Desal®
PURE WATER
Membrane Technology & Applications

PRODUCT CATALOG

GE Infrastructure
Water & Process Technologies

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Desal Pure Water Catalog

GE Infrastructure
Water & Process Technologies
www.gewater.com

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GE WATER & PROCESS TECHNOLOGIES IS A LEADING MANUFACTURER AND WORLDWIDE MARKETER OF HIGH-TECH EQUIPMENT AND COMPONENTS FOR WATER PURIFICATION AND FLUIDS HANDLING.

Water & Process Technologies, a unit of GE Infrastructure, is the only company in the world that manufactures membrane, membrane elements, membrane equipment and filters across the complete filtration spectrum: reverse osmosis (RO), nanofiltration (NF), ultrafiltration (UF), microfiltration (MF), and particle filtration (PF). A pioneer in the commercial application of corssflow membranes, Water & Process Technologies understands what it takes to consistently create the precise surface characteristics required for specialized membrane separation.

Water & Process Technologies, a platform created from integration of GE Betz, GE and GE Glegg in 2003, is a leading global supplier of water, wastewater and process system solutions. Water & Process Technologies delivers customer value by improving customer performance and product quality and by reducing operating costs and extending equipment life in a broad range of products and services. These products and services are used to optimize total water/process system performance, safeguard customer assets from corrosion, fouling and scaling, and protect the environment through water and energy conservation.

GE Commitment to Quality

At GE, we exceed our customers' expectations by working together to continuously improve quality and meet new challenges.

Dedication to aggressive research and development spending has placed the company at the forefront of membrane technology. Such efforts have improved the quality of existing membranes, and led to the commercial viability of new products, most notably thin-film membranes (TFM®). GE directs a greater percentage of annual revenues into research and development than other enterprises in the membrane industry.

Skilled technicians, together with state-of-the-art equipment and regimented quality control practices, enable GE to closely control the manufacturing process and ensure quality and consistency in each element. Much of the technology and equipment used are proprietary to GE and contribute to the exceptional performance of Desal Membrane Products.

GE consistently delivers quality products. Customers are reassured knowing that GE constantly verifies product quality and performance through rigorous testing to ensure compliance with the tough performance specifications customers demand and deserve.

From assistance in system design and product selection to start-up assistance and after sale support, customers are encouraged to take advantage of our unique resources before, during and after the sale. We invite you to explore our capabilities, and trust that you'll be delighted with what you find.

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Principles of Filtration and Separation Technology

The use of membranes to selectively remove, separate, or concentrate extremely small substances from water is a technological success story of modern-day times. Membrane processes go beyond conventional filtration. There are basically four classes of membranes in use today, each removing different types and/or sizes of substances from the given fluid. The four membrane classes, or separation technologies, are named **Reverse Osmosis (RO), Nanofiltration (NF), Ultrafiltration (UF) and Microfiltration (MF)**.

Although the four classes of membranes look similar, they are functionally unique. Membranes require highly advanced polymer chemistry and manufacturing techniques involving the coating of thin layers of various types of polymers, or plastics, onto backing materials. Depending on the material, process and chemistry involved, either a reverse osmosis, nanofiltration, ultrafiltration, or microfiltration membrane will emerge.

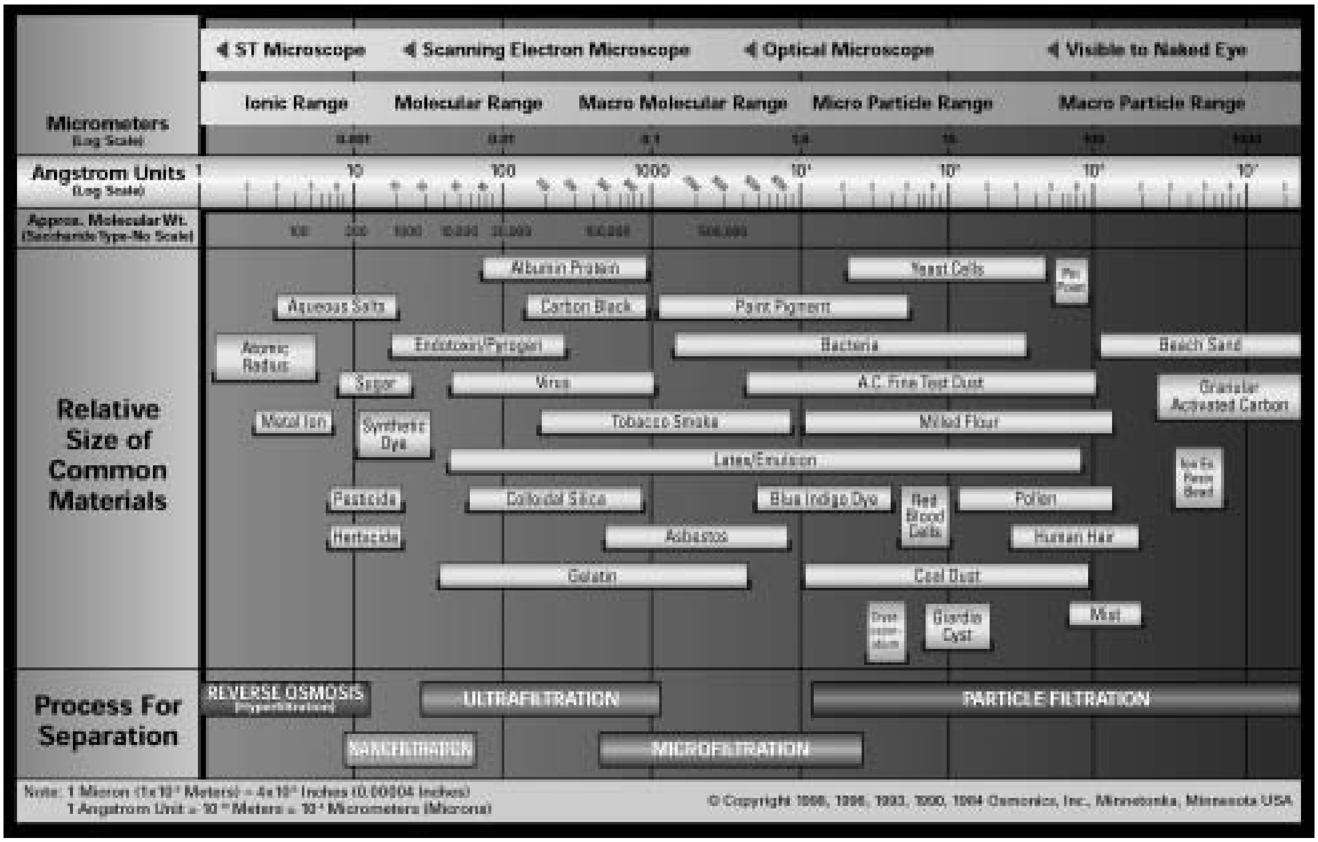
The principal difference between each type of membrane is in the size of the pores, with reverse osmosis membrane pores being the smallest. Each membrane performs very different functions in varying application environments. In general, RO and NF membranes are capable of separating substances as small as ions from feed streams, while UF and NF membranes typically separate larger molecules. All four membrane types allow water to pass.

The filtration spectrum, illustrated on the following page, shows that membrane separation technology removes extremely small substances ranging in size from the ionic to the molecular. These substances are so small that they are typically measured in terms of *Angstroms* (1 Angstrom = one 10 billionth of a meter). The combination of membrane pore size and chemistry removes ionic, molecular, and organic substances measuring between 1 and 50,000 Angstroms.

Typically, RO membranes reject at the ionic level, and NF membranes are usually used to reject multivalent and divalent cations while allowing monovalent ions to pass, thus displaying a unique ability to separate differing ions from one another on the basis of their chemistry. UF and MF membranes reject molecules on the basis of size, with UF retaining particles larger than 30 and MF membranes retaining particles larger than 500. UF and MF membranes are typically rated in terms of pore size and porosity, while RO and NF membranes are rated in terms of percent rejection of a specific salt, and in terms of flow.

Principles of Filtration and Separation Technology

MEMBRANE FILTRATION SPECTRUM

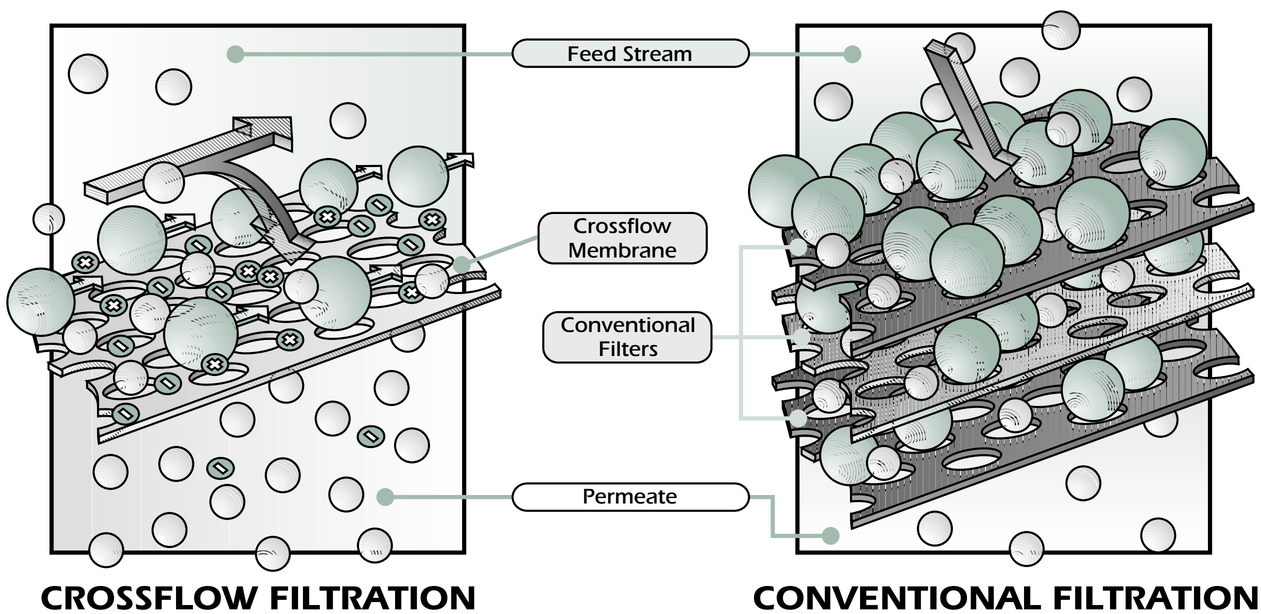


Principles of Filtration and Separation Technology

CROSSFLOW MEMBRANE FILTRATION VS. CONVENTIONAL FILTRATION

RO, NF, UF and MF separation technologies all combine *pressure* with unique *membranes* to remove or concentrate substances from a feed solution, or stream. However, *crossflow filtration* differentiates itself from conventional filtration by employing distinct fluid dynamics to its advantage. The *feed stream* is split into two streams: a *permeate stream* and a *concentrate stream*. In differing applications, it may be either the permeate or the concentrate stream that is of interest to the user.

As illustrated below, part of the feed stream is going through the membrane (creating the filtered permeate stream), and part going across or *parallel* to the membrane, creating the concentrate stream, or *brine*. This crossflow filtration system is unlike conventional dead end filters, which flow in one direction – *through* the filter.

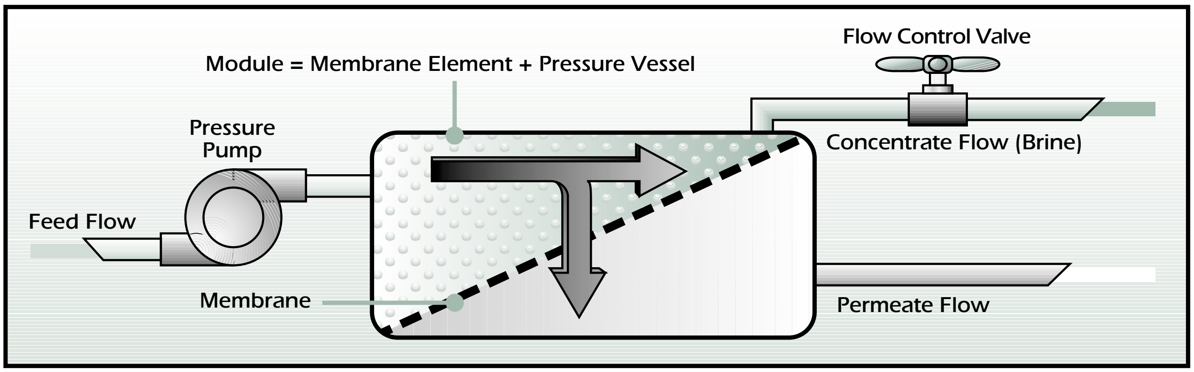


The major advantage of crossflow filtration is that the components of the feed stream that are selectively rejected by the membrane are constantly swept away, thus continually cleaning the membrane surface. This prolongs its life and reduces maintenance and cleaning costs. In contrast, conventional filters accumulate the captured components on the filter medium and must be periodically cleansed replaced, posing obvious economic and/or environmental disadvantages.

Principles of Filtration and Separation Technology

HOW MEMBRANE TECHNOLOGY IS APPLIED

In common applications, the membrane element is housed inside a pressure vessel that accepts inflowing, pressurized feed solution provided by a feed pump.



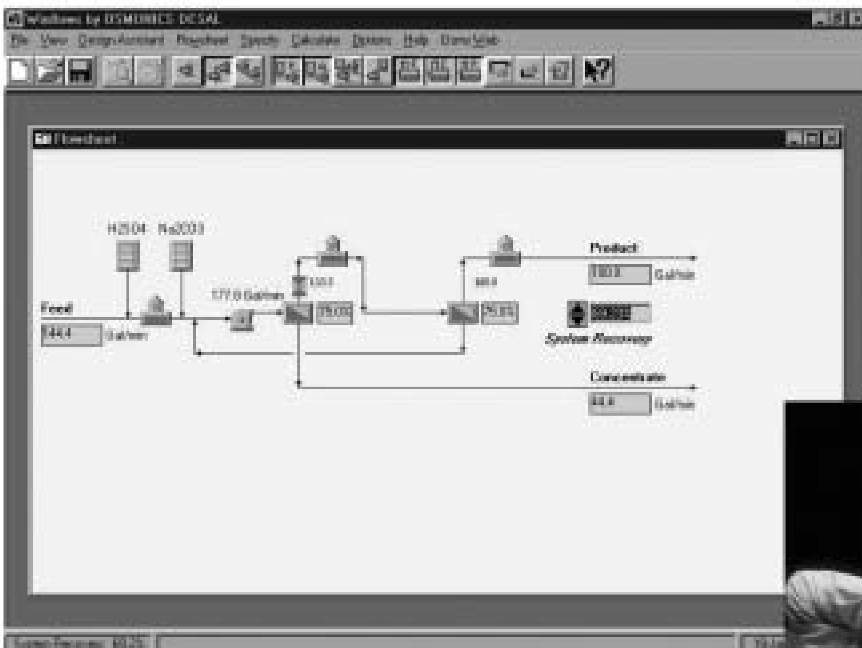
CROSSFLOW MEMBRANE PROCESS

The crossflow and permeate recovery is regulated by a flow control valve. It is important that this pressure is regulated in such a manner that sufficient feed stream is allowed to pass, thereby cleaning the membrane surface. Otherwise membrane fouling may occur. Simultaneously, it is also important that pressure is regulated in such a manner that optimum pressure exists upon the membrane surface to create the permeate stream.

As applications and feed streams vary, it is evident how critical the role is of the membrane since it's functional responsibility is to be the selective gatekeeper of the passing, pressurized feed stream. Responsiveness to different feed streams under different pressures can produce different outcomes. This is why it is critical to utilize the right membrane for your operation to achieve the greatest efficiency. Desal Membrane Products offers the most complete product line in the industry.

Winflows is the most up-to-date membrane system design program available. Never before has a membrane design program allowed such complex, sophisticated designs, or been as easy to use. It's all part of Osmonics' commitment to bringing you the best design tools possible.

Winflows is complex enough for the most sophisticated designer, yet easy enough for beginners to use. For example, Winflows includes complex system configurations such as designs with feed by-pass, recycle, two-pass, and two-stage configurations. With the two-pass and two-stage configurations, designers even have the ability to choose interpass pumps. By opening multiple window, users have easy access to information about how design changes affect performance. And for beginners, Auto Design Wizard leads designers through the whole process, step by step.



Winflows Version 2.1 puts you in control with these and more great features:

- Determine individual membrane performance
- Use the Auto Design Wizard for step-by-step design
- Print product spec sheets on demand
- Access in-depth, user-friendly Help files

To download Winflows Version 2.1 FREE, or to obtain a copy of the Winflows software, please fill out a Winflows request form at http://my.osmonics.com/winflows2003.

A-SERIES | AD ELEMENTS
Seawater, High Rejection

MODEL	OVERALL LENGTH (in)	NOMINAL DIA. (in)	OUTER WRAP	END CONNECTION	PAGE
AD2540FF	40	2.5	FRP	male	12
AD4040FF	40	4	FRP	male	12
AD8040F	40	8	FRP	flush	12

A-SERIES | AG ELEMENTS
Brackish Water, High Rejection

MODEL	OVERALL LENGTH (in)	NOMINAL DIA. (in)	OUTER WRAP	END CONNECTION	PAGE
AG2540FF	40	2.5	FRP	male	16
AG2540TF	40	2.5	tape	male	16
AG4025T	25	4	tape	flush	16
AG4026F	26	4	FRP	flush	16
AG4040C	40	4	Durasan	flush	16
AG4040CF	40	4	Durasan	male	16
AG4040FF	40	4	FRP	male	16
AG4040NF	40	4	Net	male	16
AG4040TF	40	4	tape	male	16
AG8040C	40	8	Durasan	flush	16
AG8040F	40	8	FRP	flush	16
AG8040F-400	40	8	FRP	flush	16
AG8040N	40	8	Net	flush	16
AG8040N-400	40	8	Net	flush	16

A-SERIES | AK ELEMENTS
Brackish Water, Low Pressure

MODEL	OVERALL LENGTH (in)	NOMINAL DIA. (in)	OUTER WRAP	END CONNECTION	PAGE
AK2540FF	40	2.5	FRP	male	18
AK2540TF	40	2.5	tape	male	18
AK4040C	40	4	Durasan	flush	18
AK4040CF	40	4	Durasan	male	18
AK4040FF	40	4	FRP	male	18
AK4040NF	40	4	Net	male	18
AK4040TF	40	4	tape	male	18

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A-SERIES | AK ELEMENTS

Brackish Water, Low Pressure (cont.)

MODEL	OVERALL LENGTH (in)	NOMINAL DIA. (in)	OUTER WRAP	END CONNECTION	PAGE
AK8040C	40	8	Durasan	flush	18
AK8040F	40	8	FRP	flush	18
AK8040F-400	40	8	FRP	flush	18
AK8040N	40	8	Net	flush	18
AK8040N-400	40	8	Net	flush	18

C-SERIES | CD ELEMENTS

High Rejection

CD4025T	25	4	tape	flush	20
CD4040F	40	4	FRP	flush	20
CD8040F	40	8	FRP	flush	20

C-SERIES | CE ELEMENTS

Brackish Water

CE2540FF	40	2.5	FRP	male	22
CE4025T	25	4	tape	flush	22
CE4026F	26	4	FRP	flush	22
CE4040C	40	4	Durasan	flush	22
CE4040F	40	4	FRP	flush	22
CE4040FF	40	4	FRP	male	22
CE4040NF	40	4	Net	male	22
CE8040F	40	8	FRP	flush	22
CE8040N	40	8	Net	flush	22

C-SERIES | CG ELEMENTS

High Flux

CG2540FF	40	2.5	FRP	male	24
CG4040F	40	4	FRP	flush	24
CG8040F	40	8	FRP	flush	24

DURASLICK™ RO MEMBRANE ELEMENTS

Low Fouling

DURASLICK RO 2540	40	2.5	FRP	male	26
DURASLICK RO 4040	40	4	FRP	male	26
DURASLICK RO 8040	40	8	FRP	flush	26
DURASLICK RO 4040 HS	40	4	FRP	male	26
DURASLICK RO 8040 HS	40	8	FRP	flush	26

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Reverse Osmosis

DURATHERM® HWS MEMBRANE ELEMENTS

Hot Water Sanitization

MODEL	OVERALL LENGTH (in)	NOMINAL DIA. (in)	OUTER WRAP	END CONNECTION	PAGE
DURATHERM HWS RO 2521	21	2.5	Durasan	male	28
DURATHERM HWS RO 2526	26	2.5	Durasan	male	28
DURATHERM HWS RO 2540	40	2.5	Durasan	male	28
DURATHERM HWS RO 4014	14	4	Durasan	male	28
DURATHERM HWS RO 4040	40	4	Durasan	male	28
DURATHERM HWS RO 8040	40	8	Durasan	flush	28

DURATHERM® STD MEMBRANE ELEMENTS

High Temperature

DURATHERM STD RO 2540	40	2.5	Durasan	male	33
DURATHERM STD RO 4040	40	4	Durasan	flush	33
DURATHERM STD RO 8040	40	8	Durasan	flush	33

NSF STANDARD 61 CERTIFIED MEMBRANE ELEMENTS

AG4040FF-CERT	40	4	FRP	male	38
AG8040F-400-CERT	40	8	FRP	flush	38
AG8040F-CERT	40	8	FRP	flush	38
AK4040FF-CERT	40	4	FRP	male	38
AK8040F-400-CERT	40	8	FRP	flush	38

Nanofiltration

C-SERIES | CK ELEMENTS

High Flow

CK2540FF	40	2.5	FRP	male	40
CK4040FF	40	4	FRP	male	40
CK8040F	40	8	FRP	flush	40
CK8040N	40	8	Net	flush	40

H-SERIES | HL ELEMENTS

Water Softening

HL2540FF	40	2.5	FRP	male	42
HL2540TF	40	2.5	tape	male	42
HL4040FF	40	4	FRP	male	42

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Nanofiltration

H-SERIES | HL ELEMENTS

Water Softening (cont.)

MODEL	OVERALL LENGTH (in)	NOMINAL DIA. (in)	OUTER WRAP	END CONNECTION	PAGE
HL4040TF	40	4	tape	male	42
HL8040F	40	8	FRP	flush	42
HL8040F-400	40	8	FRP	flush	42
HL8040N	40	8	Net	flush	42

SEASOFT™ MEMBRANE ELEMENTS

Seawater Softening

SEASOFT HR 8040	40	8	FRP	flush	44
SEASOFT HF 8040	40	8	FRP	flush	44

DURASLICK™ NF MEMBRANE ELEMENTS

Low Fouling

DURASLICK NF 2540	40	2.5	FRP	male	46
DURASLICK NF 4040	40	4	FRP	male	46
DURASLICK NF 4040 HS	40	4	FRP	male	46
DURASLICK NF 8040	40	8	FRP	flush	46
DURASLICK NF 8040 HS	40	8	FRP	flush	46

NSF STANDARD 61 CERTIFIED MEMBRANE ELEMENTS

HL4040FF-CERT	40	4	FRP	male	48

Ultrafiltration

G-SERIES | GM ELEMENTS

Pretreatment for RO/NF

GM2540FF	40	2.5	FRP	male	50
GM4040F	40	4	FRP	flush	50
GM8040F	40	8	FRP	flush	50

P-SERIES | PW ELEMENTS

Post-Treatment for RO/NF

PW4025T	25	4	tape	flush	52
PW4040F	40	4	FRP	flush	52
PW4040T	40	4	tape	flush	52
PW8040F	40	8	FRP	flush	52

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Microfiltration

E-SERIES | EW ELEMENTS

Pretreatment for RO/NF

MODEL	OVERALL LENGTH (in)	NOMINAL DIA. (in)	OUTER WRAP	END CONNECTION	PAGE
EW4025T	25	4	tape	flush	54
EW4026F	26	4	FRP	flush	54
EW4040F	40	4	FRP	flush	54
EW4040T	40	4	tape	flush	54
EW8040F	40	8	FRP	flush	54

Seawater, High Rejection

The **A-Series** family of proprietary thin-film reverse osmosis membrane elements are characterized by high flux and excellent sodium chloride rejection.

AD High Rejection Seawater Elements are selected when **extremely high quality permeate** is demanded from seawater that is relatively high in TDS. These elements provide excellent rejection characteristics when operated at pressure of over 800 psi (5,516 kPa) and elevated seawater temperature conditions.

AD High Rejection Seawater Elements feature high-pressure construction, a fiberglass outer wrap and standard feed spacers.

ELEMENT SPECIFICATIONS

MODEL	FLOW GPD (m^3/d)	REJECTION AVG./MIN.	ACTIVE AREA FT² (m^2)
AD2540FF	380 (1.4)	99.6% / 99.2%	26 (2.4)
AD4040FF	1,250 (4.7)	99.6% / 99.2%	88 (8.2)
AD8040F	5,500 (20.8)	99.6% / 99.2%	375 (34.8)

Specification is based on a 32,000 mg/L NaCl solution at 800 psi (5,516 kPa) operating pressure, 77˚F (25˚C), pH 7.5 and 7% recovery. Individual flux may vary +25%/-15%. Average salt rejection after a minimum of 24 hours of continuous operation.

OPERATING AND DESIGN PARAMETERS

THIN-FILM MEMBRANE (TFM®)

TYPICAL OPERATING PRESSURE	TYPICAL OPERATING PROCESS FLUX	MAXIMUM PRESSURE	MAXIMUM TEMPERATURE	RECOMMENDED pH	CHLORINE TOLERANCE
800 psig (5,516 kPa)	10-20 GFD (15-35 LMH)	1,200 psig (8,274 kPa)	122˚F (50˚C)	Optimum Rejection pH: 7.0-7.5 Operating pH Range: 4.0-11.0 Cleaning pH range: 2.0-11.5	1,000 ppm-hrs., Dechlorination recommended

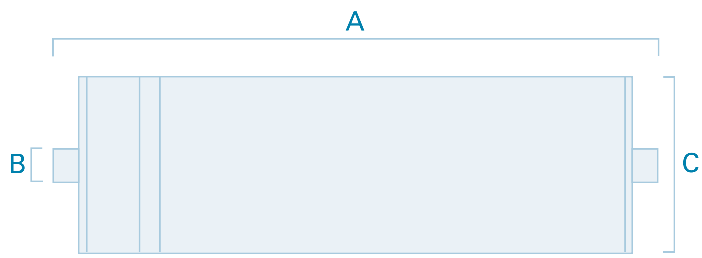
Feed NTU: <1, Feed SDI: <5

Seawater, High Rejection

MAXIMUM PRESSURE DROP	ELEMENTS PER PRESSURE VESSEL					
	1	**2**	**3**	**4**	**5**	**6**
∆P - psig (kPa)	10 (69)	20 (138)	30 (207)	38 (262)	45 (310)	50 (345)

ELEMENT DIMENSIONS AND WEIGHT

MODEL NUMBER LEGEND



MODEL	DIMENSIONS INCHES(MM)			DRY BOXED
	A	**B**	**C***	**WEIGHT** LBS (KG)
AD2540FF	40.00 (1016)	0.750 (19)	2.40 (61)	5 (2.3)
AD4040FF	40.00 (1016)	0.750 (19)	3.88 (99)	12 (5.5)
AD8040F	40.00 (1016)	1.125 (29)	7.88 (200)	32 (14.5)

* The element diameter (dimension C) is designed for optimum performance in OSMONICS pressure vessels. Other pressure vessel dimension and tolerance may result in excessive bypass and loss of capacity.

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Brackish Water, High Rejection

The **A-Series** family of proprietary thin-film reverse osmosis membrane elements are characterized by high flux and excellent sodium chloride rejection.

AG High Rejection Brackish Water Elements are selected when **high rejection and operating pressures as low as 200 psig** are desired. These elements allow moderate energy savings, and are considered a standard in the industry.

AG High Rejection Brackish Water Elements feature tape, net , fiberglass and Durasan® outer wrap and standard feed spacers.

ELEMENT SPECIFICATIONS

MODEL	FLOW GPD (m^3/d)	REJECTION AVG./MIN.	ACTIVE AREA FT^2 (m^2)
AG2540FF	710 (2.7)	99.5% / 99.0%	28 (2.6)
AG2540TF	710 (2.7)	99.5% / 99.0%	28 (2.6)
AG4025T	1,560 (5.9)	99.5% / 99.0%	60 (5.6)
AG4026F	1,560 (5.9)	99.5% / 99.0%	60 (5.6)
AG4040C	2,350 (8.9)	99.5% / 99.0%	90 (8.4)
AG4040CF	2,350 (8.9)	99.5% / 99.0%	90 (8.4)
AG4040FF	2,200 (8.3)	99.5% / 99.0%	85 (7.9)
AG4040NF	2,200 (8.3)	99.2% / 98.5%	85 (7.9)
AG4040TF	2,200 (8.3)	99.5% / 99.0%	85 (7.9)
AG8040C	9,850 (37.3)	99.5% / 99.0%	380 (35.3)
AG8040F	9,200 (34.8)	99.5% / 99.0%	350 (32.5)
AG8040F-400	10,500 (39.8)	99.5% / 99.0%	400 (37.2)
AG8040N	9,200 (34.8)	99.2% / 98.5%	350 (32.5)
AG8040N-400	10,500 (39.8)	99.2% / 98.5%	400 (37.2)

Specification is based on a 2,000 mg/L NaCl solution at 225 psi (1,551 kPa) operating pressure, 77˚F (25˚C), pH 7.5 and 15% recovery. Individual flux may vary +25%/-15%. Average salt rejection after a minimum of 24 hours of continuous operation.

