



FILMTEC Membranes

System Design: Membrane System Design Guidelines

Membrane System Design Guidelines

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

A membrane system should be designed such that each element of the system operates within a frame of recommended operating conditions to minimize the fouling rate and to exclude mechanical damage. These element operating conditions are limited by the maximum recovery, the maximum permeate flow rate, the minimum concentrate flow rate and the maximum feed flow rate per element. The higher the fouling tendency of the feed water the stricter are the limits of these parameters. The proposed limits are recommended guidelines based on many years of experience with FILMTEC membranes.

The average flux of the entire system, i.e. the system permeate flow rate 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 feed waters are typically designed at high flux values whereas systems operating on poor quality feed waters are designed at low flux values. However, even within the same feed water 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 systems, but they are not meant to be limits.

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 and 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 – 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 enjoy a trouble free system operation and an increased membrane life.

Membrane System
Design Guidelines
for 8-Inch
FILMTEC Elements

The following tables show the recommended guidelines for designing RO systems with 8-inch FILMTEC elements according to feed water type.

Table 3.4 Design guidelines for 8-inch FILMTEC elements in water treatment applications

Feed source	RO Permeate	Well Water	Surface Supply		Wastewater (Filtered Municipal Effluent)		Seawater		
					MF ¹	Conventional	Well or MF ¹	Open intake	
Feed silt density index	SDI < 1	SDI < 3	SDI < 3	SDI < 5	SDI < 3	SDI < 5	SDI < 3	SDI < 5	
Average system flux	gfd	21-25	16-20	13-17	12-16	10-14	8-12	8-12	7-10
	l/m ² h	36-43	27-34	22-29	20-27	17-24	14-20	13-20	11-17
Maximum element recovery %	30	19	17	15	14	12	15	13	

Active Membrane Area	Maximum permeate flow rate, gpd (m ³ /d)							
	320 ft ² elements	9,000 (34)	7,500 (28)	6,500 (25)	5,900 (22)	5,300 (20)	4,700 (18)	6,700 (25)
365 ft ² elements	10,000 (38)	8,300 (31)	7,200 (27)	6,500 (25)	5,900 (22)	5,200 (20)		
380 ft ² elements	10,600 (40)	8,600 (33)	7,500 (28)	6,800 (26)	5,900 (22)	5,200 (20)	7,900 (30)	7,200 (27)
390 ft ² elements	10,600 (40)	8,900 (34)	7,700 (29)	7,000 (26)	6,300 (24)	5,500 (21)		
400 ft ² elements	11,000 (42)	9,100 (34)	7,900 (30)	7,200 (27)	6,400 (24)	5,700 (22)		
440 ft ² elements	12,000 (45)	10,000 (38)	8,700 (33)	7,900 (30)	7,100 (27)	6,300 (24)		

Element type	Minimum concentrate flow rate ² , gpm (m ³ /h)							
	BW elements (365 ft ²)	10 (2.3)	13 (3.0)	13 (3.0)	15 (3.4)	16 (3.6)	18 (4.1)	
BW elements (400 ft ² and 440 ft ²)	10 (2.3)	13 (3.0)	13 (3.0)	15 (3.4)	18 (4.1)	20 (4.6)		
NF elements	10 (2.3)	13 (3.0)	13 (3.0)	15 (3.4)	18 (4.1)	18 (4.1)		
Full-fit elements	25 (5.7)	25 (5.7)	25 (5.7)	25 (5.7)	25 (5.7)	25 (5.7)		
SW elements	10 (2.3)	13 (3.0)	13 (3.0)	15 (3.4)	16 (3.6)	18 (4.1)	13 (3.0)	15 (3.4)

Element type	Active area ft ² (m ²)	Maximum feed flow rate ² , gpm (m ³ /h)							
		BW elements	365 (33.9)	65 (15)	65 (15)	63 (14)	58 (13)	52 (12)	52 (12)
BW or NF elements	400 (37.2)	75 (17)	75 (17)	73 (17)	67 (15)	61 (14)	61 (14)		
BW elements	440 (40.9)	75 (17)	75 (17)	73 (17)	67 (15)	61 (14)	61 (14)		
Full-fit elements	390 (36.2)	85 (19)	75 (17)	73 (17)	67 (15)	61 (14)	61 (14)		
SW elements	320 (29.7)	65 (15)	65 (15)	63 (14)	58 (13)	52 (12)	52 (12)	63 (14)	56 (13)
SW elements	380 (35.3)	72 (16)	72 (16)	70 (16)	64 (15)	58 (13)	58 (13)	70 (16)	62 (14)

¹ MF: Microfiltration - continuous filtration process using a membrane with pore size of <0.5 micron.

² The maximum recommended pressure drop across a single element is 15 psid (1bar) or 50 psid (3.5 bar) across multiple elements in a pressure vessel, whichever value is more limiting. We recommend designing at maximum of 80% (12 psid) for any element in a system.

Note: The limiting values listed above have been incorporated into the ROSA (Reverse Osmosis System Analysis) software. Designs of systems in excess of the guidelines results in a warning on the ROSA printout.

Membrane System Design Guidelines for Midsize FILMTEC Elements

The following tables show the recommended guidelines for designing RO systems with 2.5 and 4-inch FILMTEC elements in light industrial and small commercial applications.

Light industrial systems in Table 3.5 have the same requirements as for large systems, requiring stable performance over several years. They are typically for piloting large systems, with continuous operation, CIP facilities and none (or minimal) concentrate recirculation. The expected membrane lifetime is more than 3 years.

