MEMBRANES

pass all the right tests

By Warren Casey

Faced with one of the fastest growth rates of any county in the U.S., Florida's Collier County recently undertook one of the largest reverse osmosis (RO) plant expansions on record. Like many water utilities in Florida, Collier County relies heavily on the RO process to produce drinking water from saline well water.

The county owns and operates two RO membrane treatment facilities. The North County Regional Water Treatment Plant has a total membrane capacity of 20 million gal per day (mgd), consisting of a 12-mgd nanofiltration system fed from the surficial Tamiami Aquifer and an 8-mgd RO system fed from the deeper, more saline Hawthorn Aquifer. The South County Regional Water Treatment Plant, also fed from the Hawthorn Aquifer and site of the recent RO expansion, had an initial RO capacity of 8 mgd. The first phase of membrane treatment became operational in 2004.

In February 2007, the county successfully commissioned a 12-mgd RO expansion to bring the total south county plant capacity to 20 mgd.

The RO expansion, one and a half times the size of the original system, included many challenges during its design, construction and startup phases. Success depended on many factors, including teamwork among the county personnel; Hazen & Sawyer, the project engineer; Poole & Kent, the general contractor; AEWT Biwater, the RO system supplier; and Toray Membrane, the membrane manufacturer.

New well capacity, required for simultaneous operation of the existing and expansion RO skids, was not fully operational during startup. This created a balancing act of sorts. During portions of the startup, only one of the six newly installed skids could operate at any one time due to the fact that permeate could not be sent to distribution until the new skids were cleared by the Florida Department of Environmental Protection (FDEP). Clearance depended not only on meeting U.S. Environmental Protection Agency (EPA) primary and secondary standards but also producing bacteria-free water—not an easy task when drawing samples from unchlorinated permeate immediately after startup.

Membrane Performance Objective

The typical objective of an RO system is to produce a certain capacity and quality of permeate water at applied pressures less than the limits specified by the design engineer.

This objective becomes more difficult to meet when the salinity of the feedwater is expected to increase with time, as is the case with the south county RO expansion. The existing RO skids were designed for a maximum feed total dissolved solids (TDS) level of 6,300 mg/L with a typical range of 5,200 to 5,700 mg/L; however, the expansion RO units were required to be designed for 8,000 mg/L TDS due to withdrawals from more saline sections of the Hawthorn aquifer. The overall TDS increase is due mainly to increases

A plant expands its treatment options to address feedwater that increases in salinity by the day

Continues on page 54 ▶

44_ProblemSolvers_0408.indd 52 4/2/08 1:44:01 PM

◀ *Continued from page 52*

Table 1: Water Quality (mg/L)

Constituent	Design Feedwater	Specified Permeate Limits	Feedwater at Startup	Projected Permeate	Actual Average Permeate
Calcium	212		200	1.0	0.7
Magnesium	199		200	1.0	0.6
Sodium	1850	70	1400	26	28
Strontium	12		13	0.06	0.05
Bicarbonate	244		180	4.5	19
Chloride	3050	110	2500	39	46
Sulfate	880		820	5.2	3.7
Fluoride	1.6		0.8	0.01	< 0.03
Silca	16		16	0.4	< 0.16
TDS	6300	220	5340	77	81

in the sodium and chloride levels.

The required permeate quality, to be met initially and at the end of five years, is shown in Table 1.

In addition to TDS, limits on sodium and chlorides were established. The initial feed pressure was specified to be less than 270 psi and less than 350 psi at the end of five years, with limits on the amount of interbank boost pressure that can be applied. Well-designed multibank RO systems utilize devices that boost the feed pressure to the second bank. This balances the amount of permeate produced in each bank by supplying the net driving pressure required to increase permeate production in the second bank. The net effect also lowers the required pressure to the first bank; however, the amount of interbank boost is limited to prevent too high of a flux in gallons per square ft per day (gfd) in the second bank, where the concentrated feedwater has a higher fouling potential.

Continues on page 56 ▶

write in 803

write in 730

write in 726

44_ProblemSolvers_0408.indd 54 4/2/08 1:46:26 PM

American Water Works Association
ACE 08
ANNUAL CONFERENCE & EXPOSITION

THE WORLD'S WATER EVENT

The most comprehensive and diverse water conference in the world is in **Atlanta, Georgia,** June 8-12, 2008, at the Georgia World Congress Center.