OPERATING AND DESIGN PARAMETERS

THIN-FILM MEMBRANE (TFM®)

TYPICAL OPERATING PRESSURE	TYPICAL OPERATING PROCESS FLUX	MAXIMUM PRESSURE	MAXIMUM TEMPERATURE	RECOMMENDED pH	CHLORINE TOLERANCE
200 psig (1,379 kPa)	10-20 GFD (15-35 LMH)	600 psig (4,137 kPa) TAPE 450 psig (3,103 kPa)	122˚F (50˚C)	Optimum Rejection pH: 7.0-7.5 Operating pH Range: 4.0-11.0 Cleaning pH range: 2.0-11.5	1,000 ppm-hrs., Dechlorination recommended

Feed NTU: <1, Feed SDI: <5

Brackish Water, High Rejection

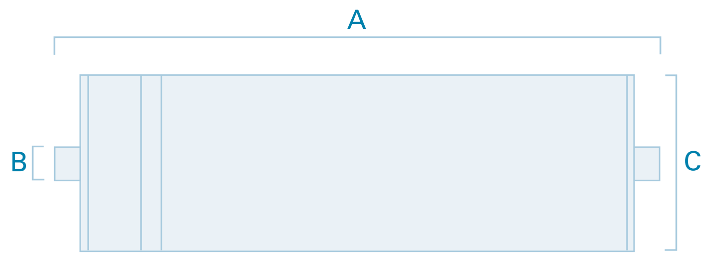
MAXIMUM PRESSURE DROP	ELEMENTS PER PRESSURE VESSEL					
	1	2	3	4	5	6
ΔP - psig (kPa)	10 (69)	20 (138)	30 (207)	38 (262)	45 (310)	50 (345)

ELEMENT DIMENSIONS AND WEIGHT

MODEL NUMBER LEGEND

AG4040NF

- Membrane Type: AG
- Element Size: 4040
- Outer Wrap: N=Net, T=Tape, F=Fiberglass, C=Durasan
- Center Tube: F=Stinger Style, Blank=Flush Cut



MODEL	DIMENSIONS INCHES(MM)			DRY BOXED
	A	B	C*	WEIGHT LBS (KG)
AG2540FF	40.00 (1016)	0.750 (19)	2.40 (61)	5 (2.3)
AG2540TF	40.00 (1016)	0.750 (19)	2.40 (61)	5 (2.3)
AG4025T	25.00 (635)	0.625 (16)	3.88 (99)	5 (2.3)
AG4026F	26.25 (667)	0.625 (16)	3.88 (99)	6 (2.7)
AG4040C	39.25 (1016)**	0.625 (16)	3.88 (99)	12 (5.5)
AG4040CF	40.00 (1016)	0.750 (19)	3.88 (99)	12 (5.5)
AG4040FF	40.00 (1016)	0.750 (19)	3.88 (99)	12 (5.5)
AG4040NF	40.00 (1016)	0.750 (19)	3.88 (99)	12 (5.5)
AG4040TF	40.00 (1016)	0.750 (19)	3.88 (99)	12 (5.5)
AG8040C	40.00 (1016)	1.125 (29)	7.88 (200)	32 (14.5)
AG8040F	40.00 (1016)	1.125 (29)	7.88 (200)	32 (14.5)
AG8040F-400	40.00 (1016)	1.125 (29)	7.88 (200)	32 (14.5)
AG8040N	40.00 (1016)	1.125 (29)	7.88 (200)	32 (14.5)
AG8040N-400	40.00 (1016)	1.125 (29)	7.88 (200)	32 (14.5)

* The element diameter (dimension C) is designed for optimum performance in GE pressure vessels. Other pressure vessel dimension and tolerance may result in excessive bypass and loss of capacity.

** Including ATDs

760 Shadowridge Drive, Vista, CA 92083-7986 USA, Phone (760) 598-3334, Fax (760) 598-3335

Brackish Water, Low Pressure

The **A-Series** family of proprietary thin-film reverse osmosis membrane elements are characterized by high flux and excellent sodium chloride rejection.

AK Low Pressure Brackish Water Elements are selected when **high rejection and extremely low operating pressures** are desired. These elements allow significant energy savings since good rejection is achieved at operating pressures as low as 100 psig.

AK Low Energy Brackish Water Elements feature a net, tape, fiberglass or Durasan outerwrap and standard feed spacers.

ELEMENT SPECIFICATIONS

MODEL	FLOW GPD (m^3/d)	REJECTION AVG./MIN.	ACTIVE AREA FT² (m^2)
AK2540FF	710 (2.7)	99.0% / 98.0%	29 (2.6)
AK2540TF	710 (2.7)	99.0% / 98.0%	27 (2.5)
AK4040C	2,475 (9.4)	99.0% / 98.0%	95 (8.8)
AK4040CF	2,350 (8.9)	99.0% / 98.0%	90 (8.4)
AK4040FF	2,200 (8.3)	99.0% / 98.0%	85 (7.9)
AK4040NF	2,200 (8.3)	98.5% / 98.0%	85 (7.9)
AK4040TF	2,200 (8.3)	99.0% / 98.0%	89 (8.3)
AK8040C	9,900 (37.5)	99.0% / 98.0%	380 (35.3)
AK8040F	9,200 (34.8)	99.0% / 98.0%	365 (33.9)
AK8040F-400	10,500 (39.8)	99.0% / 98.0%	400 (37.2)
AK8040N	9,200 (34.8)	98.5% / 98.0%	350 (32.5)
AK8040N-400	10,500 (39.8)	98.5% / 98.0%	400 (37.2)

Specification is based on a 500 mg/L NaCl solution at 115 psi (793 kPa) operating pressure, 77˚F (25˚C), pH 7.5 and 15% recovery. Individual flux may vary +25%/-15%. Average salt rejection after a minimum of 24 hours of continuous operation.

OPERATING AND DESIGN PARAMETERS

THIN-FILM MEMBRANE (TFM®)

TYPICAL OPERATING PRESSURE	TYPICAL OPERATING PROCESS FLUX	MAXIMUM PRESSURE	MAXIMUM TEMPERATURE	RECOMMENDED pH	CHLORINE TOLERANCE
110 psig (758 kPa)	10-20 GFD (15-35 LMH)	400 psig (2,758 kPa)	122˚F (50˚C)	Optimum Rejection pH: 7.0-7.5 Operating pH Range: 4.0-11.0 Cleaning pH range: 2.0-11.5	1,000 ppm-hrs., Dechlorination recommended

Feed NTU: <1, Feed SDI: <5

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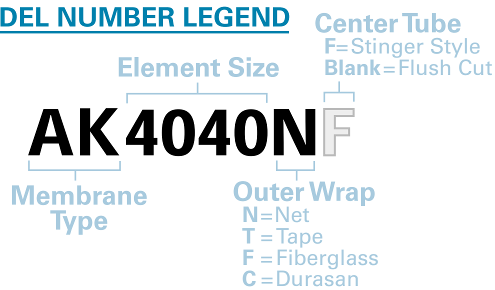
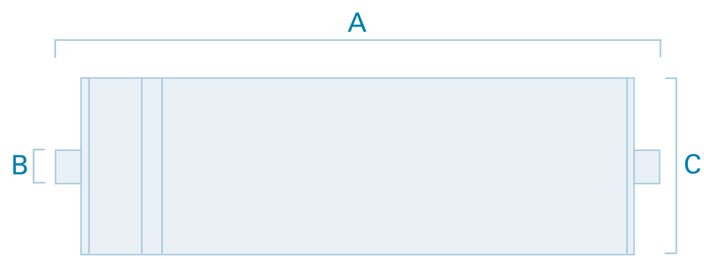
MAXIMUM PRESSURE DROP	ELEMENTS PER PRESSURE VESSEL					
	1	2	3	4	5	6
∆P - psig (kPa)	10 (69)	20 (138)	30 (207)	38 (262)	45 (310)	50 (345)

ELEMENT DIMENSIONS AND WEIGHT

MODEL NUMBER LEGEND





MODEL	DIMENSIONS INCHES(MM)			DRY BOXED
	A	B	C*	WEIGHT LBS (KG)
AK2540FF	40.00 (1016)	0.750 (19)	2.40 (61)	5 (2.3)
AK2540TF	40.00 (1016)	0.750 (19)	2.40 (61)	5 (2.3)
AK4040C	39.25 (1016)**	0.625 (16)	3.88 (99)	12 (5.5)
AK4040CF	40.00 (1016)	0.750 (19)	3.88 (99)	12 (5.5)
AK4040FF	40.00 (1016)	0.750 (19)	3.88 (99)	12 (5.5)
AK4040NF	40.00 (1016)	0.750 (19)	3.88 (99)	12 (5.5)
AK4040TF	40.00 (1016)	0.750 (19)	3.88 (99)	12 (5.5)
AK8040C	40.00 (1016)	1.125 (29)	7.88 (200)	32 (14.5)
AK8040F	40.00 (1016)	1.125 (29)	7.88 (200)	32 (14.5)
AK8040F-400	40.00 (1016)	1.125 (29)	7.88 (200)	32 (14.5)
AK8040N	40.00 (1016)	1.125 (29)	7.88 (200)	32 (14.5)
AK8040N-400	40.00 (1016)	1.125 (29)	7.88 (200)	32 (14.5)

* The element diameter (dimension C) is designed for optimum performance in GE pressure vessels. Other pressure vessel dimension and tolerance may result in excessive bypass and loss of capacity.
** Including ATDs

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High Rejection

The **C-Series** family, a triacetate/diacetate blend, has a higher flux and better mechanical stability than standard celulose acetate. C-Series elements offer a lower per element cost and increased chlorine resistance compared to thin-film elements.

CD High Rejection Elements are used for **brackish water desalination** and **process stream concentration** at 425 psig operating pressure (2,930 kPa).

CD High Rejection Brackish Water Elements feature a tape or fiberglass outer wrap and standard feed spacers.

ELEMENT SPECIFICATIONS

MODEL	FLOW GPD (m^3/d)	REJECTION AVG./MIN.	ACTIVE AREA FT^2 (m^2)
CD4025T	1,025 (3.9)	98.5% / 96.5%	55 (5.1)
CD4040F	1,600 (6.1)	98.5% / 96.5%	90 (8.4)
CD8040F	6,000 (22.7)	98.5% / 96.5%	350 (32.5)

Specification is based on a 2,000 mg/L NaCl solution at 425 psi (2,930 kPa) operating pressure, 77˚F (25˚C), pH 7.5 and 15% recovery. Individual flux may vary +25%/-15%. Average salt rejection after a minimum of 24 hours of continuous operation.

OPERATING AND DESIGN PARAMETERS

CELLULOSE TRIACETATE/DIACETATE BLEND

TYPICAL OPERATING PRESSURE	TYPICAL OPERATING PROCESS FLUX	MAXIMUM PRESSURE	MAXIMUM TEMPERATURE	RECOMMENDED pH	CHLORINE TOLERANCE
140-400 psig (965-2,758 kPa)	10-18 GFD (17-30 LMH)	450 psig (3,103 kPa)	86˚F (30˚C)	Operating pH Range: 5.0-6.5 Cleaning pH range: 3.0-8.0	1 ppm maximum, Continuous 30 ppm for 30 min. during chlorine sanitization

Feed NTU: <1, Feed SDI: <5

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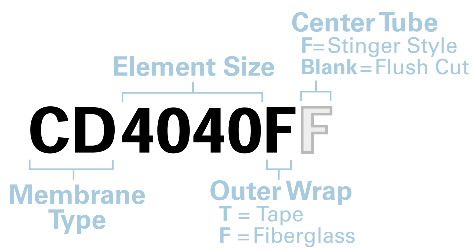
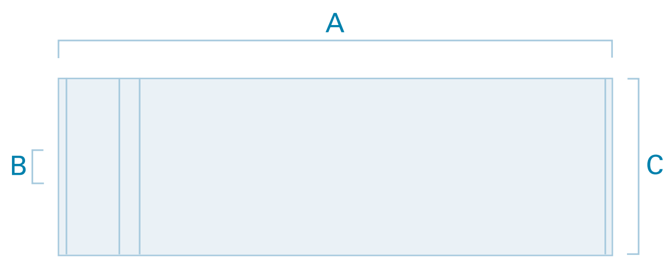
MAXIMUM PRESSURE DROP	ELEMENTS PER PRESSURE VESSEL					
	1	**2**	**3**	**4**	**5**	**6**
ΔP - psig (kPa)	10 (69)	20 (138)	30 (207)	38 (262)	45 (310)	50 (345)

ELEMENT DIMENSIONS AND WEIGHT

MODEL NUMBER LEGEND





MODEL	DIMENSIONS INCHES(MM)			DRY BOXED
	A	**B**	**C***	**WEIGHT** LBS (KG)
CD4025T	25.00 (635)	0.625 (16)	3.88 (99)	5 (2.3)
CD4040F	40.00 (1016)	0.625 (16)	3.88 (99)	12 (5.5)
CD8040F	40.00 (1016)	1.125 (29)	7.88 (200)	32 (14.5)

* The element diameter (dimension C) is designed for optimum performance in GE pressure vessels. Other pressure vessel dimension and tolerance may result in excessive bypass and loss of capacity.

Brackish Water

The **C-Series** family, a triacetate/diacetate blend, has a higher flux and better mechanical stability than standard celulose acetate. C-Series elements offer a lower per element cost and increased chlorine resistance compared to thin-film elements.

CE Brackish Water Elements are used for **brackish water desalination** and **process stream concentration** at 425 psig (2,930 kPa) operating pressure.

ELEMENT SPECIFICATIONS

MODEL	FLOW GPD (m^3/d)	REJECTION AVG./MIN.	ACTIVE AREA FT^2 (m^2)
CE2540FF	630 (2.4)	97.5% / 95.0%	27 (2.5)
CE4025T	1,300 (4.9)	97.5% / 95.0%	59 (5.5)
CE4026F	1,300 (4.9)	97.5% / 95.0%	59 (5.5)
CE4040C	2,150 (8.1)	97.5% / 95.0%	95 (8.8)
CE4040F	2,100 (7.9)	97.5% / 95.0%	95 (8.8)
CE4040FF	2,000 (7.6)	97.5% / 95.0%	85 (7.9)
CE4040NF	2,000 (7.6)	97.0% / 95.0%	85 (7.9)
CE8040F	8,000 (30.3)	97.5% / 95.0%	350 (32.5)
CE8040N	8,000 (30.3)	97.0% / 95.0%	350 (32.5)

Specification is based on a 2,000 mg/L NaCl solution at 425 psi (2,930 kPa) operating pressure, 77˚F (25˚C), pH 7.5 and 15% recovery. Individual flux may vary +25%/-15%. Average salt rejection after a minimum of 24 hours of continuous operation.

OPERATING AND DESIGN PARAMETERS

CELLULOSE TRIACETATE/DIACETATE BLEND

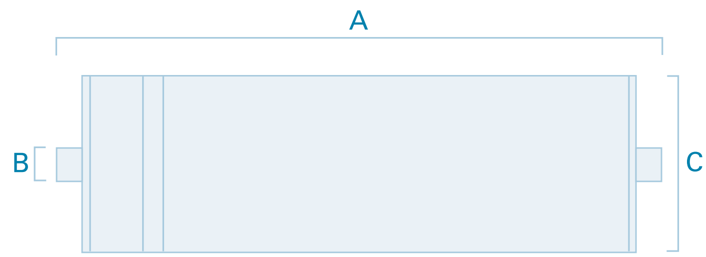
TYPICAL OPERATING PRESSURE	TYPICAL OPERATING PROCESS FLUX	MAXIMUM PRESSURE	MAXIMUM TEMPERATURE	RECOMMENDED pH	CHLORINE TOLERANCE
140-400 psig (965-2,758 kPa)	10-18 GFD (17-30 LMH)	450 psig (3,103 kPa)	86˚F (30˚C)	Operating pH Range: 5.0-6.5 Cleaning pH range: 3.0-8.0	1 ppm maximum, Continuous 30 ppm for 30 min. during chlorine sanitization

Feed NTU: <1, Feed SDI: <5

MAXIMUM PRESSURE DROP	ELEMENTS PER PRESSURE VESSEL					
	1	2	3	4	5	6
ΔP - psig (kPa)	10 (69)	20 (138)	30 (207)	38 (262)	45 (310)	50 (345)

ELEMENT DIMENSIONS AND WEIGHT

MODEL NUMBER LEGEND



MODEL	DIMENSIONS INCHES(MM)			DRY BOXED
	A	B	C*	WEIGHT LBS (KG)
CE2540FF	40.00 (1016)	0.750 (19)	2.40 (61)	5 (2.3)
CE4025T	25.00 (635)	0.625 (16)	3.88 (99)	5 (2.3)
CE4026F	26.25 (667)	0.625 (16)	3.88 (99)	6 (2.7)
CE4040C	40.00 (1016)	0.625 (16)	3.88 (99)	12 (5.5)
CE4040F	40.00 (1016)	0.625 (16)	3.88 (99)	12 (5.5)
CE4040FF	40.00 (1016)	0.750 (19)	3.88 (99)	12 (5.5)
CE4040NF	40.00 (1016)	0.750 (19)	3.88 (99)	12 (5.5)
CE8040F	40.00 (1016)	1.125 (29)	7.88 (200)	32 (14.5)
CE8040N	40.00 (1016)	1.125 (29)	7.88 (200)	32 (14.5)

* The element diameter (dimension C) is designed for optimum performance in GE pressure vessels. Other pressure vessel dimension and tolerance may result in excessive bypass and loss of capacity.

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High Flux

The **C-Series** family, a triacetate/diacetate blend, has a higher flux and better mechanical stability than standard celulose acetate. C-Series elements offer a lower per element cost and increased chlorine resistance compared to thin-film elements.

CG High Flux Elements are used for **brackish water desalination** and **process stream concentration** at 225 psig (1,551 kPa) operating pressure.

ELEMENT SPECIFICATIONS

MODEL	FLOW GPD (m³/d)	REJECTION AVG./MIN.	ACTIVE AREA FT² (m²)
CG2540FF	600 (2.3)	93.0% / 85.0%	27 (2.5)
CG4040F	2,000 (7.6)	93.0% / 85.0%	90 (8.4)
CG8040F	7,300 (27.6)	93.0% / 85.0%	350 (32.5)

Specification is based on a 500 mg/L NaCl solution at 210 psi (1,448 kPa) operating pressure, 77˚F (25˚C), pH 7.5 and 15% recovery. Individual flux may vary +25%/-15%. Average salt rejection after a minimum of 24 hours of continuous operation.

OPERATING AND DESIGN PARAMETERS

CELLULOSE TRIACETATE/DIACETATE BLEND

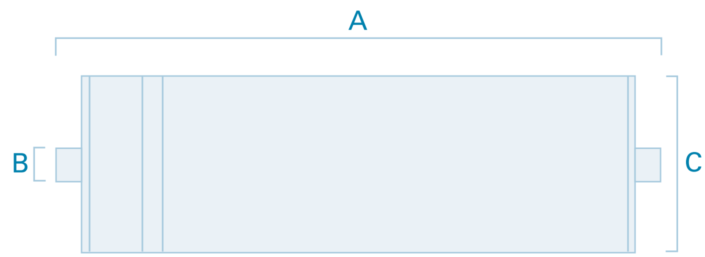
TYPICAL OPERATING PRESSURE	TYPICAL OPERATING PROCESS FLUX	MAXIMUM PRESSURE	MAXIMUM TEMPERATURE	RECOMMENDED pH	CHLORINE TOLERANCE
60-200 psig (414-1,379 kPa)	10-18 GFD (17-30 LMH)	450 psig (3,103 kPa)	86˚F (30˚C)	Operating pH Range: 5.0-6.5 Cleaning pH range: 3.0-8.0	1 ppm maximum, Continuous 30 ppm for 30 min. during chlorine sanitization

Feed NTU: <1, Feed SDI: <5

MAXIMUM PRESSURE DROP	ELEMENTS PER PRESSURE VESSEL					
	1	2	3	4	5	6
∆P - psig (kPa)	10 (69)	20 (138)	30 (207)	38 (262)	45 (310)	50 (345)

ELEMENT DIMENSIONS AND WEIGHT

MODEL NUMBER LEGEND



MODEL	DIMENSIONS INCHES(MM)			DRY BOXED
	A	B	C*	WEIGHT LBS (KG)
CG2540FF	40.00 (1016)	0.750 (19)	2.40 (61)	5 (2.3)
CG4040F	40.00 (1016)	0.625 (16)	3.88 (99)	12 (5.5)
CG8040F	40.00 (1016)	1.125 (29)	7.88 (200)	32 (14.5)

* The element diameter (dimension C) is designed for optimum performance in GE pressure vessels. Other pressure vessel dimension and tolerance may result in excessive bypass and loss of capacity.

Low Fouling RO

Duraslick™ is a new family series of membrane elements engineered **for use with fouling-prone brackish water applications.** Duraslick is designed to utilize an innovative three-layer membrane, of which a proprietary middle layer creates extreme smoothness, and provide a high rejection of sodium chloride.

Independent studies have demonstrated that **Duraslick RO elements** are superior to standard polyamide spiral wound membrane elements for desalination of **difficult feed water sources**. Duraslick RO elements retrofit existing RO systems to obtain lower fouling, reduced overall energy usage, increased membrane service life and an **extension of operating time between required cleanings**, which in turn reduces expenditures on required chemicals. **Duraslick RO-HS** elements are specially designed for comparatively higher suspended solids levels. The Duraslick RO element construction features a fiberglass outer wrap.

ELEMENT SPECIFICATIONS

MODEL	FLOW GPD (m^3/d)	REJECTION AVG./MIN.	ACTIVE AREA FT² (m^2)
DURASLICK RO 2540	675 (2.6)	98.6% / 97.0%	27 (2.5)
DURASLICK RO 4040	2,000 (7.6)	98.6% / 97.0%	85 (7.9)
DURASLICK RO 8040	7,700 (29.1)	98.6% / 97.0%	350 (32.5)
DURASLICK RO 4040 HS	1,500 (5.7)	98.6% / 97.0%	64 (5.9)
DURASLICK RO 8040 HS	6,100 (23.1)	98.6% / 97.0%	278 (25.8)

Specification is based on a 500 mg/L NaCl solution at 225 psi (1,551 kPa) operating pressure, 77˚F (25˚C), pH 7.5 and 15% recovery. Individual flux may vary +25%/-15%. Average salt rejection after a minimum of 24 hours of continuous operation.

OPERATING AND DESIGN PARAMETERS

DURASLICK

TYPICAL OPERATING PRESSURE	TYPICAL OPERATING PROCESS FLUX	MAXIMUM PRESSURE	MAXIMUM TEMPERATURE	RECOMMENDED pH	CHLORINE TOLERANCE
200 psig (1,379 kPa)	10-15 GFD (15-25 LMH)	600 psig (4,137 kPa)	122˚F (50˚C)	Optimum Rejection pH: 5.5-7.0 Operating pH Range: 2.0-11.0 Cleaning pH range: 1.0-11.5	<500 ppm-Hours

Low Fouling RO

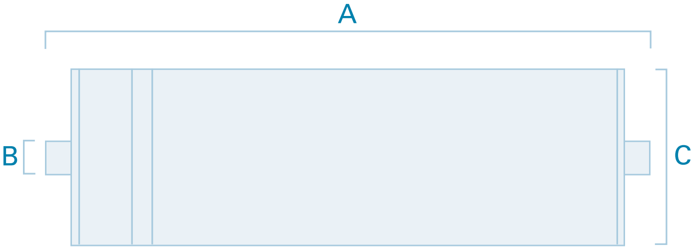
MAXIMUM PRESSURE DROP	ELEMENTS PER PRESSURE VESSEL					
	1	2	3	4	5	6
∆P - psig (kPa)	10 (69)	20 (138)	30 (207)	38 (262)	45 (310)	50 (345)

ELEMENT DIMENSIONS AND WEIGHT

MODEL NUMBER LEGEND

DURASLICK RO 4040 HS

- Membrane Type: DURASLICK
- RO=Reverse Osmosis
- Element Size: 4040
- HS=High Solids



MODEL	DIMENSIONS INCHES(MM)			DRY BOXED
	A	B	C	WEIGHT LBS (KG)
DURASLICK RO 2540*	40.00 (1016)	0.750 (19)	2.40 (61)	5 (2.3)
DURASLICK RO 4040*	40.00 (1016)	0.750 (19)	3.88 (99)	12 (5.5)
DURASLICK RO 8040	40.00 (1016)	1.125 (29)	7.88 (200)	32 (14.5)
DURASLICK RO 4040 HS*	40.00 (1016)	0.750 (19)	3.88 (99)	12 (5.5)
DURASLICK RO 8040 HS	40.00 (1016)	1.125 (29)	7.88 (200)	32 (14.5)

Length includes ATDs. Elements are shipped dry.
* Element includes external permeate tube.

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Hot Water Sanitization

The Duratherm® HWS RO elements provide reliable performance at continuous operating temperatures up to 122˚F (50˚C) in low crossflow environments with water-like viscosity and no suspended solids, or for processes which require periodic hot water sanitizing up to 194˚ F (90˚C). They feature high temperature tolerant materials including the DURASAN® outer wrap.

ELEMENT SPECIFICATIONS

MODEL	FLOW GPD (m^3/d)	MAX. CROSSFLOW GPM (m^3/H)	REJECTION AVG.	ACTIVE AREA ft^2 (m^2)
DURATHERM HWS RO 2521	270 (1.0)	4 (0.9)	99.0%	11 (1.0)
DURATHERM HWS RO 2526	410 (1.6)	4 (0.9)	99.0%	17 (1.5)
DURATHERM HWS RO 2540	600 (2.3)	4 (0.9)	99.0%	25 (2.3)
DURATHERM HWS RO 4014	760 (2.9)	20 (4.5)	99.0%	30 (2.8)
DURATHERM HWS RO 4040	2,200 (8.3)	20 (4.5)	99.0%	85 (7.9)
DURATHERM HWS RO 8040	9,200 (34.8)	65 (14.8)	99.0%	350 (32.5)

Specifications are based on a 2,000 mg/L NaCl solution at 225 psig (1,551 kPa) operating pressure, 77˚F (25˚C), pH 7.5, and 15% recovery, after 24 hours. Individual flux may vary +25%/-15%. In most case, flow rate will stabilize to 50-70% of the initial flowrate after the preliminary high water temperature cycles. Since final flowrate is dependant of individual temperature excursion profile, final individual flowrate is not guaranteed. Average salt rejection after a minimum of 24 hours of continuous operation and preliminary hot water sanitation cycles.

OPERATING AND DESIGN PARAMETERS

DO NOT EXCEED 20 GFD (33 LMH)

TEMPERATURE	MAXIMUM PRESSURE
5˚C - 50˚C	**600 psig - 41 bar**
51˚C - 90˚C	**hot water sanitizing ONLY**

RECOMMENDED pH

TYPE	OPERATING RANGE BELOW 50˚C	CLEANING RANGE BELOW 50˚C
DURATHERM HWS RO	**2.0 - 10.0**	**2.0 - 11.5**

Chlorine Tolerance: 500 ppm-hours, at temperature below 50˚C.
Dechlorination Recommended.

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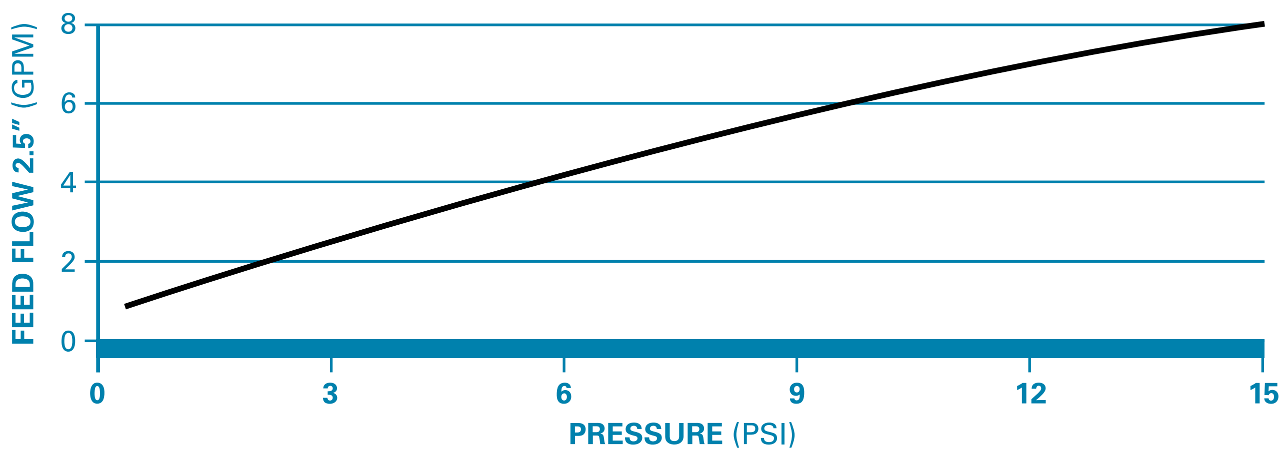
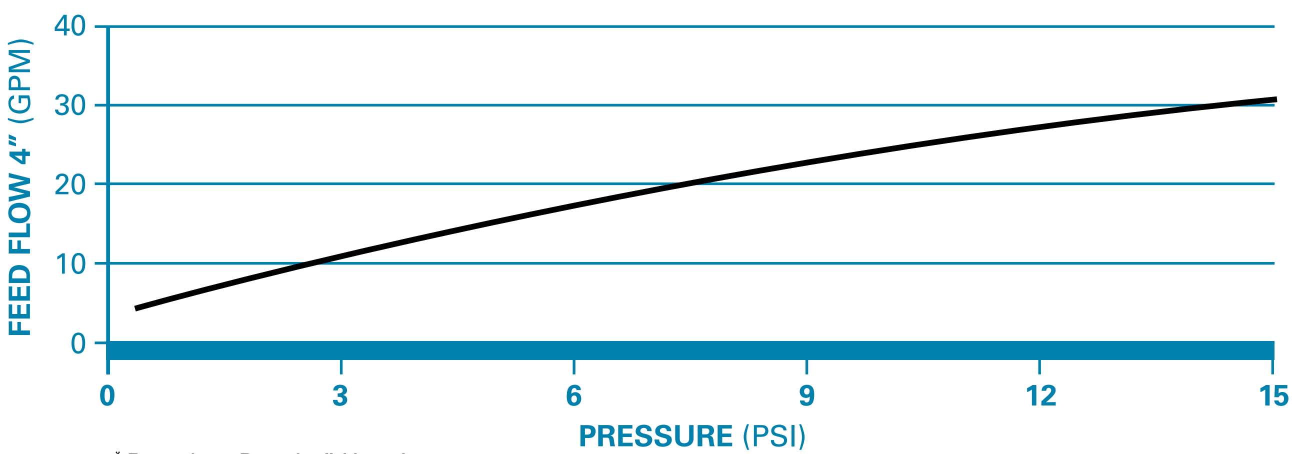
MAXIMUM PRESSURE DROP	ELEMENTS PER PRESSURE VESSEL				
	1	2	3	4	5
ΔP - psig (kPa)	15 (103)	30 (207)	45 (310)	60 (414)	60 (414)

PRESSURE DROP vs. FLOW (AT 25˚C, 1cP)



* Based on Desal 2.5" Housings
* Use as a guidline, delta P will vary based on tolerances of housing.

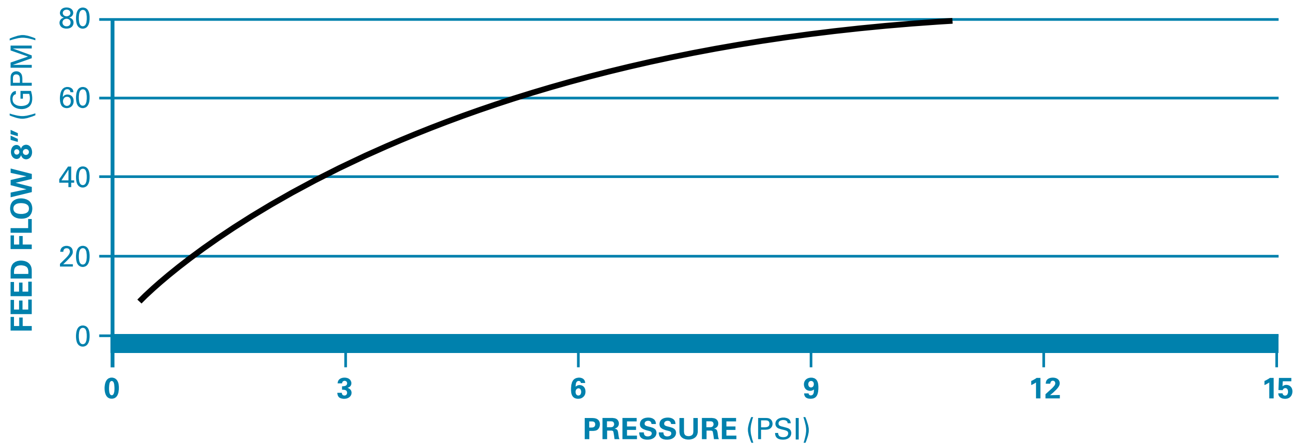
PRESSURE DROP vs. FLOW (AT 25˚C, 1cP)



* Based on Desal 4" Housings
* Use as a guidline, delta P will vary based on tolerances of housing.

