CASE STUDY

RO | UF | MBR |

Drinking Water
Delaware, Ohio, USA

TORAY

Toray's Durable PVDF Hollow-fiber Ultrafiltration Membranes Selected for Plant Upgrade at the City of Delaware

OVERVIEW

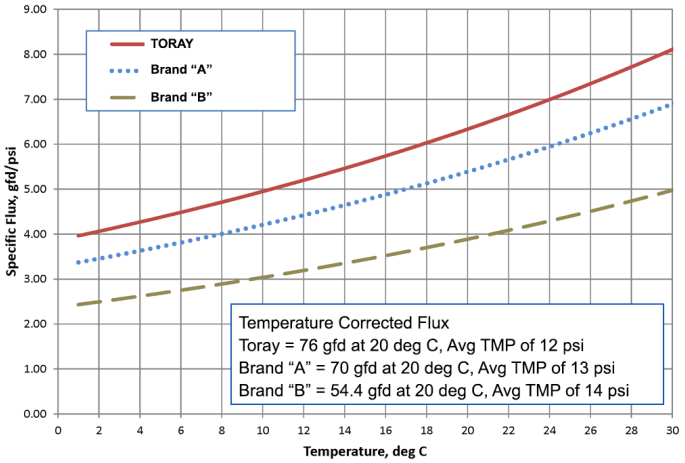
The City of Delaware's Water Treatment Plant (WTP) started operating in 1889. The plant's raw water source is a blend of surface water from the Olentangy River and groundwater from a limestone aquifer. Under the EPA's Long Term 2 Enhanced Surface Water Treatment Rule (LT2), the WTP's feedwater is classified as Bin 2, which requires a 4-log removal of Cryptosporidium. As a result, the City would convert its 6.0 MGD lime softening plant to a 7.2 MGD membrane treatment facility utilizing a 4.5 MGD ultrafiltration (UF) system to comply with LT2. A total of seven proposals were initially submitted during the UF system's bidding phase, narrowed down to three showing the best in terms of projected capital and operating costs and membrane performance. The three selections would be piloted for further evaluation, including UF modules by Toray.

PILOT EVALUATION

The pilot's objective was to determine the full-scale facility's operating parameters and meet Ohio's EPA drinking water requirements. The shortlisted UF modules were piloted for 2,000 hours during the colder months, where the raw water temperature ranged from 1°C to 18°C, and the feed water turbidities were as high as 45 NTU. Figure 1 shows the change in specific flux with increasing temperature, where Toray demonstrated to have the highest sustainable flux.

Toray's polyvinylidene fluoride (PVDF) membranes have high resistance to chemicals, allowing for consistent flux rates after cleaning. As a result, Toray UF modules required only one clean-in-place (CIP) every two months and used less air during backwash (3.5 scfm for Toray vs. 9.0 scfm for Brand "A"). The consultant further noted that "membrane strength and reliability are the most important criteria and based on manufacturer's testing data and published studies, Toray also has the strongest membrane fiber on the market today." (Cook 2013). Also, Bin 2

Figure 1: Specific flux versus temperature



classification of the City's water source requires higher pressure (20 psi) for membrane integrity tests, increasing the likelihood of fiber breaks. Thus, membrane fiber integrity played an essential role in UF module selection for the City's plant upgrade, where Toray performed well in the pilot and assessments.

To help operators check for membrane integrity during pressure decay tests (PDT), Toray provided modules with transparent filtrate site tubes, as shown in Figure 3. The full-scale plant would also incorporate clear tubes on the drainage and backwash overflow lines to provide additional information to the operators.

DECISION MATRIX

Post-pilot, the membranes were further evaluated against non-monetary factors. As illustrated in Table 2, a decision matrix chart helped determine the best UF system for the City, where Toray scored the most points and recommended for the WTP's improvement plans.

Table 1 — Quick Facts	
Pre-treatment	200 µm strainers
No. of trains	3
Max. capacity / train	2.25 MGD
Modules per train	48
Configuration	4 rows of 12 modules
Max. net flux (gfd)	60.5
Recovery	>95%
Start-up	1Q 2015

"Toray has the strongest membrane fiber on the market today." URS (now AECOM)

Figure 2: UF system designed and constructed by H2O Innovation, Inc. (www.h2oinnovation.com)

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TABLE 2 — CITY OF DELAWARE UF EQUIPMENT SELECTION DECISION MATRIX

	Capital Cost	Operational Costs	Experience	Financial Strength	Customer Service	Reliability	Skid Size / Flexibility	Membrane Pore Size	Membrane Strength	Flux Conservatism	Reduction in Winter Flux	Trans-membrane Pressure	Cleaning Interval	Volume of Chemicals Used	Organics Removal	Overall Pilot Performance	
	Importance Factor (1–10, with 10 being the most important)																
	5	5	8	6	7	10	5	2	8	3	3	4	6	2	4	6	
	Score (1–10, with 10 being the best)																
Brand "A"	10	8	6	8	8	8	10	8	8	7	8	10	8	8	9	8	
Brand "B"	6	10	10	10	8	8	8	10	8	8	6	8	8	8	10	8	
Toray	8	9	7	8	8	10	8	10	10	7	8	10	10	10	8	8	
	Weighted Score																Total
Brand "A"	50	40	48	48	56	80	50	16	64	21	24	40	48	16	36	48	685
Brand "B"	30	50	80	60	56	80	40	20	64	24	18	32	48	16	40	48	706
Toray	40	45	56	48	56	100	40	20	80	21	24	40	60	20	32	48	730

This decision matrix was intended to be used as a tool for aiding the City in determining the best system; however, the City was open to making the final decision based on other criteria as well and was not obligated by this decision matrix.

Table 3 — Design data of UF membrane modules			
Manufacturer brand	Toray	Brand "A"	Brand "B"
Pore size, microns	0.01	0.03	0.02
Area (sq.ft.) of each MF module	775	829	550
Summer Conditions (17°C)			
Peak Flux (gfd) with N-1 skids	68.12	62.3	53.25
Net flux with N-1 skids	60.48	56.54	47.85
Net Capacity (N-1) required	4,500,000	4,500,000	4,500,000
Overall Recovery	95.0%	94.9%	95.0%
Normalized Average TMP, psig	12.0	13.0	14.0
Winter Conditions (3°C)			
Peak Flux (gfd) with N-1 skids	49.95	45.69	33.13
Net flux with N-1 skids	44.35	47.47	29.77
Net Capacity (N-1) required	3,300,000	3,300,000	2,800,000
Overall Recovery	95.0%	94.2%	95.0%
Transmembrane Pressure, psig	12.0	12.0	18.5

Figure 3: filtrate site tubes

REFERENCE

Cook. Jeremy. "Design and Permitting of UF/NF System with Surface Water and Groundwater Supplies." 2013 Membrane Technology Conference & Exposition. San Antonio, TX. February 2013.

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