Join thousands of water professionals at ACE08 to help shape the future of safe water.

www.awwa.org/ace08

Register Now

write in 708

Waterworks Central
The Valve Source for the Municipal Waterworks Wholesaler.

Attn: Waterworks Sales People

SPECIAL ANNOUNCEMENT:

Great news! Your job just got easier.
Waterworks Central: Your source for Valves.

Call today for the free Waterworks Central Reference Tab.
The permanent Reference Tab for your Price Book to help you continue to provide superior customer service.

Waterworks Central: Saving you time and money.
Phone: 267-733-3883 / Fax: 267-751-6060
www.waterworkscentral.com

write in 734

◀ *Continued from page 54*

Membrane Selection Process

The membrane performance objective required use of an RO element with a minimum specific flux of 0.113 gfd/psi and a chloride ion rejection greater than 99% at the end of five years, normalized to original element test conditions. To determine the specific flux of an RO element, divide the test flux (in gfd) by the net driving pressure of the test conditions (in psi). The rejection rating of an RO element for the factory test conditions is usually listed on the element spec sheet; however, because properly designed systems utilize safety factors, the rejection rating of an RO element should be derated to project performance after five years.

On paper, a limited offering of RO elements from various membrane manufacturers met the requirements. In March 2006, single-element testing was performed at the south county plant to further qualify RO elements for the project. The county and the project engineer conducted the testing using 4-in.-diameter elements and included the use of concentrate recycle to simulate operating conditions within a full-scale system.

Operating data was used to calculate specific fluxes and normalized salt passages for the candidate membranes. After one month of testing, three specific RO elements were identified as being qualified to bid on the full-scale plant.

After bids were received, but prior to receiving a notice to proceed, the successful lowest bidder was required to pass a proof test to be conducted by the county and project engineer. This proof testing utilized 4-in.-diameter elements and a scaled down version of the full-scale RO pressure vessel array. The proof test was operated at the design recovery and permeate flux of the full-scale plant. If membrane performance of the low bidder during the proof

44_ProblemSolvers_0408.indd 56 4/2/08 1:46:43 PM

test failed to meet the required permeate quality and feed pressure specifications, then proof testing proceeded with the second lowest bidder's elements.

At the conclusion of the membrane selection process, Toray TM720-400 elements, being the lowest priced and having passed all of the tests, were chosen for the expansion. This element has a specific flux of 0.126 gfd/psi and a salt rejection of 99.7%, based on factory test conditions. The 8-in.-diameter by 40-in.-long element has 400 ft of membrane surface and utilizes a 31-mL feed channel spacer which results in low differential pressures during operation.

System Description

The RO system and pretreatment employed at the South Collier County Regional Water Treatment Plant is typical of many systems throughout Florida. Unaerated well water is treated with acid and scale inhibitor as it enters the building. The raw water contains a significant amount of hydrogen sulfide and allowing exposure to air would result in formation of elemental sulfur, a tenacious membrane foulant. Keeping wells and supply lines air-tight is extremely important. The combination of acid and antiscalant prevents carbonate and sulfate compounds forming when saturation levels are exceeded within the feed-concentrate channels of the RO elements. Cartridge filtration, rated at 5 microns, follows the chemical additions and immediately precedes the high-pressure RO pumps. The RO feed pumps are rated at 400 hp and controlled by a variable frequency drive.

The 12-mgd RO expansion consists of six 2-mgd skids, arrayed in a two-bank configuration of 40 pressures in the first bank and 20 pressure vessels in the second bank. Each pressure vessel contains six RO

Not exactly the
"Water Pipe"
you were looking for?

Introducing WaterInfoLink.com, the industry search engine that makes searches easier

Scrolling through pages of irrelevant results from a general search engine makes your job more difficult. There's a new and better way to meet daily information needs. Created exclusively for water and wastewater professionals, WaterInfoLink.com is the search engine that simplifies business searches by focusing specifically on industry information.

