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FILMTEC Membranes

New Desalination System Produces High-Quality, Low-Boron Potable Water

Site Information

Location

Weihai City, China

Purpose

Turn seawater into process water and drinking water for plant while meeting WHO's limit of 0.5 mg/L boron.

Comparative Performance

Using a two-pass desalination process, boron levels were cut to less than 0.5 mg/L along with other feed water components meeting specifications.a

FILMTEC™ BW30-400 elements are used in the second-pass stage of the desalination process at the Huaneng Weihai Power Plant. (Photo courtesy of Huaneng Weihai Power Plant.)

With fresh water in short supply, the Huaneng Weihai Power Plant turned to an abundant supply of seawater to produce both process water for the plant and drinking water for plant employees. A significant challenge to developing the desalination process was meeting the World Health Organization's limit of 0.5 mg/L boron. Officials at the plant decided on a two-pass system using FILMTEC™ membranes, cutting the total ion level to 4 mg/L or less, with boron at less than 0.5 mg/L.

Introduction

Since its founding in 1987, Weihai City in the Shandong Province of China has grown into a cultural and industrial center of over 2.4 million inhabitants. With six commercial ports and over 100 fishing ports, Weihai is an active participant in domestic and international markets and is considered one of China's most important coastal cities. The modern urban environment and beautiful natural scenery combine to make Weihai very attractive to visitors, hosting over 34 million tourists since the late 1980s.

However, Weihai's success is also the source of a significant problem—the supply of fresh water. The burgeoning population and industrial facilities are placing an increasingly heavy strain on Weihai's limited fresh water sources. Recognizing the need for an alternative, less expensive process water supply, the Huaneng Weihai Power Plant, which provides power for Weihai City and surrounding areas, turned to the sea.

Membrane desalination is becoming widely accepted, and this technology is being challenged to purify water to increasingly stringent standards. One of the major challenges today is the removal of boron. The World Health Organization (WHO) has placed a provisional limit of 0.5 mg/L of boron in potable water. A number of desalination facilities are struggling to meet this limit as they deal with locally high levels of boron in sea water and the limited ability of conventional treatment methods to remove it. To address this challenge, the Huaneng Weihai Power Plant decided to use FILMTEC reverse osmosis (RO) membranes.

FILMTEC Membranes and Boron Removal

Seawater has an average boron concentration of 4.5 mg/L.[1] The level varies from location to location depending on the level of naturally occurring boron in the surrounding land mass and the boron content of waste water discharged to the sea.

Boron, like silica, is difficult to remove by conventional RO treatments because it forms a weak acid. It does not dissociate until a pH of about 9.4, which is higher than the neutral pH at which RO membranes generally operate. Depending on the feed water composition, high pH operation may lead to scaling problems that affect operation of the process and increase the cleaning frequency.

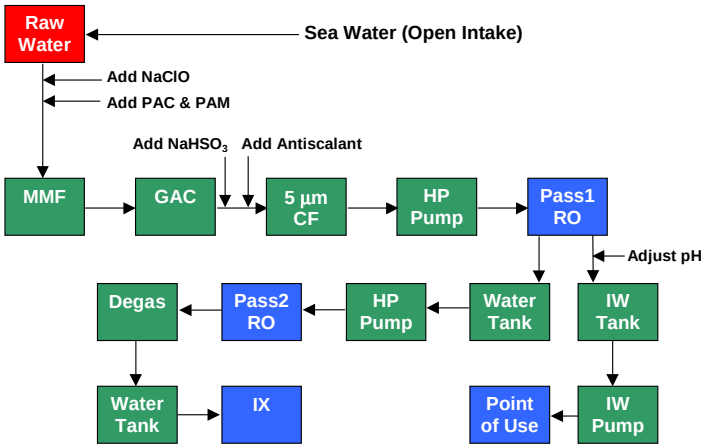
The approach recommended to ensure removal of boron in addition to other compounds was to install a two-pass RO pretreatment system. The first stage uses FILMTEC SW30HR-380 elements, which have the highest active area of seawater membrane elements on the market, purifying 22.7 m^3/day (6,000 gpd) of water with a minimum rejection of 99.7% based on standard test conditions. The high capacity of these elements combined with low fouling behavior and a strong response to modern cleaning chemicals and methods, offers the best economics for large water purification applications.

The second stage uses FILMTEC BW30-400 elements. These elements feature both high productivity and high rejection. Average product water flow is 40 m^3/day (10,500 gpd) with a stabilized salt rejection of 99.5%.

Plant Operation

The primary goal of the plant is to produce water that meets drinking water standards and then further treat it for boiler make-up feed water. Figure 1 is a flow chart of the desalination process. Table 1 lists specific parameters of the RO units.

Figure 1. Flow chart of desalination process.



MMF: multimedia filter
GAC: granular activated carbon
IW: industrial water
CF: cartridge filter
HP: high pressure
IX: ion exchange

Table 1. Description of reverse osmosis system.

Parameter	Pass 1	Pass 2
Permeate flow, m^3/h (gpm)	2 × 52 (2 × 229)	2 × 40 (2 × 176)
System recovery (%)	40	75
Element type	SW30HR-380	BW30-400
Array ratio	17	4:3
Number of elements	6/PV	6/PV
Energy cost (kWh/m^3)	4.68	0.96

Plant Performance

The desalination plant produces very high quality water with low total dissolved solids (TDS), total organic carbon (TOC), silica, and boron (Figure 2, Table 2). This low level of boron is achieved without increasing the pH for the second stage of the process. Eighty percent (80%) of the water is used as boiler make-up feed. Twenty percent (20%) goes to the homes of employees for drinking water and for other uses.

