitable for use with air. Some ion exchange systems use a gravel support bed with the resin bed. Here, an air lance may be inserted through the manway and pushed down into the resin bed, just above the support bed. Air lancing is labor intensive and care must be taken to avoid damage to the tank lining and internal distributors. Distributing the support bed will cause resin leakage through unscreened underdrains. Therefore, air lancing this type of unit is risky.

Prior to air mixing, the water level in the exchange tank must be lowered to prevent the air mix from blowing the resin out the vent line. If too little water is left above the resin bed, the air does not create sufficient movement of the resin beads to adequately loosen the dirt particles. About 1 ft of water left above the bed usually works best for air mixing. After the air mix, it is necessary to backwash the resin bed to remove the foulants that have been dislodged from the resin beads.

Some foulants are heavier than the resin beads and therefore they do not backwash out. Fine sand particles and iron or rust particles are the most common foreign materials that are not effectively removed by backwashing. Some foulants are too big and too heavy to be removed except by physically passing the resin beads through a screen. In most cases, these large particles do not seriously affect the performance of the resin and can be ignored. Where they must be removed, the process can be painfully time consuming and it may be better to replace the resin.

Some types of foulants do not come off the resin or out of the bed. It is always best to try cleaning a small sample of the resin in a column. The most effective techniques can then be adapted to the full resin bed, or a decision can be made that cleaning will not be effective and that resin replacement is advisable.

Some types of foulants, such as resin fines, can be classified so that they form a layer on the surface of the resin bed but cannot be backwashed out by any practical method. Here, it may be possible to vacuum, siphon or manually scrape the surface layer off the top of the good resin underneath.

Summary

Selection and implementation of particle filtration systems may be required to protect downstream ion exchange units. If there are suspended solids present in a water supply, and the filter system is not working optimally or is not present at all, there is a risk of the build-up of solids in the downstream resin bed. Procedures described above can help remedy the problem, but it is important to remember that it is not the frequency of cleaning but the effectiveness of cleaning that determines the outcome. *wqp*

Acknowledgements

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