

Evaluating MF Membranes

By Tom Knoell

Groundwater
replenishment system
weighs its expansion
options

California's Orange County Water District (OCWD) operates the Groundwater Replenishment System (GWRS), an advanced wastewater treatment facility located in Fountain Valley, Calif. As an indirect potable reuse facility, the GWRS provides 70 million gal per day (mgd) of purified wastewater for groundwater recharge and maintenance of a seawater intrusion barrier for protection of the local groundwater basin.

The facility was commissioned in 2008 and consists of three major treat-

ment processes: microfiltration (MF), reverse osmosis (RO) and advanced oxidation (ultraviolet disinfection with hydrogen peroxide). Source water to the GWRS consists of secondary municipal wastewater provided by the neighboring Orange County Sanitation District. The overwhelming success of the GWRS project has propelled OCWD officials to embark on an expansion from its current capacity of 70 mgd to 100 mgd.

Increased capacity was already incorporated into the initial plant design, so current expansion efforts have focused principally on upsizing the three treatment processes. Increasing production to 100 mgd will require an estimated 42-mgd increase in RO pretreatment capacity. Because major infrastructure already exists, expansion is somewhat limited to the use of similar MF technologies. This would result in reduced capital

MF Process

cost, as the technology could be incorporated readily into the existing facility. Impacts, therefore, would be minimized.

The GWRS currently utilizes the CS technology of Siemens Water Technologies. This process consists of a submersible MF system comprised of 26 basins, each housed with membranes constructed of polypropylene (PP) material. Since demonstration testing and commissioning of the GWRS, Siemens developed a polyvinylidene fluoride (PVDF) membrane that is interchangeable with the existing CS system. The chemistry of PVDF potentially offers several advantages over the PP membrane, including higher polymer durability (which can lead to prolonged membrane life and more aggressive chemical cleanings), higher permeability (reduced capital cost and operational cost) and improved filtrate water quality (enhanced RO pretreatment). The PVDF membrane represents the only alternative to the PP membrane presently installed in the GWRS due to existing patents.

Advancements associated with the PVDF membrane could translate into providing all of the required production needed for expansion of the GWRS with limited investment in additional infrastructure. The 26 basins currently are loaded with 608 membranes each (the design capacity is 684). There are also two vacant basins that were constructed for eventual expansion.

By loading all 28 basins with PVDF membranes and operating the membranes at a higher flux rate (relative to the PP membranes), the needed increase in RO pretreatment capacity could be met without constructing additional MF basins and infrastructure. Continuing to utilize the PP membrane would require not only filling out all

Figure 1. MF Membrane Demonstration Cleaning Procedures

Procedure	Polypropylene	PVDF
Chemical Cleaning	Step 1: 2% w/w caustic 0.5% w/w Siemens detergent Step 2: 2% w/w citric acid	Step 1: 2% w/w citric acid Step 2: 500 mg/L hypochlorite (free chlorine)
Maintenance Wash	N/A	200 mg/L hypochlorite (free chlorine) or 0.2% w/w sulfuric acid



Polypropylene membranes, each containing 15,000 fibers with a nominal pore size of 0.20 microns.

existing MF basins, but constructing additional basins as well.

Objective

The objective of this study was to assess PVDF membrane performance and determine expansion design criteria based on operations with secondary wastewater unique to the GWRS. To satisfy the objectives, onsite pilot testing was conducted at the GWRS pilot-plant facility—a facility dedicated to the evaluation and optimization of the GWRS processes. Over the course of these trials, higher flux rates and alternative cleaning strategies (e.g., maintenance washes) would be tested to optimize PVDF membrane performance. This would provide critical information regarding flux improvements, chemical usage, power consumption and, most importantly, impacts of these process changes on existing operations.

Methods

Membrane operating parameters.

The guidelines for treating secondary wastewater with the Siemens CS process are not only membrane dependent, but site specific as well. Only through pilot testing can actual operating parameters be established successfully.

