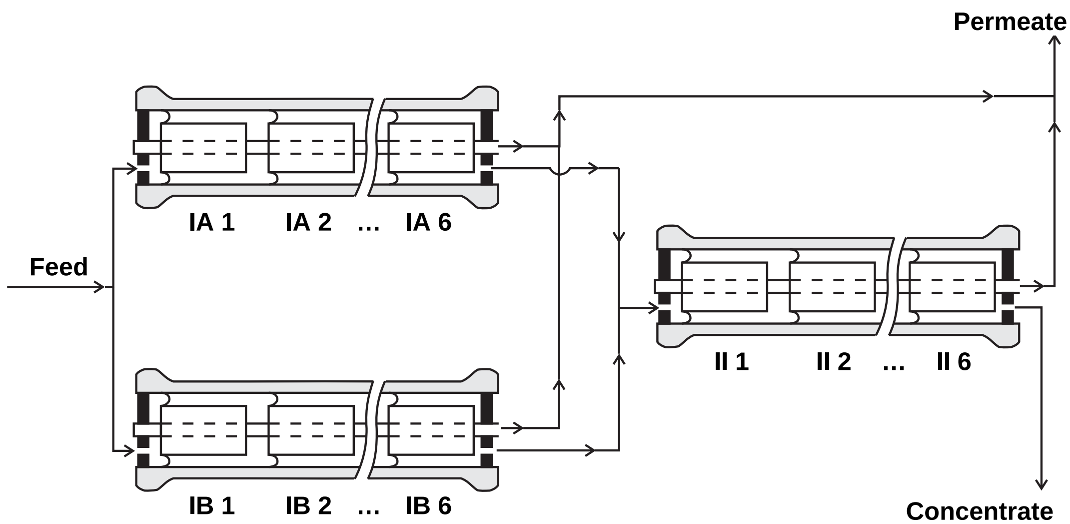
FILMTEC Membranes

System Design: System Performance Projection

System Operating Characteristics

Before a system performance projection is run, one should be familiar with the operating characteristics of a system. These will be explained using a typical example. Figure 3.10 shows a two-stage system with three six-element pressure vessels using a staging ratio of 2:1.

Figure 3.10 Typical two-stage configuration for spiral-wound RO/NF elements



Two-stage systems are generally capable of operating at an overall recovery rate of 55 to 75%. For such systems the average individual recovery rate per element will vary from 7 to 12%. To operate a two-stage system at an overall recovery much higher than 75% will cause an individual element to exceed the maximum recovery limits shown in *Membrane System Design Guidelines (Section 3.9)*. When this happens, a third stage will have to be employed which places 18 elements in series, shifting the average element recovery rate to lower values.

If two-stage systems are operated at too low a recovery (e.g. < 55%), the feed flow rates to the first-stage vessels can be too high, causing excessive feed/concentrate-side pressure drops and potentially damaging the elements. For example, a particular FILMTEC™ 8-inch element may have a maximum feed flow rate in the range of 50–70 gpm (11–16 m^3/h) depending on the water source. More information is available in *Membrane System Design Guidelines (Section 3.9)*.

As a result, systems with lower than 50% recovery will typically use single-stage configurations. Maximum flow considerations can also limit the staging ratio. It is unlikely to find systems with staging ratios greater than 3:1. When a single RO element is run, the operating variables are readily measured, and performance can be easily correlated. When a large number of elements are combined in a system with a multiple staging (i.e. combination of elements in parallel and in series) configuration and only inlet operating variables are known, system performance prediction becomes considerably more complex. Feed pressures and salt concentrations for each element in series are changing. The rate and extent of these changes are dependent not only on the inlet conditions and overall recovery, but also on the stage configuration, i.e., staging ratio(s).

