FILMTEC Membranes
System Design: Introduction

Introduction

An entire reverse osmosis (RO)/nanofiltration (NF) water treatment system consists of the pretreatment section, the membrane element section, and the post-treatment section. Pretreatment techniques are discussed in *Water Chemistry and Pretreatment (Section 2*). Post-treatment is employed to achieve the required product quality. In seawater desalination, this is usually pH adjustment, rehardening and disinfection. In ultrapure water (UPW) production, the permeate is usually post-treated by polishing ion exchange demineralization.

In this section, the membrane system is addressed. The system includes a set of membrane elements, housed in pressure vessels that are arranged in a certain manner. A high-pressure pump is used to feed the pressure vessels. Instrumentation, spare parts and tools for services are added as required. A clean-in-place (CIP) system facilitates cleaning of the membranes. This is described in *Cleaning and Sanitization (Section 6)*.

The membrane system is a complete plant with an inlet for feed water and outlets for permeate and concentrate. RO/NF system performance is typically characterized by two parameters, permeate (or product) flow and permeate quality. These parameters should always be referenced to a given feed water analysis, feed pressure and recovery. The goal of the designer of an RO/NF system for a certain required permeate flow is to minimize feed pressure and membrane costs while maximizing permeate quality and recovery.

The optimum design depends on the relative importance of these aspects. The recovery of brackish water systems is limited by the solubility of sparingly soluble salts (see *Scaling Calculations, Section 2.4*) -- 90% is about the maximum. In seawater desalination, the limit of about 50% recovery is dictated by the osmotic pressure of the concentrate stream, which approaches the physical pressure limit of the FILMTEC™ seawater element.

Obtaining the requested salt rejection is mainly a matter of membrane selection. The NF (NF270 > NF200 > NF90), brackish water (BW) (extra low energy (XLE) > BW30LE > BW30), SW (seawater), and SWHR (seawater high rejection) versions of the FILMTEC NF and RO membrane have higher salt rejections in this order, but they also need higher feed pressures under the same conditions. Therefore, the NF to BW30LE membrane is typically applied to feed waters up to 2,000 mg/L total dissolved solids (TDS), BW30 up to 10,000 mg/l, and SW and SWHR to high salinity feed waters up to 50,000 mg/L. For given operating conditions, the permeate quality can be calculated.

The feed pressure needed to produce the required permeate flow for a given membrane depends on the designed permeate flux (permeate flow rate per unit membrane area). The higher the permeate flow per unit of active membrane area, the higher the feed pressure. In seawater systems the permeate flux is relatively low even at maximum allowed pressure. However, the permeate flux could be very high in brackish water systems without reaching the limit of 600 psi (41 bar) for brackish water elements. Although it is tempting to increase the permeate flux to minimize the costs for membrane elements, the flux has to be limited to minimize fouling.

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Introduction (cont.)

From experience, the flux limit to be used in system design depends on the fouling tendency of the feed water. A system designed with high permeate flux rates is likely to experience higher fouling rates and more frequent chemical cleaning. Only experience can set the limits on permeate flux for different types of waters. When designing a membrane system for a specific feed water, it is advantageous to know the performance of other membrane systems operating on the same water. However, quite often there are no other membrane systems for comparison. Then the system design suggestions in *Design Guidelines for 8-inch (Section 3.9.1)* and *Midsize FILMTEC elements (Section 3.9.2)* could be followed.

Further information required to design a system is best collected by using the forms of Table 3.1 and Table 3.2 below. The more complete this information, the better the system design can be optimized towards the customer's needs.

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Table 3.1 System design information

Quotation Number:.............. Date Requested:........................
Date Submitted: .... Requested By: ....

Customer/OEM: ....
Address:..
Proposed Location: ....
Brief Description:...
....
....

Required Product Flow Rate (gpd or m^3/h): ....
Expected Recovery: ....
Annual Water Temperature Range High °C: ....
Low °C:...
Design °C: ....

NF/RO Plant: ❒ Indoors ❒ Outdoors

Designed for Continuous Use: ❒ Yes ❒ No
If not, state needed peak hourly capacity:......................

Plant Will Be Operated By:

Enduser	❒ Yes	❒ No
Trained Personnel	❒ Yes	❒ No
Equipment Manufacturer	❒ Yes	❒ No
Others	❒ Yes	❒ No

Water Source:
❒ Well Water ❒ Softened water
❒ Surface Water ❒ Filtered Effluent Water
❒ Sea Water ❒ Other

Existing Pretreatment ❒ Yes ❒ No SDI...

List of Pretreatment Steps:...
....
Planned Pretreatment: ....

Bacterial Control:	❒ Yes	❒ No	Dechlorination:	❒ Ac-Filter
Chlorine Used	❒ Yes	❒ No		❒ Na-Bisulfite
Chloramines Used:	❒ Yes	❒ No		❒ Other
Antiscalant Used:	❒ Yes	❒ No	Which One?...	

Desired Acidification: ❒ HCl ❒ H_2SO_4 ❒ None

Brief Description of Other Pretreatment Steps: ....
(e.g., clarification, flocculation, multimedia/sand filtration, etc. ....
....

Application: ❒ Potable Water
❒ Industrial Supply for: ❒ Boiler Feed ❒ Pharma ❒ Electronics ❒ Other

Specify Water Quality Needed after RO Treatment: ....
....

State Other Desired Design Criteria:...
....

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Table 3.2 Water analysis for reverse osmosis/nanofiltration

Sample identification: ....

Feed source: ....

Conductivity: .... pH: .... Temperature (°C): ....

Feed water analysis:

Please indicate units (mg/L as ion or ppm as $CaCO_3$ or meq/L)

NH_4^+	....	CO_2	....
K^+	....	CO_3^{2-}	....
Na^+	....	HCO_3^-	....
Mg^{2+}	....	NO_3^-	....
Ca^{2+}	....	Cl^-	....
Ba^{2+}	....	F^-	....
Sr^{2+}	....	SO_4^{2-}	....
Fe^{2+}	....	PO_4^{2-}	....
Fe (tot)	....	S^{2-}	....
Mn^{2+}	....	SiO_2 (colloidal)	....
Boron	……………...	SiO_2 (soluble)	....
Al^{3+}	....		

Other ions: ....

TDS (by method): ....

TOC: ....

BOD: ....

COD: ....

AOC ....

BDOC ....

Total alkalinity (m-value): ....

Carbonate alkalinity (p-value): ....

Total hardness: ....

Turbidity (NTU): ....

Silt density index (SDI): ....

Bacteria (count/mL): ....

Free chlorine: ....

Remarks: ....

(odor, smell, color, biological activity, etc.) ....

....

....

Analysis by: ....

Date: ....

FILMTEC Membranes
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