The typical operating flux for the PP membrane in the GWRS is 20 gal per sq ft per day (gfd), with a backwash interval of 22 minutes and an average chemical cleaning interval of 21 days. The stated range of operating flux for the PVDF membrane is 25 to 30 gfd, with a backwash interval of 22 minutes. The anticipated cleaning interval is 30 days. Additionally, the PVDF membranes routinely undergo maintenance washes—30-minute cycles in which the basin is taken out of service, chemicals added and the contents circulated. The frequency of maintenance washes depends



CS pilot systems at the GWRS pilot-plant facility

on the fouling nature of the source water being treated, and can take place as often as daily.

Pilot systems. Evaluations were conducted using two Siemens pilot systems: one loaded with PP membranes and the other with PVDF membranes. This parallel evaluation allowed for critical comparisons between the two membrane chemistries. Without operating in parallel, it would be difficult to decipher PVDF performance relative to water quality, operating conditions, membrane type, etc.

The PVDF membrane was scheduled to be evaluated at elevated flux rates of 15% to 40% higher than the existing GWRS MF design flux of 20 gfd. Ultimately, the PVDF membrane would have to exhibit successful operations at a flux rate of 28 gfd to be considered in the present expansion scenario. Conducting these evaluations would allow staff to assess the claims of enhanced permeability and the potential increase in fouling kinetics commonly associated with operating high-flux membranes.

As the membranes continue to operate, backwashing becomes less effective as foulants accumulate on and within the membrane pores. Chemical cleanings are then employed to remove the foulants and restore membrane permeability. The cleaning regimens performed on both membrane types are presented in Figure 1.

Cleaning at the pilot scale was necessary to demonstrate effectiveness of the cleaning procedure. Because new membranes were used, their initial performance may not be representative of typical operations. Multiple trials were conducted, therefore, to assess

membrane permeability as well as the effectiveness of the cleaning procedures.

Results

With the engineering team needing direction on which MF membrane to design into the expansion, testing was fast-tracked and completed over the course of six months. During this period, six trials were completed with the PVDF membrane and four trials with the PP membrane. A detailed breakdown of all trials is summarized in Figure 2.

Overall, the PP membrane outperformed the PVDF membrane in all trials, averaging 16 days vs. eight days for the PVDF membrane. Upon completion of trial No. 1, PVDF operating flux was increased 30% to 26 gfd. Additional trials were conducted at this operating flux with the inclusion of maintenance washes at various intervals—from 24 hours to 72 hours. These efforts failed to extend PVDF runtimes to any appreciable extent.

Conclusions

The PVDF MF membrane has exhibited successful performance on a variety of water types other than municipal wastewater. Demonstration testing using secondary wastewater at OCWD, however, indicated that the PVDF membrane could not achieve the projected runtimes while operating at the asserted elevated flux rates. Shortened runtimes precluded trials at the targeted 28-gfd flux rate. Routine maintenance washes with strong oxidants were introduced as a means of extending PVDF runtimes. The frequency and chemical composition of the maintenance washes provided no benefit in enhancing PVDF

Figure 2. MF Membrane Demonstration Performance Summary

Polypropylene Membrane			PVDF Membrane		
Trial	Flux (gfd)	Runtime (days)	Flux (gfd)	Runtime (days)	Maintenance Wash (hours)
1	20.1	-	20.1	20	none
2	20.1	17	26	11	72
3	20.1	9	26	3	72
4	20.1	-	26	3	24
5	20.1	17	26	10	72
6	20.1	20	26	3	72

membrane operations. Even incorporating daily maintenance washes failed to extend the PVDF cleaning intervals.

Having a pilot-plant facility and onsite resources available to conduct these evaluations proved invaluable. It provided OCWD with critical information

regarding the selection of MF membranes for the existing facility and future expansion of the GWRS. Relying on documented successes at other facilities as sole selection guidance would have resulted in plant performance that was significantly different from what was designed.

Membrane performance is highly dependent on the type of water treated as well as where the water is treated.

Collaborating with Siemens early in the procurement process proved to be beneficial to both parties, as these evaluations alleviated future problems the GWRS likely would have experienced by introducing the PVDF membrane. As a result, OCWD has continued using the PP membrane in the existing facility and will use it in any future GWRS expansion. **MT**

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