Lower Pressure, **Lower Cost**

By John Potts

Nanofiltration system helps facility improve energy efficiency

Treating water with nanofiltration membranes is effective, but the process continues to be burdened by the reputation that it is expensive to carry out, due to the high energy costs associated with developing the pressure necessary to make it work. That reputation is becoming less deserving as improvements are made in membranes and treatment system configuration.

About 10 years ago, a Dutch engineering firm developed a membrane vessel and membrane train configuration intended to significantly reduce operating pressure in nanofiltration. It was successful, and the process was implemented under the phrase, "center feed."

About seven years ago, the town of Jupiter, Fla., began planning a nanofiltration plant to replace its lime softening plant. The town wished to maintain its position on the leading edge of water treatment technology, and sent a representative to Holland to see if the center feed technology could be applied in the U.S. About four years ago, construction started on the Jupiter plant, and about a year-and-a-half ago it went online.

End view of Jupiter, Fla., plant's five nanofiltration trains

A Twist on the Dutch Model

Operating data now is available to demonstrate the low pressures under which this plant operates. These low pressures lead to significantly lower electrical costs.

The plant consists of five 2.9-million-gal-per-day (mgd) trains operating at 85% recovery. The center feed configuration was modified in Jupiter to accommodate an "end feed-center exit" flow path, or the reverse of the Dutch concept. Pilot testing led the town to believe that this configuration provided more positive flow control, and a year and a half of successful operation have shown that to be the correct decision.

The membrane vessels appear normal in that there are six-element vessels with end caps as well as side ports on each end. However, these vessels also have side ports in the middle, which effectively transforms them into three-element vessels.

Low-Pressure Design

The production of "low-energy" membranes, which are more permeable than their predecessors and therefore require less pressure to make the same amount of water, has helped lower energy costs associated with the treatment process.

These highly permeable nanofiltration membranes normally require relatively high feed flow in the lead two or three membranes in each vessel. This ensures the necessary feed flow will remain to provide adequate water for the last three membranes to make permeate. This relatively high flow through the

Side view of a Jupiter nanofiltration train depicting the vessel center exits and collection piping

lead elements results in relatively high Delta P, the non-recoverable head loss along the length of a vessel. The center exit configuration eliminates that requirement and virtually eliminates Delta P.

In Jupiter, the startup feed pressure is approximately 57 psi. Stage 1 Delta P is about 3 psi, and Stage 2 Delta P is about 5 psi. This may not sound like much pressure reduction, but when viewed in the context that the feed pressure is 57 psi, if the Delta P was the normal 20 psi, feed pressure would have to be 70 psi.

At the Jupiter plant, the changes made in the "standard" train configuration that led to this significant reduction in operating cost have not had any impact on reliability, membrane performance or system maintenance. Even after a year and a half of operation, the membranes have yet to be cleaned. This is significant for nanofiltration in southeast Florida, where the high organic content of the warm groundwater generally leads to fairly frequent cleaning.

Energy-Efficient Pumping

The system includes approximately 45 raw water supply wells, four raw water booster pumps and five feedwater pumps. All of the pumps, including the raw water supply well pumps, are equipped with variable-frequency drive units. This means that achieving the proper flow throughout the system is never achieved by unnecessary pressure loss across a control valve.

A significant criterion during pump selection was efficiency. All pumps are not created equal when it comes to efficiency, and the increase in cost for 3% to 4% in efficiency gain pays for itself quickly. The success achieved at this state-of-the-art facility is a true advancement in the use of membranes for water treatment.

Further Increasing Efficiency

Even at a facility as advanced as the Jupiter Nanofiltration Plant, a close examination reveals that there is still room to reduce operating pressure and therefore further reduce operating cost.

Membrane designers routinely design piping systems in a membrane plant with relatively high velocities, sometimes pushing the upper limits on velocities in pipes. In some cases this is appropriate in order to provide scouring velocities and prevent accumulation of corrosive elements. In the case of nanofiltration, however, those factors usually are not present and the higher velocities lead to higher head losses.

The same is true for control valves, which are almost always one or two pipe sizes smaller than the pipe. This improves control characteristics, but at the expense of a higher velocity and the consequent higher head losses. At the Jupiter facility, these losses can be estimated at 7 to 10 psi, which, again, does not sound like much. However, when feed pressure is 57 psi, recovering 7 to 10 psi is reducing the required pressure by 12% to 17%.

Increasing the efficiency or, stated differently, reducing the operating cost, in nanofiltration is not a matter of a single large reduction, but rather of individually small improvements that add up to a significant improvement. MT

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