WaterInfoLink.com is brought to you by the publishers of *Water & Wastes Digest* and *Storm Water Solutions*, leading authorities in the industry. By indexing the most relevant and authoritative sites, WaterInfoLink.com delivers published articles, journals, white papers, supplier sites, association news, product guides, and regulatory news in an easy to use format. There's no registration process required. Simply go to WaterInfoLink.com and enter keywords to get the information you are seeking.

WaterInfoLink.com –
What's your keyword?

Brought to you by

WATER & WASTES DIGEST STORM WATER SOLUTIONS

write in 748

write in 789

44_ProblemSolvers_0408.indd 58 4/2/08 1:47:07 PM

elements. Each skid is designed to operate at a feedwater recovery rate of 75% and an average flux of 14 gfd.

Interbank pressure is boosted with an energy recovery device to help balance the flux between banks. Permeate from each skid is collected in a main header, along with the permeate produced from the four existing 2-mgd skids, and sent to the degassifiers located outside the membrane building.

The degassifiers utilize a gas scrubbing system to handle odor originating from the hydrogen sulfide gas removed from the RO permeate. The RO concentrate is discharged via deep well injection.

The RO system building was constructed in 2001 with space and piping flexibility to add the cartridge filter housings and the RO skids required for the 12-mgd expansion without service interruptions to the existing RO skids.

Startup

The specifications required each RO skid to pass a series of tests conducted three to four weeks apart. The startup test comprised of testing the unchlorinated permeate for the presence of coliform bacteria and compliance with Florida Administrative Code 62-550, which essentially requires that the permeate meet all EPA primary and secondary standards.

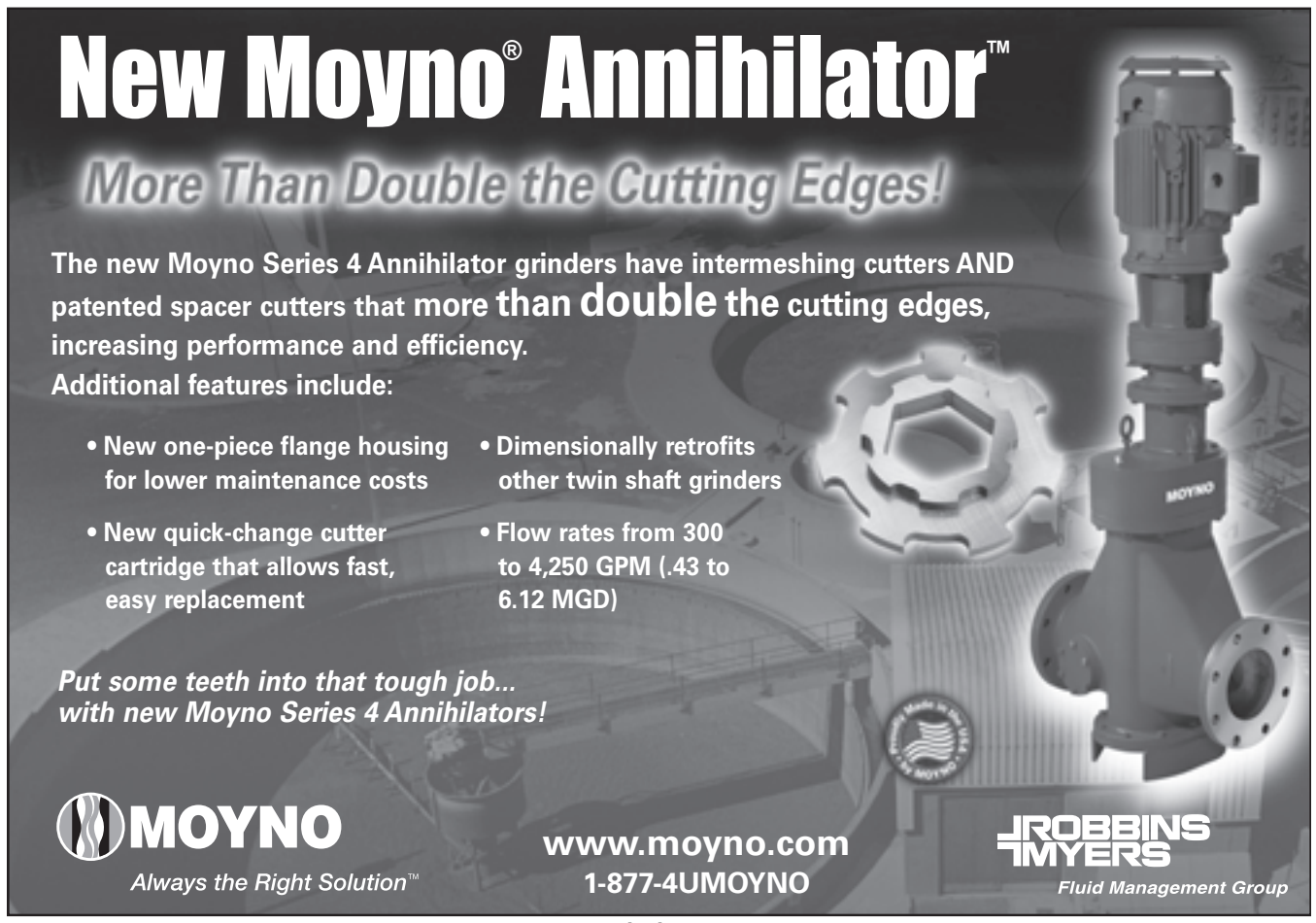
The second test, the performance test, consisted of three continuous days of run time for each RO skid with frequent data collection to ensure that performance met specifications.

