Versaflex® RO 9110

Demonstrates membrane compatibility and antiscalant performance during extended field trial

Results and discussion

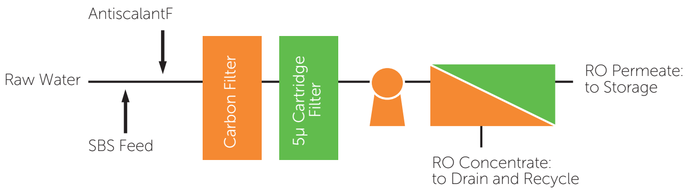
Plant background: A field trial was conducted at a plant that produces ethanol from molasses and other sugar production by-products. The plant produces most of its own energy, relying on plant boilers for its electricity. A reverse osmosis (RO) unit supplies purified water for both the boilers and the process.

System design: The feed water comes from a local reservoir and is stored in a raw water tank prior to being pumped through media filter for clarification and carbon filters to remove residual chlorine. It is then dosed with sodium bisulfite and antiscalant and passes through 5 micron cartridge filters before being pumped to the RO unit.

The RO unit consists of a single stage with four pressure vessels (6 elements/vessel). At startup conditions, permeate flow was 22 m^3/hr, and concentrate flow was 7 m^3/hr. In addition, 10 m^3/hr of the concentrate is recycled and blended with the feed water.

The RO uses brackish water FILMTEC BW30-400 membranes supplied by Dow. These are standard polyamide, thin-film composite membranes that are representative of the industry standard in membrane materials of construction.

Figure 1: RO pretreatment system design



Operating conditions: The plant operating conditions are shown in Table 1. Prior to the trial, the system was treated with 7 - 10 ppm of a competitive product for scale control. A continuous feed of DBNPA (5 - 7 ppm) was added for microbial control. The system was cleaned every 4 weeks or when the permeate flow dropped below 15 m^3/hr.

The feed water SDI (Silt Density Index) is a standard measure of feed water plugging factors and is determined using standard methods[1]. The SDI at the site was significantly higher than the SID < 3, which is generally recommended by membrane or chemical suppliers, indicating the potential for colloidal and/or silt fouling of the membranes.

[1] The SDI is a timed measure of flow through a 0.45-micron filter pad. SDI testing is a widely accepted method for estimating the rate at which colloidal and particle fouling will occur in RO systems. See *ASTM D4189 - 07 Standard Test Method for Silt Density Index (SDI) of Water.*

Highlights

1. Versaflex RO 9110 was tested in an operating RO system for seventy days. The system had a slight tendency to form $CaCO_3$ scale, which was increased due to elevated temperatures and concentrate recycling. The water had a significant tendency to deposit colloidal foulants.

2. Phase One of the trial dosed Versaflex RO 9110 at 10 ppm for 31 days. Both flux and salt rejection remained stable, indicating Versaflex RO 9110 is compatible with polyamide thin film elements.

3. Phase Two ran from day 31 to day 70. The dose was reduced to between 4 and 6 ppm. Flux and salt rejection remained steady, indicating successful $CaCO_3$ scale control.

4. Versaflex RO 9110 helped control colloidal fouling, maintaining the membranes in clean condition.

5. At the conclusion of the trial, the customer opted to continue treating with Versaflex RO 9110. With increased pretreatment to reduce the colloidal fouling tendency, the dose of Versaflex RO could be further reduced.

Table 1: RO operating conditions

Paramater	Measurements	Notes
Years of service	1	
Operation	12–14 (hrs/day)	RO storage tanks determine
Feed water temperature	30–40°C	
Feed water flow	30–35 m^3/hr	
Feed water pressure	13 bar	
Permeate flow (total)	20 m^3/hr	Design target
Concentrate flow	7 m^3/hr	Design target
Concentrate pressure	10 bar	Design target
Recycle flow	10 m^3/hr	Design target
Percent recovery	75%	Calculated (Includes recycle)
pH	7.25	
Turbidity	0.51 NTU	
Conductivity	273 (µS/cm)	
Total hardness	90–100 (as $CaCO_3$, ppm)	
Chloride	45 (as Cl, ppm)	
P-Alkalinity	55 (as $CaCO_3$, ppm)	
SDI	5.5-6.0	Recommended SDI is < 3

Trial procedure

The system was cleaned prior to switching antiscalant products. Flow, pressure and conductivity data were provided for the permeate and the concentrate streams. Temperature was assumed constant throughout the trial period. The data were analyzed using standard normalization software which takes into account changes in pressure, flow and salinity and calculates a "normalized permeate flow."

