



## DOW™ Ultrafiltration

High Turbidity and Temperature Fluctuation No Obstacle for DOW™ Ultrafiltration

### Site Information

**Location:**

HeBei, China

**Capacity:**

1200 m<sup>3</sup>/h (5283 gpm)

**Purpose:**

Pretreat sea water prior to RO system

**Time in Operation:**

Since 2005

**Performance:**

Turbidity < 0.2 NTU;  
SDI < 2



*Skids of DOW™ Ultrafiltration modules in the HeBei facility. (Photo courtesy of HeBei DaTang WangTang International HuaTan Electricity Co. Ltd.)*

### Introduction

HeBei DaTang WangTang International HuaTan Electricity Co. Ltd. is located in the harbor commercial development area in the province of HeBei. WangTang has a production capacity of over 4 million kW. In 2006, the two-phase coastal electricity stations produced up to 250 billion kWh of electricity. Reverse osmosis (RO) technology is used to desalinate sea water for boiler make-up water supply and other industrial water needs.

The raw water source presented two significant challenges for the system designer: high turbidity and wide temperature fluctuation. Due to the rise and fall of tides, the sea water turbidity oscillates greatly on a daily basis. The temperature range is about 27°C between the hottest and the coldest months. DOW™ Ultrafiltration membranes were able to overcome the challenges and demonstrate reliable performance, resulting in product water with turbidity averaging less than 0.2 NTU and silt density index (SDI) averaging less than 2.

DOW™  
Ultrafiltration  
Modules

The SFP-2660 module is particularly ideal for systems with capacities of 50 m<sup>3</sup>/h (220 gpm) or less, although customers with larger facilities also choose this module because of construction or economic constraints. At 6 inches (15 cm) diameter, the SFP-2660 module allows a more compact, alternative design for space-constrained installations.

DOW™ Ultrafiltration modules are made with high-strength, hollow-fiber membranes that have excellent features and benefits:

- 0.03 µm nominal pore diameter for removal of bacteria, viruses, and particulates (including colloids) to protect downstream processes such as reverse osmosis
- Polyvinylidene fluoride (PVDF) polymeric hollow fibers for high strength and chemical resistance that lead to longer membrane life
- Hydrophilic PVDF fibers for easy cleaning and wettability that help maintain long-term performance
- Outside-in flow configuration for high tolerance to feed solids that helps reduce the need for pretreatment processes
- Unplasticized polyvinylchloride (U-PVC) housing, which helps eliminate the need for costly pressure vessels

Water Treatment  
Process

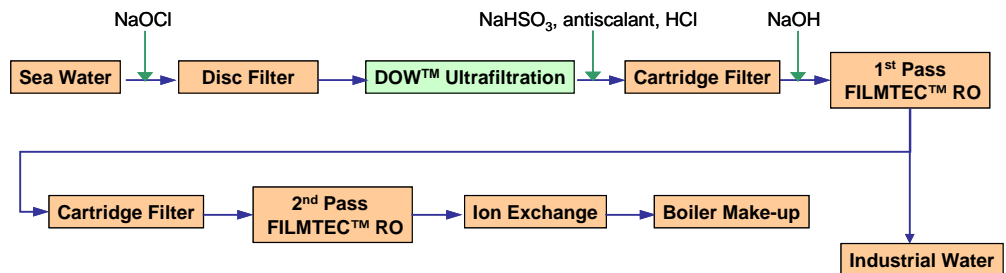
Table 1 indicates the average raw water analysis. Raw water turbidity varies from 20 to 100 NTU.

Table 1. Raw water analysis.

Parameter	Unit	Value
Fe <sup>2+</sup>	mg/L	0.025
Fe <sup>3+</sup>	mg/L	0.07
Turbidity	NTU	<100
Temperature	°C	13
Total suspended solids (TSS)	mg/L	50
Total organic content (TOC)	mg/L	4.0
Oil	mg/L	1.2
pH	—	8.0
Non-active SiO <sub>2</sub>	mg/L	22.5

Figure 1 is a diagram of the water treatment process. Raw water is diverted from the bay area of the Yellow Sea. The sea water's chemical oxygen demand (COD) level is less than 10 mg/L and turbidity decreases to 100 NTU at the raw water inlet. Thus, no coagulation is needed for pretreatment. Only an oxidizing agent (sodium hypochlorite, NaOCl) is used to disinfect the raw water.

Figure 1. Water treatment process.



**Water Treatment Process, cont.**

The disc filter is able to filter out large molecules and prevent irreversible damage to the membrane. A 200- $\mu\text{m}$  disc filter is used to achieve a self-controlled wash at hourly intervals at a design turbidity of 15 NTU. Sodium bisulfite ( $\text{NaHSO}_3$ ) is dosed at 3 ppm to remove any residual oxidizing agent remaining in the water. An antiscalant is dosed at 1 ppm to prevent RO membrane scaling.