Due to the extensive testing required for the startup test, there was a three- to four-week period before clearance was received from the FDEP. The clearance was needed since the permeate would be sent to distribution during the performance test; however, the permeate during the startup test had to be directed to drain. All

write in 741

write in 735

write in 769



write in 740

44_ProblemSolvers_0408.indd 59 4/2/08 1:47:21 PM

of the RO skids passed the startup test in a timely fashion.

For this project, great care was taken to ensure a sterile loading environment. RO elements were stored in their original packaging prior to being loaded. The loading crew wore sanitary gloves and hair nets, and vessel parts removed for loading were stored in a sanitary manner. Four of the RO skids took the minimum of two days to pass the bacteria test, while the last two required an extra day or so. The quick clearance was remarkable in that this same process has taken as long as four weeks at other sites.

During the performance test, samples of the feed, permeate and concentrate from each RO skid were drawn four times for laboratory analysis. Table 1 summarizes the results. The feedwater quality and temperature were fairly constant during the testing periods. The projected permeate quality, based on the actual feed analysis, temperature, recovery and permeate flows, is also listed in Table 1, as is the average of all permeate analyses from the six skids. It is important to note the following:

- The permeate quality was very similar for all six RO skids; however, chloride readings from the lab for the feed, permeate and concentrate were erratic and most likely included errors.
- The average permeate quality at startup is well below the specified limits, even when normalized to the design levels for the specified analyses and design temperature of 28°C (the actual temperature ranged from 26°C to 28°C during the performance test).
- Based on actual specific ion rejection rates and a salt passage increase factor of 7% per year, it is projected that the permeate sodium, chloride and TDS values at the end of five years will be well below the specified maximum limits.
- The reported permeate sodium and hardness results were very consistent and contained little scatter. Using these stable cation results, the actual permeate chloride level can be adjusted using an ionic charge balance. The resulting chloride level is 33 mg/L, which is slightly below the projected value.
- The actual permeate bicarbonate was higher than the projected level. This is a benefit, taking into account that re-adding alkalinity is part of the post-treatment process.
- The actual and projected permeate qualities are in close agreement.

Table 2 lists typical data regarding feed and differential pressures during startup. As shown in Table 2, the actual and projected feed pressures are in close agreement, as are the differential pressures across each bank.

The low differential pressure is achieved with the use of a 31-mL feed channel spacer. The startup feed pressure, when normalized to the design conditions, is well below the 270-psi requirement. Based on the startup pressures and an annual flux decline rate of 7%, the projected feed pressure at the end of five years is well

ADVERTISEMENT

44_ProblemSolvers_0408.indd 60 4/2/08 1:48:42 PM

Table 2: Typical Pressure Data (psi)

	Bank 1 Feed Pressure	Bank 1 Differential Pressure	Bank 2 Boosted Feed Pressure	Bank 1 Differential Pressure
Projected	215	9	280	9
Actual	211	11	274	9

below the limit of 350 psi.

