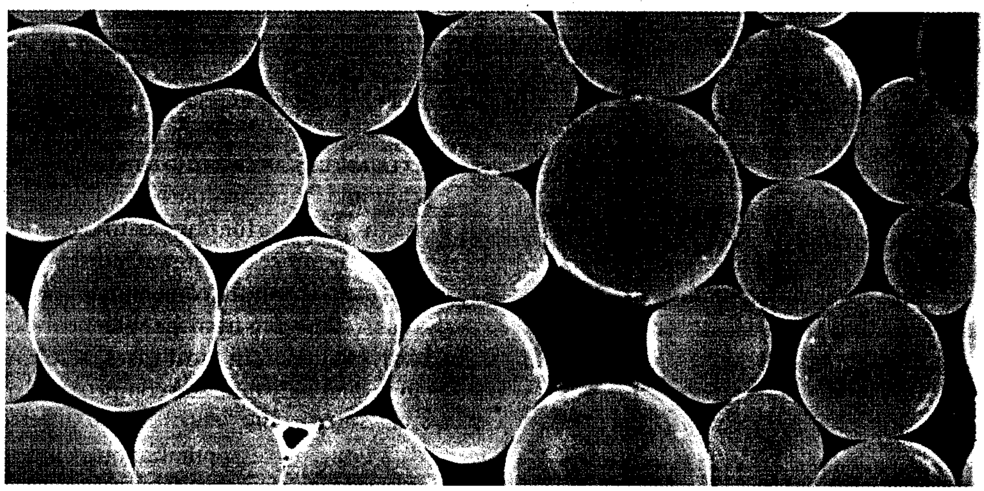
Heavy Metals Removal Using Ion Exchange

Optimize ion exchange for maximum effectiveness.

By Francis J. DeSilva

▼▼▼▼▼▼▼



The first ion exchange resins were developed to remove ions found in common water supplies. These include ions of calcium, magnesium, sodium, sulfates, chlorides, bicarbonates, carbonates and silica.

The petrochemical, electroplating, semiconductor, printed circuit board and other industries have experienced major growth and development in the last 50 years.

The processes involved in these industries have introduced dissolved contaminants into wastewater discharge streams that are not normally found in water supplies. Until recently there was very little information on how to remove these contaminants, and there was little perceived urgency to do so because environmental regulations had not yet been written and resource recovery did not seem to be an economical or viable option.

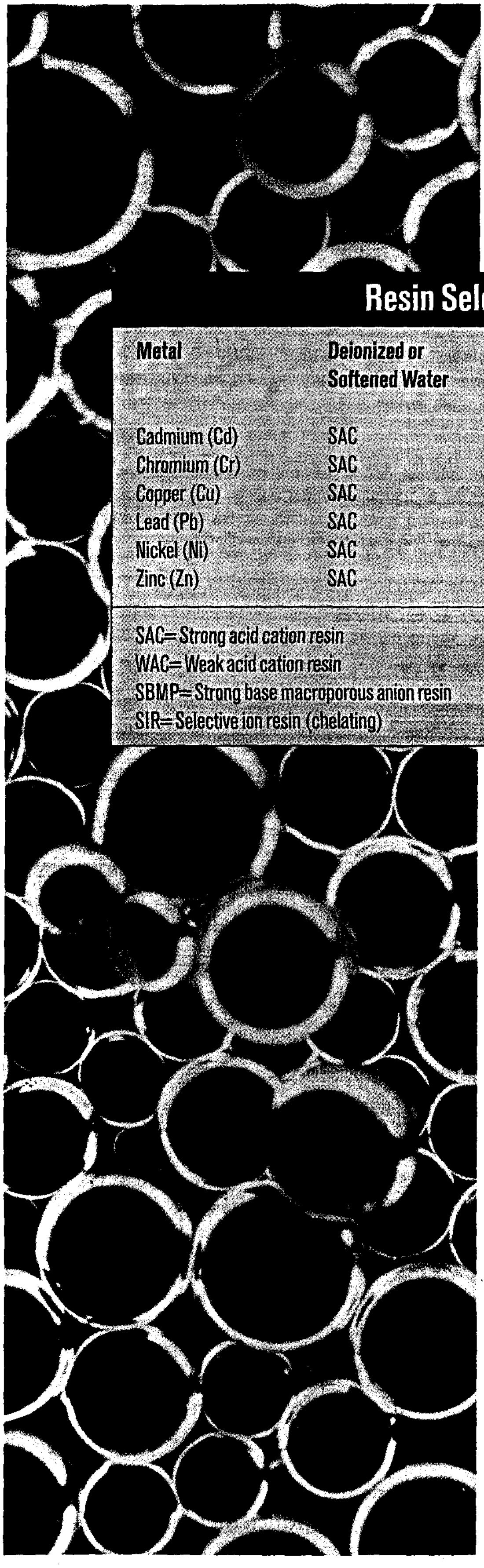
As industries and their waste volumes grew, it was apparent that dissolved contaminants had to be removed from wastewater. We now recognize that some of these ions are valuable, and therefore recovery is economically rewarding. In the last 20 years ion exchange resins have been developed with improved capabilities to remove heavy metals. Only recently, however, has product recovery become widely recognized as a way of reducing waste treatment costs.