Table 3.5 Design guidelines for FILMTEC elements in light industrial and small seawater applications

Feed source	RO permeate	Well water	Softened Municipal	Surface	Wastewater (filtered tertiary effluent)		Seawater	
					MF ¹	Conventional	Well or MF ¹	Open intake
Feed silt density index	SDI < 1	SDI < 3	SDI < 3	SDI < 5	SDI < 3	SDI < 5	SDI < 3	SDI < 5
Typical target flux, gfd (l/m ² h)	22 (37)	18 (30)	16 (27)	14 (24)	13 (22)	11 (19)	13 (22)	11 (19)
Maximum element recovery %	30	19	17	15	14	12	15	13
Element diameter	Maximum permeate flow rate, gpd (m³/d)							
2.5-inch	800 (3.0)	700 (2.6)	600 (2.3)	500 (1.9)	500 (1.9)	400 (1.5)	700 (2.6)	600 (2.3)
4.0-inch	2,300 (8.7)	1,900 (7.2)	1,700 (6.4)	1,500 (5.7)	1,400 (5.3)	1,200 (4.5)	1,800 (6.8)	1,500 (5.7)
Element type	Minimum concentrate flow rate, gpm (m³/h)¹							
2.5-inch diameter	0.7 (0.16)	1 (0.2)	1 (0.2)	1 (0.2)	1 (0.2)	1 (0.2)	1 (0.2)	1 (0.2)
4.0-inch diameter (except full-fits)	2 (0.5)	3 (0.7)	3 (0.7)	3 (0.7)	4 (0.9)	5 (1.1)	3 (0.7)	4 (0.9)
Full-fit 4040	6 (1.4)	6 (1.4)	6 (1.4)	6 (1.4)	6 (1.4)	6 (1.4)	NA	NA
Element type	Active area ft² (m²)	Maximum feed flow rate U.S. gpm (m³/h)	Maximum pressure drop per element psig (bar)	Maximum feed pressure psig (bar)				
Tape-wrapped 2540	28 (2.6)	6 (1.4)	13 (0.9)	600 (41)				
Fiberglassed 2540	28 (2.6)	6 (1.4)	15 (1.0)	600 (41)				
Seawater 2540	29 (2.7)	6 (1.4)	13 (0.9)	1,000 (69)				
Tape-wrapped 4040	87 (8.1)	14 (3.2)	13 (0.9)	600 (41)				
TW30-4040	82 (7.6)	14 (3.2)	13 (0.9)	600 (41)				
Fiberglassed 4040	82 (7.6)	16 (3.6)	15 (1.0)	600 (41)				
SW Fiberglassed 4040	80 (7.4)	16 (3.6)	15 (1.0)	1,000 (69)				
Full-fit 4040	85 (7.9)	18 (4.1)	15 (1.0)	600 (41)				

¹ MF: Microfiltration - continuous filtration process using a membrane with pore size of <0.5 micron.

²We recommend that the pressure drop for new/clean elements be at least 20% below the maximum.

Note: The limiting values listed above have been incorporated into the ROSA (Reverse Osmosis System Analysis) software. Designs of systems in excess of the guidelines results in a warning on the ROSA printout.

Membrane System
Design Guidelines
for Midsize
FILMTEC Elements
(cont.)

In Table 3.6, the small commercial systems are typically between 1–6 elements that are either regularly replaced or else cleaned (every half year or year) or performance loss is acceptable. The expected element lifetime is not more than 3 years. This is a low-cost, compact solution for intermittently operated systems.

Table 3.6 Design guidelines for FILMTEC elements in small commercial applications

Feed source	RO permeate	Softened Municipal	Well water	Surface or Municipal Water
Feed silt density index	SDI < 1	SDI < 3	SDI < 3	SDI < 5
Typical target flux, gfd (l/m ² h)	30 (51)	30 (51)	25 (42)	20 (34)
Maximum element recovery %	30	30	25	20
Maximum permeate flow rate, gpd (m³/d)				
2.5-inch diameter	1,100 (4.2)	1,100 (4.2)	900 (3.4)	700 (2.7)
4.0-inch diameter	3,100 (11.7)	3,100 (11.7)	2,600 (9.8)	2,100 (7.9)
Minimum concentrate flow rate¹, gpm (m³/h)				
2.5-inch diameter	0.5 (0.11)	0.5 (0.11)	0.7 (0.16)	0.7 (0.16)
4.0-inch diameter	2 (0.5)	2 (0.5)	3 (0.7)	3 (0.7)

Element type	Active area ft ² (m ²)	Maximum feed flow rate U.S. gpm (m ³ /h)	Maximum pressure drop per element ¹ psig (bar)	Maximum feed pressure psig (bar)
Tape-wrapped 2540	28 (2.6)	6 (1.4)	13 (0.9)	600 (41)
Fiberglassed 2540	28 (2.6)	6 (1.4)	15 (1.0)	600 (41)
Seawater 2540	29 (2.7)	6 (1.4)	13 (0.9)	1,000 (69)
Tape-wrapped 4040	87 (8.1)	14 (3.2)	13 (0.9)	600 (41)
TW30-4040	82 (7.6)	14 (3.2)	13 (0.9)	600 (41)
Fiberglassed 4040	82 (7.6)	16 (3.6)	15 (1.0)	600 (41)
SW Fiberglassed 4040	80 (7.4)	16 (3.6)	15 (1.0)	1,000 (69)

¹ We recommend that the pressure drop for new/clean elements be at least 20% below the maximum.

Note: The limiting values listed above have been incorporated into the ROSA (Reverse Osmosis System Analysis) software. Designs of systems in excess of the guidelines results in a warning on the ROSA printout.

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>

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