Working Together

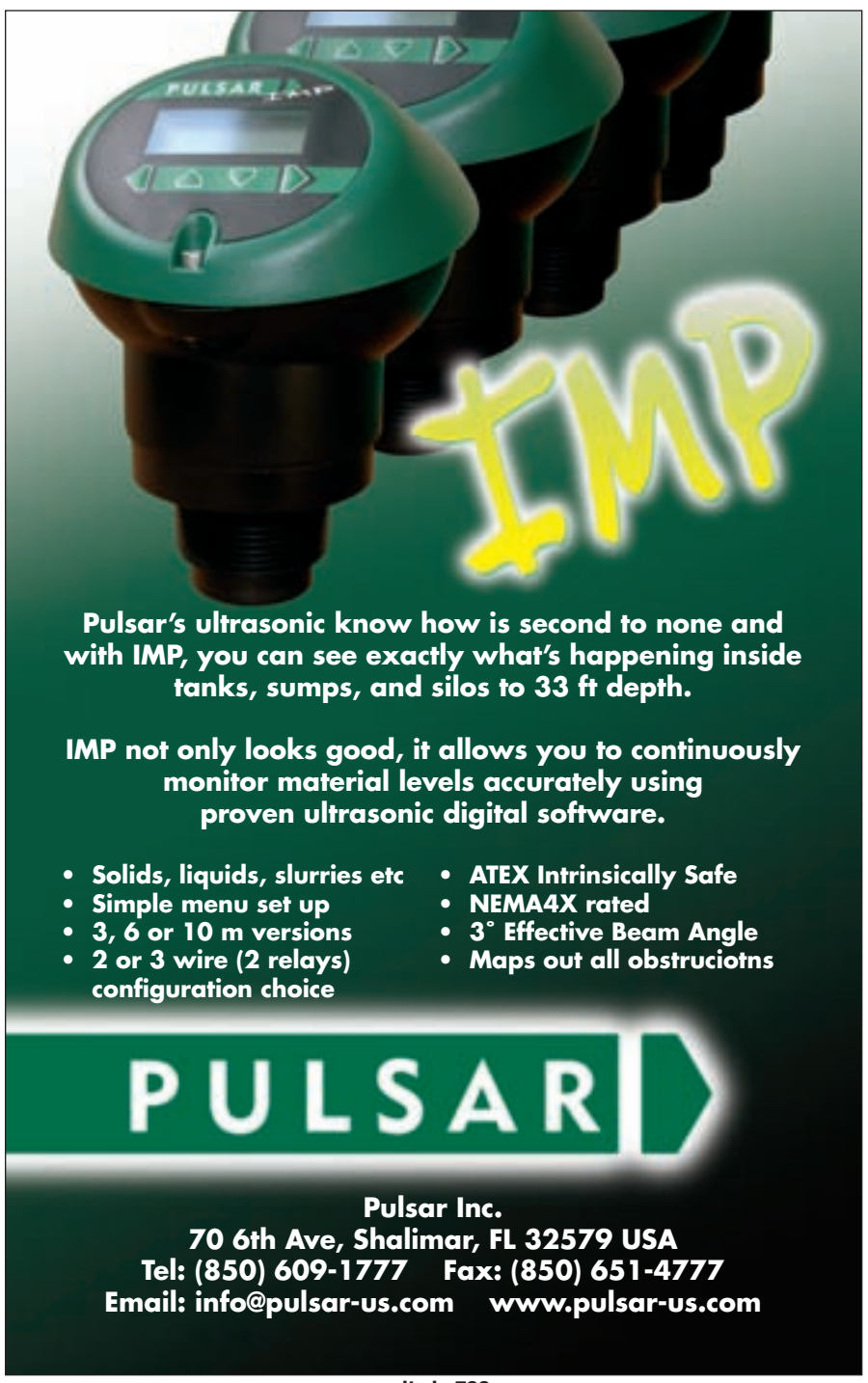
The successful startup of the South Collier County Regional Water Treatment Plant 12-mgd expansion was a coordinated effort between the county, engineer, contractor, subcontractor and vendors.