Figure 2. Levels of selected seawater components at various stages of the desalination process.

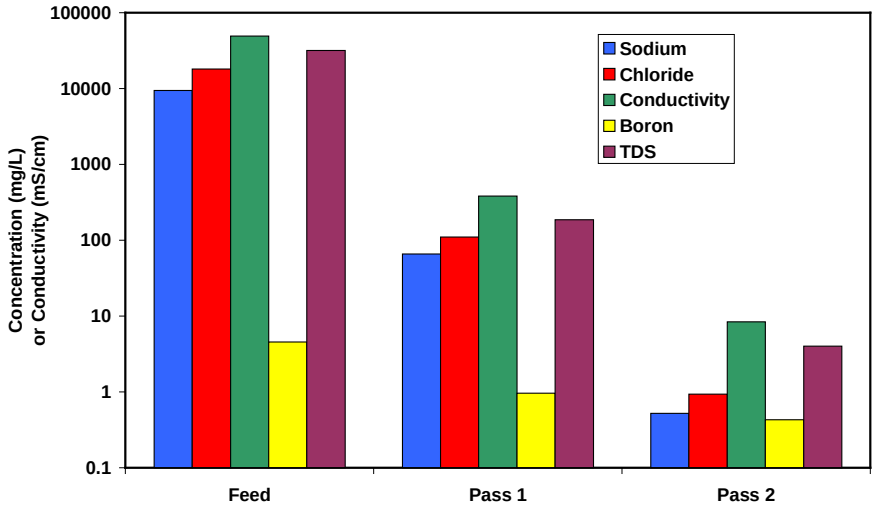
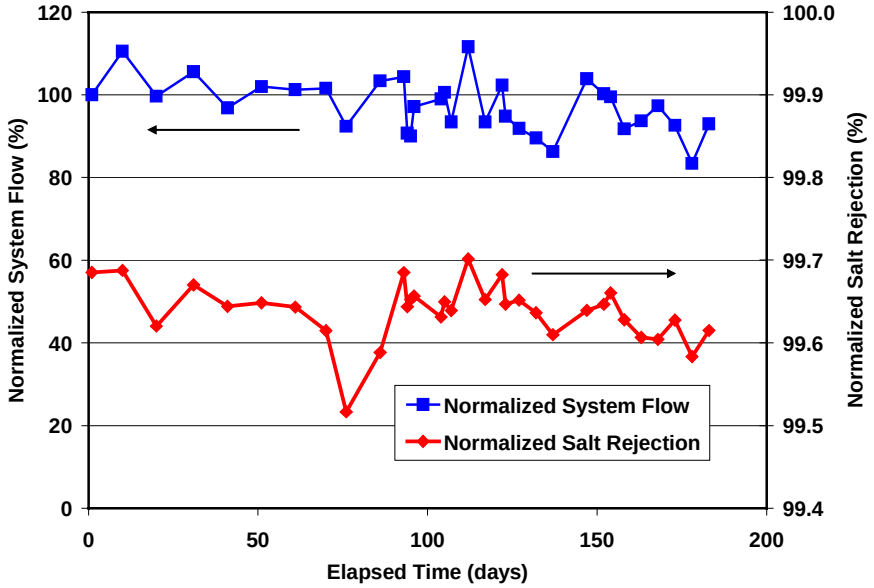


Table 2. Water quality after one and two passes within the desalination process.

Component	Feed	Pass 1 (mg/L)	Pass 2
Cations			
Calcium	382	0.53	—
Copper	0.05	<0.003	<0.003
Iron	0.15	<0.002	<0.002
Magnesium	1,100	0.99	0.17
Potassium	580	4.91	0.031
Sodium	9,400	66.0	0.52
Strontium	7.5	0.007	0.001
Zinc	0.075	<0.002	<0.002
Anions			
Alkalinity, as $CaCO_3$	106.8	1.2	—
Alkalinity, as HCO_3	130	1	—
Chloride	18,048	110	0.94
Sulfate	2,040	0.6	—
Other			
TOC	<2.5	1.0	0.1
Boron	4.57	0.97	0.43
Phosphorus	0.33	<0.012	<0.012
Silica	41.4	<0.79	<0.79

After a year and a half of operation, performance continues to be very stable (Figure 3). No cleaning has been required within that time period. The Huaneng Weihai plant is currently the largest sea water desalination demonstration project operating successfully in China.

Figure 3. Representative system flow and salt rejection with new desalination system.



Conclusions

FILMTEC reverse osmosis elements used in a two-pass desalination process successfully cut boron levels to less than 0.5 mg/L without raising the pH of the feed. Other feed water components, such as sodium, chloride, conductivity, TOC, and TDS, are also reduced to levels that meet specifications for potable water. The process has been operating reliably for 1.5 years, with no cleaning required thus far.

References

[1] Lide, D.R., ed., *CRC Handbook of Chemistry and Physics*, 83rd ed., Boca Raton, FL, CRC Press, Inc., Section 14-16, 2002-2003.