Hot Water Sanitization

PRESSURE DROP vs. FLOW (AT 25˚C, 1cP)



* Based on Desal 8" Housings
* Use as a guidline, delta P will vary based on tolerances of housing.

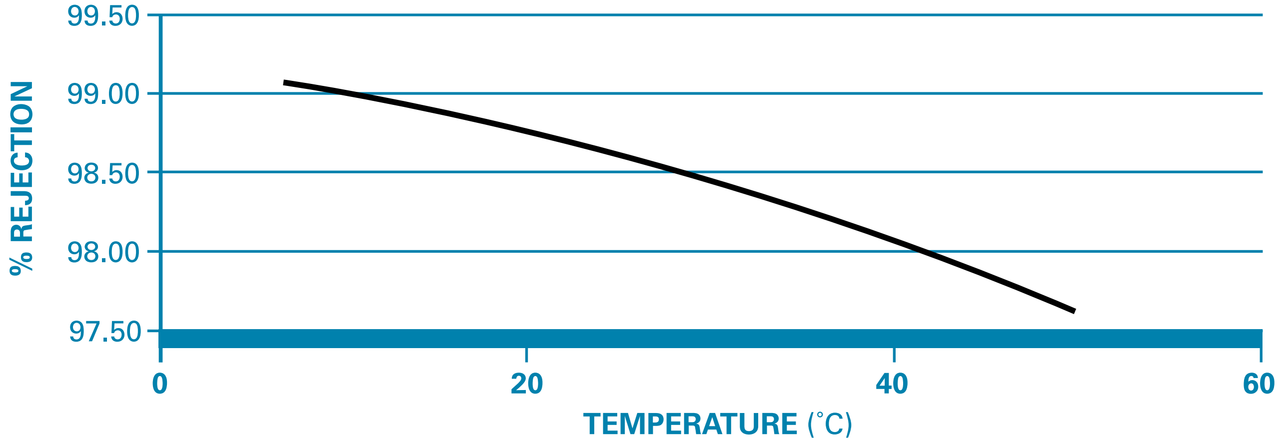
Maximum Temperature: 50˚C during operation and 50˚C during cleaning.
Hot water sanitizing up to 90˚C.

Maximum Recommended Elements Per Housing: 6 elements

Hot Water Sanitization Recommendations: For optimal performance, Duratherm HWS RO elements should always be cleaned using approved CIP procedures and flushed with fouling-free water before the sanitization process. Feed pressure during sanitization should not exceed 40 psi and the crossflow should not incur a pressure drop greater than 2 psi per element. Heating rate to sanitizing temperature and cool down should not be faster than 5˚C/minute. Maximum sanitization temperature is 90˚C.

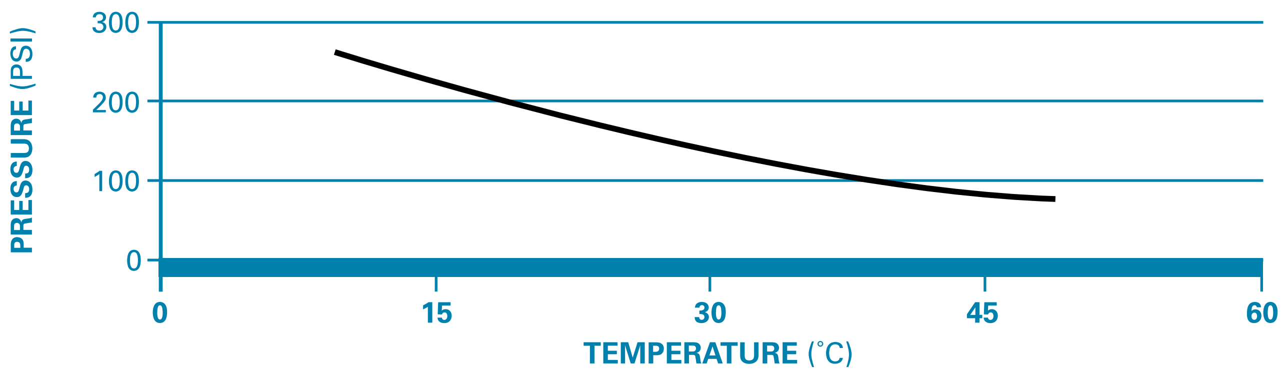
Hot Water Sanitization

NaCL REJECTION (20 GFD/33 LMH)



* Based on 2,000 ppm NaCL

NET DRIVING PRESSURE (20 GFD/33 LMH)



* Based on 2,000 ppm NaCL

ELEMENT DIMENSIONS AND WEIGHT

MODEL NUMBER LEGEND

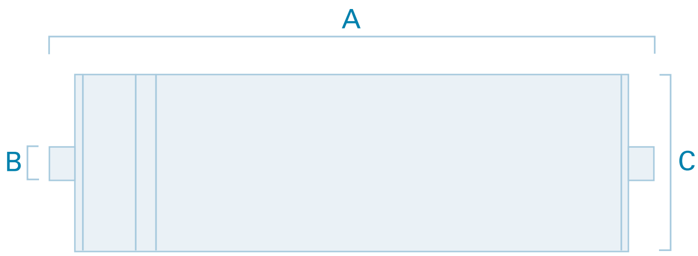
Element Size

DURATHERM HWS RO 4040 HS

Membrane Type

HWS=Hot Water Sanitization
RO=Reverse Osmosis

HS=High Solids



MODEL	DIMENSIONS INCHES(MM) A	B	C*	DRY BOXED WEIGHT LBS (KG)
DURATHERM HWS RO 2521**	21.00 (533)	0.750 (19)	2.40 (61)	1.3 (0.6)
DURATHERM HWS RO 2526**	26.00 (660)	0.750 (19)	2.50 (64)	3.7 (1.7)
DURATHERM HWS RO 2540**	40.00 (1016)	0.750 (19)	2.40 (61)	5.0 (2.3)
DURATHERM HWS RO 4014**	14.00 (356)	0.750 (19)	3.88 (99)	2.0 (0.9)
DURATHERM HWS RO 4040**	40.00 (1016)	0.750 (19)	3.88 (99)	12.0 (5.5)
DURATHERM HWS RO 8040	40.00 (1016)	1.125 (29)	7.88 (200)	32.0 (14.5)

* The element diameter (dimension C) is designed for optimum performance in GE pressure vessels. Other pressure vessel dimension and tolerance may result in excessive bypass and loss of capacity.

** Element includes external permeate tube.

Length includes ATDs. Elements are shipped dry.

High Temperature

The Duratherm® STD RO elements provide reliable performance at continuous operating temperatures up to 158˚F (70˚C) in low crossflow environments with water-like viscosity and no suspended solids, or for processes which require periodic hot water sanitizing up to 194˚ F (90˚C). They feature high temperature tolerant materials including the DURASAN® outer wrap.

ELEMENT SPECIFICATIONS

MODEL	FLOW GPD (m^3/d)	MAX. CROSSFLOW GPM (m^3/H)	REJECTION AVG.	ACTIVE AREA ft^2 (m^2)
DURATHERM STD RO 2540	425 (1.6)	4 (0.9)	99.5%	25 (2.3)
DURATHERM STD RO 4040	1,600 (6.1)	20 (4.5)	99.5%	90 (8.4)
DURATHERM STD RO 8040	6,500 (24.6)	65 (14.8)	99.5%	350 (32.5)

Specifications are based on a 2,000 mg/L NaCl solution at 225 psig (1,551 kPa), 77˚F (25˚C), 15% recovery, pH 6.5, after 24 hours. Individual element flux may vary +25%/-15%.

OPERATING AND DESIGN PARAMETERS

RECOMMENDED pH

TYPE	OPERATING RANGE BELOW 50˚C	OPERATING RANGE ABOVE 50˚C	CLEANING RANGE BELOW 50˚C
DURATHERM STD RO	**2.0 - 10.0**	**3.0 - 9.0**	**2.0 - 11.5**

Chlorine Tolerance: 500 ppm-hours, at temperature below 50˚C.
Dechlorination Recommended.

DO NOT EXCEED 20 GFD (33 LMH) **OR 2,000 WAGNER UNITS UNDER ANY CIRCUMSTANCE**

TEMPERATURE	MAXIMUM PRESSURE
5˚C - 50˚C	**600 psig - 41 bar**
51˚C - 70˚C	**300 psig - 21 bar**
71˚C - 90˚C	**hot water sanitizing ONLY**

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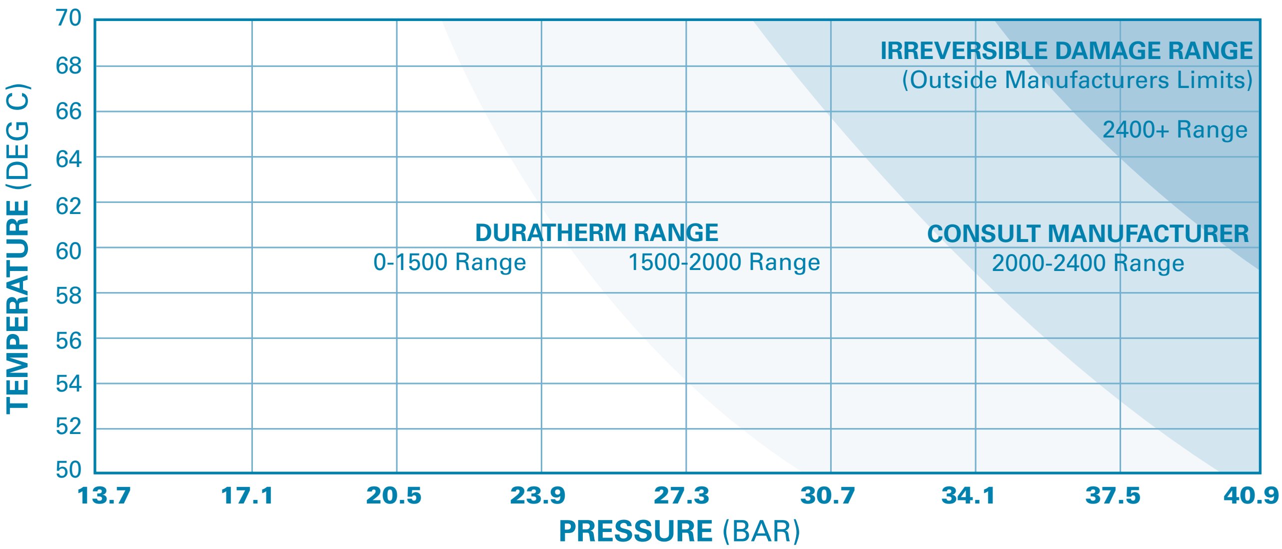
High Temperature

WAGNER DIAGRAM

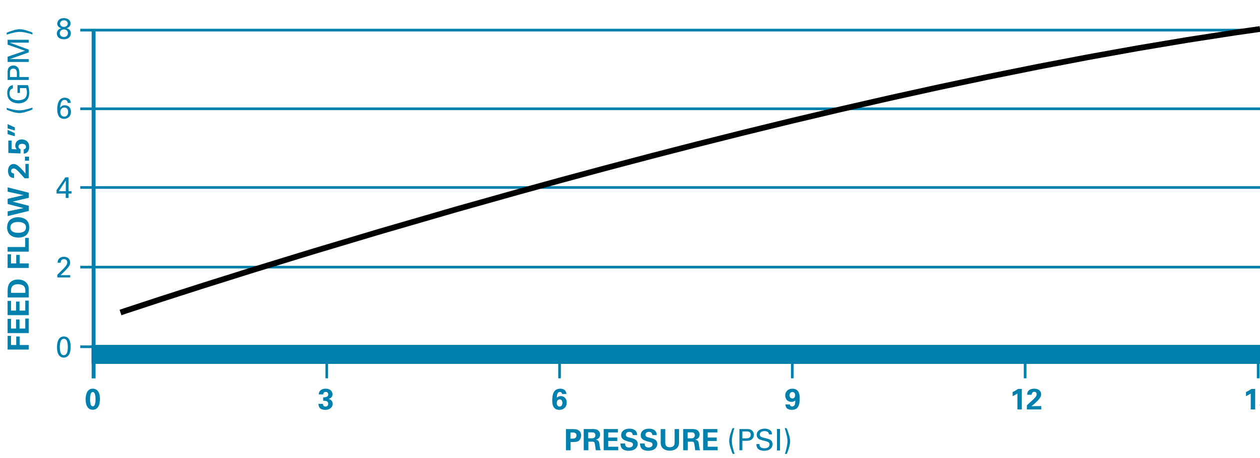
Wagner Unit = Temperature (°C) **x Pressure** (Bar)



MAXIMUM PRESSURE DROP

RANGE	5°C-50°C psig (bar)	51°C-60°C psig (bar)	61°C-70°C psig (bar)
PER ELEMENT	12 (0.8)	6 (0.4)	3 (0.2)
PER HOUSING	60 (4.1)	30 (2.1)	15 (1.0)

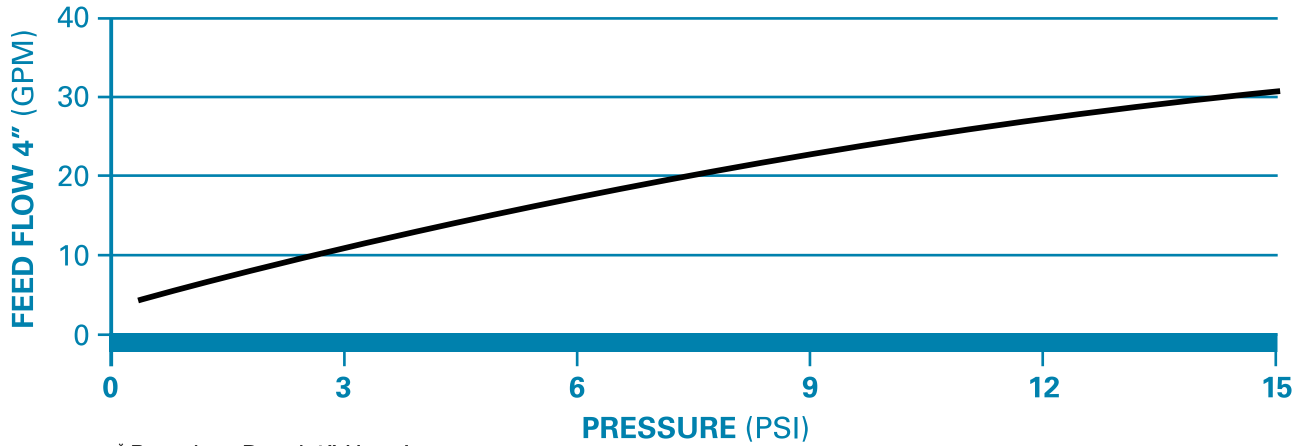
PRESSURE DROP vs. FLOW (AT 25°C, 1cP)



* Based on Desal 2.5" Housings
* Use as a guidline, delta P will vary based on tolerances of housing.

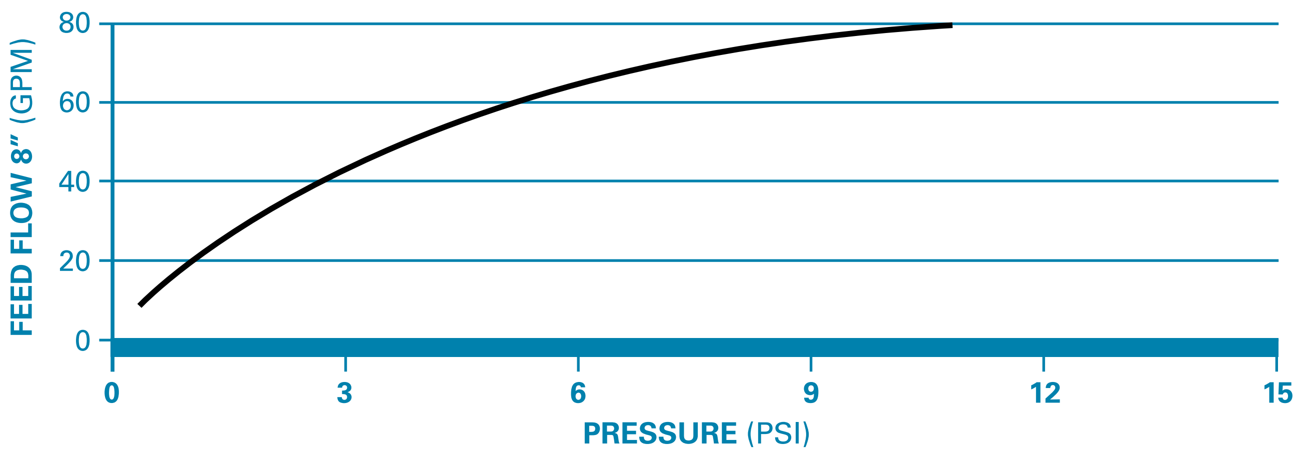
High Temperature

PRESSURE DROP vs. FLOW (AT 25˚C, 1cP)



* Based on Desal 4" Housings
* Use as a guidline, delta P will vary based on tolerances of housing.

PRESSURE DROP vs. FLOW (AT 25˚C, 1cP)

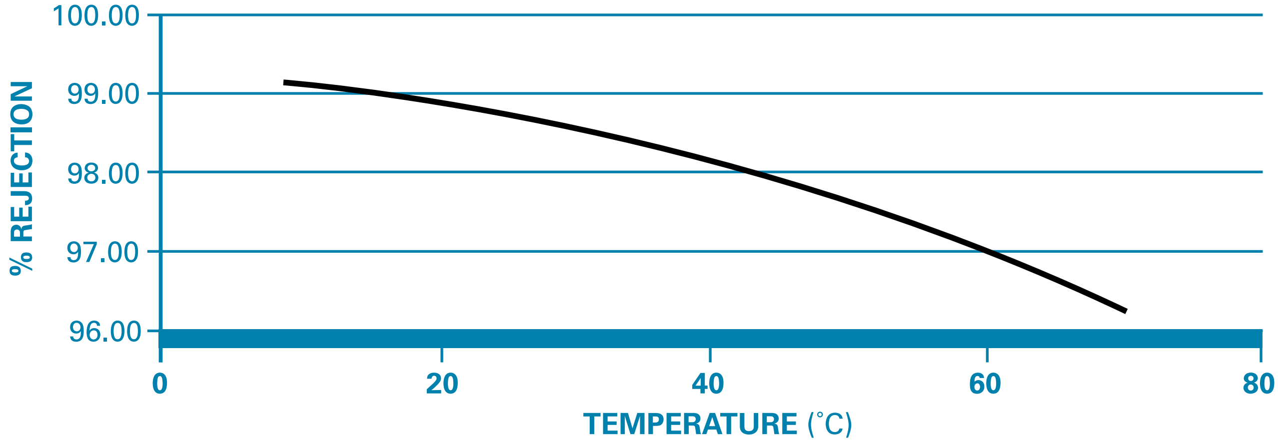


* Based on Desal 8" Housings
* Use as a guidline, delta P will vary based on tolerances of housing.

Maximum Temperature: 70˚C during operation and 50˚C during cleaning.
Hot water sanitizing up to 90˚C.

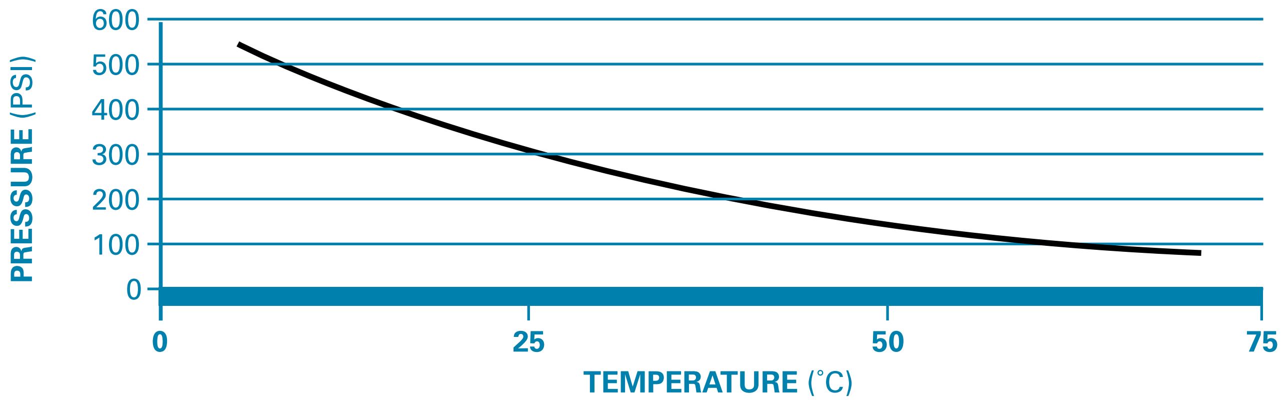
Maximum Recommended Elements Per Housing: 5 elements

NaCL REJECTION (20 GFD/33 LMH)



* Based on 2,000 ppm NaCL

NET DRIVING PRESSURE (20 GFD/33 LMH)



* Based on 2,000 ppm NaCL

ELEMENT DIMENSIONS AND WEIGHT

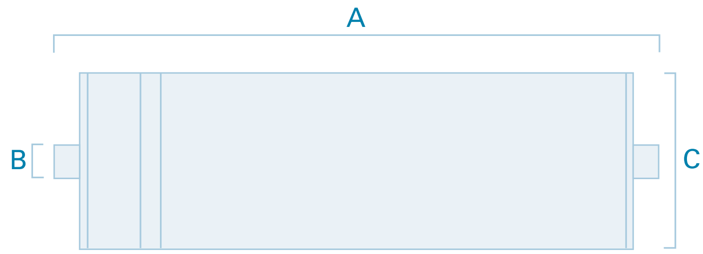
MODEL NUMBER LEGEND

Element Size

DURATHERM STD RO 4040

Membrane Type

STD=Standard
RO=Reverse Osmosis



MODEL	DIMENSIONS INCHES(MM) A	B	C*	DRY BOXED WEIGHT LBS (KG)
DURATHERM STD RO 2540**	40.00 (1016)	0.750 (19)	2.40 (61)	5 (2.3)
DURATHERM STD RO 4040	40.00 (1016)	0.625 (16)	3.88 (99)	12 (5.5)
DURATHERM STD RO 8040	40.00 (1016)	1.125 (29)	7.88 (200)	32 (14.5)

* The element diameter (dimension C) is designed for optimum performance in GE pressure vessels. Other pressure vessel dimension and tolerance may result in excessive bypass and loss of capacity.

** Element includes external permeate tube.

Length includes ATDs. Elements are shipped dry.

Certified Membrane Elements

The National Sanitation Foundation (NSF) provides conformity assessment services in the areas of public health for the food preparation and plumbing water industries. NSF is an organization accredited by the American National Standard Institute (ANSI) to certify products against several ANSI/NSF Standards, including NSF Standard 61. ANSI/NSF Standard 61 is a testing protocol that assures customers and regulators that products do not contribute unsafe levels of contaminants to drinking water.

AG and AK certified elements are selected when **inimitable confidence** is demanded from drinking water system components.

AG and AK certified elements feature a fiberglass outer wrap and standard feed spacers.

ELEMENT SPECIFICATIONS

MODEL	FLOW GPD (m^3/d)	REJECTION AVG./MIN.	ACTIVE AREA FT^2 (m^2)
AG4040FF-CERT	2,200 (8.3)	99.5% / 99.0%	85 (7.9)
AG8040F-400-CERT	10,500 (39.8)	99.5% / 99.0%	400 (37.2)
AG8040F-CERT	9,200 (34.8)	99.5% / 99.0%	350 (32.5)
AK4040FF-CERT	2,200 (8.3)	99.0% / 98.0%	85 (7.9)
AK8040F-400-CERT	10,500 (39.7)	99.0% / 98.0%	400 (37.2)

AG specification is based on a 2,000 mg/L NaCl solution at 225 psi (1,551 kPa) operating pressure, 77˚F (25˚C), pH 7.5 and 15% recovery. Individual flux may vary +25%/-15%. Average salt rejection after a minimum of 24 hours of continuous operation.
AK specification is based on a 500 mg/L NaCl solution at 115 psi (793 kPa) operating pressure, 77˚F (25˚C), pH 7.5 and 15% recovery. Individual flux may vary +25%/-15%. Average salt rejection after a minimum of 24 hours of continuous operation.

OPERATING AND DESIGN PARAMETERS

THIN-FILM MEMBRANE (TFM®)

	TYPICAL OPERATING PRESSURE	TYPICAL OPERATING PROCESS FLUX	MAXIMUM PRESSURE	MAXIMUM TEMPERATURE	RECOMMENDED pH	CHLORINE TOLERANCE
AG	200 psig (1,379 kPa)	10-20 GFD (15-35 LMH)	600 psig (4,137 kPa)	122˚F (50˚C)	Optimum Rejection pH: 7.0-7.5 Operating pH Range: 4.0-11.0 Cleaning pH range: 2.0-11.5	1,000 ppm-hrs., Dechlorination recommended
AK	100 psig (689 kPa)	10-20 GFD (15-35 LMH)	400 psig (3,758 kPa)	122˚F (50˚C)	Optimum Rejection pH: 7.0-7.5 Operating pH Range: 4.0-11.0 Cleaning pH range: 2.0-11.5	1,000 ppm-hrs., Dechlorination recommended

Feed NTU: <1, Feed SDI: <5

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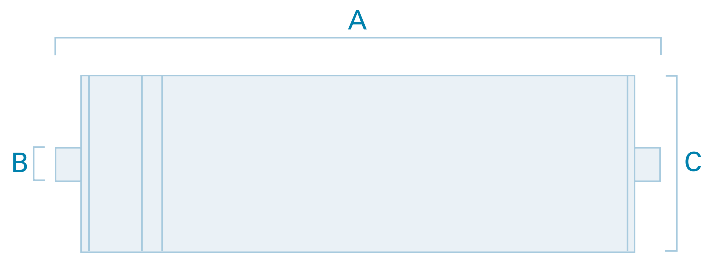
Certified Membrane Elements

MAXIMUM PRESSURE DROP	ELEMENTS PER PRESSURE VESSEL					
	1	2	3	4	5	6
ΔP - psig (kPa)	10 (69)	20 (138)	30 (207)	38 (262)	45 (310)	50 (345)

ELEMENT DIMENSIONS AND WEIGHT

MODEL NUMBER LEGEND



MODEL	DIMENSIONS INCHES(MM)			DRY BOXED
	A	B	C*	WEIGHT LBS (KG)
AG4040FF-CERT	40.00 (1016)	0.750 (19)	3.88 (99)	12 (5.5)
AG8040F-400-CERT	40.00 (1016)	1.125 (29)	7.88 (200)	32 (14.5)
AG8040F-CERT	40.00 (1016)	1.125 (29)	7.88 (200)	32 (14.5)
AK4040FF-CERT	40.00 (1016)	0.750 (19)	3.88 (99)	12 (5.5)
AK8040F-400-CERT	40.00 (1016)	1.125 (29)	7.88 (200)	32 (14.5)

* The element diameter (dimension C) is designed for optimum performance in GE pressure vessels. Other pressure vessel dimension and tolerance may result in excessive bypass and loss of capacity.

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High Flux

The **C-Series** family, a triacetate/diacetate blend, has a higher flux and better mechanical stability than standard cellulose acetate. C-Series elements offer a lower per element cost and increased chlorine resistance compared to thin-film elements.

CK Nanofiltration Elements are used for **water softening, color removal, and reduction of THM potential** when chlorine is required. They feature a fiberglass or net outer wrap and standard feed spacers.

ELEMENT SPECIFICATIONS

MODEL	FLOW GPD (m^3/d)	REJECTION AVG	ACTIVE AREA FT^2 (m^2)
CK2540FF	600 (2.3)	97%	27 (2.5)
CK4040FF	2,000 (7.6)	97%	90 (8.3)
CK8040F	9,500 (36.0)	97%	380 (35.3)
CK8040N	9,500 (36.0)	97%	378 (35.1)

Specification is based on a 2,000 mg/L $MgSO_4$ solution at 225 psi (1,551 kPa) operating pressure, 77˚F (25˚C), pH 7.5 and 10% recovery. Individual flux may vary +25%/-15%. Average salt rejection after a minimum of 24 hours of continuous operation.

OPERATING AND DESIGN PARAMETERS

CELLULOSE TRIACETATE/DIACETATE BLEND

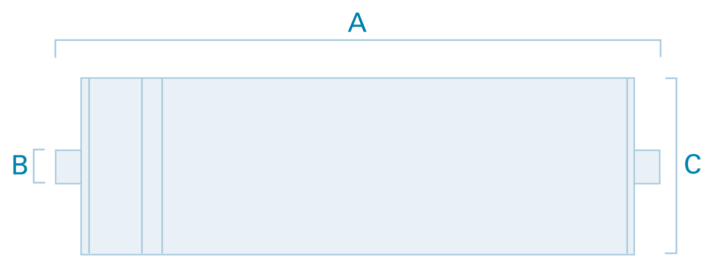
TYPICAL OPERATING PRESSURE	TYPICAL OPERATING PROCESS FLUX	MAXIMUM PRESSURE	MAXIMUM TEMPERATURE	RECOMMENDED pH	CHLORINE TOLERANCE
60-200 psig (414-1,379 kPa)	10-18 GFD (17-30 LMH)	450 psig (3,103 kPa)	86˚F (30˚C)	Operating pH Range: 5.0-6.5 Cleaning pH range: 3.0-8.0	1 ppm maximum, Continuous 30 ppm for 30 min. during chlorine sanitization

High Flux

MAXIMUM PRESSURE DROP	ELEMENTS PER PRESSURE VESSEL					
	1	2	3	4	5	6
ΔP - psig (kPa)	10 (69)	20 (138)	30 (207)	38 (262)	45 (310)	50 (345)

ELEMENT DIMENSIONS AND WEIGHT

MODEL NUMBER LEGEND



MODEL	DIMENSIONS INCHES(CM)			DRY BOXED
	A	B	C*	WEIGHT LBS (KG)
CK2540FF	40.00 (1016)	0.750 (19)	2.40 (61)	5 (2.3)
CK4040FF	40.00 (1016)	0.750 (19)	3.88 (99)	12 (5.5)
CK8040F	40.00 (1016)	1.125 (29)	7.88 (200)	32 (14.5)
CK8040N	40.00 (1016)	1.125 (29)	7.88 (200)	32 (14.5)

* The element diameter (dimension C) is designed for optimum performance in GE pressure vessels. Other pressure vessel dimension and tolerance may result in excessive bypass and loss of capacity.

