System Design

Membrane System Design Guidelines for 8-inch FilmTec™ Elements

The factor which has the greatest influence on the membrane system design is the fouling tendency of the feedwater. Membrane fouling is caused by particles and colloidal material which are present in the feedwater and are concentrated at the membrane surface. The Silt Density Index (SDI) value of the pretreated feedwater correlates fairly well with the amount of fouling material present. The concentration of the fouling materials at the membrane surface increases with increasing permeate flux (the permeate flowrate per unit membrane area) and increasing element recovery (the ratio of permeate flowrate to feed flowrate for a single element). A system with high permeate flux rates is, therefore, likely to experience higher fouling rates, requiring more frequent chemical cleaning.

A membrane system should be designed such that each element of the system operates within a range of recommended operating conditions to minimize the fouling rate and to help avoid mechanical damage. These element operating conditions are limited by the:

- Maximum recovery
- Maximum permeate flowrate
- Minimum concentrate flowrate
- Maximum feed flowrate

The higher the fouling tendency of the feedwater, the stricter are the limits of these parameters. The proposed limits are recommended guidelines based on many years of experience with FilmTec™ Elements.

The average flux of the entire system, i.e., the system permeate flowrate related to the total active membrane area of the system, is a characteristic number of a design. The system flux is a useful number to quickly estimate the required number of elements for a new project. Systems operating on high-quality feedwaters are typically designed at higher flux values, whereas systems operating on poor-quality feedwaters are designed at lower flux values.

However, even within the same feedwater category, systems are designed with higher or lower flux values, depending on the focus being either on minimizing the capital expenses or minimizing the long-term operational expenses. The ranges of flux values given in the tables below are typical numbers for the majority of the systems.

A continuous RO/NF process designed according to the system design guidelines and with a well-designed and operated pretreatment system will show stable performance with no more than about four cleanings per year in standard applications. Exceeding the recommended limits may result in:

- More frequent cleanings
- Reduced capacity
- Increased feed pressure
- Reduced membrane life

A moderate violation of the limits for a short time may be acceptable as long as the physical limits – the maximum pressure drop and the maximum feed pressure (refer to the element product data sheet – are not exceeded. On the other hand, a conservative approach is to anticipate a higher fouling tendency and to design the system according to the stricter limits in order to benefit from a trouble-free system operation and an increased membrane life.

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The following table show the recommended guidelines for designing RO systems with 8-inch FilmTec™ Elements according to feedwater type.

Table 1 Design guidelines for 8-inch FilmTec™ Elements in water treatment applications

Feed Source		RO Permeate	Well Water	Surface Water			Wastewater (Filtered Municipal Effluent or Industrial Effluent)			Seawater		
				Ultrafiltration	Generic membrane filtration or advanced conventional pretreatment	Generic conventional pretreatment	Ultrafiltration	Generic membrane filtration (MBR/MF/UF)	Conventional pretreatment	Well or Open Intake with Ultrafiltration	Open Intake with generic membrane filtration or advanced conventional treatment	Open Intake with generic conventional pretreatment
Feed Silt Density Index (%/min)		SDI < 1	SDI < 3	SDI < 2.5	SDI < 3	SDI < 5	SDI < 2.5	SDI < 3	SDI < 5	SDI < 2.5	SDI < 3	SDI < 5
Maximum Element Recovery (%)		30	19	19	17	15	15	14	13	15	14	13
Active Membrane Area		**Maximum Permeate Flow, gpd**										
365-ft² elements		10,200	8,500	8,500	7,200	6,600	6,300	5,900	5,200	--Not Recommended--		
370-ft² elements		10,200	8,500	8,500	7,200	6,600	6,300	5,900	5,200	7,800	7,400	7,000
380-ft² elements		10,700	8,900	8,900	7,500	6,900	6,500	6,000	5,300	7,900	7,600	7,200
390-ft² elements		10,920	9,200	--Not Recommended--			--Not Recommended--			--Not Recommended--		
400-ft² elements		11,200	9,300	9,300	7,900	7,300	6,800	6,400	5,700	8,400	8,000	7,600
440-ft² elements		12,300	10,300	10,300	8,700	8,000	7,600	7,100	6,300	9,200	8,800	8,360
Design Flux Range, gfd (lmh)		**21 – 25 (36 – 43)**	**16 – 20 (27 – 34)**	**16 – 20 (27 – 34)**	**13 – 17 (22 – 29)**	**12 – 16 (20– 27)**	**11 – 15 (19– 26)**	**10 – 14 (17 – 24)**	**8 – 12 (14 – 20)**	**9 – 11 (15 – 19)**	**8 – 10 (14 – 17)**	**7 – 10 (12 – 17)**
Max. Element Flux, gfd (lmh)		**28 (48)**	**22.7 (39)**	**22.7 (39)**	**20 (34)**	**18 (31)**	**17 (29)**	**16 (27)**	**14 (24)**	**21 (36)**	**20 (34)**	**19 (32)**
Element Type		**Minimum Concentrate Flowrate, gpm (m³/h)**										
BW/NF elements (365 ft²)		10 (2.3)	13 (3.0)	13 (3.0)	13 (3.0)	15 (3.4)	14 (3.2)	14 (3.2)	16 (3.6)	--Not Recommended--		
BW/NF elements (400 ft² and 440 ft²)		10 (2.3)	13 (3.0)	13 (3.0)	13 (3.0)	15 (3.4)	14 (3.2)	14 (3.2)	16 (3.6)	--Not Recommended--		
Mesh-wrap elements ‡		25 (5.7)	25 (5.7)	25 (5.7)			25 (5.7)			--Not Recommended--		
Hypershell™ ‡		20 (4.5)	20 (4.5)	20 (4.5)			20 (4.5)			--Not Recommended--		
SW elements		10 (2.3)	– NR–	--Not Recommended--			14 (3.2)	14 (3.2)	16 (3.6)	13 (3.0)	14 (3.2)	15 (3.4)
Element Type	**Active Area ft² (m²)**	**Maximum Feed Flowrate, gpm (m³/h)**										
BW elements	365 (33.9)	65 (15)	65 (15)	65 (15)	63 (14)	58 (13)	52 (12)	52 (12)	52 (12)	--Not Recommended--		
BW/NF elements	400 (37.2)	75 (17)	75 (17)	75 (17)	73 (17)	67 (15)	61 (14)	61 (14)	61 (14)	--Not Recommended--		
BW elements	440 (40.9)	75 (17)	75 (17)	75 (17)	73 (17)	67 (15)	61 (14)	61 (14)	61 (14)	--Not Recommended--		
Mesh-wrap elements ‡	390 (36.2)	115 (26)	110 (25)	110 (25)			105 (24)			--Not Recommended--		
Hypershell™ ‡	390 (36.2)	105 (24)	100 (23)	100 (23)			95 (21)			--Not Recommended--		
SW elements	370 (34.4)	65 (15)	– NR–	--Not Recommended--			--Not Recommended--			63 (14)	60 (13.5)	56 (13)
SW elements	380 (35.3)	72 (16)	– NR–	--Not Recommended--			--Not Recommended--			70 (16)	66 (15)	62 (14)
SW elements	400 (37.2)	72 (16)	– NR–	--Not Recommended--			--Not Recommended--			70 (16)	66 (15)	62 (14)

‡Maximum feed flow for Mesh-wrap and Hypershell™ includes bypass. Consider that maximum feed flow inside the element is 80 gpm (18.2 m³/h).

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