POLYMEX™
RO, NF & UF Membranes

Purify. Protect. Preserve.

Contents

Part 1

Market Applications

Sea Water Desalination

Waste Water Treatment

Petrochemical Industries

Food & Beverage Industry

Power Generation

Municipal Water Supply

Pharmaceutical Industry

As a sharply rising membrane manufacturer, POLYMEX has greatly optimized the membrane products for water treatment and material separation and provides the users with steady high-performance membrane products. Meanwhile, it provides a range of membrane product options and optimized product configurations. POLYMEX's membrane element products play a vital role in many fields, including: production of pure and ultra-pure water for the semiconductor and electronics industries, seawater and brackish water desalination, waste water treatment, chemical and petrochemical processes, food and beverage processing, biopharmaceuticals, municipal water treatment and supply , fire power plan water supply and water reuse etc.

As a competitive membrane supplier, POLYMEX can satisfy all the above markets while providing technical support in water treatment and material separation. Our technical team works together to develop filtration and special separation membrane products suitable for various processing requirements and application scenarios. POLYMEX is committed to producing the highest quality membrane products. Our membrane application engineers have accumulated rich membrane application experience and professional knowledge in various industries and fields for decades. Based on water source, water quality requirements and system operation expectations, we help users optimize membrane treatment system design and selection of membrane products to provide value-added technical services and promote the establishment of high-efficiency water treatment and material separation systems.

1.1 Recommended Membrane Products for Seawater Desalination

With high salt rejection rate, POLYMEX SW series RO membranes are engineered specifically for seawater, high salinity water, and concentrated brackish water with the total salt content exceeds 10,000ppm. UC SW series membranes excel in rejection rate, permeate flow rate, compression resistance, fouling resistance, and membrane performance consistency.

1.2 Recommended Membrane Products for Wastewater Treatment

POLYMEX XFR series RO membranes provide unique anti-fouling performance in treatment, which can effectively remove pollutants and reduce COD in water. Waste water POLYMEX NF membranes offer a finer selective separation of certain salts and compounds, which can significantly enhance the recovery efficiency of useful particles especially precious metals in waste water, as well as a more thorough treatment of sewage to maximize the waste water reuse.

1.3 Recommended Membrane Products for Chemical & Petroleum Industry

POLYMEX XFR series RO membranes feature high flux, lower pressure without compromising standards of high rejection. The energy saving properties of the FRLE series membranes along with lower fouling ensure that this element provides optimum performance with cost savings. POLYMEX produces membrane elements with a 34 mil feed spacer which makes a wider feed-in passage, providing significant reduction in fouling rate and increasing membrane efficiency by restoring nominal performance after cleaning The control of the salt content, pH value, concentration of organic matter, and suspended matter content in the cooling water within reasonable allowable range, and the reuse of the concentrate discharge after treatment not only improves the water reuse rate and saves water resources, but also greatly improves the overall condition of the circular cooling water. The wastewater generated in the production process of chemical products is characterized by large discharge volume, high toxicity, high concentration of organic matter, high salt content, high chroma, high content of refractory organic compounds, on the other hand , the wastewater also contains a lot of usable material. Membrane technology plays an important role in the chemical process, in energy saving and consumption reduction, and in clean production.

1.4 Recommended Membrane Products for Food & Beverages

The food and beverage industry has implemented a food hygiene and safety permit system that requires purified water, usually pure water, to be used for process water and drinking water. The use of NF membrane not only improves the quality of food. and beverage, but also meets industry regulations and standards.

POLYMEX NF membranes used in beverage processing provide high productivity and high rejection rate of salts. The NF membranes exhibit desirable features such as high retention or removal of organic matter, colloids, particles, bacteria, viruses, low energy consumption, efficient water utilization, low operating costs as well as small sizes, simplicity in operation, convenience in maintenance, better adaptability, and long service life. The specially designed NF membranes provide thick feed spacer of 48mil, which can improve antifouling, reduce pressure drop, and improve cleaning efficiency.

1.5 Recommended Membrane Products for Pharmaceutical Industries

POLYMEX HSRO elements are mainly used in the deep desalination treatment of water in the biomedical field. They are able to withstand the disinfection treatment of hot water at 85° C, which can fully meet the requirements of making pure water in the important processes, such as raw material production, separation and purification, end product preparation, washing process, cleaning process and disinfection process.