Water Softening

The **H-Series** proprietary thin-film nanofiltration membrane elements are characterized by an approximate molecular weight cut-off of 150-300 daltons for uncharged organic molecules. Divalent and multivalent ion rejection is dependent upon feed concentration and composition.

HL Nanofiltration Elements are used for water **softening, color removal, and reduction of THM potential**. They feature a fiberglass outer wrap and standard feed spacers.

ELEMENT SPECIFICATIONS

MODEL	FLOW GPD (m³/d)	REJECTION AVE.	ACTIVE AREA FT² (m²)
HL2540FF	780 (3.0)	98.0%	27 (2.5)
HL2540TF	780 (3.0)	98.0%	27 (2.5)
HL4040FF	2,400 (9.1)	98.0%	89 (8.2)
HL4040TF	2,400 (9.1)	98.0%	89 (8.2)
HL8040F	10,100 (38.2)	98.0%	350 (32.5)
HL8040F-400	11,500 (43.5)	98.0%	400 (37.2)
HL8040N	10,100 (38.2)	97.5%	350 (32.5)

Specification is based on a 2,000 mg/L $MgSO_4$ solution at 100 psi (690 kPa) operating pressure, 77˚F (25˚C), pH 7.5 and 15% recovery. Individual flux may vary +25%/-15%. Average salt rejection after a minimum of 24 hours of continuous operation.

OPERATING AND DESIGN PARAMETERS

THIN-FILM MEMBRANE (TFM®)

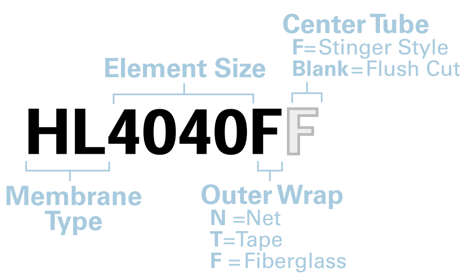
TYPICAL OPERATING PRESSURE	TYPICAL OPERATING PROCESS FLUX	MAXIMUM PRESSURE	MAXIMUM TEMPERATURE	RECOMMENDED pH	CHLORINE TOLERANCE
70-300 psig (483-2,069 kPa)	12-20 GFD (20-35 LMH)	600 psig (4,137 kPa) TAPE 450 psig (3,103 kPa)	122˚F (50˚C)	Operating pH Range: 3.0-9.0	<0.1 ppm

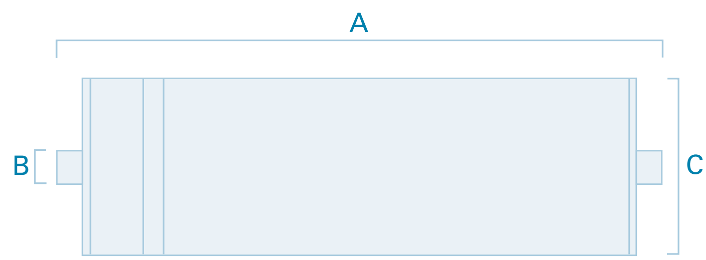
Feed NTU: <1, Feed SDI: <5

MAXIMUM PRESSURE DROP	ELEMENTS PER PRESSURE VESSEL					
	1	2	3	4	5	6
∆P - psig (kPa)	10 (69)	20 (138)	30 (207)	38 (262)	45 (310)	50 (345)

ELEMENT DIMENSIONS AND WEIGHT

MODEL NUMBER LEGEND





MODEL	DIMENSIONS INCHES(MM)			DRY BOXED
	A	B	C*	WEIGHT LBS (KG)
HL2540FF	40.00 (1016)	0.750 (19)	2.40 (61)	5 (2.3)
HL2540TF	40.00 (1016)	0.750 (19)	2.40 (61)	5 (2.3)
HL4040FF	40.00 (1016)	0.750 (19)	3.88 (99)	12 (5.5)
HL4040TF	40.00 (1016)	0.750 (19)	3.88 (99)	12 (5.5)
HL8040F	40.00 (1016)	1.125 (29)	7.88 (200)	32 (14.5)
HL8040F-400	40.00 (1016)	1.125 (29)	7.88 (200)	32 (14.5)
HL8040N	40.00 (1016)	1.125 (29)	7.88 (200)	32 (14.5)

* The element diameter (dimension C) is designed for optimum performance in GE pressure vessels. Other pressure vessel dimension and tolerance may result in excessive bypass and loss of capacity.

Seawater Softening

The **Seasoft** series is a new family of nanofiltration elements specifically designed for seawater pretreatment. Seasoft elements feature a 3-layer, extremely scaling-resistant membrane as well as special construction design for short residence time to prevent scale formation.

Seasoft HR elements are distinctly designed for applications requiring high hardness and sulfate rejection as well as **20-30% sodium chloride rejection**.

Seasoft HF elements are distinctly designed for applications requiring high hardness and sulfate rejection as well as high **flux at low pressure**.

Seasoft elements feature a fiberglass outer wrap.

ELEMENT SPECIFICATIONS

MODEL	FLOW GPD (m^3/d)	REJECTION AVE.	ACTIVE AREA FT^2 (m^2)
SEASOFT HR 8040	9,100 (34.4)	98.0%	400 (37.2)
SEASOFT HF 8040	11,700 (44.3)	96.0%	400 (37.2)

Specification is based on a 2,000 mg/L $MgSO_4$ solution at 100 psi (690 kPa) operating pressure, 77˚F (25˚C), pH 7.5 and 15% recovery. Individual flux may vary +25%/-15%. Average salt rejection after a minimum of 24 hours of continuous operation.

OPERATING AND DESIGN PARAMETERS

SEASOFT™

TYPICAL OPERATING PRESSURE	TYPICAL OPERATING PROCESS FLUX	MAXIMUM PRESSURE	MAXIMUM TEMPERATURE	RECOMMENDED pH	CHLORINE TOLERANCE
70-400 psig (483-2,758 kPa)	10-15 GFD (15-25 LMH)	600 psig (4,137 kPa)	122˚F (50˚C)	Operating pH Range: 2.0-11.0 Cleaning pH Range: 1.0-11.5	1,000 ppm-hrs., Dechlorination recommended

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Seawater Softening

MAXIMUM PRESSURE DROP	ELEMENTS PER PRESSURE VESSEL					
	1	2	3	4	5	6
∆P - psig (kPa)	10 (69)	20 (138)	30 (207)	38 (262)	45 (310)	50 (345)

ELEMENT DIMENSIONS AND WEIGHT

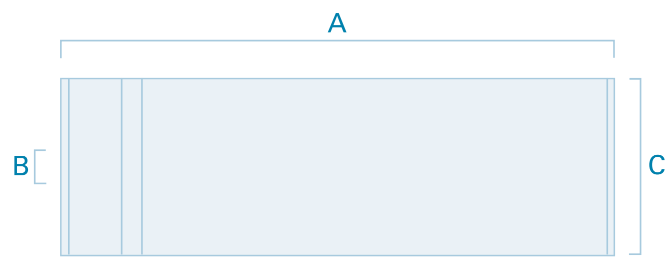
MODEL NUMBER LEGEND

Element Size

SEASOFT HR 8040

Membrane Type

HR=High Rejection
HF=High Flux



MODEL	DIMENSIONS INCHES(MM)			DRY BOXED
	A	B	C*	WEIGHT LBS (KG)
SEASOFT HR 8040	40.00 (1016)	1.125 (29)	7.88 (200)	32 (14.5)
SEASOFT HF 8040	40.00 (1016)	1.125 (29)	7.88 (200)	32 (14.5)

* The element diameter (dimension C) is designed for optimum performance in GE pressure vessels. Other pressure vessel dimension and tolerance may result in excessive bypass and loss of capacity.

Length includes ATDs. Elements are shipped dry.

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Low Fouling NF

Duraslick™ is a new family series of membrane elements engineered **for use with fouling-prone brackish water applications**. Duraslick is designed to utilize an innovative three-layer membrane, of which a proprietary middle layer creates extreme smoothness, and provide a high rejection of sodium chloride.

Independent studies have demonstrated that **Duraslick NF elements** are superior to standard polyamide spiral wound membrane elements for desalination of **difficult feed water sources**. Duraslick NF elements retrofit existing systems to obtain lower fouling, reduced overall energy usage, increased membrane service life and an **extension of operating time between required cleanings**, which in turn reduces expenditures on required chemicals. **Duraslick NF-HS** elements are specially designed for comparatively higher solid levels. The Duraslick NF element construction features a fiberglass outer wrap.

ELEMENT SPECIFICATIONS

MODEL	FLOW GPD (m^3/d)	REJECTION AVE.	ACTIVE AREA FT² (m²)
DURASLICK NF 2540	690 (2.6)	96.0%	24 (2.2)
DURASLICK NF 4040	2,200 (8.3)	96.0%	78 (7.2)
DURASLICK NF 4040 HS	1,700 (6.4)	96.0%	61 (5.6)
DURASLICK NF 8040	10,200 (38.6)	96.0%	350 (32.5)
DURASLICK NF 8040 HS	7,600 (28.8)	96.0%	263 (24.4)

Specification is based on a 2,000 mg/L $MgSO_4$ solution at 100 psi (690 kPa) operating pressure, 77˚F (25˚C) and 15% recovery. Individual flux may vary +25%-15%. Average salt rejection after a minimum of 24 hours of continuous operation.

OPERATING AND DESIGN PARAMETERS

DURASLICK™

TYPICAL OPERATING PRESSURE	TYPICAL OPERATING PROCESS FLUX	MAXIMUM PRESSURE	MAXIMUM TEMPERATURE	RECOMMENDED pH	CHLORINE TOLERANCE
100 psig (690 kPa)	10-15 GFD (15-25 LMH)	600 psig (4,137 kPa)	122˚F (50˚C)	Optimum Rejection pH: 5.5-7.0 Operating pH Range: 2.0-11.0 Cleaning pH Range: 1.0-11.5	1,000 ppm-hrs., Dechlorination recommended

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MAXIMUM PRESSURE DROP	ELEMENTS PER PRESSURE VESSEL					
	1	2	3	4	5	6
∆P - psig (kPa)	10 (69)	20 (138)	30 (207)	38 (262)	45 (310)	50 (345)

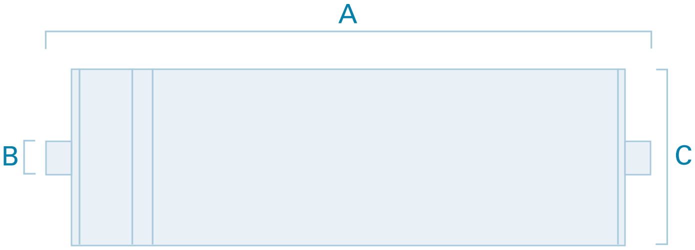
ELEMENT DIMENSIONS AND WEIGHT

MODEL NUMBER LEGEND

Element Size

DURASLICK NF 4040 HS

Membrane Type · NF=Nanofiltration · HS=High Solids



MODEL	DIMENSIONS INCHES(MM)			DRY BOXED
	A	B	C	WEIGHT LBS (KG)
DURASLICK NF 2540*	40.00 (1016)	0.750 (19)	2.40 (61)	5 (2.3)
DURASLICK NF 4040*	40.00 (1016)	0.750 (19)	3.88 (99)	12 (5.5)
DURASLICK NF 4040 HS*	40.00 (1016)	0.750 (19)	3.88 (99)	12 (5.5)
DURASLICK NF 8040	40.00 (1016)	1.125 (29)	7.88 (200)	32 (14.5)
DURASLICK NF 8040 HS	40.00 (1016)	1.125 (29)	7.88 (200)	32 (14.5)

* Element includes external permeate tube.
Length includes ATDs. Elements are shipped dry.

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Certified Membrane Elements

The National Sanitation Foundation (NSF) provides conformity assessment services in the areas of public health for the food preparation and plumbing water industries. NSF is an organization accredited by the American National Standard Institute (ANSI) to certify products against several ANSI/NSF Standards, including NSF Standard 61. ANSI/NSF Standard 61 is a testing protocol that assures customers and regulators that products do not contribute unsafe levels of contaminants to drinking water.

HL certified elements are selected when **inimitable confidence** is demanded from drinking water system components.

HL certified elements feature a fiberglass outer wrap and standard feed spacers.

ELEMENT SPECIFICATIONS

MODEL	FLOW GPD (m^3/d)	REJECTION AVE.	ACTIVE AREA FT^2 (m^2)
HL4040FF-CERT	2,450 (9.3)	98.0%	89 (8.2)

Specification is based on a 2,000 mg/L $MgSO_4$ solution at 100 psi (690 kPa) operating pressure, 77˚F (25˚C), pH 7.5 and 15% recovery. Individual flux may vary +25%/-15%. Average salt rejection after a minimum of 24 hours of continuous operation.

OPERATING AND DESIGN PARAMETERS

THIN-FILM MEMBRANE (TFM®)

TYPICAL OPERATING PRESSURE	TYPICAL OPERATING PROCESS FLUX	MAXIMUM PRESSURE	MAXIMUM TEMPERATURE	RECOMMENDED pH	CHLORINE TOLERANCE
70-300 psig (483-2,069 kPa)	15-25 GFD (25-40 LMH)	600 psig (4,137 kPa)	122˚F (50˚C)	Operating pH Range: 3.0-9.0	<0.1 ppm

Feed NTU: <1, Feed SDI: <5

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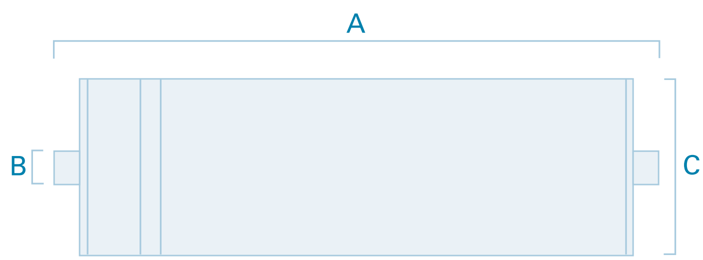
MAXIMUM PRESSURE DROP	ELEMENTS PER PRESSURE VESSEL					
	1	2	3	4	5	6
∆P - psig (kPa)	10 (69)	20 (138)	30 (207)	38 (262)	45 (310)	50 (345)

ELEMENT DIMENSIONS AND WEIGHT

MODEL NUMBER LEGEND



MODEL	DIMENSIONS INCHES(MM)			DRY BOXED
	A	B	C	WEIGHT LBS (KG)
HL4040FF-CERT	40.00 (1016)	0.750 (19)	3.88 (99)	12 (5.5)

* The element diameter (dimension C) is designed for optimum performance in GE pressure vessels. Other pressure vessel dimension and tolerance may result in excessive bypass and loss of capacity.

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Pretreatment for RO/NF

The **G-Series** family of proprietary thin-film ultrafiltration membrane elements are characterized by a molecular weight cut-off of 8,000 on polyethylene glycol and a smooth, fouling resistant membrane surface.

GM Elements are used for RO pretreatment, color/TOC reduction and colloidal iron and silica removal. They feature a fiberglass outer wrap and standard feed spacers.

ELEMENT SPECIFICATIONS

MODEL	MOLECULAR WEIGHT CUTOFF	ACTIVE AREA FT² (m²)
GM2540FF	8 kD	27 (2.5)
GM4040F	8 kD	90 (8.4)
GM8040F	8 kD	360 (34.4)

OPERATING AND DESIGN PARAMETERS

THIN-FILM MEMBRANE (TFM®)

TYPICAL OPERATING PRESSURE	TYPICAL OPERATING PROCESS FLUX	MAXIMUM TEMPERATURE	RECOMMENDED pH	CHLORINE TOLERANCE
40-150 psig (276-1,034 kPa)	10-25 GFD (15-40 LMH)	122˚F (50˚C)	Operating pH Range: 2.0-11.0 Cleaning pH Range: 1.0-11.5	1,000 ppm-Days

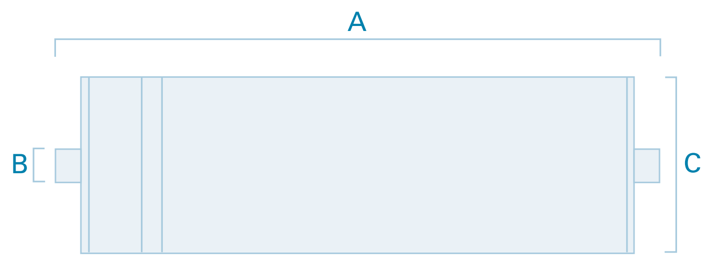
Feed NTU: <1, Feed SDI: <5

Pretreatment for RO/NF

MAXIMUM PRESSURE DROP	ELEMENTS PER PRESSURE VESSEL				
	1	2	3	4	5
ΔP - psig (kPa)	10 (69)	20 (138)	30 (207)	40 (276)	50 (345)

ELEMENT DIMENSIONS AND WEIGHT

MODEL NUMBER LEGEND



MODEL	DIMENSIONS INCHES(MM)			DRY BOXED
	A	B	C	WEIGHT LBS (KG)
GM2540FF	40.00 (1016)	0.750 (19)	2.40 (61)	5 (2.3)
GM4040F	40.00 (1016)	0.625 (16)	3.88 (99)	12 (5.5)
GM8040F	40.00 (1016)	1.125(29)	7.88 (200)	32 (14.5)

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Pre/Post-Treatment for RO/NF

The **P-Series** family of polyethersulfone ultrafiltration membrane elements are characterized by a 10,000 molecular weight cut-off and greater than 96% rejection of Cytochrome-C (13,300 MW protein).

PW Elements are used for pretreatment of process water and post treatment of ultrapure water.

PW Ultrafiltration elements feature a tape or fiberglass outer wrap and standard feed spacers.

ELEMENT SPECIFICATIONS

MODEL	MOLECULAR WEIGHT CUTOFF	ACTIVE AREA FT² (m²)
PW4025T	10kD	50 (4.6)
PW4040F	10kD	85 (7.9)
PW4040T	10kD	85 (7.9)
PW8040F	10kD	350 (32.5)

OPERATING AND DESIGN PARAMETERS

TYPICAL OPERATING PRESSURE	TYPICAL OPERATING PROCESS FLUX	MAXIMUM TEMPERATURE	RECOMMENDED pH	CHLORINE TOLERANCE
80-135 psig (552-931 kPa)	Pre treatment 10-25 GFD (15-40 LMH) Post treatment 25-35 GFD	122˚F (50˚C)	Operating pH Range: 2.5-11.0 Cleaning pH Range: 2.0-11.5	5,000+ ppm days

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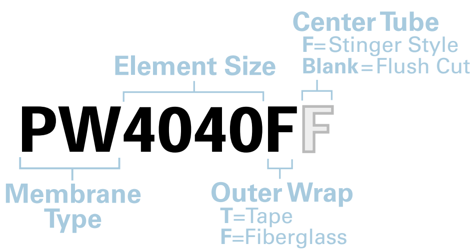
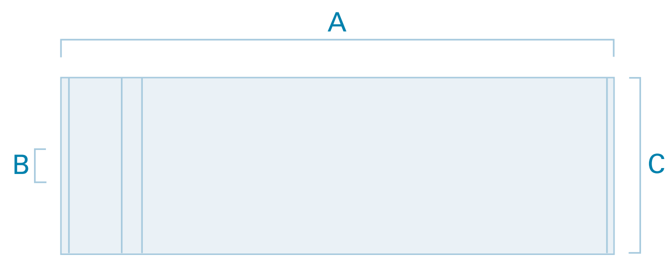
Post-Treatment for RO/NF

MAXIMUM PRESSURE DROP	ELEMENTS PER PRESSURE VESSEL				
	1	2	3	4	5
ΔP - psig (kPa)	10 (69)	20 (138)	30 (207)	40 (276)	50 (345)

ELEMENT DIMENSIONS AND WEIGHT

MODEL NUMBER LEGEND





MODEL	DIMENSIONS INCHES(MM)			DRY BOXED
	A	B	C	WEIGHT LBS (KG)
PW4025T	25.00 (635)	0.625 (16)	3.88 (99)	5 (2.3)
PW4040F	40.00 (1016)	0.625 (16)	3.88 (99)	12 (5.5)
PW4040T	40.00 (1016)	0.625 (16)	3.88 (99)	12 (5.5)
PW8040F	40.00 (1016)	1.125 (29)	7.88 (200)	32 (14.5)

Pre/Pretreatment for RO/NF

The **E-Series** family consists of microfiltration elements utilizing polysulfone membrane.

The EW family of elements should be selected when pretreatment is in need to keep an RO or a Nanofiltration system running. EW will remove suspended solids and other known foulants.

EW Microfiltration elements feature a tape or fiberglass outer wrap and standard feed spacers.

ELEMENT SPECIFICATIONS

MODEL	PORE SIZE MICRON	ACTIVE AREA FT² (m²)
EW4025T	0.04	55 (5.1)
EW4026F	0.04	50 (4.6)
EW4040F	0.04	85 (7.9)
EW4040T	0.04	85 (7.9)
EW8040F	0.04	370 (34.4)

OPERATING AND DESIGN PARAMETERS

TYPICAL OPERATING PRESSURE	TYPICAL OPERATING PROCESS FLUX	MAXIMUM TEMPERATURE	RECOMMENDED pH	CHLORINE TOLERANCE
30-150 psig (207-1,034 kPa)	Pre treatment 10-30 GFD (15-50 LMH) Post treatment 10-40 GFD (15-70) LMH	122˚F (50˚C)	Operating pH Range: 2.5-11.0 Cleaning pH Range: 2.0-11.5	5,000+ ppm days

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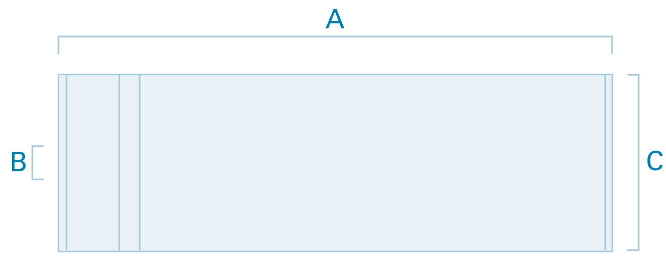
MAXIMUM PRESSURE DROP	ELEMENTS PER PRESSURE VESSEL				
	1	2	3	4	5
∆P - psig (kPa)	10 (69)	20 (138)	30 (207)	40 (276)	50 (345)

ELEMENT DIMENSIONS AND WEIGHT

MODEL NUMBER LEGEND

EW4040FF

- EW: Membrane Type
- 4040: Element Size
- F: Outer Wrap — T=Tape, F=Fiberglass
- F: Center Tube — F=Stinger Style, Blank=Flush Cut



MODEL	DIMENSIONS INCHES(MM)			DRY BOXED
	A	B	C	WEIGHT LBS (KG)
EW4025T	25.00 (635)	0.625 (16)	3.88 (99)	5 (2.3)
EW4026F	26.25 (667)	0.625 (16)	3.88 (99)	6 (2.7)
EW4040F	40.00 (1016)	0.625 (16)	3.88 (99)	12 (5.5)
EW4040T	40.00 (1016)	0.625 (16)	3.88 (99)	12 (5.5)
EW8040F	40.00 (1016)	1.125 (29)	7.88 (200)	32 (14.5)

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Reverse Osmosis

A-SERIES | AG ELEMENTS

Brackish Water, High Rejection

MODEL	OVERALL LENGTH (in)	NOMINAL DIA. (in)	OUTER WRAP	END CONNECTION	PAGE
AG2026TF	26	2.0	tape	male	58
AG2425T	25	2.4	tape	flush	58
AG2514TF	14	2.5	tape	male	58
AG2521TF	21	2.5	tape	male	58
AG2526TF	26	2.5	tape	male	58
AG3218T	18	3.2	tape	flush	58
AG3308T	8	3.3	tape	flush	58
AG4014TF	14	4.0	tape	male	58
AG4021TF	21	4.0	tape	male	58

A-SERIES | AK ELEMENTS

Brackish Water, Low Pressure

AK2514TF	14	2.5	tape	male	60
AK2521TF	21	2.5	tape	male	60
AK2526TF	26	2.5	tape	male	60
AK3218T	18	3.2	tape	flush	60
AK3308T	8	3.3	tape	flush	60
AK4021TF	21	4.0	tape	male	60
AK4014TF	14	4.0	tape	male	60

C-SERIES | CE ELEMENTS

Brackish Water

CE2026TF	26	2.0	tape	male	62

Nanofiltration

H-SERIES | HL ELEMENTS

Water Softening

HL2514T	14	2.5	tape	flush	64
HL2521TF	21	2.5	tape	male	64
HL3218T	18	3.2	tape	flush	64
HL3308T	8	3.3	tape	flush	64
HL4014TF	14	4.0	tape	male	64
HL4021TF	21	4.0	tape	male	64

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Ultrafiltration

P-SERIES | PW ELEMENTS

Post-Treatment for RO/NF

MODEL	OVERALL LENGTH (in)	NOMINAL DIA. (in)	OUTER WRAP	END CONNECTION	PAGE
PW3308T	8	3.3	tape	flush	66
PW3220T	18	3.2	tape	flush	66

Microfiltration

E-SERIES | EW ELEMENTS

Pretreatment for RO/NF

EW3220T	20	3.2	tape	flush	68
EW3310T	10	3.3	tape	flush	68

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Brackish Water, High Rejection

The **A-Series** family of proprietary thin-film reverse osmosis membrane elements are characterized by high flux and excellent sodium chloride rejection.

AG High Rejection Brackish Water Elements are selected when **high rejection and operating pressures as low as 200 psig** are desired. These elements allow moderate energy savings, and are considered a standard in the industry.

AG High Rejection Brackish Water Elements feature a tape outer wrap and standard feed spacers.

ELEMENT SPECIFICATIONS

MODEL	FLOW GPD (m^3/d)	REJECTION AVG./MIN.	ACTIVE AREA FT^2 (m^2)
AG2425T	510 (1.93)	99.5% / 99.0%	20 (1.8)
AG2514TF	170 (0.64)	99.5% / 99.0%	7 (0.6)
AG2521TF*	325 (1.23)	99.5% / 99.0%	13 (1.2)
AG2526TF	470 (1.78)	99.5% / 99.0%	17 (1.6)
AG3218T	755 (2.86)	99.5% / 99.0%	29 (2.7)
AG3308T	320 (1.21)	99.5% / 99.0%	12 (1.2)
AG4014TF	585 (2.21)	99.5% / 99.0%	23 (2.1)
AG4021TF*	1,050 (3.97)	99.5% / 99.0%	42 (3.9)

Specification is based on a 500 mg/L NaCl solution at 205 psi (1,516 kPa) operating pressure, 77˚F (25˚C), pH 7.5 and 15% recovery. Individual flux may vary +25%/-15%. Average salt rejection after a minimum of 24 hours of continuous operation.

*Specification is based on a 2,000 mg/L NaCL solution at 220 psig (1,516 kPa) operating pressure, 77˚F (25˚C), pH 7.5 and 15% recovery. Individual flux may vary +25%/-15%. Average salt rejection after a minimum of 24 hours of continuous operation.

OPERATING AND DESIGN PARAMETERS

THIN-FILM MEMBRANE (TFM®)

TYPICAL OPERATING PRESSURE	TYPICAL OPERATING PROCESS FLUX	MAXIMUM PRESSURE	MAXIMUM TEMPERATURE	RECOMMENDED pH	CHLORINE TOLERANCE
200 psig (1,379 kPa)	10-20 GFD (15-35 LMH)	450 psig (3,103 kPa)	122˚F (50˚C)	Optimum Rejection pH: 7.0-7.5 Operating pH Range: 4.0-11.0 Cleaning pH range: 2.0-11.5	1,000 ppm-hrs., Dechlorination recommended

Feed NTU: <1, Feed SDI: <5

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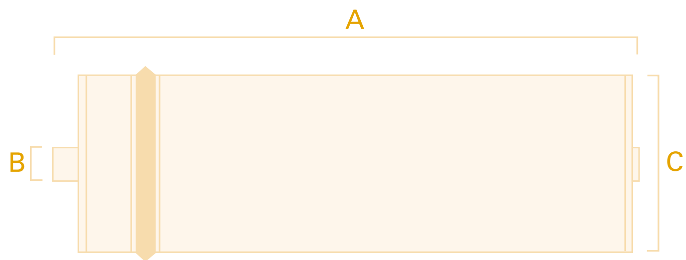
Brackish Water, High Rejection

ELEMENT DIMENSIONS AND WEIGHT

MODEL NUMBER LEGEND



MODEL	DIMENSIONS INCHES(MM)			DRY BOXED
	A	B	C*	WEIGHT LBS (KG)
AG2026TF	26.00 (660)	0.750 (19)	2.02 (51)	1.1 (0.5)
AG2425T	25.00 (635)	0.625 (16)	2.40 (61)	0.7 (0.3)
AG2514TF	14.00 (356)	0.750 (19)	2.50 (64)	0.8 (0.4)
AG2521TF	21.00 (533)	0.750 (19)	2.40 (61)	1.3 (0.6)
AG2526TF	26.00 (660)	0.750 (19)	2.40 (61)	3.7 (1.7)
AG3218T**	18.00 (457)	0.750 (19)	3.20 (81)	2.2 (1.0)
AG3308T**	8.00 (203)	0.750 (19)	3.30 (84)	1.3 (0.6)
AG4014TF	14.00 (356)	0.750 (19)	3.88 (99)	2.0 (0.9)
AG4021TF	21.00 (533)	0.750 (19)	3.88 (99)	2.2 (1.0)

* The element diameter (dimension C) is designed for optimum performance in GE pressure vessels. Other pressure vessel dimension and tolerance may result in excessive bypass and loss of capacity

** Ametek Style - Designed to fit into an Ametek housing that has been equipped with a brine control valve.

Brackish Water, Low Pressure

The **A-Series** family of proprietary thin-film reverse osmosis membrane elements are characterized by high flux and excellent sodium chloride rejection.

AK Low Pressure Brackish Water Elements are selected when **high rejection and extremely low operating pressures** are desired. These elements allow significant energy savings since good rejection is achieved at operating pressures as low as 100 psig.

AK Low Energy Brackish Water Elements feature a tape outer wrap and standard feed spacers.

ELEMENT SPECIFICATIONS

MODEL	FLOW GPD (m^3/d)	REJECTION AVG./MIN.	ACTIVE AREA FT^2 (m^2)
AK2514TF	170 (0.64)	99.0% / 98.0%	7 (0.6)
AK2521TF	325 (1.23)	99.0% / 98.0%	13 (1.2)
AK2526TF	470 (1.78)	99.0% / 98.0%	17 (1.6)
AK3218T	755 (2.86)	99.0% / 98.0%	29 (2.7)
AK3308T	350 (1.21)	99.0% / 98.0%	12 (1.2)
AK4014TF	585 (2.21)	99.0% / 98.0%	21 (2.0)
AK4021TF	1,050 (3.97)	99.0% / 98.0%	42 (3.9)

Specification is based on a 500 mg/L NaCl solution at 115 psi (793 kPa) operating pressure, 77˚F (25˚C), pH 7.5 and 15% recovery. Individual flux may vary +25%/-15%. Average salt rejection after a minimum of 24 hours of continuous operation.