The cartridge filters prevent particles from transferring into the treated water and damaging the membrane. Five-micron polypropylene filters with a flow capacity of 60  $\text{m}^3/\text{h}$  each are used for the cartridge filters. Sodium hydroxide ( $\text{NaOH}$ ) is added to the RO feed to achieve an optimal pH for RO feed water between 6 and 9.

A portion of the first-pass RO water is used for other industrial purposes. The remaining water goes through a second-pass RO and ion exchange resin to obtain water ready for boiler make-up supply.

Table 2 provides the operating parameters for the ultrafiltration and reverse osmosis unit operations. Table 3 further describes the ultrafiltration process.

Table 2. Operating parameters for unit operations.

Parameter	Unit	Disc Filter	UF	1 <sup>st</sup> Pass RO	2 <sup>nd</sup> Pass RO
Component	—	—	SFP-2660	FILMTEC™ SW30HR LE-400/	FILMTEC™ BW30-400
Capacity	$\text{m}^3/\text{h}$	1200	1200 (840+360)	450	315
Number of skids	—	3	7+3	3	3
Number of modules per skid	—	—	60	—	—
Total number of modules	—	—	600	—	—
Capacity per skid	$\text{m}^3/\text{h}$	400	120	150	105
Recovery	%	—	95	—	—
Design flux	$\text{L}/\text{m}^2\text{h}$	—	60	—	—

Table 3. Ultrafiltration operating process.

Parameter	Frequency	Duration	Chemical Consumption
Filtration	56 min	56 min	—
Air scour	56 min	40—60 s	—
Backwash	56 min	4 min	15 ppm NaOCl
Forward flush	56 min	60 s	—
CEB <sup>a</sup>	None	None	—
CIP <sup>b</sup>	8 months	6 h	<i>Alkaline:</i> 0.05% NaOH, 0.2% NaOCl <i>Acid:</i> 0.36% HCl

<sup>a</sup>Chemically Enhanced Backwash

<sup>b</sup>Clean-in-Place

Figure 2 shows the raw feed water turbidity fluctuation over a 4-month period. Feed water turbidity varied greatly from about 30 to 100 NTU. However, the product water turbidity was approximately 0.2 NTU and never exceeded 0.3 NTU (right scale). The two zero data points for the feed water were due to the failure of the turbidity meter and are not related to the UF performance. The outside-in flow configuration of the DOW™ Ultrafiltration modules enabled the UF system to meet the challenge of wide-ranging feed water turbidity and produce a stable RO feed water.

Figure 2. Product and raw water turbidity versus time.

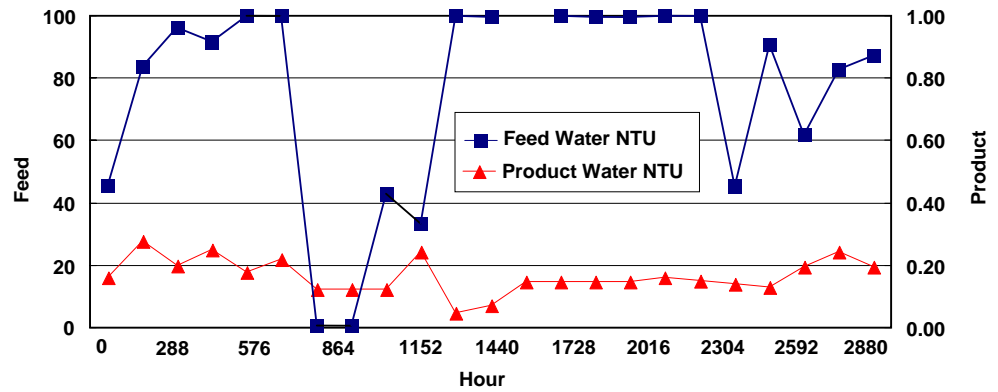
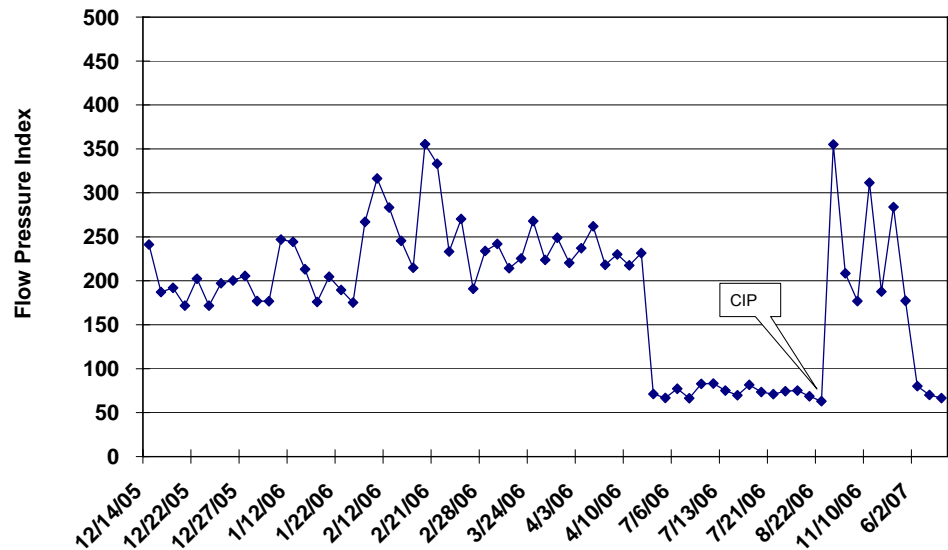