Many plants today, especially in the Northeast and the Midwest, were built before environmental pressures or economical heavy metals recovery processes existed. Some companies must remove certain materials from their plant discharges due to environmental legislation. Others are motivated by economic benefits.

Most ion exchange resins have ionic capacities that are equivalent to an equal volume of caustic or acid at a concentration of 5-10%. The ion exchange process is regenerable. The typical regeneration process requires about 100 gallons of water per cubic foot of resin (15 bed volumes). The ion exchange process is optimized when the ratio of regeneration wastewater to the amount of water processed during the service cycle is minimized. There are three ways to get the most out of the ion exchange process:

1. Optimize the wastewater generating process to take maximum advantage of ion exchange resin use.
2. Select the best resin for the specific situation.
3. Develop an optimal operating procedure for ion exchange resin performance in the specific application.

Optimizing the process involves investigative work to determine exactly what is present in the wastewater and its



source. Most cationic exchange resins are good at removing most cationic metals; however, ordinary ions such as calcium or magnesium in the wastewater may compete with the contaminant ions for exchange sites and therefore act as an interference. If calcium or magnesium is present, find out where it comes from; the manufacturing process in the plant,

Resin Selection Guide

Metal	Deionized or Softened Water	Hard Water pH>6.5	Hard Water pH<6.5
Cadmium (Cd)	SAC	WAC	SIR
Chromium (Cr)	SAC	SAC or WAC	SIR
Copper (Cu)	SAC	WAC or SBMP	SIR
Lead (Pb)	SAC	SAC	SIR
Nickel (Ni)	SAC	SAC or WAC	SIR
Zinc (Zn)	SAC	WAC	SIR

SAC= Strong acid cation resin
WAC= Weak acid cation resin
SBMP= Strong base macroporous anion resin
SIR= Selective ion resin (chelating)

or from the city water that is used as the water source for the plant. If the source is merely city water, a simple water softener can be used upstream to remove the calcium and the magnesium before the water is introduced to the process. In this situation, the process wastewater discharge will include only the contaminating ions plus sodium ions from the effluent of the water softener. In most cases, sodium ions offer only minimal competition to the heavy metals.

Other process optimization includes segregation of wastes. For example, an older plating operation may have a trench into which all rinse tanks drain. This trench may therefore contain metals from several operations. Depending on the total wastewater chemistry, it may not be easy to remove all of the metals at once. If the waste rinse waters can be segregated and each metal treated separately, removal may be more efficient. More important, there are no mixed metals to contend with when removal is done for recovery.

