Water & Process Solutions

Blackhawk Southern US Power Station Experiences Excellent Performance from FILMTEC™ BW30HR-440*i* Membranes

At-a-Glance

LOCATION

Southern United States

Project Purpose:

Upgrade performance of the RO system used to treat make-up denim water at a power plant by selecting membranes with better product quality (particularly in removal of SiO_2), consistent product flow and robust cleanability.

Design Capacity:

Six reverse osmosis trains, each expected to produce 400 gpm of pure water using 571.4 gpm of feed (70% recover).

System Key Facts:

- Six reverse osmosis trains at the power plant all operating with non-Dow membranes. Only two would have membrane upgrades.
- Each train contains 105 8-inch RO elements arranged in a single-pass, two-stage configuration.
- Pretreatment before RO includes sand filtration and cartridge filtration. Polishing post-RO is done with a large mixed bed of ion exchange resin.
- One train was replaced with the Dow Filmtec™ BW30HR-440*i* membrane and the other with the Dow Filmtec™ BW30-440*i* membrane.
- Make-up water is required for any power plant and a consistent adequate flow rate of pure water is critical. Doing so at low pressure pays dividends in energy saved and a widened operating window.

Performance:

- The BW30HR-440*i* has demonstrated the ability to maintain 21% more product water flow with about 10% lower pressure.
- The ionic load reaching the mixed bed polisher is at least 25% lower with the BW30HR-440*i*.
- The BW30HR-440*i* produces higher-quality water, reducing demand on the mixed bed polisher and saving money on regeneration chemicals for the mixed bed.

Time in Operation:

Since 2009

Background

A 227 MW gas-fired power plant operating in the southern United States generates electricity and steam for the public power grid and the adjacent oil refinery.

To treat their make-up demin water, the power plant depends on six parallel reverse osmosis (RO) trains. In August 2009, the plant sought to upgrade performance of their RO system by replacing the membranes installed in two of the six trains. Important factors in membrane selection included better product quality, particularly in the removal of (SiO_2), consistent product flow and robust cleanability to recover product flow in case of a periodic upset in pre-treatment.

Water Treatment System Parameters

Each of the six reverse osmosis trains at the power plant contains 105 8" RO elements arranged in a single-pass, two-stage configuration. Each train is expected to produce 400 gpm of pure water using 571.4 gpm of feed (70% recovery).

Pre-treatment before the RO includes sand filtration and cartridge filtration. Polishing after the RO is performed with a large mixed bed of ion exchange resin.

Properties of the feed water entering each RO train is summarized in Table 1.

Table 1. RO feedwater analysis.

Feed Water Analysis	
Temperature	15°C
pH	8.7
Total Dissolved Solids	481.2 mg/L
Potassium (K)	5 mg/L
Sodium (Na)	41.7 mg/L
Magnesium (Mg)	28 mg/L
Calcium (Ca)	44 mg/L
Strontium (Sr)	1 mg/L
Barium (Ba)	0.07 mg/L
Carbonate (CO_3)	8.068 mg/L
Bicarbonate (HCO_3)	255 mg/L
Nitrate (NO_3)	1.8 mg/L
Chloride (Cl)	22 mg/L
Fluoride (F)	1.5 mg/L
Sulfate (SO_4)	60 mg/L
Silica (SiO_2)	13.6 mg/L

Membrane Selection

Leading up to the August 2009 decision to upgrade the membranes in two of the RO trains, all six trains had been operating with non-Dow membranes. The power plant decided to replace one train with Dow's newly-released FILMTEC™ BW30HR-440*i* membrane, and to replace a different train with its predecessor, the FILMTEC BW30-440*i* membrane.

Both of these FILMTEC products benefit from an element construction that includes 440 ft^2 of active area—the most available in the industry. They also both feature Dow's patented iLEC™ Interlocking Endcap technology, which minimizes leakage around the o-ring that connects adjacent elements because the o-ring is seated firmly in a compression seal where it is not susceptible to the usual wear and tear experienced by standard interconnector designs.

However, the new BW30HR-440*i*, "HR" for High Rejection, additionally offers advantages from new innovations in membrane chemistry. Higher rejection and higher flow typically oppose each other and an improvement in one usually comes with a compromise in the other. But with the latest chemistry developments from Dow, both were improved simultaneously in the BW30HR membrane. Additionally, the new HR membrane chemistry possesses fouling-resistant properties, which pays back the operator in more peace-of-mind by providing more consistent product flow and more reliable operation.