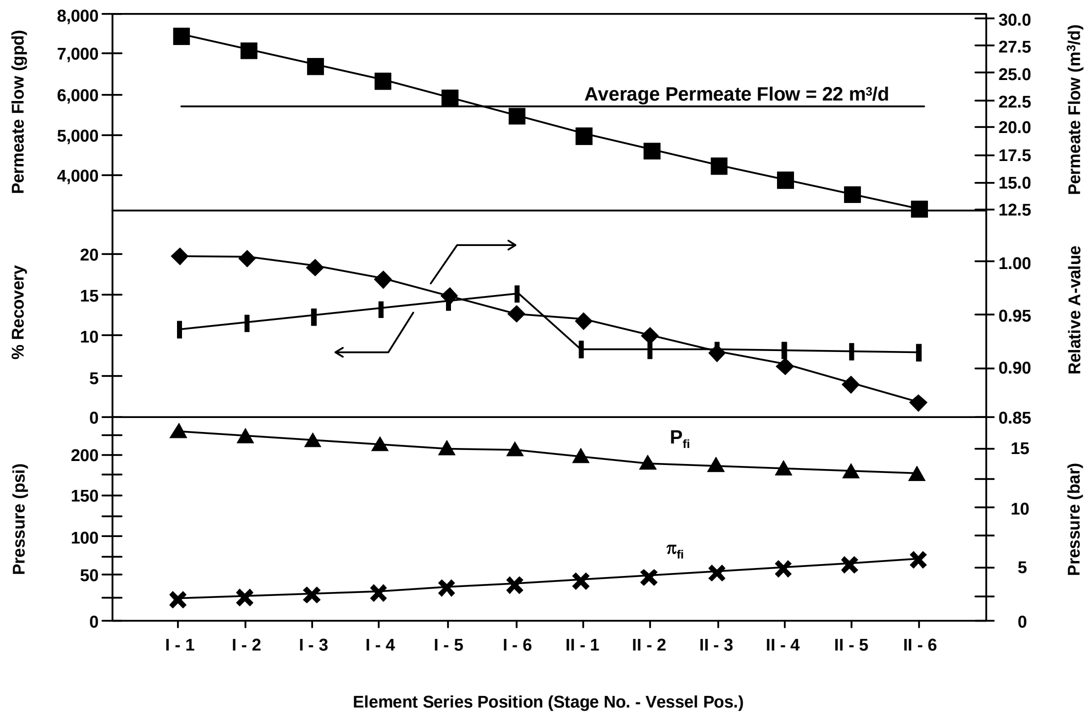
* Trademark of The Dow Chemical Company

System Operating Characteristics (cont.)

Figure 3.11 illustrates the dynamic nature of predicting system performance based on the sum of individual element performances within the system. It shows how five different element performance parameters vary throughout the twelve series positions in a 2:1 array of six-element pressure vessels. The system is operating at 75% recovery and 25°C with a feed osmotic pressure of 20 psi (1.4 bar, which roughly corresponds to a 2,000 mg/L feed TDS). The inlet feed pressure has been adjusted so that the lead BW element is producing 7,500 gpd (28.4 m^3/d), the maximum recommended permeate flow for this particular element used on a well water system with feed SDI < 3.

The top third of Figure 3.11 shows individual element permeate flows decreasing uniformly throughout the series configuration from 7,500 gpd (28.4 m^3/d) in the lead element of the first stage to approximately 3,300 gpd (12.5 m^3/d) in the last element of the second stage. The average element permeate rate is 5,800 gpd (22 m^3/d) or 77% of the maximum allowable limit.

Figure 3.11 Individual element performance in a system 2:1 array of 8-inch BW30 elements (example)



Permeate flow decreases because the net driving pressure, $\Delta P - \Delta\pi$, is uniformly declining. (ΔP is the pressure difference between the feed side and the permeate side of the membrane; $\Delta\pi$ is the osmotic pressure difference between both sides). This is evident by looking at the two curves in the bottom third of the figure. The upper curve shows how the inlet feed pressure to each element (P_{fi}) decreases due to the upstream concentrate-side pressure losses within each element.

The bottom curve shows how the inlet feed osmotic pressure to each element (π_{fi}) is increasing as salt-free (mostly) permeate is progressively removed by each upstream element, leaving behind a steadily increasing concentrate concentration. The difference between these two pressure curves is roughly equivalent to the net permeation driving force.

* Trademark of The Dow Chemical Company

System Operating Characteristics
(cont.)

The middle portion of Figure 3.11 exhibits two subtle but important effects. The left-hand scale shows how individual element recovery varies within the twelve element (series) sequence. The break occurs between the first and second stages. In general, the individual recovery profile will increase in both stages but typically more strongly in the first. The system designer, utilizing a computer program, must verify that the last element in the first stage does not exceed the appropriate recovery limit. As element recovery increases, the effective osmotic pressure that the membrane "sees" will be higher due to concentration polarization. This inefficiency reduces permeate flows and can lead to membrane scaling or fouling if allowed to go to excess.

The other curve in the middle portion of Figure 3.11 (right-hand scale) illustrates an interesting phenomenon exhibited by the FILMTEC membrane. It shows that the membrane water permeability coefficient, or A-value, is a reversible function of salt concentration, decreasing at higher salinity and increasing at lower salinity. The water permeability declines by almost 15% in this example through the series of twelve elements, and this must be taken into consideration if an accurate design for system permeate flow rate is to be obtained.

FILMTEC Membranes
For more information about FILMTEC membranes, call the Dow Liquid Separations business:

North America:	1-800-447-4369
Latin America:	(+55) 11-5188-9222
Europe:	(+32) 3-450-2240
Pacific (ex. China):	+800-7776-7776
China:	+10-800-600-0015

http://www.filmtec.com

Notice: The use of this product in and of itself does not necessarily guarantee the removal of cysts and pathogens from water. Effective cyst and pathogen reduction is dependent on the complete system design and on the operation and maintenance of the system.

Notice: No freedom from any patent owned by Seller or others is to be inferred. Because use conditions and applicable laws may differ from one location to another and may change with time, Customer is responsible for determining whether products and the information in this document are appropriate for Customer's use and for ensuring that Customer's workplace and disposal practices are in compliance with applicable laws and other governmental enactments. Seller assumes no obligation or liability for the information in this document. NO WARRANTIES ARE GIVEN; ALL IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE ARE EXPRESSLY EXCLUDED.

*Trademark of The Dow Chemical Company

Form No. 609-02056-1004