CASE STUDY

RO | UF | MBR |

Drinking Water
North Dakota, USA

TORAY

Design Expectations Exceeded with Toray Ultrafiltration Membranes at Oliver-Mercer-North Dunn

SYSTEM DESIGN

The Oliver-Mercer-North Dunn (OMND) Drinking Water Treatment Plant (WTP) operates as part of the Southwest Pipeline Project (SWPP) to deliver a continuous supply of drinking water to communities in southwest North Dakota.

OMND uses a two-stage ultrafiltration (UF) system with Toray's hollow-fiber UF membrane modules to treat Lake Sakakawea's surface water. The second stage treats backwash water from the first stage, and the product water from the second stage is returned to the head of the plant. Table 1 lists the raw water quality of the UF feed.

The UF filtrate is fed to a reverse osmosis (RO) system using Toray's low-pressure membrane elements to reduce hardness, Total Dissolved Solids (TDS), and sulfate to the City's potable standards. The UF/RO membrane treatment system's final product water is blended with 60% RO permeate and 40% UF filtrate.

Figure 1: UF system by Wigen Water Technologies (www.wigen.com)

EXPANSION

In 2014, OMND expanded its UF capacity from 4.0 to 7.5 MGD by adding two and one skids to its primary and secondary stages, respectively. The RO capacity was increased from 2.0 to 3.0 MGD by adding one skid. The total finished water capacity of the UF/RO membrane plant would become 5.2 MGD. Table 2 outlines additional information regarding the expansion.

As shown in Figure 2, fourteen months of Toray's UF demonstrated stable operation with minimal fouling of the UF membranes and a trouble-free operation of the RO system. Toray's proprietary thermally-induced phase separation (TIPS) spinning method of the hollow-fibers has produced one of the most durable PVDF (polyvinylidene fluoride) membranes in the industry, with high chemical tolerance and robust fiber integrity.

Table 1 — 1st stage UF feed water quality

Parameter	Unit	Data	
		Min.	Max.
Total Dissolved Solids (TDS)	mg/L	380	510
Turbidity	NTU	< 1.0	31.0
Total Organic Carbon (TOC)	mg/L	2.0	4.5
Alkalinity (as $CaCO_3$)	mg/L	150	180
Total Iron (Fe)	mg/L	0.05	0.15
Total Manganese (Mn)	mg/L	0.01	0.02
Hardness (as $CaCO_3$)	mg/L	170	260
pH		7.5	8.5
Temperature	°F / °C	35 / 2	68 / 20

PROJECT HIGHLIGHT

The UF modules were packaged in a preservative solution to prevent the fibers from drying out but became subject to freezing as the temperatures dropped under sub-zero Fahrenheit (-20 °C) while in transit. If frozen, the fibers could become brittle and snap with any jarring motion. Remarkably, out of the 150 modules that shipped, only two modules suffered damage, with one module restored within the manufacturing Quality Control Release Value (QCRV). This case demonstrates the mechanical strength and integrity of Toray's durable PVDF UF membrane fibers.

Table 2 — After Phase 2 Expansion

UF system	1st stage	Primary UF: 5 skids / 52 modules
	2nd stage	Secondary UF: 2 skids / 16 modules
RO system		3 skids / 1 MGD per skid (17:9 array, 7M)
Product recovery	UF	>99% (95% primary, 90% secondary)
	RO	80%
LRV calculation		Based on conservative Darcy pipe flow model
Pre-treatment		200 µm screen

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Figure 2: Instantaneous Trans-membrane Pressure (TMP)

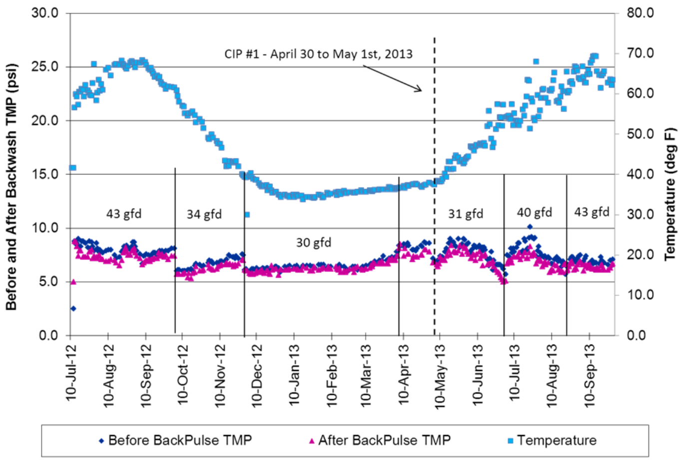

Figure 3 — RO skid using Toray RO membrane elements

MEMBRANE PERFORMANCE

First Stage Operation

- The transmembrane pressure (TMP) did not exceed 10 psi, one-third of the maximum TMP (29 psi), as shown in Figure 2.
- Clean-in-place (CIP) performed after one year of operation for operator training purposes only.
- After observing the positive performance of the membranes in terms of fouling and permeability, the backwash flux rate was decreased from 1.5x to 1.1x filtrate flow.
- The first stage instantaneous flux could be increased 20% to a new temperature corrected flux of 58 gfd at 20°C, granting plant operators the flexibility of adjusting the softened bypass water blend ratio to 50-50 to increase the plant capacity, if desired.

Second Stage Operation

- With feed turbidities 20 times that of the first stage, the second stage was cleaned only once within fourteen months, indicating excellent process resiliency and ability to handle upsets.
- The train was cleaned after the TMP reached approximately 10 psi demonstrating the membranes' ability to handle a high concentration of solids while maintaining a low fouling rate.
- The TMP rose above 10 psi after ten months of operation. CIP was performed after one year of operation, which reduced the TMP from 13 to less than 1 psi.

RESULTS

- The successful operation of phase 1 led to the expansion of phase 2, and design expectations were exceeded.
- The first stage UF system flux rate can be increased by 20% if desired by the end-user.
- The second stage treated feed turbidities of 55 NTU with peaks of up to 620 NTU, where the operation was stable for over one year with TMP values below the operating limit.
- Daily Log Removal Values (LRV) at 4-log using very conservative parameters.

Five years after the expansion:

- No pinning of fibers was required on any of the UF modules.
- LRV values continue to be stable at greater than 4-log on the primary UF system.
- CIP performed only once per year on the primary UF system and only 2–3 times per year on the secondary UF system.

REFERENCE

Guibert, Susan. "Operations and LRV Calculations at North Dakota's Southwest Pipeline Project Oliver-Mercer-North Dunn (OMND) Drinking Water Treatment Facility." 2014 Membrane Technology Conference & Exposition. Las Vegas, NV. March 2014.

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