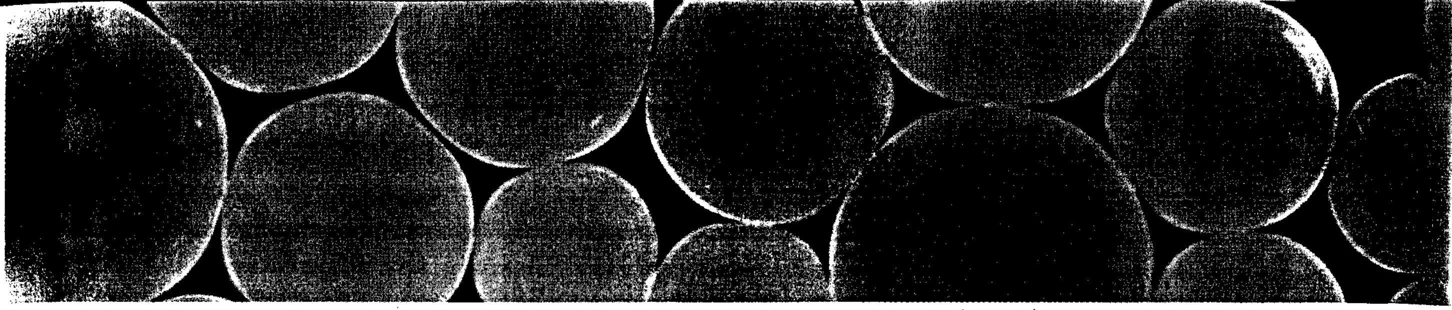
Resin selection should be based on an accurate wastewater chemistry. For existing wastewater treatment applications, obtaining the total ionic chemistry of the stream is simply a matter of submitting samples to a lab. For new applications, however, assumptions must be made and percentages calculated to characterize the wastewater discharge and estimate the strength of its various constituents.

Deionized water indicates that the presence of cations such as calcium, magnesium or sodium – and anions like sulfate, bicarbonate, chloride or silica – would be from the solution or chemical process itself and not from the raw water. Softened water contains less than 500 ppm of sodium (as calcium carbonate), and the concentration of calcium and magnesium is insignificant in the raw water compared to the concentration of the heavy metal ions to be removed.

Standard industrial grade strong acid cation resins can select most heavy metals over sodium but cannot select them over calcium or magnesium. This kind of resin, which is the least expensive, is usually limited to use on wastewaters where the raw water going into the process is either softened or demineralized. Because all resins of this type to varying degrees have high affinities for the hydrogen ion, pH plays an important role in resin selection. Weakly acidic cation and chelating resins have unusually high affinities for divalent ions. In most cases the choice between weakly acidic cation resins and chelating types is based entirely on the effect the pH plays in the operating capacity of these resins.

The chelating types can operate in a lower pH range than the weakly acidic types; however, the weakly acidic types have a little higher operating capacity and are less expensive. Both weakly acidic and chelating resins can select most of the heavy metal ions preferentially over monovalent ions commonly found in water like potassium and sodium.

Selecting the right resin for the job must take into account several factors. First, the ultimate destination of the resin should be considered. Will it be used on a one-time basis and then disposed of or will it be regenerated? In some waste treatment applications it makes sense to use resin on a sacrificial



basis, such as when regeneration costs exceed the cost of the resin. In this approach, the metals are concentrated on the resin, which renders the wastewater discharge stream suitable for discharge. But the process requires that the resin be disposed of properly. In regenerable applications the resin will be used over numerous cycles of service and regeneration. The regeneration process will create a volume of regenerant wastewater that includes the concentrated metals. The metals can be recovered by an electrowinning process, or the regeneration waste can be treated by chemical precipitation, flocculation and settling followed by proper sludge disposal.