A summary of the typical properties of the two membranes used in this plant-scale comparison can be seen in Table 2.

Table 2. Membrane element typical properties.

	BW30HR-440*i*	BW30-440*i*
Product Flow	12,650 gpd (48 m^3/d)	11,500 gpd (43 m^3/d)
Rejection:		
NaCl	99.7%	99.5%
Silica	99.9%	99.7%
Boric Acid	83.0%	73.0%
Nitrate	98.5%	95.5%
Ammonium	99.0%	98.0%

Non-NaCl solutes tested at test conditions: 225 psig, 2,000 ppm NaCl (plus solute), 25°C and pH 7.

Installing new membranes in both trains at approximately the same time provided an excellent opportunity for the plant to test the benefits of the new BW30HR-440*i* membrane against its predecessor.

Plant Observations

Figures 1-3 compare the performance of the BW30HR-440*i* and BW30-440*i* membranes after one year of operation.

Flow Rate and Energy Usage

A reliable supply of make-up water is required for any power plant; therefore, consistently producing an adequate flow rate of pure water is critical. Doing so at lower pressure pays dividends through energy savings and also widens the operating window so that the feed pump's maximum pressure is still sufficient, even during winter months. The product flow rate from the two parallel trains is plotted in Figure 1 along with the feed pressure required to achieve that flow.

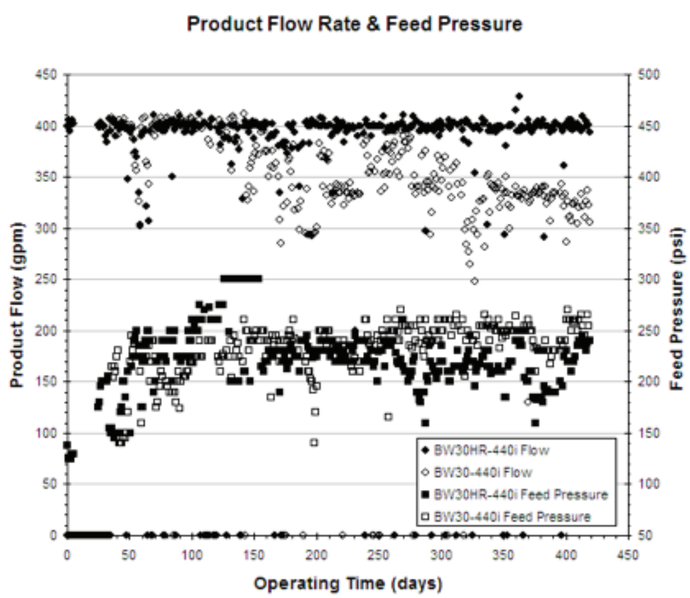

Figure 1: Product flow and feed pressure for the first year of operation.

The RO train containing BW30HR-440*i* has very consistently produced 400 gpm of product water; the required feed pressure for this train increased from about 140 psi to nearly 300 psi as the feed water temperature dropped in the winter months, but then hovered around 225 ± 25 psi. Meanwhile, the train containing BW30-440*i* initially started producing 400 gpm of product water, but after about 150 days the product flow rate began to gradually decline to about 330 gpm despite attempts to compensate by increasing the pressure to about 250 ± 20 psi. Even though both trains have been periodically cleaned, typically about every three weeks as part of regular plant maintenance, the BW30HR-440*i* has demonstrated the ability to maintain 21% more product water flow with about 10% lower pressure.

Purity

High-pressure boilers in power plants demand high purity water. To achieve this stringent water quality, a polishing unit is used down-stream of the RO train. In this case, a mixed bed polisher is used. When the mixed bed polisher is exhausted, it must be chemically regenerated, which impacts operating cost. Overall RO product quality, measured by conductivity, for the two trains can be compared in Figure 2.