With 12 mgd of new RO capacity, Collier County is ready to take on its next challenge in meeting future demands for drinking water. WWD

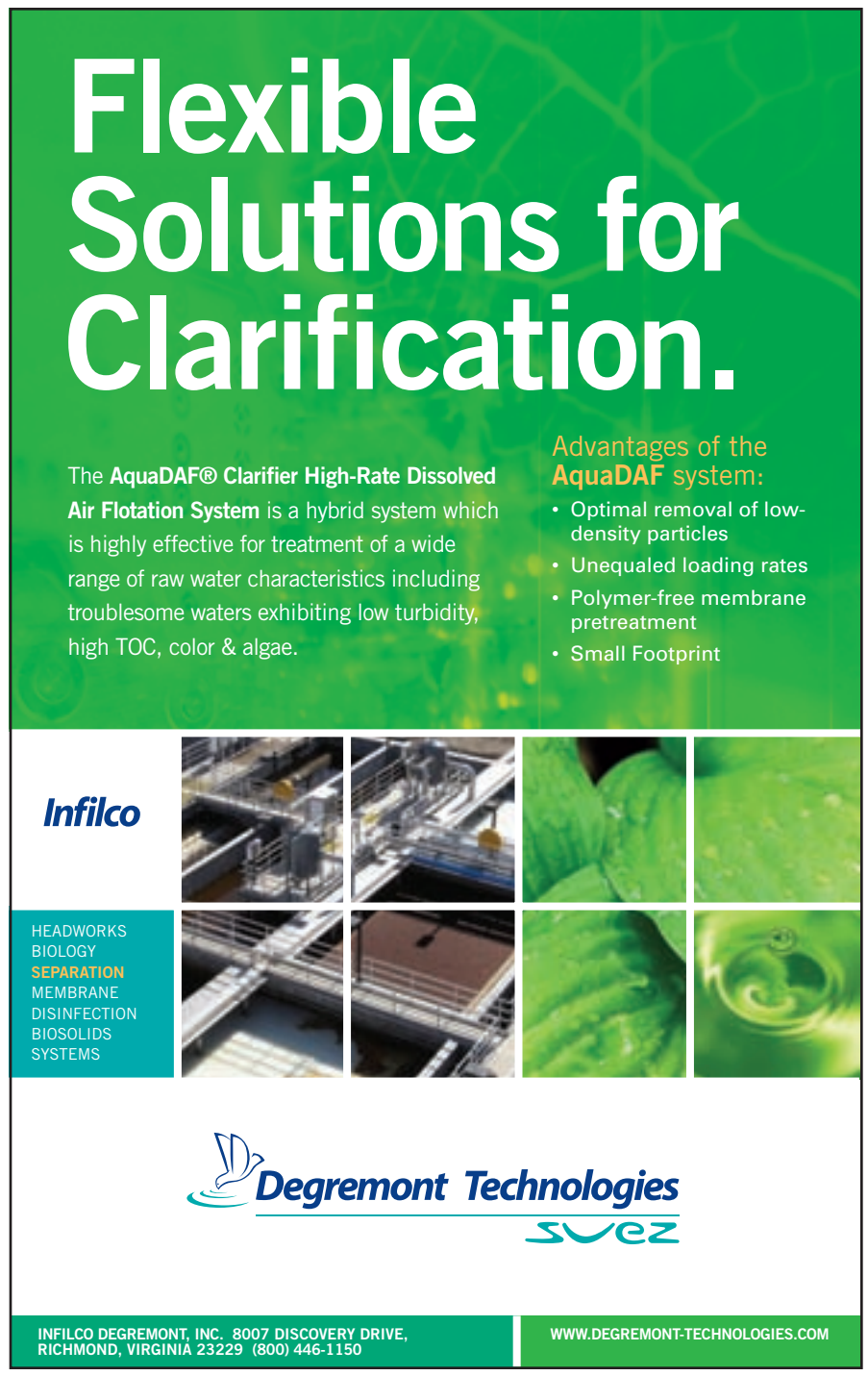
Warren Casey, P.E., is technical service manager for Toray Membrane USA. Casey can be reached by e-mail at casey.warren@toraymem.com.