Calculating the concentration of metals in a regenerated waste stream is relatively easy. Divide the total amount of water treated per cubic foot of resin by the amount of water used to regenerate that resin to get the concentration factor. Multiply this concentration factor times the influent concentration of the contaminating ion(s) to get the level of the ion in the regenerant wastewater. For example, if a cubic foot of resin treated 20,000 gal of water and it took 100 gal of water to regenerate that cubic foot, 20,000 divided by 100 equals 200. The concentration factor is 200. This is multiplied by the inlet concentration of the metal being removed. If, for example, one assumes that the metal was copper and it was at a level of 30 ppm, the concentration factor of 200 times 30 equals 6,000 ppm; therefore, the 100 gal of regenerant wastewater contains 6,000 ppm of copper.

Several portable exchange service companies are licensed to regenerate resins off site at a centralized location. This alleviates the problem of regenerant waste disposal.

A technique favored today for some applications is called "closing the loop" (Figure 1). Closing the loop eliminates any discharge from a process by recycling all of the water. This is common in the plating industry and involves using demineralized water for make-up water to rinse tanks. The wastewater from the rinse tanks is recycled through ion exchange resins to remove any metals and restore the water to its original demineralized condition. Usually two ion exchange systems are employed. One is for simple demineralization of the influent city water used for make-up of the rinse baths, and another system treats wastewater from the rinse baths. The wastewater treatment system would, of course, be regenerated sepa-

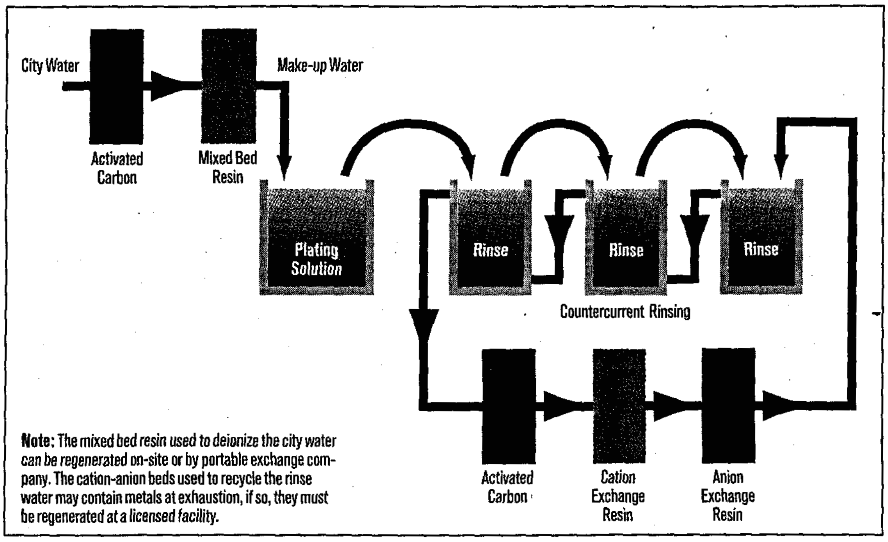


Figure 1: Rinse water recycle from a plating process.

rately because the regenerant wastes would include the concentrated metals. The optimum system would include recovery of the metal from the regenerant waste to further improve the economics of the closed loop system.

Ion exchange resins are ideally suited for removing ionic contaminants from dilute waste streams. Some streams, especially mixed wastewaters, can contain high levels of dissolved and suspended solids. These streams may require pretreatment before they can be suitably treated by ion exchange resins. Ion exchange resins can foul in the presence of suspended solids, oils, greases and some organics. Cleaning rinses that may contain detergents or degreasers should not come in contact with the resins. A good rule of thumb is to consider other treatment processes when the total dissolved solids in the wastewater stream approaches 1,000 ppm. S

Francis J. DeSilva, national sales manager for ResinTech, has been employed in the water treatment industry for more than 15 years. He has an M.S. in environmental engineering from New Jersey Institute of Technology and a B.S. in technology from Florida Institute of Technology. He was previously employed by Belco Pollution Control division of Foster Wheeler, serving as manager of the Process Department.