Figure 3 is a plot of flow pressure index (FPI) vs time for the DOW™ Ultrafiltration skid. The FPI is defined as the permeate flow divided by the transmembrane pressure (TMP). A constant FPI value indicates a good and stable UF operation performance. Figure 3 shows the FPI is mostly constant for nearly 2 years operation. The FPI decreased in May 2006 and CIP was performed in August to restore the UF performance. The FPI increased after CIP, indicating that the DOW™ Ultrafiltration membrane is easy to clean. Chemically enhanced backwash (CEB) was not performed during the time period studied. Only one clean-in-place (CIP) was performed after 8 months of operation since installation. The backwash frequency was greater than 30 minutes, further demonstrating UF as an economic choice for RO pretreatment.

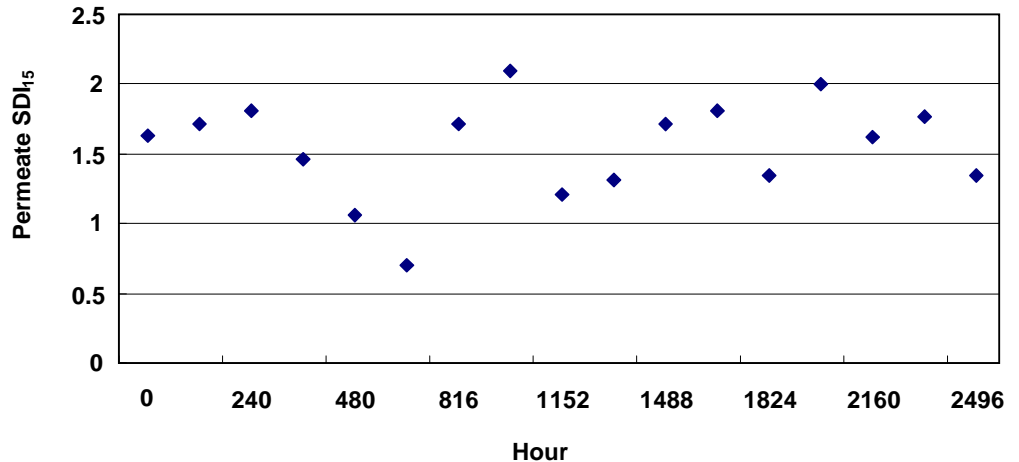
Figure 3. Flow pressure index versus time.



**UF System Performance, cont.**

Figure 4 indicates that the product water SDI value did not exceed 2.1 and ranged from 0.75 to 2.0. Although the feed water turbidity fluctuated widely, the product water SDI value remained below 2 for the majority of the time, producing excellent feed water to the sea water RO unit.

Figure 4. Average UF product water SDI versus time.



**Summary**

DOW™ Ultrafiltration modules met the challenge of high turbidity and fluctuating water temperature to produce acceptable feed water for the WangTang power plant. The only pretreatment required for the DOW™ Ultrafiltration modules is a disc filter, resulting in the elimination of coagulation, sedimentation, or media filtration unit operations. The outside-in flow configuration of the ultrafiltration module makes this possible.

DOW™ Ultrafiltration modules provide an economical and effective solution for sea water desalination and have produced water with SDI averaging less than 2 and turbidity averaging less than 0.2 NTU over three years of operation. This further enhances and ensures the performance of the RO system, resulting in optimal flux, high salt rejection, and high recovery. The UF system and RO system only require chemical cleaning once every 8 and 6 months, respectively, further indicating the reliability of the DOW™ Ultrafiltration as a pretreatment to seawater RO.

**DOW™ Ultrafiltration**  
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