Evaluating Electrochemical Treatment

Electrochemical systems offer efficient alternative

By Eric Yeggy

The water treatment industry is constantly driven to find more sustainable solutions to treatment problems. Cation exchange water softeners are extremely effective at removing hardness, but are under attack in several states due to the salt and water they discharge during regeneration. Reverse osmosis systems are effective at removing total dissolved solids (TDS), but a significant percentage of the influent water is discharged to the drain as wastewater.

Electrochemical water treatment systems are emerging as a potential solution because they reduce both hardness and TDS without the use of salt at a relatively high efficiency rate. The technology goes by several names: continuous electrolytic deionization, capacitive deionization or electrically regenerated ion exchange.

How does this technology work?

Electrochemical water treatment systems utilize electricity to induce the removal of dissolved contaminants in the water. Positively charged contaminants such as calcium, magnesium, sodium, lead and uranium are called cations. Negatively charged contaminants such as chlorides, nitrates, nitrites, sulfates and fluorides are called anions. The introduction of a negatively charged electrode, or cathode, into the water will cause positively charged cations to move toward it. A positively charged electrode, or anode, will cause negatively charged anions to move toward it. Electrochemical water treatment systems take advantage of this property by combining the electrode with ion exchange membranes.

Ion exchange membranes are made by crushing ion exchange resin, adding a binder and extruding it as a sheet. A cation resin creates a cation membrane that will only allow cations to pass through it. Conversely, an anion resin creates an anion membrane that will only allow anions to pass through it.

It is important to understand that, unlike other types of membranes, ion exchange membranes do not allow water to pass through them. Only the dissolved contaminants pass through.

The principle is thus simple: Introduce a negatively charged cathode to move the positively charged cations through a cation membrane, where they collect and concentrate, leaving treated product water behind on the other side of the membrane. Alternating anion membranes with cation membranes creates alternating concentrate and purification zones. The product water can then be released to a storage tank, where it is collected for use.

If operated continuously in this manner, the concentrate zones eventually would reach a high enough concentration to cause scaling. To prevent this, the system periodically flushes the concentrate zone to drain. Some systems also reverse polarity on the electrodes so that concentrate zones become product zones in the next cycle. A chemical cleaning cycle also may be used every six to 12 months to prevent scale buildup. Even with the flushing and cleaning cycles, these systems operate at a relatively high efficiency rate of about 80%, which means only a small percentage of the influent water is discharged as wastewater.

What are the operational requirements? Does it need a booster pump? Will it increase electricity usage?

Electrochemical systems operate at relatively low voltages, with residential units available that can plug into any household outlet. The typical operating cost of a residential unit is about $40 to $50 per year for a family of four.

Because movement through the ion exchange membranes is induced by electricity and not osmotic pressure, these systems typically have low pressure requirements and can operate efficiently on wells without the use of booster pumps.

What do these electrochemical systems remove?

Basically, anything that is ionized when dissolved in water will be reduced. A typical target for the

product water would be less than 5 grains per gal (gpg) of hardness and less than 150 ppm TDS, so these systems are not practical if your aim is to produce soft water with less than 1 gpg hardness.

Electrochemical water treatment systems will significantly reduce cations like calcium, magnesium, sodium, lead and uranium, plus anions such as chlorides, nitrates, nitrites, sulfates and fluorides.

Do electrochemical systems have any limitations?

Each system is unique. In order to completely understand the limitations of a specific system, consult with the manufacturer. Most electrochemical system manufacturers will probably recommend a prefilter to remove sediment, which may clog the membranes, and chlorine, which could damage the system. Source water that is high in iron could be problematic and may require additional pretreatment. Silica also may present challenges. Consult with the manufacturer on these issues to get a clear picture of the operational limitations.

How are system performace claims verified?

The Water Quality Assn. (WQA) has published a new performance standard for electrochemical water treatment systems called WQA ORD1201. Several manufacturers are currently seeking certification to the new standard through the WQA Gold Seal Certification Program. Certified systems will have gone through extensive testing using a 30-day protocol that incorporates variable use patterns to ensure that they deliver a 75% reduction in hardness and TDS for an extended period of time under conditions that simulate the variable use patterns encountered in the field. The test water contains 20 gpg of hardness and 750 mg/L of TDS to ensure a rigorous challenge.

The standard also covers materials safety testing to ensure that the materials used in construction will not leach harmful chemicals into the water. It incorporates structural integrity testing to ensure that the product will be able to stand up to cyclic and hydrostatic pressures encountered in the home. Literature requirements are incorporated to make sure that there are no false or misleading claims, and that all the operational parameters are disclosed. The standard also incorporates testing to characterize energy usage and any chemical usage for cleaning steps, so there will be no surprises on the operational requirements.

Electrochemical water treatment systems promise to address many of the issues that challenge this industry. They operate at low voltage using relatively small amounts of energy at low pressures, making them applicable to well water applications. The water they produce is not corrosive, because they do not remove all of the TDS, and they reduce hardness to less than 5 gpg without the use of salt or chemicals for daily operation. *wqp*

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