Tests are considered to be successful when flow and salt passage do not show a "significant" loss. For the purposes of the trial, a significant change in flux was considered a drop to below 15 m^3/hr, which would signal the onset of a typical cleaning.

The system was operated at 75% recovery and included recycle of concentrate to the feed stream. Analysis indicated the water had a slight tendency to form $CaCO_3$ scale, which was increased due to elevated temperatures and concentrate recycling. The water had a significant tendency to deposit colloidal foulants on the membrane system. The plant favored a conservative approach, partially due to the high SDI of the feed water. Therefore, Versaflex RO 9110 was dosed at the same product level as the competitive antiscalant.

The trial was therefore performed in two phases. In Phase 1 (days 1–31), the system was operated using 10 ppm of Versaflex RO 9110. Because this represented an overfeed of the product, this phase was used to determine if the polymer had a detrimental effect on the membrane. In Phase 2 (days 31–70), the antiscalant dose was reduced to 4–6 ppm.

During both phases of the trial, the flux to the RO was stable at about 20 m^3/hr, as shown in Figure 2. The orange dashed lines on the plot represent the experimental error in the system, based on the accuracy of the pressure meter readings being $\pm$ 0.5 bar. This was determined by analyzing the raw data and including a factor to account for operator variability.

Phase One: During Phase 1 of the trial (days 1–31), flux remained steady within the margin of error. However, increased variability was noted in the measurements after about day 21, likely due to a slow colloidal fouling from the unusually high SDI of the feed water. Versaflex RO 9110 is designed to control scaling and is mildly effective against colloidal materials. Thus, an acceptable flux was maintained despite the high SDI.

Phase Two: During Phase 2 (days 31 - 70), the product dosage was dropped to 4 - 6 ppm of Versaflex RO 9110. Performance remained stable during this time as well, indicating that no carbonate scale formed on the membrane elements. A system shutdown occurred between day 42 and day 50. As part of the shutdown, the system was cleaned, resulting in an increased flux, as seen on day 50 when operation resumed. Flux continued to be stable during the remainder of the trial. Salt rejection (Figure 3) also remained stable during the entire trial.

Figure 2: Flux performance with Versaflex RO 9110

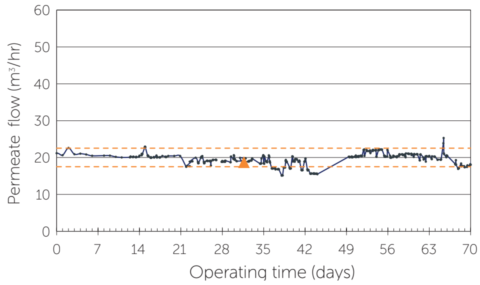
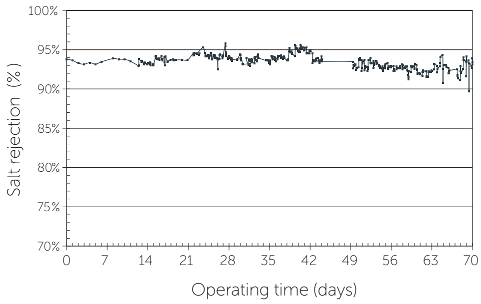


Figure 3: Salt rejection performance with Versaflex RO 9110



Conclusions

Both flux and salt rejection remained stable during the course of the trial, indicating that (1) Versaflex RO 9110 is compatible with polyamide thin film elements and (2) Versaflex RO 9110 is able to prevent carbonate scaling throughout the course of the trial. At the conclusion of the trial, the customer opted to continue treating with Versaflex RO 9110.

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