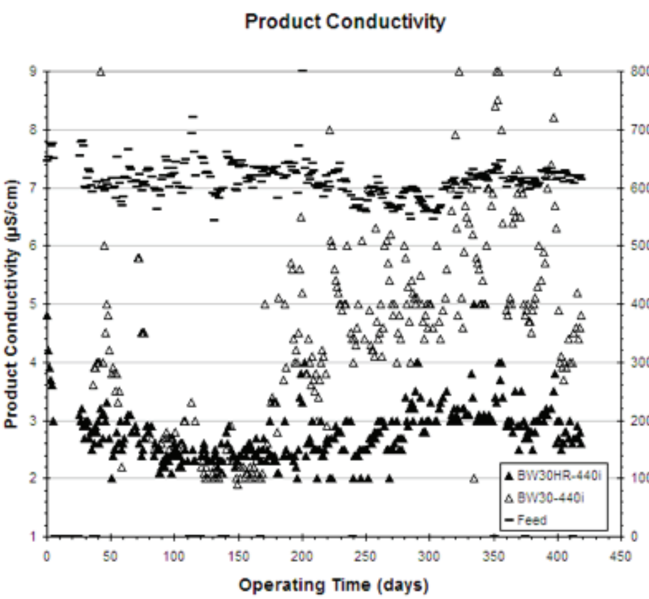

Figure 2: Product conductivity for the first year of operation.

With few exceptions, the product conductivity from BW30HR-440*i* is typically better than 3 µS/cm while the conductivity from the BW30-440*i* is typically above 3 µS/cm and trending toward a range of 4-7 µS/cm. Therefore, the ionic load reaching the mixed bed polisher is at least 25% lower (and sometimes better than 50% lower) with the BW30HR-440*i*, reducing chemical costs proportionately.

Any silica that enters the steam-condensate cycle through the make-up water becomes concentrated in the high-pressure boiler, and the fraction that partitions into the steam deposits on the turbines and reduces the efficiency of the generators. To prevent losses due to poorer turbine efficiency or higher blowdown rates, the mixed bed polishers are regenerated based on silica breakthrough. Regeneration frequency can be reduced, leading to cost savings in chemical consumption, when the upstream RO membranes reject more silica.

Rejection of silica is illustrated in Figure 3 for the two RO products.

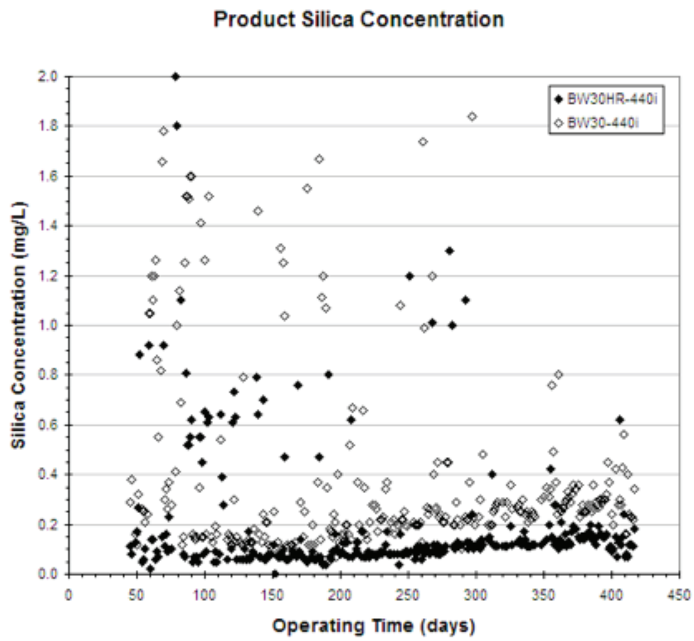

Figure 3. Product silica concentration for the first year of operation.

The concentration of silica in the product water is commonly half as much for the BW30HR-440*i* as it is for BW30-440*i*, helping to reduce the cost of regeneration chemicals spent on the mixed bed polishers.

CONCLUSION

After one year of operation at the southern United States power plant, the BW30HR-440*i* membrane produces more water using less energy than its predecessor. This saves operating cost through energy savings and provides peace of mind by extending the operating window so that a sufficient supply of make-up water can still be produced even in the colder seasons of the year.

At the same time, BW30HR-440*i* also produces higher-quality water that reduces the demand on the mixed bed polisher, saving money on regeneration chemicals for the mixed bed.

Plus, the superior rejection of silica made possible by the BW30HR-440*i* membrane reduces the amount of silica that must be removed by the mixed bed polisher, extending the throughput between regenerations of the polishing beds, and saving chemical costs.

For more information about DOW™ Ultrafiltration and FILMTEC™ reverse osmosis membranes, including all scientific data and supporting reference materials, call the Dow Water & Process Solutions business:

North America: 1-800-447-4369
Latin America: (+55) 11-5188-9222
Europe: (+32) 3-450-2240
Pacific: +60 3 7958 3392
Japan: +813 5460 2100
China: +86 21 2301 1000

Or visit our website at dowwaterandprocess.com.

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