OPERATING AND DESIGN PARAMETERS

THIN-FILM MEMBRANE (TFM®)

TYPICAL OPERATING PRESSURE	TYPICAL OPERATING PROCESS FLUX	MAXIMUM PRESSURE	MAXIMUM TEMPERATURE	RECOMMENDED pH	CHLORINE TOLERANCE
100 psig (690 kPa)	10-20 GFD (15-35 LMH)	400 psig (3,758 kPa)	122˚F (50˚C)	Optimum Rejection pH: 7.0-7.5 Operating pH Range: 4.0-11.0 Cleaning pH range: 2.0-11.5	1,000 ppm-hrs., Dechlorination recommended

Feed NTU: <1, Feed SDI: <5

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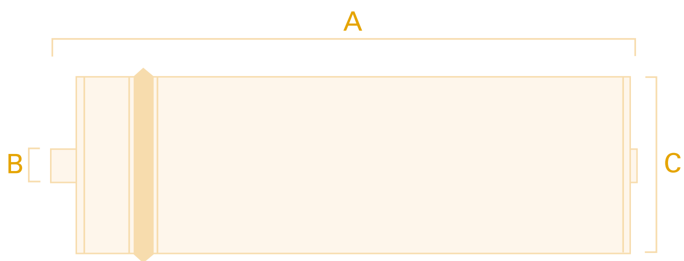
ELEMENT DIMENSIONS AND WEIGHT

MODEL NUMBER LEGEND



MODEL	DIMENSIONS INCHES(MM)			DRY BOXED
	A	B	C*	WEIGHT LBS (KG)
AK2514TF	14.00 (356)	0.75 (19)	2.50 (64)	0.8 (0.4)
AK2521TF	21.00 (533)	0.75 (19)	2.50 (64)	1.3 (0.6)
AK2526TF	26.00 (660)	0.75 (19)	2.50 (64)	3.7 (1.7)
AK3218T**	18.00 (457)	0.75 (19)	3.20 (81)	2.2 (1.0)
AK3308T**	8.00 (203)	0.75 (19)	3.30 (84)	1.3 (0.6)
AK4014TF	14.00 (356)	0.75 (19)	3.88 (99)	2.0 (0.9)
AK4021TF	21.00 (533)	0.75 (19)	3.88 (99)	2.2 (1.0)

* The element diameter (dimension C) is designed for optimum performance in GE pressure vessels.
Other pressure vessel dimension and tolerance may result in excessive bypass and loss of capacity

** Ametek Style - Designed to fit into an Ametek housing that has been equipped with a brine control valve.

Brackish Water

The **C-Series** family, a triacetate/diacetate blend, has a higher flux and better mechanical stability than standard celulose acetate. C-Series elements offer a lower per element cost and increased chlorine resistance compared to thin-film elements.

CE Brackish Water Elements are used for **brackish water desalination** and **process stream concentration** at 425 psig (2,930 kPa) operating pressure.

ELEMENT SPECIFICATIONS

MODEL	FLOW GPD (m^3/d)	REJECTION AVG./MIN.	ACTIVE AREA FT^2 (m^2)
CE2026TF	245 (0.93)	97.5% / 95.0%	10 (1.0)

Specification is based on a 2,000 mg/L NaCl solution at 425 psi (2,930 kPa) operating pressure, 77˚F (25˚C), pH 7.5 and 15% recovery. Individual flux may vary +25%/-15%.

OPERATING AND DESIGN PARAMETERS

CELLULOSE TRIACETATE/DIACETATE BLEND

TYPICAL OPERATING PRESSURE	TYPICAL OPERATING PROCESS FLUX	MAXIMUM PRESSURE	MAXIMUM TEMPERATURE	RECOMMENDED pH	CHLORINE TOLERANCE
140-400 psig (965-2,758 kPa)	10-18 GFD (17-30 LMH)	450 psig (3,103 kPa)	86˚F (30˚C)	Operating pH Range: 5.0-6.5 Cleaning pH range: 3.0-8.0	1 ppm maximum, Continuous 30 ppm for 30 min. during chlorine sanitization

Feed NTU: <1, Feed SDI: <5

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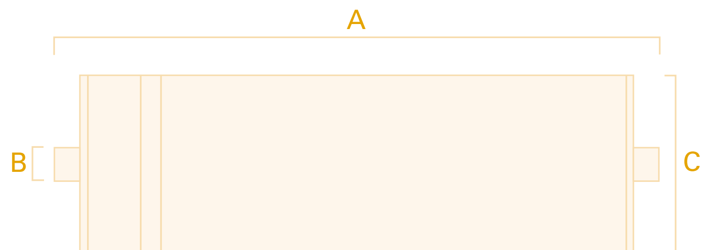
ELEMENT DIMENSIONS AND WEIGHT

MODEL NUMBER LEGEND



MODEL	DIMENSIONS INCHES(MM)			DRY BOXED
	A	B	C*	WEIGHT LBS (KG)
CE2026TF	26.00 (660)	0.75 (19)	2.00 (51)	1.1 (0.5)

* The element diameter (dimension C) is designed for optimum performance in GE pressure vessels. Other pressure vessel dimension and tolerance may result in excessive bypass and loss of capacity

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The **H-Series** proprietary thin-film nanofiltration membrane elements are characterized by an approximate molecular weight cut-off of 150-300 daltons for uncharged organic molecules. Divalent and multivalent ion rejection is dependent upon feed concentration and composition.

HL Nanofiltration Elements are used for water **softening, color removal, and reduction of THM potential**. They feature a tape outer wrap and standard feed spacers.

ELEMENT SPECIFICATIONS

MODEL	FLOW GPD (m^3/d)	REJECTION AVE.	ACTIVE AREA FT^2 (m^2)
HL2514T	220 (0.83)	98.0%	6 (0.6)
HL2521TF	380 (1.44)	98.0%	13 (1.2)
HL3218T	950 (3.60)	98.0%	29 (2.7)
HL3308T	400 (1.51)	98.0%	13 (1.2)
HL4014TF	700 (2.65)	98.0%	23 (2.1)
HL4021TF	1280 (4.85)	98.0%	40 (3.7)

Specification is based on a 2,000 mg/L $MgSO_4$ solution at 100 psi (690 kPa) operating pressure, 77˚F (25˚C), pH 7.5 and 15% recovery. Individual flux may vary +25% / -15%.

OPERATING AND DESIGN PARAMETERS

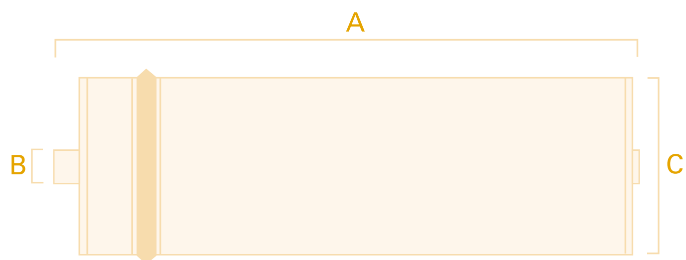
THIN-FILM MEMBRANE (TFM®)

TYPICAL OPERATING PRESSURE	TYPICAL OPERATING PROCESS FLUX	MAXIMUM PRESSURE	MAXIMUM TEMPERATURE	RECOMMENDED pH	CHLORINE TOLERANCE
100 psig (690 kPa)	12-20 GFD (20-35 LMH)	450 psig (3,103 kPa)	122˚F (50˚C)	Operating pH Range: 3.0-9.0	<0.1 ppm

Water Softening

ELEMENT DIMENSIONS AND WEIGHT

MODEL NUMBER LEGEND



MODEL	DIMENSIONS INCHES(MM) A	B	C*	DRY BOXED WEIGHT LBS (KG)
HL2514T	14.00 (356)	0.75 (19)	2.50 (64)	0.8 (0.4)
HL2521TF	21.00 (533)	0.75 (19)	2.50 (64)	1.3 (0.6)
HL3218T**	18.00 (457)	0.75 (19)	3.20 (81)	2.2 (1.0)
HL3308T**	8.00 (203)	0.75 (19)	3.30 (84)	1.3 (0.6)
HL4014TF	14.00 (356)	0.75 (19)	4.00 (102)	2.0 (0.9)
HL4021TF	21.00 (533)	0.75 (19)	4.00 (102)	2.2 (1.2)

* The element diameter (dimension C) is designed for optimum performance in GE pressure vessels. Other pressure vessel dimension and tolerance may result in excessive bypass and loss of capacity

** Ametek Style - Designed to fit into an Ametek housing that has been equipped with a brine control valve.

Pre/Post Treatment for RO/NF

The **P-Series** family of polyethersulfone ultrafiltration membrane elements are characterized by a 10,000 molecular weight cut-off and greater than 96% rejection of Cytochrome-C (13,300 MW protein).

PW Elements are used for pretreatment of process water and post treatment of ultrapure water.

PW Ultrafiltration elements feature a tape outer wrap and standard feed spacers.

ELEMENT SPECIFICATIONS

MODEL	MOLECULAR WEIGHT CUTOFF	ACTIVE AREA FT² (m²)
PW3308T	10kD	13 (1.2)
PW3220T	10kD	26 (2.4)

OPERATING AND DESIGN PARAMETERS

TYPICAL OPERATING PRESSURE	TYPICAL OPERATING PROCESS FLUX	MAXIMUM TEMPERATURE	RECOMMENDED pH	CHLORINE TOLERANCE
80-135 psig (500-930 kPa)	Pre treatment 10-25 GFD (15-40 LMH) Post treatment 25-35 GFH (40-60 LMH)	122˚F (50˚C)	Operating pH Range: 2.5-11.0 Cleaning pH Range: 2.0-11.5	5,000+ ppm days

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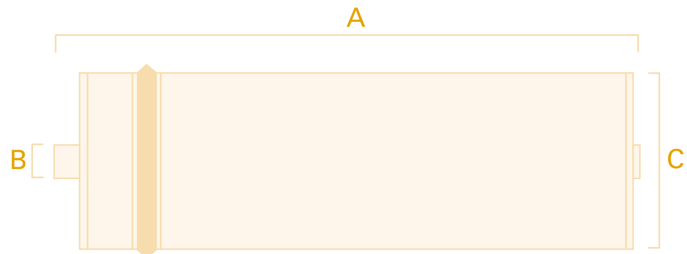
Post Treatment for RO/NF

ELEMENT DIMENSIONS AND WEIGHT

MODEL NUMBER LEGEND



MODEL	DIMENSIONS INCHES(MM) A	B	C	DRY BOXED WEIGHT LBS (KG)
PW3308T**	8.75 (203)	.625 (16)	3.30 (84)	1.3 (0.6)
PW3220T**	18.00 (457)	.625 (16)	3.20 (81)	2.3 (1.0)

** Ametek Style - Designed to fit into an Ametek housing that has been equipped with a brine control valve.

Pretreatment for RO/NF

The **E-Series** family consists of microfiltration elements utilizing polysulfone membrane.

The EW family of elements should be selected when pretreatment is in need to keep an RO or a Nanofiltration system running. EW will remove suspended solids and other known foulants.

EW Microfiltration elements feature a tape outer wrap and standard feed spacers.

ELEMENT SPECIFICATIONS

MODEL	PORE SIZE MICRON	ACTIVE AREA FT² (m²)
EW3310T	0.04	14 (1.3)
EW3220T	0.04	26 (2.4)

OPERATING AND DESIGN PARAMETERS

TYPICAL OPERATING PRESSURE	TYPICAL OPERATING PROCESS FLUX	MAXIMUM TEMPERATURE	RECOMMENDED pH	CHLORINE TOLERANCE
30-150 psig (200-1,000 kPa)	10-40 GFD (10-70 LMH)	122˚F (50˚C)	Operating pH Range: 2.5-11.0 Cleaning pH Range: 2.0-11.5	5,000+ ppm days

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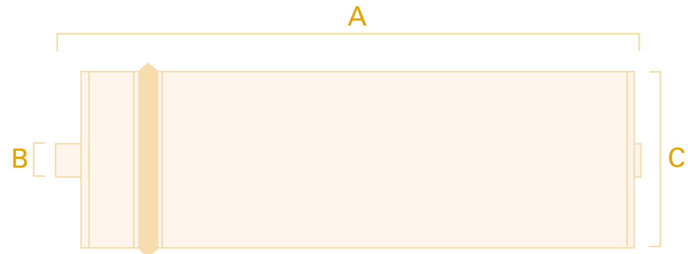
Pretreatment for RO/NF

ELEMENT DIMENSIONS AND WEIGHT

MODEL NUMBER LEGEND



MODEL	DIMENSIONS INCHES(MM)			DRY BOXED
	A	B	C	WEIGHT LBS (KG)
EW3310T**	10 (254)	1.187 (30)	3.30 (84)	1.4 (0.6)
EW3220T**	20 (508)	1.187 (30)	3.20 (81)	2.3 (1.0)

** Ametek Style - Designed to fit into an Ametek housing that has been equipped with a brine control valve.

INDUSTRIAL

PERMEATE CARRIER	Epoxy-coated polyester
FEED SPACER	Polypropylene
CENTRAL TUBE	ABS for 2.5 & 4 inch diameter elements Noryl* for 8.0 inch diameter elements
GLUE	Urethane
BRINE SEAL	Buna-N
O-RINGS	Buna-N
EXTERNAL WRAP	Polypropylene tape, FRP or Durasan
ANTI-TELESCOPING DEVICE	ABS

** Noryl is a trademark of General Electric Company*

COMMERCIAL

PERMEATE CARRIER	Epoxy-coated polyester
FEED SPACER	Polypropylene
CENTRAL TUBE	PVC, ABS, Polypropylene. Varies in size.
GLUE	Urethane
BRINE SEAL	EPDM
O-RINGS	EPDM
EXTERNAL WRAP	Polypropylene tape
ANTI-TELESCOPING DEVICE	ABS

This is a typical construction. Call for specifics.

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DURASAN® OUTER WRAP

The Durasan sleeve consists of a rigid, tubular plastic "cage" that contains and protects the spiral-wound element. This design functionally maintains a **controlled bypass** around the outside of the element that eliminates the voids and dead spaces conducive to bacterial growth and adhesion. Proven in sensitive applications, Durasan offers comparatively **high rejection** with a **sanitary design** that provides **quick rinse ability ideal for CIP** sanitary systems.

NETWRAP™ OUTER WRAP

Netwrap is an innovative, polypropylene outer wrap feature of GE **Full-Fit**™ design elements that has **no bypass** around the outside of the element. Netwrap is designed to protect the spiral-wound element as well as form a close fit within the pressure vessel walls, without the use of a brine seal. Netwrap is a **sanitary design** that functionally experiences **low pressure drop**, which may lead to substantial energy savings.

FIBERGLASS (FRP) OUTER WRAP

Fiberglass (FRP) element casings are engineered for best use with high pressure, **industrial** applications where rigorous sanitary limitations do not apply. The fortified **durability** of FRP provides heightened protection of the spiral-wound element. FRP is chemically tolerant, enabling contact with **high pH** cleaners.

TAPE OUTER WRAP

Tape outer wrap offers the most **economical** option for spiral-wound membrane elements. A standard in the industry since its inception, tape-wrapped elements have demonstrated historical success with light commercial applications. Tape elements operate at comparably **low pressure** and are intended for use without cleaning, until replacement is necessary.

QUICK REFERENCE COMPARISON

	DURASAN	NETWRAP	FRP	TAPE
SANITARY DESIGN	BEST	BEST	NOT INTENDED FOR	NOT INTENDED FOR
CLEANING ABILITY	BEST	BEST	BEST	NOT INTENDED FOR
REJECTION PERFORMANCE	BEST	GOOD	BEST	GOOD
ENERGY SAVING PERFORMANCE	GOOD	BEST	GOOD	GOOD
ELEMENT COST	GOOD	GOOD	BEST	BEST

BEST GOOD NOT INTENDED FOR

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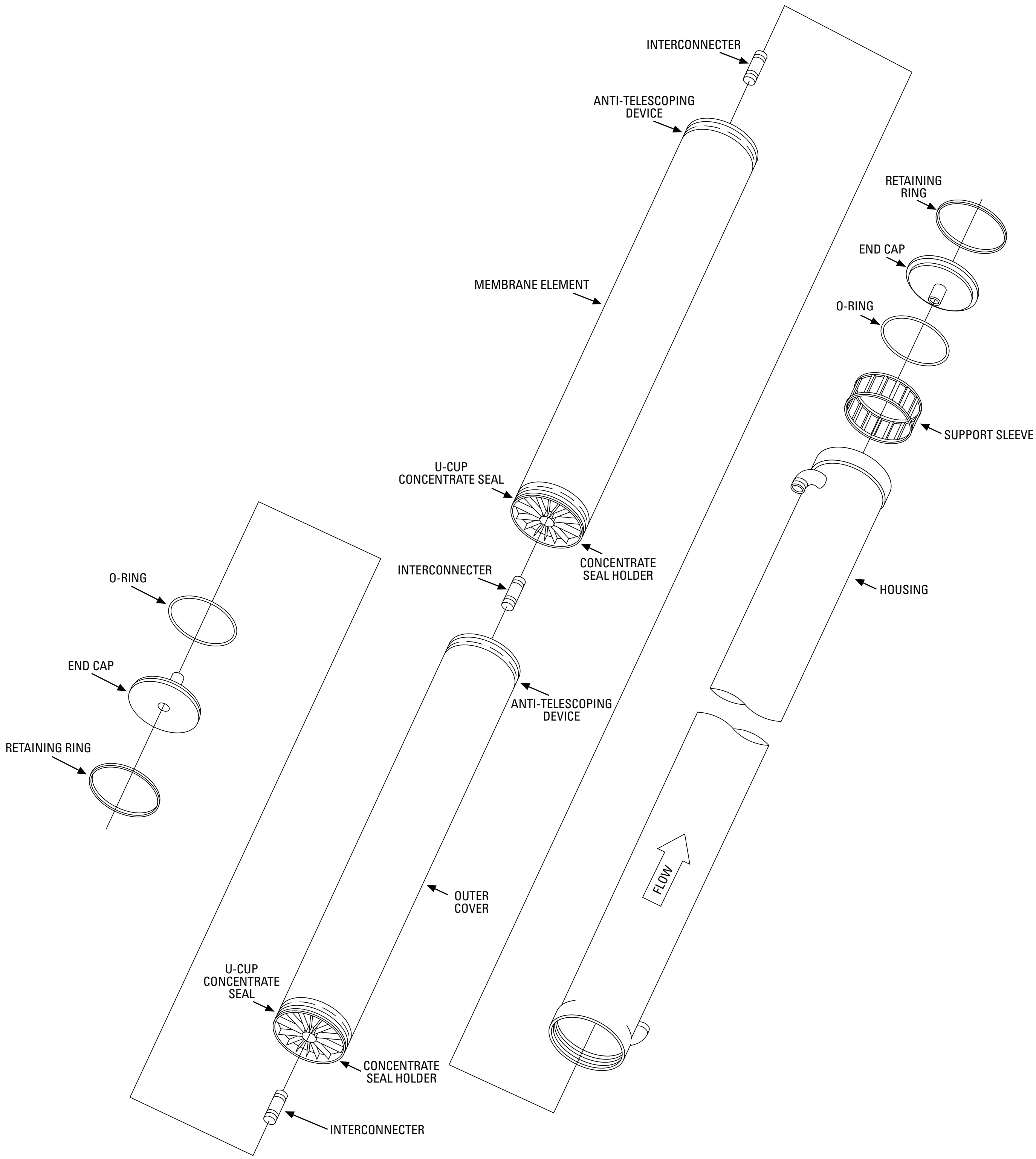
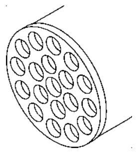
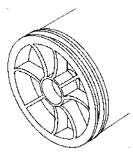
Parts Terminology



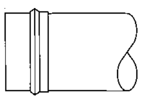


FLAT DISC STYLE

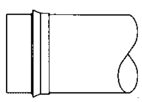


U-CUP STYLE

Anti-Telescoping Device (ATD)
The anti-telescoping disc is connected to the element to provide support to the ends of the element preventing displacement of the outer portion relative to the permeate tube (telescoping).

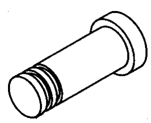


CHEVRON SEAL

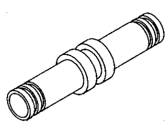


U-CUP SEAL

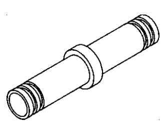
Brine Seal
The brine seal, most often located at the feed end of the element, seals the outer-most part of the element with the inside of the pressure vessel wall and directs the feed solution to the spiral membrane. The brine seal minimizes passage of the feed solution around the outside of the element, optimizing the spiral wound design configuration.



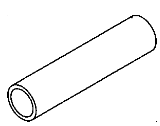
Dead End Plugs (DEP)
The closed end plug is used to seal the open end of the permeate tube farthest from the permeate removal end of the pressure vessel when permeate removal is from only one end of the vessel. It is used in retrofit situations where there is space between the upstream element and the pressure vessel end cap.



Interconnector (IC)
The interconnector is used to connect the permeate tubes of adjacent elements.



Product End Adaptor (PEA)
The product end adapter is used to connect the permeate tube of the element to the permeate port of the pressure vessel end cap assembly.



Spacer Tube
The spacer tube is used as a permeate tube extension to fill space between the upstream element(s) and the permeate port of the pressure vessel end cap assembly. It is often utilized in retrofit situations with a product end adaptor and/or a closed end plug.

The spacer tube helps prevent shifting of the elements in the pressure vessel in conjunction with a thrust ring provided by the system manufacturer.

U-CUP SEALS

PART NUMBER	DESCRIPTION	MATERIAL	KIT CROSS REF.
1116160	U-Cup Seal for 4" Elements	EPDM	None
1118751	U-Cup Seal for 8" Elements	EPDM	None

PRODUCT END ADAPTERS

1162524	PEA OSMO, Kit, EC Adapter, VC, Filmtec	PVC/EPDM	None
1206619	PEA (Filmtec Style) Codeline 4" vessel (4B) 1205463/1205581	PVC/Buna-N	Kit 62
1227365	PEA Codeline 8" vessel	PET/EPDM	Kit 106
1227368	PEA UOP 8" vessel	Noryl/EPDM	Kit 109
1227362	PEA Desal 8" vessel	Noryl/EPDM	Kit 103
1206525	UOP & Filmtec Style, VC Accessory Kit for 4" Elements Contains: 1 ea. 1205406 PEA 2 ea. 1205580 O-ring 2 ea. 1205581 O-ring	 PSO Buna-N Buna-N	Kit 82

DEAD END PLUGS

1206575	DEP 2.5" & 4" Element (Filmtec Style)	Celcon/Buna-N	Kit 101
1229773	DEP 8" 1.12 OD/Two O-rings included w/ 8" DEP	PSO/EPDM	Kit 119

ACCESSORY/RELOAD KITS

1226284	Purewater 4" Contains: 1 ea. 1205503 Interconnector 8 ea. 1205592 O-ring	 Celcon EPDM	Kit 170
1206581	Accessory Kit for 2.5" Elements Contains: 1 ea. 1205503 Interconnector 4 ea. 1205581 O-ring	 Celcon Buna-N	Kit 6
1206598	Accessory Kit for 8" Elements Contains: 1 ea. 1205451 Interconnector 8 ea. 1205571 O-ring	 Noryl EPDM	Kit 24

OPERATING TERMINOLOGY

A-value: (see *Water Permeation Coefficient*)

Assymmetric Membrane: (see *Membrane*)

Algae: A group of single-celled plants which includes both sea water and fresh water varieties.

Alkalinity: A measurement of the quantity of chemicals present in water which can neutralize acids. These include carbon dioxide, bicarbonate, carbonate and hydroxides.

Amphoteric: A substance, such as aluminum, capable of acting as either an acid or base.

Anions: A negatively charged ion. (see *Ion*)

Array: The arrangement of pressure tubes in a reverse osmosis system. Typically, there will be a number of pressure tubes in parallel whose concentrate will be combined to form the feed to another group of pressure tubes.

ATD: Anti-Telescoping Device. The ATD is connected to the spiral-wound element to provide support to the ends of the element preventing displacement of the outer position relative to the permeate tube.

Bacteria: Bacteria are single cell microorganisms capable of replicating on their own. They can be divided into two broad categories, aerobic (requiring oxygen) and anaerobic (not requiring oxygen). Bacteria can live in a very broad range of habitats. Some, for example pseudomonads, can thrive in environments containing a very low level of nutrients. These bacteria are frequently slime producers and are a major problem in water treatment systems. Other bacteria, which adhere to surfaces, secrete a gelatinous material that serves to protect the bacteria from chemical disinfectants. This combination of bacteria and their protective coating is sometimes referred to as biofilm. The concentration of bacteria in water is commonly given in terms of colony forming units (cfu) per ml. A colony-forming unit is a viable bacterium able to replicate to form a whole colony when incubated in a given environment.

Blinding: The accumulation of foreign material on the lead end of a membrane element such that there are excessive pressure losses across the membrane element.

Boundary Layer: A thin film of slowly moving water adjacent to the rejecting surface of the membrane. Since water is removed from this film through the membrane, and the water in this film does not mix with the bulk stream, the concentration of solutes, colloids, and suspended matter in the boundary layer is greater than in the bulk stream.

Brackish Water: A water containing between 1,000mg/L and 15,000mg/L of dissolved solids.

Brine: The concentrated stream of water from a reverse osmosis unit. The term *concentrate* is preferred.

Brine Seal: A synthetic rubber seal attached to the outer surface of the shell of the membrane element which forces water to flow past the membrane rather than bypass the membrane element.

Cation: A positively charged ion. (see **Ion**)

Cellulase: An enzyme which causes the decomposition of cellulose.

Cellulose Acetate: A synthetic polymer derived from naturally occurring cellulose and widely used in the fabrication of membranes. The polymers used for water purification membranes may be diacetate, triacetate or blends of these materials.

Chloramines: Chemicals used to disinfect municipal water. They are formed by reacting ammonia and free chlorine and may occur naturally when free chlorine combines with ammonia arising from the breakdown of vegetation. Chloramines are strong oxidants that are highly toxic in hemodialysis applications.

Chlorinated Hydrocarbons: A group of organic chemicals formed by reacting petroleum derived chemicals with chlorine. Such chemicals include pesticides (insecticides) and herbicides and are frequently potent carcinogens.

Chlorine: (see *Chlorinated Hydrocarbons*)

Chlorophenoxyls: (see *Chlorinated Hydrocarbons*)

Colloid: Undissolved, submicron-sized suspended particles that are well dispersed in a solution and will not readily settle out on standing.

Compaction: The undesirable physical compression of a reverse osmosis or ultra filtration membrane that results in reduced flux rates. The phenomenon is accelerated at higher temperatures and pressures.

Concentration Polarization: The ratio of the concentration of the solutes at the membrane surface to the concentration in the bulk solution. Concentration Polarization (also known as the Beta value) is a result from boundary layer formation.

$$ß = \frac{C_{surface}}{C_{bulk}} \approx e^{.7^*\left[\frac{Q_p}{.5^*(Q_f - Q_b)}\right]}$$

$ß$ = Concentration polarization
$C_{surface}$ = Concentration of salt at membrane surface
C_{bulk} = Concentration of salt in bulk solution
Q_p = Flow of permeate
Q_f = Flow of feed
Q_b = Flow of brine

Conductivity: The ability of an aqueous solution to carry electric current depends on the presence of ions in the solution. Conductivity is a quantitative measure which describes this ability. Solutions of inorganic ions are relatively good conductors (and exhibit high conductivity), whereas solutions of organic molecules are rather poor conductors (and exhibit low conductivity). Highly purified water is also a poor conductor. Conductivity is expressed in units of Siemens/cm (also known as mhos/cm). Conductivity measurements are frequently encountered in monitoring the performance of reverse osmosis equipment. Conductivity is temperature dependent and should be measured with a temperature-compensated meter. The usual reference temperature is 25°C. Conductivity measurements are sometimes used to estimate total dissolved solids in water. While convenient, this practice is imprecise. (see also *Resistivity*)

Dalton: A unit of mass 1/12 the mass of Carbon^{12}. Named after John Dalton (1766-1844), founder of atomic theory and the first theorist since Democritus (Greek, 5th century BC) to describe matter in terms of small particles.

Deionization: Removal of ions from water by exchange with other ions associated with fixed charges on a resin.

Differential Pressure: The difference in pressure between the upstream and downstream sides of a filter. It can also be the difference in pressure between two points in a system or of a component in such a system.

Disinfection: Disinfection is the process of killing microorganisms, usually by one of a variety of chemical agents, such as formaldehyde and sodium hypochlorite. Disinfection lowers the number of micro-organisms without necessarily killing all those present. Although total killing of all organisms is virtually impossible, sterilization will reduce the number of organisms to a safe predetermined level. Sterilization can generally only be achieved routinely by heat, gamma irradiation, ethylene oxide, and, in certain cases, special filtration. Of these methods, only filtration is suitable for mass sterilization of water and none is suitable for sterilization of water treatment equipment used in hemodialysis facilities. However, a proprietary chemical disinfectant incorporating paracetic acid as the active ingredient has been recently qualified as a sterilant and this agent may be suitable for sterilization of certain water system components.

Endotoxin: Bacterial lipopolysaccharide, a substance released from the cell walls of gram-negative bacteria when the organism is broken down.

Feed Water: Water entering a purification system or an individual piece of purification equipment, such as an ultrafilter or reverse osmosis system.

Fluoride: A salt of hydrofluoric acid which may occur naturally in water supplies or be added by municipal processes for the prevention of dental cavities. Fluoride is considered toxic in the hemodialysis setting and has been implicated with renal bone disease.

Flux Rate: The rate per unit of area at which water passes through a semi-permeable membrane, such as those used for ultra filtration or reverse osmosis.

Fouling: The deposition of insoluble materials, such as bacteria, colloids, oxides and water-borne debris, onto the surface of a reverse osmosis or ultra filtration membrane. Fouling is associated with decreased flux rates and may also reduce the rejection rates of reverse osmosis membranes.

Fungus: A parasitic plant that produces no chlorophyll and is dependent on other life forms for its existence.

Grains of Hardness: Although the theoretical hardness of water is the sum of the concentrations of all metallic ions, other than the alkali metals, it is commonly expressed as the equivalent concentration of calcium carbonate in grains. Ionic concentrations can be expressed in terms of their combining potential (Eq/L), the number of moles (mo/L), or their masses in any of several conventions. In the English system masses are expressed in terms of pounds (avoirdupois) which contain 7000 grains each. Although considered outdated in most of the world, the US water purification industry continues to express hardness in units of grains/gal expressed as calcium carbonate. Grains/gal expressed as calcium carbonate can be converted to metric units (mg/L) by multiplying the former by 17.1. Grains/gal expressed as calcium carbonate can also be converted into mEq/L of a univalent ion, such as sodium (Na^+) by multiplying by 0.342. Care must be taken in using these conversion factors to size equipment based on ion exchange principles since the ionic content of the water will depend on the type of ions present as well as their total mass.