For more information, write in 1119 on this issue's Reader Service Card.

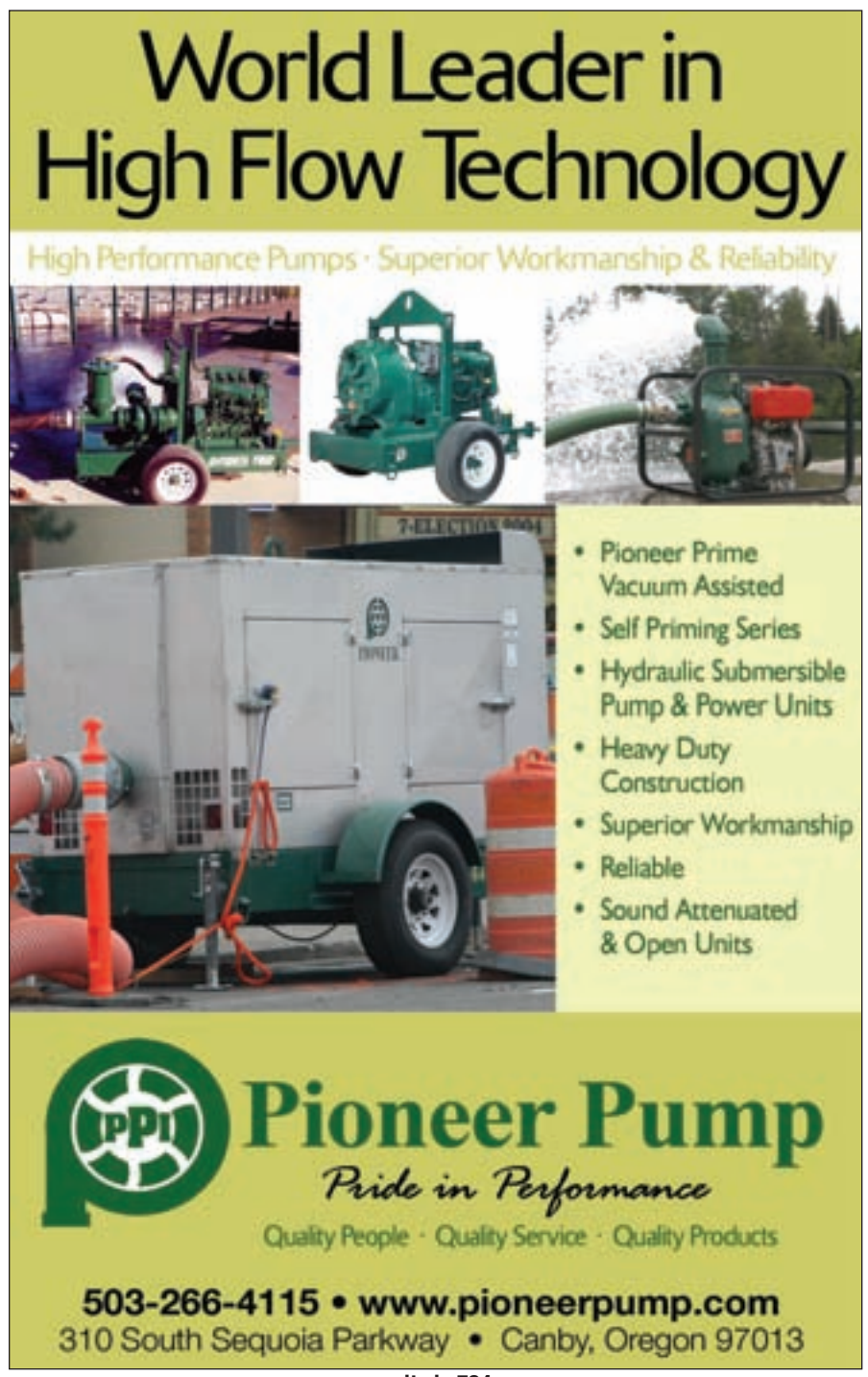
LEARN MORE
For additional articles on this topic, visit:
www.wwdmag.com/lm.cfm/wd040812



write in 722



write in 732



write in 724

44_ProblemSolvers_0408.indd 61 4/2/08 1:49:23 PM