Hardness: Hardness was originally defined as a measure of the ability of water to precipitate soaps made from fatty carboxylic acids. These "soaps" precipitated in the presence of calcium and/or magnesium ions. Today, hardness is used to describe the total concentration of calcium and magnesium, expressed as mg/L or calcium carbonate. It is generally calculated from measurement of calcium and magnesium ion concentrations, using:

Hardness (mg $CaCO_3$ /L) = 2.497 x Ca (mg/L) + 4.118 x Mg (mg/L)

Homogeneous Membrane: (see *Membrane*)

Humic Acid: A water-soluble organic compound composed of decayed vegetable matter which is leached into a water source by runoff. Present in most surface waters. Higher concentrations cause a brownish tint. Difficult to remove except by ultrafiltration or reverse osmosis.

Hydrolysis: A chemical process resulting from reactions with water; frequently used in reference to the breakdown of polymers.

Hydrophilic: Pertaining to a substance which readily absorbs water (“water-loving”).

Hydrophobic: Pertaining to a substance that does not readily absorb water (“water-hating”).

Interconnector: The interconnector is used to connect the permeate tubes of adjacent spiral-wound elements.

Ion: An atom or molecule having either a positive or negative electrical charge. Positively charged ions are referred to as cations and ions having a negative charge are termed anions.

Ion Exchange: Ion exchange is based on the principle of electroneutrality, that is, charged species are stable only when they exist as balanced pairs of positive and negative charges. Ion exchange resins, the materials used to carry out the process of ion exchange, are particles which contain fixed charges on their surface. To maintain electroneutrality, each of these charges has an ion of equal and opposite charge held to it; these ions are called counter ions.

The counter ions are mobile and can leave the fixed charge if some other counter ion is available to replace it. The replacement ion must be of the same charge as the initial counter ion in order to maintain electroneutrality. The initial counter ion is established by washing the resin with a concentrated solution of the desired counter ion. For example, the softener resins are cation exchangers containing carboxylic acids on their surfaces. If these resins are washed with strong NaCl solutions, the predominant cation in the solution is Na^+ and it will become the counter ion. In use, the perfusing water will provide competing counter ions, such as Ca^{2+}. Because of the preference of carboxylic acids for Ca^{2+} over Na^+ in dilute solutions, the water will be depleted of Ca^{2+} in exchange for Na^+ initially present.

Ionic Strength: A measure of the extent to which a solution is ionized. It is one-half the sum of the molal concentration of ions times the charge on that ion squared.

$$I = .5\sum C_i * Z_i^2$$

I = Ionic strength (mole/kg)
C_i = Concentration of each ion (mole/kg)
Z_i = Charge on the ion

Laminar Flow: A type of flow characterized by minimal internal mixing (turbulence), and characterized by being directly proportional to the differential pressure. For flow in pipe, it can be expected to occur if the Reynolds number is less than 2,100.

Langelier Saturation Index: The precipitation of calcium and magnesium carbonates in water purification systems is a serious cause of system failure. The insolubility of these compounds are a complex function of the pH of the water, the dissolved carbon dioxide content, the carbonate content, the presence of other salts, and the temperature. The Langelier Saturation Index is a method of predicting whether or not carbonate deposits will form under given conditions. Calculation of the Langelier Saturation Index is complex and will not normally be done by hemodialysis personnel. Reverse osmosis vendors may use the index in determining the maximum recovery and rejection rates that can be obtained from a reverse osmosis system before carbonate deposits will seriously reduce water quality and recovery. It should be noted that the utility of such determinations is limited to those situations in which a softener is not used as part of the pre-treatment scheme for reverse osmosis.

Lignin: A polysaccharide found in the cell walls of plants; a breakdown product of decaying vegetation which may be present in surface water supplies.

Membrane: Membrane is a thin film made with structures designed to provide selective transport of solutes. In general, the selectivity of a membrane is based on its ability to pass or exclude species according to their size. Membrane structures may become homogeneous or asymmetric. Homogeneous membranes have structures which are uniform in cross-section, at least to a magnification of 100x. Most homogeneous membranes have been developed for micro-filtration and hemodialysis.

Membranes reduce not only the flow of undesirable solutes, but also the flow of solvent. In order to minimize the reduction in solvent flow, asymmetric membranes have been developed. These membranes are made with asymmetric cross-sections, that is, they consist of two parallel layers. The resistance to flow of the skin layer, which gives the membrane its filtration selectivity, is minimized by reducing its thickness. The resistance to flow of the thicker support layer, which provides structural strength, is minimized because of its open pore structure. These different layers may be made from the same material, as in asymmetric cellulose acetate membranes, or from different materials, as in thin-film composite membranes.

Membranes used in water treatment equipment are fabricated in two forms, as flat sheets or as hollow fibers.

Membrane Element: An assembly of membrane, support materials, and flow channels which can be installed in a reverse osmosis unit in the field. The smallest assemblage of membrane available to the end user.

Microfiltration (MF): Filtration designed to remove particles and bacteria in the range of 0.1 to 3 microns in diameter.

Microporous: In the context of water purification, membranes having an average pore size which is between 0.1 and 1.0 microns in diameter.

Module: A module is the complete assembly of housing, membranes, interconnecting devices and caps.

Molecular Weight: The sum of the atomic weights of the constituents which make up a molecule. Often used to indicate size when referring to ultrafiltration of saccharide compounds (see *Dalton*).

Monovalent Ion: A cation or anion having a single electrical charge.

Nanofiltration (NF): A pressure driven operation in which the membrane fractionates components of a fluid predominantly according to their size and charge. It is mainly used for the separation of multivalent ions and uncharged organic molecules, which have molecular weights between 200 and 1,000 Dalton. The membranes used in nanofiltration are characterized by a charged surface and pore diameters in the range of 1-3 nm.

Net Pressure: (see *Transmembrane Pressure*)

Nitrate: An anion comprised of one nitrogen atom and three oxygen atoms. Nitrates are considered toxic in hemodialysis water and are also harmful to infants when consumed orally.

NTU: The unit for nephelometric turbidity. In nearly all cases, it has replaced Jackson turbidity. Although the two are not exactly the same, they are frequently considered equivalent.

Osmosis: The naturally occurring phenomenon where water diffuses through a membrane from a dilute solution to a more concentrated solution.

Osmotic Pressure: When a solution, such as salt water, is separated from pure water by a membrane which is impermeable to the salt, a flow of water will occur from the pure water to the salt solution. The driving force for this flow is called the osmotic pressure and its magnitude depends on the number of salt particles in the solution. Note that the osmotic pressure depends on the number of particles and not on the total mass of particles. For example, 1 g/L of a small solute, such as sodium chloride, will exert a greater osmotic pressure than 1 g/L of a large solute, such as protein. For water to flow from the salt solution to the pure water, the solution must be exposed to a hydrostatic pressure greater than its osmotic pressure. This is the principle of reverse osmosis.

Oxidants (oxidizing agents): Chemicals which provide oxygen and accept and electron in an oxidation reduction reaction. Free chlorine and chloramines are oxidants which are widely used for disinfection.

Ozone: An extremely active oxidizing agent which consists of three oxygen atoms. It is formed by the action of a high voltage electrical field on oxygen or air.

Parallel: In water purification, an arrangement of equipment in a side-by-side configuration such that water flow is divided and passes through one or both of these branches.

Permeate: (see *Product Water*)

pH: Water (H_2O) can dissociate into two ions: hydrogen (H^+) and hydroxyl (OH). These ions can also be added to water in combination with other oppositely charged ions. Thus, a solution of hydrochloric acid added to water provides both H^+ and chloride anion, Cl^- . The concentration of H^+ in the water is a measure of the water's acidity and the concentration of OH^-, a measure of its alkalinity.

To simplify quantitation of H^+ differences, where numbers with a wide range of exponents are encountered, scientists devised a logarithmic scale called pH. The pH values range form 1 to 14. A pH value of 7 is considered neutral. Lower values of pH indicate acidic conditions and higher pH values indicate alkaline conditions. Because pH is a logarithmic scale, an increase of 1 pH unit corresponds to a ten-fold change in acidity.

Phenols: Weak aromatic acids, which are indicative of industrial pollution of water supplies. When combined with chlorine, they produce an objectionable taste and odor. However, while indicative of pollution, phenols themselves are not known to be hazardous to hemodialysis patients.

Polyamide: A synthetic polymer of the nylon family used in the fabrication of reverse osmosis and ultra filtration membranes.

Polysulfone: A synthetic polymer used in the fabrication of reverse osmosis and ultrafiltration membranes, which are characterized by extreme thermal stability and chemical resistance.

Polyvalent Ion: A cation or anion having a multiple electrical charge.

Polyvinyl Chloride (PVC): A thermoplastic material produced by the polymerization of vinyl chloride. Used extensively in the U.S. for piping, food packaging, and injection molded plastic parts. PVC is the most common pipe material used in the U.S. for dialysis applications.

Pore: An opening in a membrane or filter matrix.

Potassium Permanganate: An oxidizing agent commonly used for the regeneration of manganese greensand iron filters and occasionally used as a disinfectant.

ppm: Parts per million; commonly considered equivalent to milligrams per liter (mg/L).

Precursors: Compounds such as humic acid which may lead to the creation of other compounds, such as THM.

Pressure Drop: Expenditure of a certain amount of energy is required for a fluid flow through any channel, such as pipe, particle bed, or membrane. The pressure at any point is a measure of the energy content of the fluid at that point. Since some of this energy is expended in flowing to a second point downstream, the pressure at the downstream point is less than at the original point. The amount of energy expended, and hence the decrease in pressure (or pressure drop), is dependent on the flow rate and viscosity of the fluid, and or PSI, or in the SI system, kPa (kilopascals) or Kg/cm^2. Pressure drop is sometimes referred to colloquially as "delta-P."

Product Water: The purified water stream from purification equipment, such as reverse osmosis units and ultra filters.

Recirculation: Recirculation is the term used to refer to the process of bringing back some part of the exit liquid stream (retentate) from the membrane in contact with the feed stream.

Recovery (percent recovery): A measurement applied to reverse osmosis and ultra filtration equipment which characterizes the ratio of product water to feed water flow rates. The measurement is descriptive of reverse osmosis or ultra filtration equipment as a system and not of individual membrane elements. Expressed as a percentage, recovery is defined as:

$$\%Rec = \frac{Q_p}{Q_f} * 100$$

$\%Rec$ = Percent recovery
Q_p = Flow of the permeate
Q_f = Flow of the feed

Rejection (percent rejection): A measure of the ability of a reverse osmosis membrane to remove salts. Expressed as a percentage, rejection is defined as:

$$\%R = 100 - \%T = \left[1 - \left(\frac{C_p}{.5 * (C_f + C_b)}\right)\right] * 100$$

$\%R$ = Percent rejection
$\%T$ = Transmission
C_p = Concentration of salt in permeate
C_f = Concentration of salt in feed
C_b = Concentration of salt in brine

Resistivity: Resistivity is a measure of the current-resisting characteristics of a substance when an electrical charge is applied (and is the reciprocal of conductivity). The standard unit of resistance is the Ohm. Because of the variable nature of water, a distance between measuring probes must be maintained if accurate measurements are desired. The almost universal standard distance for this is the centimeter, hence the "Ohm-cm." Resistivity measurements, like conductivity measurements, can be used in many ways to improve the management of a water purification system, and are commonly used to assess the quality of water produced by deionizers. Because temperature effects resistivity of water, temperature-compensating devices are frequently used. These adjust the resistance meter to indicate what the water resistance would be at one temperature, usually 25°C.

Retentate: The concentrated stream that discharges from a membrane system.

Reverse Osmosis (RO): The separation of one component of a solution from another component by flowing the feed stream under pressure across a semipermeable membrane. RO concentrates ionized salts, colloids, and organics down to 150 molecular weight in the concentrate stream and provides a purified stream of water.

ROMA: Reverse Osmosis Membrane Assembly; includes vessel housing, end caps, internal interconnecting parts, O-rings, and the RO membrane.

Salt Passage Rate: A measurement of the passage of salts through a membrane. (see *Transmission*)

Scaling: In reference to reverse osmosis equipment, scaling is the precipitation of sparingly soluble salts, such as calcium carbonate, onto the surface of the membrane. Scaling is associated with decreased flux and reduced reverse osmosis rejection rates.

Sedimentation: The process by which solids are separated from water by gravity and deposited on the bottom of a container or basin.

Semi-permeable: Descriptive of a material, such as a reverse osmosis or ultrafiltration membrane, which allows the passage of some molecules and prevents the passage of others.

Series: In water purification, an arrangement of equipment in a successive or end-to-end configuration.

Silt Density Index: The Silt Density Index (SDI) is a measure of the ability of water to foul a membrane or plug a filter. SDI is measured using an apparatus which typically consists of an inlet pressure regulator and pressure gauge followed by a filter holder containing a 0.45 micron microporous membrane filter. Commercial test kits, complete with instructions on how to calculate the index, are available.

Solubility Product: In the saturated solution of an electrolyte, it is the product of the molal concentration of the ions, each raised to the power of the coefficient of that ion in the balanced ionic equation for the precipitate. Although this is frequently referred to as a constant, it varies with temperature and with ionic strength of the solution.

Spacer: A spacer in a spiral-wound element facilitates the flow of permeate to the permeate collection tube.

Stage: A stage is constituted by a group of modules that receive feed at a uniform composition.

Stiff Davis Index: The difference between the pH of a solution and the pH at which it would be saturated in calcium carbonate. This index is applicable for waters containing more than 10,000mg/L TDS.

Sterilization: A physical or chemical process that reduces the number of organisms to a safe predetermined level.

Temperature Correction Factor: A temperature correction factor (TCF) is used to normalize the flow rate for temperature variations. Please refer to the following table.

Example: A system running at 200 GPD @ 35°C with a CA membrane must now be normalized to 25°C.

From table: TCF=1.2894
The flowrate (or flux value) is divided by the TCF to obtain the normalized flow rate:
Normalized flow = 200 gpd / 1.2894 = 155 gpd @ 25°C

TEMPERATURE CORRECTION FACTORS @ 77°F (25°C)

°F	°C	(PA) POLYAMIDE MEMBRANE	(PS) POLYSULFONE MEMBRANE	(CA) CELLULOSE ACETATE MEMBRANE
40	4.44	0.484	0.609	0.560
41	5.00	0.495	0.617	0.570
42	5.56	0.505	0.626	0.579
43	6.11	0.516	0.635	0.589
44	6.67	0.527	0.644	0.599
45	7.22	0.538	0.654	0.609
46	7.78	0.549	0.663	0.619
47	8.33	0.560	0.672	0.629
48	8.89	0.572	0.682	0.640
49	9.44	0.583	0.691	0.650
50	10.00	0.595	0.701	0.661
51	10.56	0.607	0.711	0.671
52	11.11	0.620	0.721	0.682
53	11.67	0.632	0.730	0.693
54	12.22	0.645	0.741	0.704
55	12.78	0.658	0.751	0.716
56	13.33	0.671	0.761	0.727
57	13.89	0.685	0.771	0.739
58	14.44	0.698	0.782	0.750
59	15.00	0.712	0.792	0.762

˚F	˚C	(PA) POLYAMIDE MEMBRANE	(PS) POLYSULFONE MEMBRANE	(CA) CELLULOSE ACETATE MEMBRANE
60	15.56	0.726	0.803	0.774
61	16.11	0.740	0.814	0.786
62	16.67	0.755	0.825	0.799
63	17.22	0.769	0.836	0.811
64	17.78	0.784	0.847	0.823
65	18.33	0.799	0.858	0.836
66	18.89	0.815	0.869	0.849
67	19.44	0.830	0.880	0.862
68	20.00	0.846	0.892	0.875
69	20.56	0.862	0.903	0.888
70	21.11	0.879	0.915	0.902
71	21.67	0.895	0.927	0.915
72	22.22	0.912	0.939	0.929
73	22.78	0.929	0.951	0.943
74	23.33	0.946	0.963	0.957
75	23.89	0.964	0.975	0.971
76	24.44	0.982	0.988	0.985
77	25.00	1.000	1.000	1.000
78	25.56	1.018	1.013	1.015
79	26.11	1.037	1.025	1.029
80	26.67	1.056	1.038	1.044
81	27.22	1.075	1.051	1.060
82	27.78	1.095	1.064	1.075
83	28.33	1.114	1.077	1.090
84	28.89	1.134	1.090	1.106
85	29.44	1.155	1.104	1.122
86	30.00	1.175	1.117	1.138
87	30.56	1.196	1.131	Out of range

˚F	˚C	(PA) POLYAMIDE MEMBRANE	(PS) POLYSULFONE MEMBRANE	(CA) CELLULOSE ACETATE MEMBRANE
88	31.11	1.217	1.144	Out of range
89	31.67	1.239	1.158	Out of range
90	32.22	1.261	1.172	Out of range
91	32.78	1.283	1.186	Out of range
92	33.33	1.305	1.200	Out of range
93	33.89	1.328	1.214	Out of range
94	34.44	1.351	1.229	Out of range
95	35.00	1.374	1.243	Out of range
96	35.56	1.398	1.258	Out of range
97	36.11	1.422	1.273	Out of range
98	36.67	1.446	1.287	Out of range
99	37.22	1.470	1.302	Out of range
100	37.78	1.495	1.317	Out of range
101	38.33	1.521	1.333	Out of range
102	38.89	1.546	1.348	Out of range
103	39.44	1.572	1.363	Out of range
104	40.00	1.598	1.379	Out of range
105	40.56	1.625	1.395	Out of range
106	41.11	1.652	1.410	Out of range
107	41.67	1.679	1.426	Out of range
108	42.22	1.707	1.442	Out of range
109	42.78	1.735	1.459	Out of range
110	43.33	1.763	1.475	Out of range
111	43.89	1.792	1.491	Out of range
112	44.44	1.821	1.508	Out of range
113	45.00	1.851	1.525	Out of range
114	45.56	1.880	1.541	Out of range
115	46.11	1.911	1.558	Out of range

˚F	˚C	(PA) POLYAMIDE MEMBRANE	(PS) POLYSULFONE MEMBRANE	(CA) CELLULOSE ACETATE MEMBRANE
116	46.67	1.941	1.575	Out of range
117	47.22	1.972	1.592	Out of range
118	47.78	2.003	1.610	Out of range
119	48.33	2.035	1.627	Out of range
120	48.89	2.067	1.645	Out of range
121	49.44	2.100	1.662	Out of range
122	50.00	2.133	1.680	Out of range

TFM®: Thin-Film Membrane.

THM: Trihalogenated Methane Compound; Initiated by contact between free chlorine and certain organics to form materials similar to certain organic solvents. Considered a carcinogen.

Total Dissolved Solids (TDS): The sum of all organic, inorganic and ionic contents in a solution (excluding all dissolved gasses). Since a TDS meter cannot measure organic content of water, most TDS readings are an approximation. TDS measurements are widely used in the water and waste water industries monitor final water quality. The TDS meter derives its' value from resistivity and conductivity measurements of the product water.

Total Organic Carbon: Organic compounds dissolved in water are characterized by their carbon content. Total organic carbon is the mass of carbon present in a water sample, excluding the carbon present as CO_2 and/or carbonates. The values are determined by catalytically oxidizing (burning) all dissolved carbon (after CO_2/CO_3^- removal by acidification) to CO_2. The resulting CO_2 may be measured directly by infrared absorption, or it may be re-reduced in a furnace with hydrogen to form methane, which is measured by flame ionization detectors.

Transmission: is the percentage of the feed brine average concentration to pass through the membrane into the permeate.

$$\%T = \frac{C_p}{.5 * (C_f + C_b)} * 100$$

$\%T$ = Transmission
C_p = Concentration of salt in permeate
C_f = Concentration of salt in feed
C_b = Concentration of salt in brine

Transmembrane Pressure: is the pressure differential across the membrane. This is the driving force that causes permeation.

$$P_{net} = \left[\frac{P_f + P_b}{2} - P_p \right] - \left[ß^* \left(\frac{\pi_f + \pi_b}{2} \right) - \pi_p \right]$$

P_{net} = Net (transmembrane) pressure
P_f = Feed pressure
P_b = Brine pressure
P_p = Permeate pressure
ß = Concentration polarization
π_f = Osmotic pressure of feed
π_b = Osmotic pressure of brine
π_p = Osmotic pressure of permeate

TSS: Total Suspended Solids; The residual matter which can be removed from a solution by filtration.

Turbidity: Turbidity is a measure of the presence of colloidal matter in the water that remains suspended. Suspended matter in a water sample, such as clay, silt, or finely divided organic and/or inorganic material will scatter the light from an incident light beam. The extent of scattering is expressed in Jackson or Nephelometric turbidity units (JTU and NTU, respectively).

Turbulent Flow: A type of flow characterized by internal mixing (turbulence), and characterized by being proportional to the square root of the differential pressure. For flow in pipe, it can be expected to occur if the Reynolds number is greater than 4,000.

Ultra Filters: A membrane based filtration system in which the pore size ranges from .001 to 0.1 microns.

Ultrafiltration (UF): A process for removing water and low molecular solutes from a feed stream. The separation is based on size and/or shape.

USP: United States Pharmacopoeia which publishes standards for the pharmaceutical industry, including those for water quality. Was established by the U.S. Congress in 1884 to control drug makeup.

Virus: The smallest infectious microorganism, made of RNA or DNA in a protein shell and which grow only in other, living cells.

Water Permeation Coefficient: (A) is a property of the membrane which gives the rate water will permeate through the membrane per unit area at a given pressure. It will vary as a function of temperature. A-Values are typically expressed in units of [gpm/(ft^2*psi)].

$$A = \frac{Q_p}{(a * P_{net})}$$

A = Water permeation coefficient
Q_p = Flow of the permeate
a = Active area of the element
P_{net} = Net (transmembrane) pressure

WFI: Water For Injection; High-purity water intended for use as a solvent for the preparation of parenteral (injectable) solutions. Must meet specifications as listed in the USP.

ELEMENT STORAGE RECOMMENDATION

When plants are shut down, elements need to be preserved and stored in order to prevent bacterial growth on the membranes. The elements can either be left in the system or unloaded and stored. Here are our recommendations for element storage:

IN SYSTEM STORAGE: SHORT TERM (LESS THAN A MONTH)

1) Before storage procedure, the elements need to go through a CIP and be flushed clean.

2) Pump in a solution of 1% sodium bisulfite (food grade) and allow the elements to soak in it.

3) The pH of the solution should be within 3.5-9.5 and monitored periodically. If it drops out of that range, a new solution should be used since long term exposure to acidic or basic environments will harm the membranes.

4) The concentration of bisulfite should be monitored periodically. If its concentration drops below 0.1%, then a new solution should be used.

5) The temperature should be kept at 25˚C or less.

UNLOADED STORAGE: LONG TERM (MORE THAN A MONTH)

1) Before storage procedure, the elements need to go through a CIP and be flushed clean.

2) Unload the elements and allow them to drip dry.

3) Soak them in a solution of 1% sodium bisulfite (food grade) and 18% propylene glycol for 30 minutes. Monitor the concentrations of the soaking solution as it might become diluted over time and readjust accordingly.

4) Allow the elements to drip dry. Put them in plastic bags and seal them. The bags should not contain the soaking solution.

5) Store the elements in a cool warehouse with a dark environment or have them boxed. The temperature should be kept between 10-20˚C as refrigeration will help storage.

GE believes the information above is accurate. However, these are only recommendations and should be treated as that. GE offers no guarantee since the conditions and methods of use are beyond our control. We assume no liability to the process.

Cleaning Pure Water Membrane Elements

INTRODUCTION

Regular cleaning of Desal membrane elements is important because foulants can build up on membrane surfaces, reducing permeate flow and quality. A precipitant deposited on the membrane may reduce flow, cause permanent chemical damage to the membrane, and reduce membrane element life. Regular removal of foulants, which is more effective than sporadic cleaning, extends membrane element life and enhances overall system performance.

These guidelines address when to clean and what cleaners or sanitizers to use for each type of Desal membrane element. The guidelines are based on technical information which GE believes to be accurate and reliable. They are intended for persons with technical skill to use at their own discretion and risk. Because of the conditions of use are outside our control, GE does not assume liability for results obtained or damages incurred through the application of the cleaning solutions or procedures suggested.

When selecting a cleaner or sanitizer, several things must be considered, including the foulant to be removed, membrane element compatibility, and membrane type. Cleaning solutions must fall within pH ranges specified for the membrane element. In addition, the cleaner must not contain certain chemical substances incompatible with the membrane element, such as certain surface-active agents and, in some instances, oxidizing agents such as chlorine. Use of cleaning solutions other than those known to be compatible may reduce membrane life and void the Desal membrane element warranty.

Recommended pH ranges for cleaning solutions are as follows:

Membrane	**Cleaning pH Range**
Cellulose Acetate (CA)	3.0 - 8.0
Polysulfone (PS)	2.0 - 11.5
Polyamide (PA)	2.0 - 11.5

When a cleaning solution's pH approaches the extreme ends of the recommended ranges, contact time with the membrane element and solution temperature must be considered and should be minimized whenever practical.

Feedwater composition, seasonal water quality variability, system recovery rates, flow rates, operating pressure and feedwater temperatures all affect the rate of fouling. As a result, these variables should be studied for each installation before determining how often to clean the membrane elements. A change in these variables may require a change in the cleaning regimes.

Element Diameter	Cleaning rate, GPM	Feed Pressure, psig	Maximum Temperature,°C
4"	8-10	20-60	50°C for TFM™ Elements
8"	30-40	20-60	35°C for CA Elements

GE Infrastructure
Water & Process Technologies
www.gewater.com

Global Headquarters
Trevose, PA
215-355-3300

North America
Vista, CA
760-598-3334

Europe/Middle East/Africa
LeMee sur Seine, France
33-1-64-10-20-00

Asia/Pacific
Bangkok, Thailand
66-2381-4213

Cleaning Pure Water
Membrane Elements

ESTABLISHING BASELINE OPERATING CONDITIONS

Permeate flow rates, salt passages for RO membrane elements and pressure drop (initial pressure minus final pressure) should be recorded at system start-up. These records are used to establish a baseline that will be used to monitor the system to determine the proper time to clean.

Salt passage percentages are usually calculated by determining the total dissolved solids (TDS) or conductivities of the permeate, feed and concentrate (brine) streams. Calculating the ratio of TDS or conductivities in the permeate to the average TDS or conductivity between system feed and concentrate streams will determine salt passage. Using TDS, the equations are:

$$TDS_{Average} = \frac{TDS_{Feed} + TDS_{Concentrate}}{2}$$

$$\text{Salt Passage (\%)} = \frac{TDS_{Permeate}}{TDS_{Average}} \times 100$$

When current permeate flow rates are compared with start-up rates, it is important to "normalize" the data to get a more accurate comparison of system performance at different operating parameters. Permeate flow is dramatically affected by feedwater temperature, so the system operator must consider the difference in temperature in order to generate comparable data.

TEMPERATURE CORRECTION FACTORS

Temperature correction factors for all Desal reverse osmosis, nanofiltration, ultrafiltration, and microfiltration elements. The reference temperature is 77°F (25°C).

TEMPERATURE ˚F (˚C)	POLYAMIDE MEMBRANE (PA)	POLYSULFONE MEMBRANE (PS)	CELLULOSE ACETATE MEMBRANE (CA)
40 (4)	0.48	0.54	0.55
50 (10)	0.60	0.64	0.66
60 (16)	0.73	0.76	0.77
70 (21)	0.88	0.90	0.90
77 (25)	1.00	1.00	1.00
80 (27)	1.06	1.05	1.04
90 (32)	1.26	1.22	1.20

(**Note**: Because of special characteristics of the membrane, Duratherm™ does not follow temperature correction factor trends. Please consult with a GE engineer.)

Please refer to the **Operating Guidelines/Terminology** section for greater detail.

The operator should also consider other conditions in order to generate comparable data. For example, changes in the effective pressure (operating pressure less osmotic pressure and back pressure) also affect the permeate flow rate. If the TDS concentration of the feedwater changes or if system recovery changes, osmotic pressure will vary and thus change the effective pressure for RO membrane element applications. In addition, salt passage percentages for RO membrane elements are affected by operating pressure changes just as permeate flow is affected by the effective pressure and feed temperature. If the current operating pressure is noticeably different than the start-up pressure, the current reading should be adjusted and the system allowed to reach equilibrium before the reading is compared with the start-up salt passage percentages. For pressure correction factors, consult GE.

WHEN TO CLEAN

Membrane elements should be cleaned if either of the following conditions occur:

1) Membrane elements require cleaning if a 5-15% drop in permeate flow occurs after the initial flow stabilization, assuming the Silt Density Index of RO feedwater is less than 5.0 (if SDI is 5.0 or greater, consult GE for further information). In many cases, the operator may expect some irreversible loss of permeate flow due to system stabilization during the first 100 hours of initial use. This loss is usually normal flow loss and does not necessarily indicate a need for cleaning. However, the amount of lost flow should be carefully monitored in case it is the result of an RO pretreatment system malfunction or the existence of conditions not anticipated during system design.

2) Cleaning should also be considered when salt passage from RO membrane elements increases by 30 40%. For example, if an initial salt passage of 5% increases to 7%, a 40% increase has occurred. NOTE: Abrupt and significant changes in permeate flow or salt passage can also be attributed to other factors, such as defective O-rings or flow by-pass around membrane element concentrate seals.

The system operator should not make system cleaning judgements based solely on differential pressure measurements, as this may result in not cleaning frequently enough. Membrane element pressure drop increases when foulants or scale plug the feed spacers between the membrane in spiral-wound membrane elements. When the differential pressure has increased markedly, a considerable amount of contaminants/sediment already has built up in the membrane element. By the time a membrane element reaches this stage of fouling, it is difficult to restore the membrane element's flow and salt rejection performance. To prevent this, cleaning frequency decisions should be based on changes in permeate flow rates or TDS passage.

For systems with membrane elements banked in series, the circulating and soaking operations can be done on the whole group of membrane elements or on each bank individually to maintain the flow rates and pressures recommended in this section.

During the cleaner circulation process, care must be taken not to damage the membrane elements by exceeding the recommended maximum feed flow rates per membrane element. These maximum feed flow guidelines are found in the Desal membrane element specifications for each membrane element type and vary according to membrane element model used.

The system's fluid dynamics must be considered. In many cases, low circulation pressure, typically 50% of the normal operating pressure, is recommended. The objective is to have the minimum pressure needed to circulate the cleaner through the system. Operation at low pressures with high flow rates will help prevent contaminants from redepositing on the membrane surface after they have been loosened during the soak phase of the cleaning cycle. Higher pressure cleaning is acceptable as long as the fluid dynamics of the system support it. Consult the system manufacturer for its recommendation.

RECOMMENDED CLEANER CIRCULATION AND SOAKING TIMES

Most cleaners should be circulated for 10-30 minutes, followed by a 10 to 30 minute soaking period and then a final 10 minute recirculation prior to flushing to crossflow filtration machine. The cleaner should be thoroughly flushed to drain with RO quality water. NOTE: Enzyme cleaners require longer residence times to allow for complete reaction with the contaminate. Detergents containing enzymes should be allowed to recirculate and soak for at least 1-2 hours before flushing.

When contaminant removal is difficult, longer circulation and possibly additional soaking times may be useful. An additional cleaning cycle with fresh cleaning solution is usually more effective. A foulant may be composed of different types of materials, making different cleaners and/or multiple cleaning cycles necessary to increase cleaning effectiveness.

The circulation flow during cleaning should be in the same direction as during normal system operation. *Do not reverse flush from permeate manifolding through membrane element as damage will occur.*

CLEANING SOLUTION TEMPERATURES

The circulation of a heated cleaning solution through the membrane elements often proves advantageous because higher temperatures increase chemical reactions. Warm solutions often strip scale and/or contaminants faster than ambient temperature solutions. However, maximum cleaning solution temperatures should be kept under the limits specified for each membrane element model when using the cleaners cited in these guidelines. The operator risks damaging the membrane element if cleaning solution temperatures go beyond their maximum recommended cleaning temperature.

SAFETY PRECAUTIONS

When using any cleaning chemical, follow accepted safety practices. Read the labels on cleaning chemical container and refer to your crossflow filtration machine operating manual. If in doubt about handling, safety or disposal procedures, contact the cleaner supplier for detailed information before proceeding to prepare or use cleaners.

CLEANING SOLUTION PREPARATION

All solid cleaning chemicals should be fully dissolved and well mixed before the cleaning solution is introduced into the system. Use RO quality water or filtered, low hardness water (less than one grain per gallon or 17 milligrams hardness per liter of water) to prepare cleaning solutions. Acceptability of chlorine or other oxidizing agents in the water depends on the membrane contained in the membrane elements. Reuse of cleaning solutions is not recommended. Some cleaners have limited shelf life so check the age of cleaners before using them.

SUGGESTED CLEANING EQUIPMENT

A cleaning solution mixing tank with a cover and a temperature gauge is suggested. Appropriate valving, sample ports, flow meters, pH monitor, pressure gauges, recirculation pump and cartridge filter are also recommended. When selecting cleaning system equipment, the material of construction of the system's components should be chemically and physically compatible with the cleaners and temperatures to be used. A cartridge filter on the cleaning solution return-to-tank Me or feed line to the crossflow filtration machine will remove particles dislodged from the membrane elements.

AMOUNT OF CLEANING SOLUTION NEEDED

To determine the amount of cleaning solution required, estimate the hold-up volume of the cleaning loop piping and membrane element housings. Then add sufficient water to the CIP tank to prevent it from emptying when filling the system. At the beginning of the cleaning cycle, the process water in the system should be discharged to drain as it is displaced by the cleaning solution. This process will prevent dilution of the cleaning solution. To learn more about membrane cleaners available for GEWT, contact your GEWT sales representative, or call (#).

SYSTEM SANITIZING

To prevent microbial growth in a crossflow filtration system, periodic sanitization with the appropriate chemical agent may be required. The exact procedure and chemical used depends on the type of membrane element and the severity of the microbial problem.

SYSTEM SHUTDOWN FOLLOWING CLEANING

If the system is to be shut down for 72 hours or more after a cleaning, a biocidal storage solution should be prepared and recirculated into the system. (A 0.5% formaldehyde solution is preferred; other biocide or biostat agents are acceptable. Compatibility with the membrane must be determined first.) NOTE: New (PA) RO membrane elements must be run in a system for at least 8 hours before a formaldehyde solution should be used as a preservative or severe flow loss will occur.

Refer to the following pages of suggested cleaners for Desal membrane elements. The listed cleaners are not meant to be all inclusive. If you wish to use different cleaners, consult GE for compatibility. Our suggested list of cleaners includes generic cleaners and a group of proprietary cleaners that have been effective in many field applications. Remember that foulants may be comprised of more than one type of contaminant, making multiple cleanings and/or a mixture of cleaning solutions necessary.

To learn more about membrane cleaners available from GE, contact your Water & Process Technologies sales representative or call customer service at 760-598-3334.

GE Infrastructure
Water & Process Technologies
www.gewater.com

Global Headquarters
Trevose, PA
215-355-3300

North America
Vista, CA
760-598-3334

Europe/Middle East/Africa
LeMee sur Seine, France
33-1-64-10-20-00

Asia/Pacific
Bangkok, Thailand
66-2381-4213

Spiral wound elements with RO or NF membranes are primarily designed to reject dissolved solids, for example salts. If the feed water contains suspended solids that are retained by and accumulate inside the elements, or dissolved solids that are going to precipitate inside the element during normal operation, spiral wound elements will be vulnerable to fouling. Therefore, pretreatment prior to membrane filtration is extremely important to maximize efficiency and practical membrane lifetime. The objective with pretreatment is to minimize or prevent fouling and scaling of the elements, prevent membrane degradation, and minimize required element cleaning frequency.

DEFINITIONS

SCALING

When the concentration of dissolved species exceeds its solubility limit during concentration in the membrane unit, the species precipitates on the membrane surface. This phenomenon is called scaling. The species that are most likely to precipitate in operation on natural waters are calcium carbonate ($CaCO_3$), calcium sulfate ($CaSO_4$), barium sulfate ($BaSO_4$), strontium sulfate ($SrSO_4$) and silicates. Scaling starts in the downstream elements.

FOULING

Fouling refers to membrane performance decline that are caused by species that are present in the feed water and are deposited on the membrane surface or adsorbed by the membrane. This type of fouling is usually most severe in the upstream elements. Fouling symptoms include moderate to severe flux decline, increased salt passage and differential feed side pressure increases over the elements. Some types of fouling are:

- Colloidal and particulate matters. Examples of these are clay, silt, dead microorganisms, metal oxides and metal hydroxides. Metal oxides and hydroxides are usually carry-over from a pretreatment section that does not work properly.
- Microbiological fouling. Alone or mixed with other foulants, living microorganisms and their metabolic products can create serious fouling problems. Following initial attachment of microorganisms to the membrane surface, colonization may occur with the production of products such as polysaccharides and slime.
- Adsorption by the membrane of species that results in an increase in the resistance for the water flux through the membrane. In natural waters, typical such species are humics, and fulvic and tannic acids. Chemicals that are added in the pretreatment section, e.g. coagulants, might also be adsorbed by the membrane, if they enter the membrane unit.

MEMBRANE DEGRADATION

The process when membrane performance declines due to a change in the membrane chemistry is called membrane degradation. Oxidants like permanganate, persulfate and hexavalent chromium, and too high or too low pH, e.g. during cleaning, are causes of membrane degradation.

When operating on natural water, the most common cause of polyamide membrane degradation is from the oxidant chlorine entering membrane units.

Cellulose acetate membranes are made from naturally occurring polymers, so there are many microorganisms that feed on this type of membrane. Thus, when using cellulose acetate membranes, there must be a biocide in the feed water to prevent membrane degradation. Cellulose acetate membranes are chlorine-tolerant.

PRETREATMENT

Pretreatment depends to a large extent on whether the feed water is well water or surface water. Well waters typically have a low fouling potential, while most surface waters have a high fouling potential. Surface waters might reach shallow wells in a short time without much natural filtration or biodegradation of organics, so waters from shallow wells might have as high fouling potential as do surface waters. The silt density index (SDI) is a fairly good predictor of the fouling potential of the water, and it is described in section A at the end of this chapter. As a guideline, SDI_{15} of the feed to RO/NF elements should be below 5 for the membrane elements to operate satisfactorily. With SDI_{15} below 3, particulate fouling is seldom of any significance. However, microbiological fouling could still be a problem. In rare occasions, a well water can have a high concentration of colloidal particles that easily pass through the 0.45mm pores in the SDI filter pad, which results in a low SDI value, but the water still fouls the membrane elements badly.

For all types of raw water, the piping and vessels should be painted or opaque to prevent light from entering the feed water. Algae and other microorganisms need light to grow, so their growth is stopped by the prevention of light from entering the feed water. Temperature also affects the growth of microorganisms. For all types of water below 40°C, the concern for microbiological fouling increases with elevated temperatures. When the water temperature is below 12°C continuously from the source to the membrane unit, microbiological fouling is often not a problem.

WELL WATER

Deep well water is usually clear with a low concentration of suspended solids requiring only simple pretreatment, mainly protection from membrane scaling. Figure 1 shows a typical pretreatment system for well water. In some well waters, bacteria are present. The most common of these are iron bacteria, sulfate-reducing bacteria and sulfide-oxidizing bacteria. How to treat these is site specific.

Figure 1. Simple pretreatment schematic when operating on typical deep well water.

Antiscalants may precipitate at low pH values and cause membrane fouling problems. When an antiscalant is used, its injection point should be far enough downstream of the acid injection point so that there are no local points with low pH. For straight pipes, this means a distance of 20 to 40 times the pipe diameter.

SURFACE WATER

Surface water typically changes with the season, with a lot of suspended solids present during the spring run-off. When the air temperature decreases in fall, the water at the surface on many lakes becomes cooler than the water below. This results in an annual water turnover, at which cooler surface water sinks to the bottom and warmer bottom water rises to the surface. This might temporarily greatly increase the suspended solids concentration in the water at the level where the water intake to the membrane unit is located. Algae are present in all, or at least almost all surface waters, and they need light to grow. Many species of algae are mobile in water, and they want light in a certain intensity range, which results in the algae to move up and down during the day (the more intense the sunlight, the further down in the water the algae move). If the water intake to the membrane plant is at a level higher than the lowest level of the algae movement, a high concentration of algae might be present in the feed water to the membrane plant twice a day. Besides algae, surface waters frequently have a high concentration of other microorganisms. All these factors make the pretreatment for membrane units much more complex with surface water feed than with deep well water feed. Figure 2 shows a typical pretreatment layout for a membrane plant with surface water feed, where the suspended solids concentration is below 50-100 mg/L. When the concentration of microorganisms in the incoming water is low, it is better not to add hypochlorite in the pretreatment section. The hypochlorite kills and breaks down the microorganisms to produce very good nutrients for rapid microbiological growth when the hypochlorite is removed, which is in the membrane elements. However, a high concentration of microorganisms in the raw water will cause problems in the media filter as well as in the membrane elements, so biocide addition is required. As mentioned under well water, the injection point for antiscalant must be far enough downstream of the acid injection point to prevent localized low pH, where the antiscalant might precipitate.

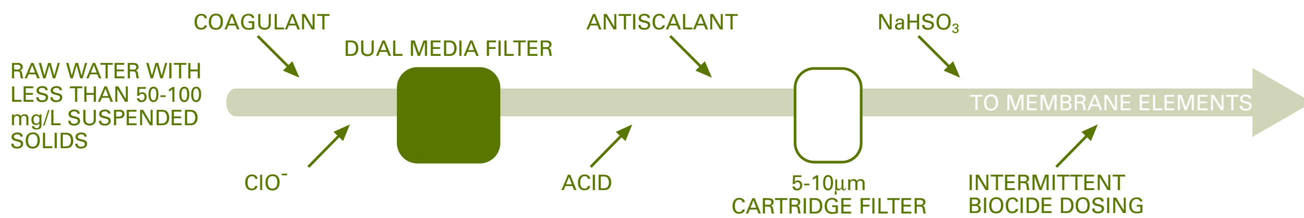


Figure 2. Typical flow schematic of the pretreatment section to a membrane unit.

When the suspended solids concentration is above 50-100 mg/L in the raw water, the dual media filter will be filled up with removed solids too fast, and has to be backwashed too frequently. In those cases, most of the suspended is removed in a clarifier upstream of the dual media filter, or may be a triple media filter. A coagulant and a flocculant are added to the raw water upstream the clarifier.

Hollow fiber UF/MF replaces the dual media filter in many cases. The UF/MF unit usually works much better with inline addition of ferric chloride as a coagulant than without any coagulant. UF/MF pretreatment costs more than dual media filtration, but it saves floor area. UF/MF pretreatment is especially advantageous when the raw water suspended solids level changes rapidly. In those cases, it is difficult to control the coagulant dosing to the dual media filter, so the filtrate might contain too much suspended solids for the RO/NF unit to operate satisfactorily. UF/MF pretreatment on the other hand always gives a permeate with a low concentration of suspended solids.

More details about some pretreatment operations are described below.

MEDIA FILTER

Most commonly used media filters are downflow double-media filters, which are backwashed in the upflow mode. The coarser medium at the top is typically anthracite, which collects the larger particles, and the lower medium is typically fine sand, which collects the smaller particles. The upper coarser medium has a lower density than the finer lower medium, so the stratification does not change during backwashing. A typical flow rate through the filter during normal operation is 5 gallons/(minute and ft^2). Addition of a coagulant, typically ferric chloride or alum, upstream the media filter greatly improves the removal rate of colloidal material. This is called in-line clarification or in-line filtration. For higher concentrations of suspended solids, three-media filters are used to increase time between backwashing. For raw waters containing more than 50-100 mg/L suspended solids, sedimentation or clarification is used upstream to remove most of the suspended solids not to overload the media filter.

COAGULANTS

Coagulants are added to agglomerate small colloidal particles, which otherwise would pass thought all the prefilters and foul the reverse osmosis membrane. The most commonly used coagulant is ferric chloride. It is very effective in a wide pH range, and it seldom carries over to the membrane unit to cause membrane fouling problems. Alum is also used, but to a less extent. Its effective pH range is narrow, and it is easily carried over the membrane unit, where it will precipitate as aluminum hydroxide. However, aluminum hydroxide is easily removed from the membrane by lowering the pH to 4. Polyaluminumchloride is an aluminum compound that has a wide effective pH range when used for coagulation. Cationic polyelectrolytes are also effective coagulants. However, many of these will foul the membrane badly if carried over, either directly from adsorption onto the membrane, or indirectly from first co-precipitation with an anionic antiscalant, forming a gelatinous precipitate, which fouls the membrane.

The required coagulant concentration in the raw water to achieve good removal of the colloidal material by a media filter is strongly dependent on the concentration of colloids. This makes it difficult to get good removal of colloidal materials when there are rapid changes in the raw water composition. In such cases, coagulant addition followed by MF or UF gives superior result compared to coagulant addition followed by media filtration.

IRON REMOVAL

Ferrous iron (divalent), which is typically present in well water, does not cause any precipitation problems, provided the water does not contact any oxidizer, e.g. air. The oxygen in the air oxidizes ferrous iron to trivalent ferric iron, which reacts with water to form ferric hydroxide, which precipitates and fouls the membrane. The reaction rates are strongly pH dependent. At pH below 5, iron precipitation is seldom a problem.

Ferrous iron can be removed by a manganese-greensand filter or aeration and/or chlorination followed by media filtration. Thus, for aerated or chlorinated feed supplies, all the iron has already precipitated, and the precipitate should be removed by a media filter.

ACID ADDITION

Acid is added either to lower the pH for membranes that are degraded at higher pH levels or to change the water chemistry, preventing scaling or fouling of the membrane. Cellulose acetate membranes typically operate in the pH range of 5-6 where the membrane lifetime is much longer than at pH 7. Polyamide type membranes are not sensitive to pH in the range of 3 to 10. It is important that the added acid is of high purity and contains a minimal amount of iron impurities. Many technical grade acids contain a high concentration of iron, and when this is added to the raw water, the iron precipitates and foul the membrane. The most commonly used acids are sulfuric acid and hydrochloric acid. Sulfuric acid forms sulfates in the raw water, which are highly rejected by both RO and NF membranes. The disadvantage with sulfuric acid addition is that the extra sulfate in the raw water might sometimes decrease maximum permeate recovery of the RO unit, because of the solubility limits of calcium sulfate, barium sulfate and strontium sulfate.

A pH decrease reduces the concentration of carbonate and bicarbonate in the feed water, preventing calcium carbonate scaling in the reverse osmosis elements. As mentioned above it also prevents aluminum hydroxide fouling in case alum is used upstream of the reverse osmosis unit, and slows down the formation of ferric hydroxide.

The disadvantage with acid addition is that carbon dioxide is formed, which is not rejected by the membrane. High levels of carbon dioxide in the water make it very aggressive, which is not tolerable in most applications. Instead of acid dosing followed by removal of carbon dioxide from the permeate, an antiscalant can substitute most or all of the acid. Antiscalants are effective in preventing calcium carbonate scaling, but do not prevent aluminum hydroxide fouling.

ANTISCALANTS AND DISPERSANTS

Antiscalants are used to prevent membrane scaling of salts, which exceed their solubility products when concentrated in the membrane system. The antiscalants delay, but do not permanently stop, the precipitation of salts. They work by being adsorbed on the salt crystal surface, preventing or drastically slowing down the salt crystal growth. Thus, the concentrated salt solution with antiscalant should leave the membrane unit as soon as possible. During shutdown, the RO unit must immediately be flushed with fresh water, or even better with permeate.

Different types of antiscalants affect different types of salts. The antiscalant that is most effective in preventing calcium carbonate scaling might not be the best one to prevent calcium sulfate scaling. Even the best one to prevent calcium sulfate scaling might not be the best one to prevent barium sulfate scaling. Antiscalant manufactures have formulations that can slow down the crystal growth of calcium carbonate, all sulfates, silica, and probably more species. Antiscalant manufacturers should be consulted regarding efficacy and dosing requirements for their products. Refer to Section B regarding conditions for saturated solutions.

Dispersants are chemicals that keep colloidal particles from agglomerating, and thus help in making the colloidal particles pass through the membrane elements to the concentrate. Some chemical formulations contain both antiscalants and dispersants.

Some antiscalants and dispersants contain organics that are nutrients for microorganisms, and thus promote microbiological growth in the membrane unit. Such an additive should not be used if it can be avoided.

ION EXCHANGE SOFTENING

Instead of acid and/or antiscalant dosing, ion exchange softening can be used to prevent scaling of the membrane. The ion exchange softener removes the divalent and multivalent cations, which otherwise would precipitate when the solution is concentrated.

Small colloidal particles are always entering the membrane unit. As long as they remain small and negatively charged they repel each other and easily exit and do not cause fouling. If high charge density divalent and multivalent cations are present, they will shield the repulsive forces between the negatively charged colloidal matters thereby facilitating their agglomeration. During concentration, the agglomerates will then foul the membrane. Ion exchange softeners remove divalent and multivalent cations, and by doing so reduce fouling propensity. For economical reasons, ion exchange softening is used mainly in small systems. It is typically used in larger systems only when the hardness level is relatively low.

CARTRIDGE FILTER SYSTEMS

Melt blown microfiber polypropylene depth filters with nominal rating 5-10 micrometer are typically used. String filters should not be used. Most of the string filters are treated with surfactants (wetting agent), which are released during operation and these may interfere with the downstream-placed reverse osmosis membrane. Cotton filters may release lint, which will promote fouling of the membrane.

STRAINER

When cartridge filters are replaced, foreign objects might end up downstream the new cartridge filters. If these objects enter the pump, the pump might be damaged and release pieces that also damage the leading membrane elements. For this reason, it is not uncommon with a strainer immediately upstream the feed pump to the membrane unit.

BIOCIDES

When the microorganism concentration is high, a biocide that kills the microorganisms is required in order for the pretreatment section to work properly. The most commonly used biocide is hypochlorite because of its low cost and high efficiency. The disadvantage with **hypochlorite** is that it degrades polyamide membranes, which are the most common RO and NF membranes. Thus, the hypochlorite has to be removed before entering these membranes. Microorganisms that have survived might then grow inside the membrane elements, because the presence of high concentrations of nutrients that were released when the hypochlorite destroyed most of the initially present microorganisms.

In RO plants with polyamide membranes, where hollow fiber microfiltration (MF) or ultrafiltration (UF) has been used as pretreatment, **chloramines** have been used successfully for years to prevent biogrowth. In other instances, chloramines have degraded polyamide RO membranes. The prevailing theory in 2002 is that heavy metals in particulate form, e.g. iron precipitates, on the membrane surface act as a catalyst for the reaction between chloramines and the membrane. With UF/MF pretreatment, no heavy metals particulates should foul the membrane, and chloramine in the feed water should not affect polyamide membranes. However, when there is a risk for heavy metals particulate fouling, chloramines should not come into contact with polyamide membranes.

Chlorine dioxide is a very effective biocide at as low concentrations as below 0.5 mg/L. In a laboratory study, polyamide RO/NF membranes soaked in 10 mg/L chlorine dioxide without any free chlorine for several months, without any membrane damage. It is very likely that chlorine dioxide will work fine to control microbiological growth in RO/NF systems with polyamide membranes. It is important that it is generated in a way that produces no free chlorine. The disadvantages with chlorine dioxide are that it is not stable, so it has to be generated on site, and that the cost is relatively high when compared to the use of chlorine.

Water treatment chemicals supply companies have **proprietary chemicals** for controlling microbiological growth in membrane systems. A typical protocol is to intermittently add one biocide to the feed water, and then periodically stop the membrane unit to clean it and sanitize with a second biocide.

REMOVAL OF OXIDANTS

The oxidation-reduction potential (ORP) of the feed water should be monitored so the presence of oxidants will be known immediately, and immediate actions can be taken. The oxidants that might be present in the feed water to a membrane unit are mainly chlorine, ozone and permanganate.

When using polyamide membranes, all of the aforementioned oxidants must be removed from the feed water. Otherwise the membrane lifetime will be reduced. The methods that remove chlorine also remove chloramines, but at a slower rate. As described under *biocides*, chloramines can also degrade polyamide membranes, mainly in presence of ferric iron.

When using cellulose acetate membranes, the feed water must be free of ferric iron, ozone and permanganate and should contain 0.5-1 ppm of free chlorine.

SODIUM BISULFITE

Sodium bisulfite ($NaHSO_3$) reacts rapidly with and removes the oxidizing agents. It is mostly purchased in the form of sodium metabisulfite ($Na_2S_2O_5$). One molecule of sodium metabisulfite consists of two molecules of sodium bisulfite from which one molecule of water has been removed. It can also be purchased in the forms as sodium bisulfite and sodium sulfite.

The best place for injection of the sodium bisulfite is between the cartridge filters and the pump, by which microbiological growth is controlled by the oxidant also in the cartridge filter.

Free chlorine in water is present as hypochlorous acid and hypochlorite ions. When the free chlorine concentration in water is determined, it is given as the amount of molecular chlorine that was needed to produce the actual present hypochlorous acid and hypochlorite ions. The reaction between molecular chlorine and water is as follows:

$$Cl_2 + H_2O \rightarrow HOCl + H^+ + Cl^-$$

How much of the hypochlorous acid that dissociates to hypochlorite ions depends on the pH. The chlorine atom in the hypochlorous acid or hypochlorite ion is reduced by the bisulfite ion as follows:

$$HSO_3^- + HOCl \rightarrow SO_4^{2-} + Cl^- + 2H^+$$

Thus one mole of bisulfite is then needed to reduce each mole of free chlorine that is present in the water. From the molecular weights of the sulfite compounds, the following concentrations are required to reduce the free chlorine.

Amount of sulfite compound to remove 1 mg/L free chlorine

COMPOUND	SODIUM METABISULFITE	SODIUM BISULFITE	SODIUM SULFITE
mg/L	1.34	1.47	1.78

For safety reasons, about double the required dose of bisulfite is added to the water, so the dose rate is typically about 3 mg/L of sulfite compound per mg/L of free chlorine.

The sulfite compounds are dissolved in water and stored in a tank before being injected into the feed water to the membrane unit. After dissolution, the sulfite and bisulfite concentrations in the storage tank decreases with time because of reaction with oxygen and also from sulfur dioxide gas leaving the tank. For this reason, a sulfite compound dissolved in water should be used within the time frame shown in the following table.

CONCENTRATION OF SULFITE COMPOUND, wt%	2	10	20	30
Maximum time for use of solution	1 week	3 weeks	1 month	6 months

ACTIVATED CARBON

For small plants, activated carbon filter can be substituted for sodium bisulfite for removal of oxidants. The carbon filter should not release any carbon fines, because these would deposit on the membrane and are practically impossible to remove. Thus, cartridge filters must be present between the activated carbon filter and the membrane unit, to stop the small amount of carbon fines that are inevitably released. Also the carbon bed often becomes a breeding ground for bacteria, which can contribute to bacterial fouling of the membrane. One advantage with activated carbon is that it very well adsorbs non-polar organics that otherwise might foul the membrane.

UV LIGHT

Vacuum UV with wavelength 185 nm works well to remove chlorine as well as chloramines.

SECTION A: SDI TEST APPARATUS

Silt Density Index (SDI AND TURBIDITY)
To check whether the pretreatment section removes enough of the incoming particles and colloidal material, the turbidity (NTU) or preferably the SDI of the feed water should be measured several times a day. An upset in the pretreatment section is then detected early and can be corrected before severe problems arise.

SDI measures the amounts of particles big enough to be retained by a 0.45 micrometer pore size filter and their water impermeability. Particles present in the water may be small enough to pass the filter, resulting in a low SDI value, but they might foul the reverse osmosis membrane heavily. Turbidity is measured by a light scattering method, and considers all particles down to very small sizes. However, it does not consider the water permeability through the "filter cake" formed by the particles. In general, SDI is a better predictor of a water solution's fouling potential than the water solution turbidity. Typical guidelines when using spiral wound elements is that SDI_{15} should be below 5 or turbidity below 1 NTU. There is no good correlation between the turbidity and SDI value of water streams.

Test Procedure:

1) Place a 0.45 micron Millipore Filter (cellulose acetate) in the filter holder.
2) Bleed out air by cracking the ball valve. Close valve and tighten pore filter holder bolts.
3) Open valve fully and with a stopwatch, immediately measure the time required to collect 500 ml of filtrate in a graduated cylinder.
4) Record the time required to collect a second 500 ml sample after 15 minutes of flowing.

SDI_{15} is calculated with the following equation:

$$SDI= [1- (t_0/t_f)]/15 \times 100$$

Where ,

SDI_{15} = Silt Density Index from the 15 minutes test
t_o = initial time in seconds to collect 500 ml
t_f = final time in seconds to collect 500 ml after 15 minutes of flowing

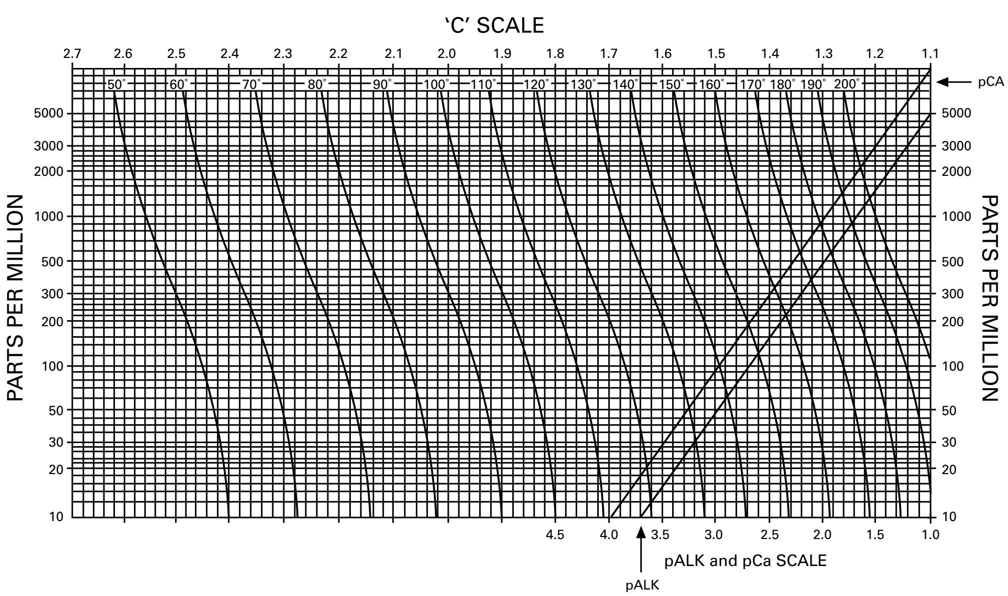
SECTION B: SCALE PREVENTION CALCULATION

Langelier Index and Calcium Sulfate Saturation, Barium Sulfate, Silica Saturation
The following sample calculations illustrate procedures for determining maximum product recovery based on the saturation of scale forming components in the reject stream of RO systems.

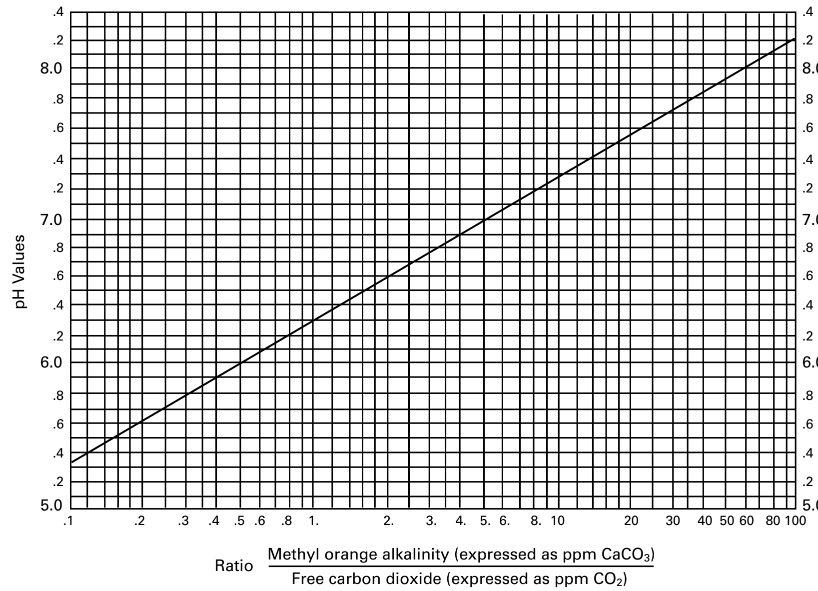
LANGELIER (or Stiff-Davis Saturation) INDEX
Calcium carbonate precipitation may be prevented by maintaining a negative Langelier or Stiff-Davis Saturation Index in the reject stream. The Langelier Saturation Index of a reject stream may be calculated in the manner shown below:

1) Determine total alkalinity, calcium, total dissolved solids and CO_2 content of the feedwater.
2) From the feedwater analysis and projected recovery rate of the RO system, calculate alkalinity, calcium, total dissolved solids, and pH of the reject stream.
3) Calculate the Langelier Saturation Index with the aid of the figures provided.

LANGELIER SATURATION INDEX CURVES



EFFECT OF BICARBONATE ALKALINITY AND CO_2 ON PH



Example:
The following sample calculation illustrates this procedure with a hypothetical feedwater analysis.

PH = 6.0
Total dissolved solids = 405 ppm
Total alkalinity (as $CaCO_3$) = 10 ppm
Calcium (as $CaCO_3$) = 65 ppm
CO_2 = 16ppm
Temperature = 25°C

Based on the feedwater analysis, reject considerations of these substances may be estimated. Assume a 75% recovery rate.

Alkalinity = $\frac{10}{1-0.75}$ = 40 mg/l

CO_2 = 16 ppm (CO_2 is not rejected)

Calcium = $\frac{65}{1-0.75}$ = 260 mg/l

Total Dissolved Solids = $\frac{405}{1-0.75}$ = 1620

PH = 6.7 (calculated from the Alkalinity/CO_2 – pH curve)
From the LSI curve, pH_s is found to be 7.94
Therefore, the LSI is 6.70 – 7.94 = -1.24

CALCIUM SULFATE SATURATION
Calculate maximum recovery (R_{max}) based on $CaSO_4$ solubility in the brine. This value must be greater than the projected recovery rate of the plant. Maximum recovery is calculated using the following equation:

$$R_{max} = \left[1 - \sqrt{\frac{1}{\frac{0.8\,K_{sp}}{(Ca^{+2})_f\,(SO_4^{-2})_f}}} \right] \times 100$$

Where: $(Ca^{+2})f\ (SO_4^{-2})f$ = $CaSO_4$ molar product in feed

K_{sp} = Solubility product of $CaSO_4$ in the reject stream

0.8 = Safety factor

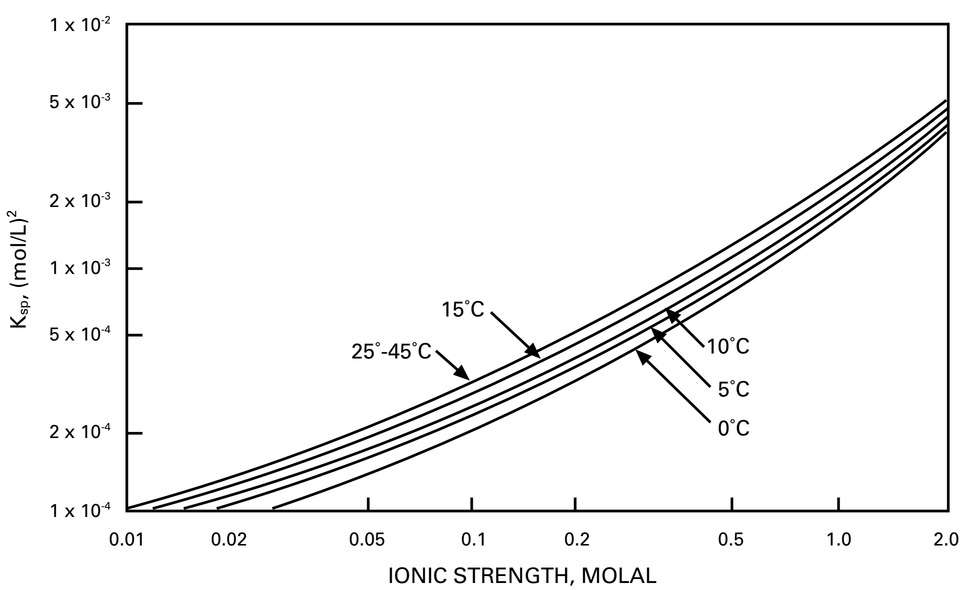
K_{sp} is obtained from the following curves. The ionic strength used to determine K_{sp} strength should be that of the reject stream.

Ionic strength = $1/2\ (M_1Z_1^2 + M_2Z_2^2\ \dots\ M_nZ_n^2)$

Where: M = moles/kg water of a particular ion

Z = The charge of a particular ion

K_{sp} FOR $CaSO_4$ VS. IONIC STRENGTH



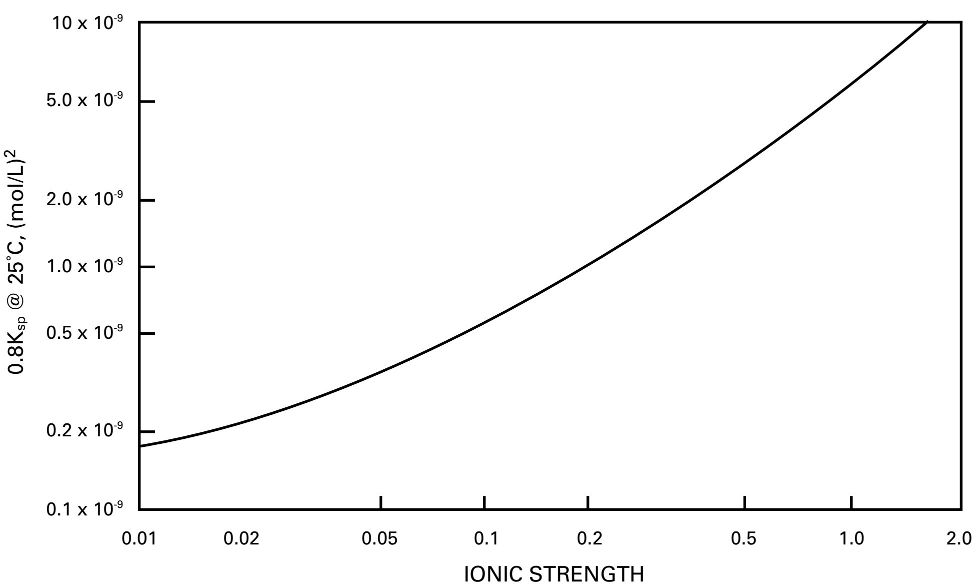
BARIUM SULFATE SATURATION
Maximum recovery calculations for $BaSO_4$ are similar to those used to calculate calcium sulfate recovery.

$$R_{max} = \left[1 - \frac{1}{\sqrt{\dfrac{0.8\ K_{sp}}{(Ba^{+2})(SO_4^{-2})_f}}} \right] \times 100$$

Where: $(Ba^{+2})_f\ (SO_4^{-2})_f$ = $BaSO_4$ mole product of feed

K_{sp} = Solubility product of $BaSO_4$ in the reject stream

0.8Ksp FOR $BaSO_4$ VS. IONIC STRENGTH



SILICA SATURATION
Silica precipitation may be prevented by maintaining the silica concentration of the concentrate stream below the saturation point of silica. The maximum recovery achievable at a given feed water silica concentration my be calculated with the following equations:

$$R_{max}SiO_2 = \left[1 - \frac{SiO_{2\ feed}}{SiO_{2\ max}} \right] \times 100$$

$SiO_{2\ max}$ = SiO_2 correction factor x (4.39 • T - 3.66)

where,

$R_{max}SiO_2$ = maximum recovery possible based on silica saturation.

$SiO_{2\ max}$ = maximum silica concentration possible based upon pH and temperature of the reject stream. The SiO_2 correction is based upon the pH of the reject stream and may be chosen from one of the expressions listed below.

T = reject stream temperature, ˚C

REJECT STREAM pH	SiO_2 CORRECTION FACTOR
4.0 - 6.5	$3.48 \bullet (pH_r)^{-0.667}$
6.5 - 7.8	1.00
7.8 - 10.0	$1.24 \bullet 10^{-5} \bullet (pH_r)^{5.45}$

pHr = pH of concentrate

Example:

Reject pH = 6.7
Temperature = 25˚C
SiO_2 in feed = 10 ppm
$SiO_{2\ max}$ = 106 ppm

$$R_{max}SiO_2 = \left[1 - \frac{10}{106} \right] \times 100 = 90.6\%$$

ELEMENT LOADING INSTRUCTIONS

1) Load an element into the upstream or feed end of the pressure vessel. The brine seal should face the upstream end of the vessel to prevent feed bypass when the unit is in operation. Leave 6" of the element exposed beyond the end of the pressure vessel to facilitate loading succeeding elements.

2) Record the serial number and location of the element.

3) Apply glycerine to the O-rings of an interconnector. With a twisting motion, insert the interconnector into the central tube on the upstream end of the previously loaded element. Rotate the interconnector to insure that the O-rings have been seated.

4) Line up a second element with the interconnector of the first element. With a gentle pushing and twisting motion, insert the interconnector into the downstream end of the second element.

5) Push both elements forward until about 6" of the second element extends beyond the feed end of the pressure vessel.

6) Record the serial number and location of the second element.

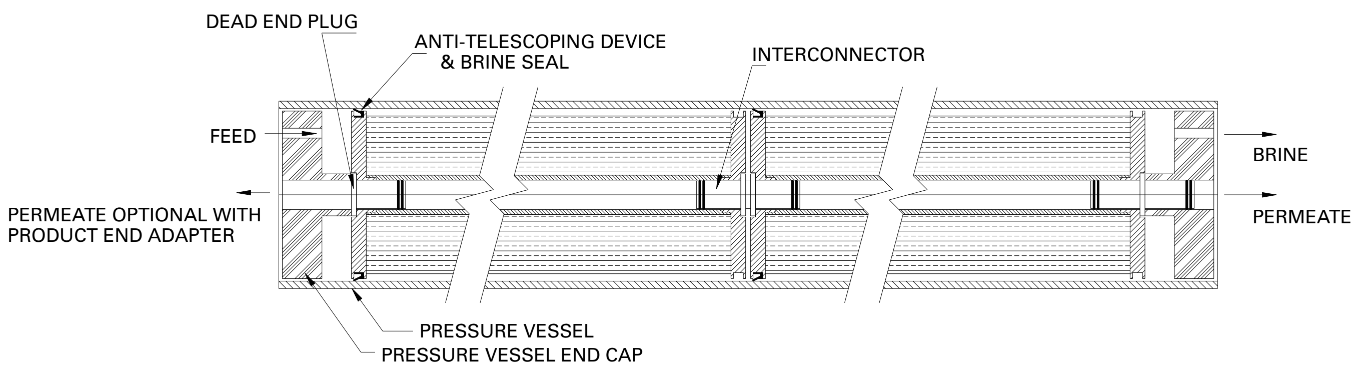
7) Repeat the loading process for the remaining elements.

8) When all elements have been loaded into a pressure vessel, insert glycerine lubricated product end adaptors into the first and last elements in the vessel.

9) Connect the downstream pressure vessel end cap to the product end adapter and secure the end cap.

10) The following figure illustrates the correct placement of interconnectors and elements within a pressure vessel.

TYPICAL INSTALLATION



PLANT START-UP

The following procedures should be followed step-by-step for the start-up of Desal spiral wound element systems.

1) Flush system without elements to remove any residual debris from system fabrication.

2) Recheck and test all in-line sensors, set points of interlocks, time delay relays and alarms.

3) Feedwater quality should be checked prior to plant start-up. Pretreatment systems must be fully operational.

4) Purge all air out of the system at low feed pressure and flow.

5) Check systems for leaks.

6) Slowly increase feed pressure and flow to obtain design performance by adjusting feed and brine throttle control valves.

7) For reverse osmosis plants, sample the reject stream to check that the Langelier Saturation Index is negative and $CaSO_4$ and silica concentrations are within acceptable limits.

8) After the system has reached design conditions and has stabilized (about 1 to 2 hours), record operating conditions and performance parameters.

9) Let the system run to waste for about 2 hours to flush out residual chemicals from the elements.

PLANT SHUTDOWN

1) At shutdown, flush the system with permeate or pretreated DI water, if available. The flush water must be free of any chemical additives.

2) Relieve system pressure and shut down feed pumps.

3) When the system is secured, insure that water does not drain from the elements. Also insure that there is no back pressure on the elements from the permeate side.*

4) For extended shutdowns (greater than one week), a preservative solution should be added to the system to eliminate biological growth.

5) If the plant is to be secured for less than one week, it is usually sufficient to merely flush the the system with fresh, pretreated feed once per day to minimize biological growth.

** If there is greater than atmospheric pressure on the permeate line during operation, check valves should be included in the permeate line to prevent even momentary back pressure on the membrane elements during a shutdown.*

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TROUBLESHOOTING GUIDE

SYMPTOMS						
SALT PASSAGE	PERMEATE FLOW	PRESSURE DROP	LOCATION	POSSIBLE CAUSES	VERIFICATION	CORRECTIVE ACTION
Normal to increased	Decreased	Normal to increased	Predominantly first stage	Metal oxide fouling	Analysis of metal ions in cleaning solution.	Improved pretreatment to remove metals. Cleaning with acid cleaners
Normal to increased	Decreased	Normal to increased	Predominantly first stage	Colloidal fouling	SDI measurement of feed. X-ray diffraction analysis of cleaning sol. residue.	Optimize pretreatment system for colloidal removal. Clean with high pH, anionic detergent formulation.
Increased	Decreased	Increased	Predominantly last stage	Scaling ($CaSO_4$, $CaSO_3$, $BaSO_4$, SiO_2)	Analysis of metal ions in cleaning sol. Check LSI of reject. Calculate maximum solubility for $CaSO_4$, $BaSO_4$, SiO_2 in reject. analysis.	Increase acid addition and scale inhibitor for $CaCO_3$ and $CaSO_4$. Reduce recovery. Clean with an acid formulation for $CaCO_3$, CaSO4 and $BaSO_4$.
Normal to moderate increase	Decreased	Normal to moderate increase	Can occur in any stage	Biological fouling	Bacteria count in permeate and reject. Slime in pipes and vessels.	Shock dosage of sodium bisulfite. Continuous feed of low conc. of bisulfite at reduced pH. Formaldehyde sterilization. Clean with alkaline anionic surfactant. Chlorine dosage up-stream with subs. dechlorination. Replace cartridge filters.
Decreased or moderately increased	Decreased	Normal	All stages	Organic fouling	Destructive testing, e.g. IR reflection analysis.	Optimization of pretreatment system (e.g. coagulation process.) Resin/activated carbon treatment. Clean with high pH detergent
Increased	Increased	Decreased	Most severe in the first stage	Chlorine oxidant attack	Chlorine analysis of feed. Destructive element test.	Check chlorine feed equipment and dechlorination equipment
Increased	Increased	Decreased	Most severe in the first stage	Abrasion of membrane by crystalline material	Microscopic solids analysis of feed. Destructive element test.	Improved pretreatment. Check all filters for media leakage.
Increased	Normal to increased	Decreased	At random	O-ring leaks. End or side seal glue leaks.	Probe test. Vacuum test. Colloidal material passage.	Replace O-rings. Repair or replace elements.
Increased	Normal to low	Decreased	All stages	Conversion too high	Check flows and pressures against design guidelines.	Reduce conversion rate. Calibrate sensors. Increase analysis and data collection.

Desal Pure Water Membrane Element Materials and Workmanship Warranty

GE Water & Process Technologies, Inc. guarantees the proposed product to be free from defects in material or workmanship when operated in accordance with written instructions for a period of one year from start-up or fifteen months from receipt, whichever is shorter. Parts not manufactured by GE are covered by their manufacturers' warranties that are normally for one year.

For general water treatment, Desal spiral-wound membrane elements are guaranteed to operate within specification for a period of 12 months from receipt provided that the element has not been abused by operating either at high temperatures, with high or low pH values, on disinfected water, or on solutions which tend to precipitate.

An element which fails to perform satisfactorily within the first 90 days after receipt, has not been mishandled, and is returned to the factory, will be replaced free of charge except for freight and local labor. If an element fails to perform satisfactorily during the balance of the warranty period and with the return of the element to the factory, GE will replace the element with a new element and will charge the User for the portion of the 12 months that the element was used plus incoming freight and local labor. Such prorated charges will be based on the list price prevailing at the time of warranty consideration. A new element supplied under warranty terms will carry the standard 12-month new element warranty. If the element has not been placed in use at the end of the permissible storage period, the date of first use shall be considered to start the end of the permissible storage period.

The customer shall be responsible for acceptance testing for the element received to ensure that they meet the published performance specifications. GE shall be notified within thirty (30) days for first use of any element not meeting specification. Should GE not receive notification of non-compliance with performance specifications within said thirty (30) day period, GE will consider that all elements are accepted.

All elements that are being returned for non-warranty must be returned unused in their original packaging. Elements returned not conforming to said criteria will be subject to rejection or added fees to restore element to sellable condition.

GE warrants storage of element as follows:

1. All dry element (excluding cellulosic elements) for six (6) months at ambient temperatures less than 100°F.
2. At temperatures between 100°F (38°C) and 122°F (50°C) for three months, provided that elements are stored in their original packaging with the polyethylene bag intact under dry conditions.
3. At temperatures over 122°F (50°C) there is no warranty.
4. All wet elements shipped from any GE facility must be stored in a cool dry location out of direct sunlight or artificial light at temperatures under 86°F (30°C) in their original packaging with the polyethylene bag intact, for a period of 3 months or expiration date which ever occurs first.

For cellulosic elements, dry or wet:

5. Stored in a cool dry location out of direct sunlight or artificial light at ambient temperatures less than 86°F (30°C) for no more than six (6) months.

If an element is to be returned for warranty inspection, the User must obtain a Return Goods Authorization (RGA) number from GE before returning the element. Elements are to be returned freight prepaid to GE and GE will return any warranty replacement element to the customer prepaid. Elements must be kept damp at all times and must be clean and bagged in a watertight bag before returning. Only GE approved cleaners, biocides, dispersants, or other chemicals may be used with the element. Use of other chemicals may void the warranty. The User is responsible for knowing the element material and for ensuring that chemicals harmful to the membrane or material are never in contact with the element.

It is the obligation of the User to maintain frequent operating data records. GE may request these records in the warranty evaluation. User must notify GE at the first sign of changes in operation of the GE machine or Desal element. Such notification should be in writing and should include all data requested on the operating log sheets.

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Return Goods Authorization

The following points apply to the return of elements to GE for warranty evaluation or returning to stock.

1. Contact the Customer Service Department to obtain Return Goods Authorization (RGA) number prior to returning product. Products returned without written authorization will be returned to the customer, freight collect.

2. The following information is required prior to the release of an RGA number:

Return for Warranty or Replacement Consideration

a) Part number/description
b) Serial numbers
c) Reason for return
d) Feed analysis, pH, temperature, operating pressure
e) Performance data, flow and rejection
f) Time online (installed date and removal)
g) Product application
h) System description (total elements, array)

Return to Stock
(New Product)

a) Part number
b) Quality
c) Reason
d) Original purchase order or sales order
e) Name of contact
f) Telephone/fax or email address

3. Elements returned in the following condition will immediately void warranty consideration.

- Unauthorized altering of the product
- Visible operational damage
- Improper storage and handling

4. Elements must be kept damp at all times and must be clean and bagged in a watertight bag before returning. Only GE approved cleaners, biocides, dispersants or other chemicals may be used with the elements.

5. There will be a service charge plus return freight for elements that test within specification range. Please contact Customer Service Department for pricing.

6. There will be a $100 or 20% (which ever is greater) restocking charge to return an order to stock.

7. Customers will receive a summary report explaining test results and warranty decisions.

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Return Goods Authorization

The following information is required before the release of a Return Good Authorization (RGA) number. For more information on the return good procedure, please see page XXX in the Sales Information section of the Product Catalog.

COMPANY INFORMATION

Company Name/Plant:______________________________________

Address:______________________________________

City:________________State:______Country:________Zip:________

Contact Name:________________Phone:________Fax:________

E-mail:______________________________________

ELEMENT/SYSTEM INFORMATION

Purchase Order No.:______________________________________

Part Number/Description:________________Qty:______Total Elements/Array:______

Reason for Return (be specific):______________________________

____

Type of Feed:____________(if available send copy of feed analysis)______Flow Rate:________

PSI:______Temperature:______TDS:______pH:______% Recovery:________

Pretreatment (yes/no):________If Yes, What Type:____________________

Cleaners/Sanitizer Used (if yes, what type):________________Frequency:________

	START-UP		**REMOVAL**		**DATE INSTALLED**	**DATE REMOVED**
	GPD	%CR	GPD	%CR		
Serial No: ________	____	____	____	____	______	______
Serial No: ________	____	____	____	____	______	______
Serial No: ________	____	____	____	____	______	______

Were returned goods in contact with hazardous and/or potentially dangerous chemical or bacteria that could pose a threat to personnel, environment or equipment? **Yes / No**

If yes, attach Material Safety Data Sheet (MSDS) and describe material as required by Federal Law.

Fax to Technical Support: **(760) 598-3335** or E-mail to: **custhelp@gesm.ge**

ACCEPTANCE OF ORDERS

Modifications of orders, shipping schedules, and shipping schedule changes are subject to acceptance by the corporate office of GE.

PAYMENT

Net 30 days on approved credit. Others, cash with order. One and one-half percent per month charge after 30 days.

SHIPMENT

Prices are Ex-Works, manufacturing facility.

QUANTITY PRICES

Quantity prices apply on firm orders with delivery scheduled during a period not in excess of six months from the date of order. Modifications of delivery schedules after the date of the order will result in adjustment to reflect the quantity price for the new quantity.

DELIVERY

GE will normally ship standard products within 60 days of the acceptance of an order. Delivery times for non-standard products will be quoted when requested. GE shall have no liability for delay in shipping any of its products unless a specific time is agreed to by GE, and even in such case, GE will have no liability for any delay in shipment if such delay is the result of any cause outside the control of GE. In every case, the obligation of GE to ship products by a specified date shall be satisfied when GE has delivered such goods or equipment to a common carrier for shipment to the buyer.

TITLE TRANSFER

Title of goods or equipment shipped will be transferred to the buyer upon delivery to a common carrier for shipment to the buyer.

TRAFFIC CLAIMS

If goods are damaged or lost in transit, it is the purchaser's responsibility to provide a properly receipted delivery bill and hold open for inspection all packages delivered by the carrier. Ex-Works, point of shipment requires buyer to file all claims with the carrier for lost or damaged goods.

TAXES

Applicable federal, state, or local sales or use taxes will be paid by the buyer.

GENERAL

All orders are subject to GE Terms and Conditions in effect at the time.

All shipments made by GE will be deemed to be made under the above terms and conditions, supplemented by the non-conflicting provisions of any purchase order accepted by GE unless otherwise indicated to GE in writing. Acceptance and/or use by the purchaser of any materials or equipment shipped by GE will constitute acceptance of the terms and conditions herein.

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Complimenting our diverse product offering, GE has a skilled breadth of staff with the expertise and the resources available to provide in-depth application assistance to our customers. From system design and product selection to start-up assistance and after sale support, customers are encouraged to take advantage of our unique resources before, during and after the sale. The following are many of the services GE offers.

Standard Water Analysis
This is a standard analysis of a customer-supplied water sample. It includes conductivity, pH, alkalinity, dissolved silica and iron, and common ions (i.e. Mg, Ca, Na, Nitrate, Phosphate, Sulfate, etc.) For non-common ions (i.e. iodide, bromide, acetate, etc.), special requests must be made by the customer. Special requests are also needed for TOC, BOD, and COD analysis.

Preliminary Screening Test
Preliminary screening tests, known as cell tests, can be done at GE. A feed sample is run using a specific set of conditions to determine the appropriate membrane that would give the desired results and application feasibility. This screening test requires a sample of at least five gallons sent by the customer.

Extensive Cell Test
This type of cell test determines the optimum membrane needed by the customer. The operating parameters required to achieve the separation needed by the customer is also given.

Cell Test Unit Rental
Cell test units may also be rented by our customers. A packet of test membranes is supplied to the customer for use with the unit. GE requires a deposit before the unit is shipped. This deposit is applied toward the rental fee.

Cell test units can also be purchased. Many of our customers, who have many feed samples to be screened, often decide to purchase the cell test unit. GE offers a low pressure (PDF 318KB) cell test unit or a high pressure (PDF 230KB), stainless steel test unit.

Pilot Test Unit
Pilot test units are used after the cell tests show that membrane screening is feasible. Pilot tests offer in-depth testing on spiral wound elements before the customer designs their commercial membrane system. A pilot test allows for optimization of the system operating parameters. Cleaning procedures can also be established with the pilot test unit.

Included with the rental fee is a full load of test elements and on-site start-up assistance anywhere in the continental United States. A deposit is necessary before the unit is shipped and will be applied toward the rental fees. Pilot test units have the option of coming with a recirculation pump (PDF 1MB) or without a recirculating pump (PDF 232KB). They are also available for purchase.

Visual Inspection and Element Re-test
This includes a visual inspection and laboratory-controlled wet-testing to determine the element flow and salt rejection (if applicable). A comparison of the results obtained in both the lab and the field can be valuable in determining whether or not the problem is membrane related.
High Performance Liquid Chromatography (HLC) is used to identify and quantify the different compounds in a tested sample by separating out the different compounds in a column. The column has a stationary phase and mobile phase and the compounds' affinity toward these two phases will dictate their separation.

Membrane Lab Services
Autopsy of a membrane element is a scientific dissection of an element to determine the reasons for a loss of performance. Chemical, physical and microbiological analyses will determine the type of foulant present and its effect on membrane performance.

The most frequent problems are:
- Biofouling
- Iron and silt (aluminum silicate) deposition
- Membrane scaling

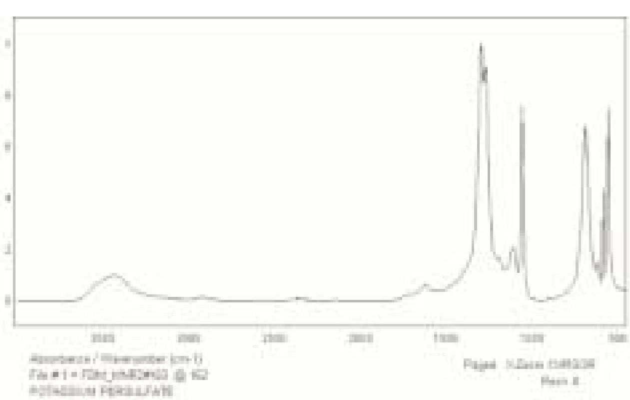
An experienced technician can usually identify the problem(s) based upon sight, smell and touch with the use of a standard light microscope. If further study is necessary, the utilization of the following may apply:
- SEM (scanning electron microscope)
- EDS (energy dispersive x-ray spectrometry)
- FTIR (Fourier transmission by infrared)

Autopsy is a destructive procedure and the membrane cannot be returned to service when completed. As there are significant costs associated with element replacement, the autopsy procedure and system downtime, autopsy is often a last resort.

For autopsy, elements should be carefully removed from the pressure vessel so no external cross contamination occurs. The element(s) should then be wrapped and sealed in a waterproof bag and quickly sent to the lab. The element(s) should not be treated with any form of preservative, as this will preclude meaningful biological examination.

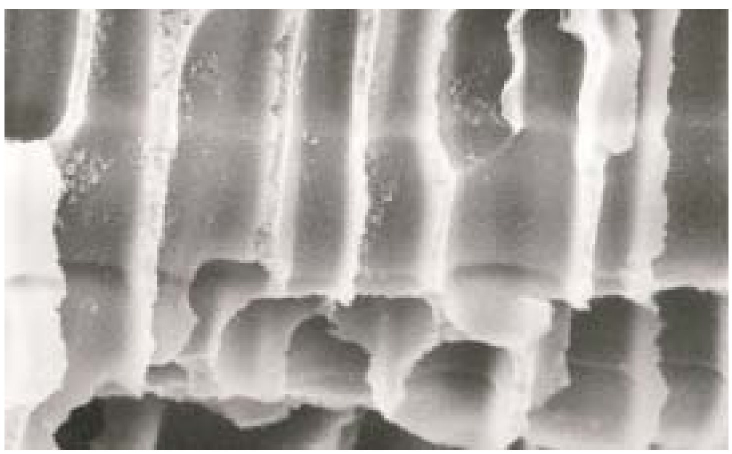
GE will provide a report on the findings for all examined elements.

FTIR – Fourier Transmission by Infrared
Fourier Transmission by Infrared (FTIR) spectroscopy is used to identify complex organic-based deposits. FTIR can determine the different functional groups present within a tested sample and their relative amounts by shining an infrared light onto the sample. The absorbency of the light by the sample at different wavelengths determines which functional groups are present. The plot is Absorbency vs. Wavenumber, which is the inverse of wavelength. One can use FTIR to compare the plots of a new membrane and a fouled membrane and determine if any unknown compounds bind to the surface of the fouled membrane, causing it to foul. A sample is shown below:



UV / Visible Spectroscopy
This is similar to FTIR in terms of purpose of usage. The only difference is that the light being used is in the UV/visible light section of the spectrum. This would be used to detect functional groups that cannot be detected using infrared light.

SEM – Scanning Electron Microscope
Scanning Electron Microscope (SEM) is used to examine the microstructure of a membrane surface by hitting the surface with an electron beam. The back scattering of the electrons and formation of characteristic x-rays allow for the determination of the topography of the surface. SEM can be used to obtain micrographs up to a magnification of X50,000. With this technology we can compare the picture of a new membrane and a fouled membrane and determine the cause of fouling. A sample picture of a membrane cross-section is shown below:



HPLC – High Performance Liquid Chromatography
High Performance Liquid Chromatography (HLC) is used to identify and quantify the different compounds in a tested sample by separating out the different compounds in a column. The column has a stationary phase and mobile phase and the compounds' affinity toward these two phases will dictate their separation.

GC – Gas Chromatography
Gas Chromatography (GC) serves the same purpose as that of liquid chromatography, however this involves vaporizing the sample. This also involves a solumn along with the stationary and mobile phases. Its advantage is that not a large amount of sample is needed for the test.

EDS - Energy Dispersive X-ray Spectrometry
Energy Dispersive X-ray Spectrometry (EDS) is used to determine the elemental constituents of a sample by shining an electron beam onto the sample. Different elements would emit different x-ray signals and the detection and conversion of these signals to voltage allows for the detection of these elements. With EDS, one can determine the elemental makeup of a membrane surface and determine what might cause a specific membrane to foul.

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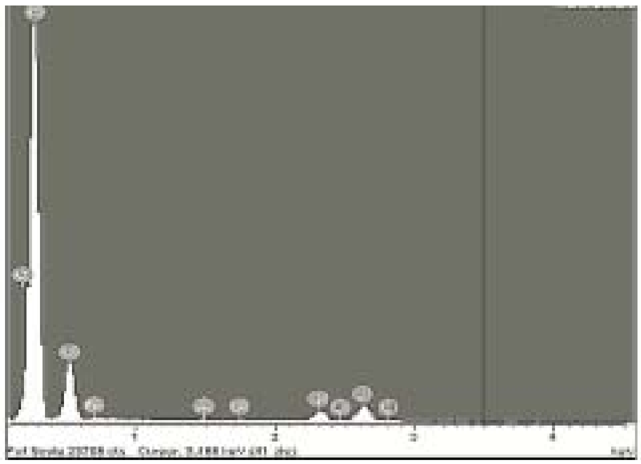
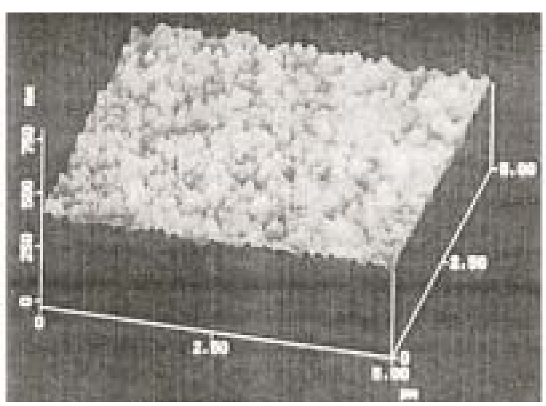
The sample EDS plot below shows the voltage pulse for a few elements such as oxygen, chlorine, carbon, iron, aluminum, silicon, and sulfur.



AFM – Atomic Force Microscope
Atomic Force Microscope (AFM) is used to investigate the surface of a solid object at an atomic level through a sharp diamond tip. As the tip surveys the surface, it detects and measures the interactive forces between the surface and itself at an atomic level. This allows for the determination of the atomic topography of the surface. With this powerful tool, extremely small foulants that bind to the membrane surface can be physically seen. A sample picture appears below:



Solution-Oriented Engineering

At GE Water & Process Technologies, we begin with the processes and applications that are specific to our customer as the starting point and work from there to provide the most optimum solution to fit their objectives. Beyond the itemized services above, GE can assist with:

- Product Characterization
- System Performance Assessment
- Test Method Development
- Technical Training / Information Resource
- Application Development
- Troubleshooting

With more than 30 years of expertise in the industry of fluids filtration and separation, GE has the ability to answer to any situation.

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