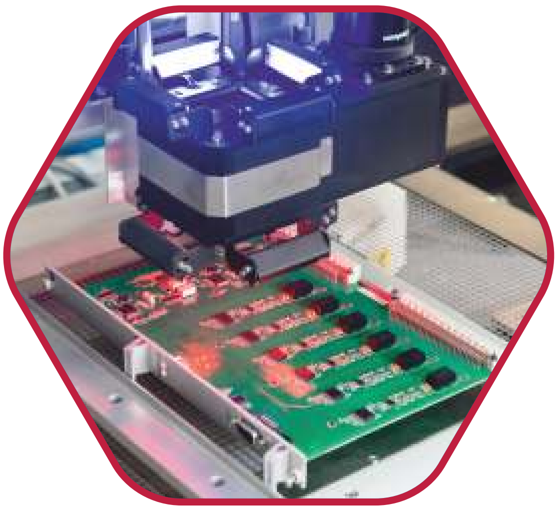
1.6 Recommended Membrane Products for Power Generation

POLYMEX BW series RO membrane products have high rejection of salt and TOC, which serves as the best product option for power plant boiler water supply applications. Power generation industry is one of the earliest applications of RO membrane technology. At present, together with seawater desalination industry, they become the biggest market of RO membranes. Especially in recent years, RO membrane technology is widely used in pre-desalination of boiler water, circulating water reuse, reuse of sewage and minimizing waste water discharge in power industry. Seawater, brackish water, municipal wastewater, and surface water are becoming increasingly preferred water sources for thermal power plants, which puts forward higher requirements for RO membrane performance.

Sugar Industry

Distilleries

Milk & Dairy Factories



Semi-conductor Manufacturing

Part 2

Product Overview

2-1 Reverse Osmosis Membrane Elements

Based on the advanced U.S membrane formulation and production technology, according to different membrane applications, and through its own research and development, POLYMEX manufactures RO membranes with stable performance, low operation pressure, high water flux, and high fouling resistance. The anti-fouling performance of the RO membrane series products has been significantly improved based on POLYMEX's proprietary high-performance composite membrane manufacturing technology. POLYMEX RO membranes can treat various feed water types, and meet the permeate water quality requirements. POLYMEX RO membrane elements are available in 8-inch and 4-inch specifications and are used in seawater desalination, thermal power plant feedwater, pure water and ultrapure water preparation, sewage treatment, chemical and petrochemical processes, food and beverage processing, municipal water treatment and other fields.

2-2 Nano Filtration Membrane Elements

POLYMEX offers NF membrane elements with varied molecular weight cut-off at 90, which can meet the needs for different types of separation process. Selective separation of certain salts or organics at relatively low operating pressures provides high-quality products for pure water and fine chemical industries. POLYMEX NF membranes are available in 8'' and 4'' sizes for food and beverage concentration and purification, municipal wastewater, near zero discharge treatment, and separation, refining and concentration of petroleum, chemical, biopharmaceuticals and beverages.

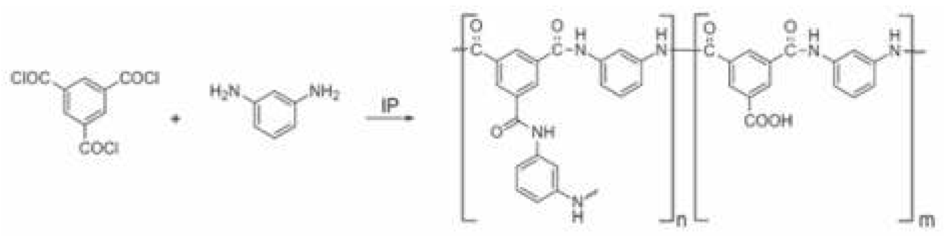
2-3 Ultra Filtration Membrane Elements

POLYMEX offers UF membranes that provide a pressure-driven purification process that separates particulate matter from soluble compounds using an ultrafine membrane media. Ultrafiltration is an excellent separation technology for desalination pre-treatment, reverse osmosis pre-treatment, and wastewater reclamation, as well as for producing potable water.

2.4 Chemical structure of the separation layers of HSRO

Reverse Osmosis Membrane

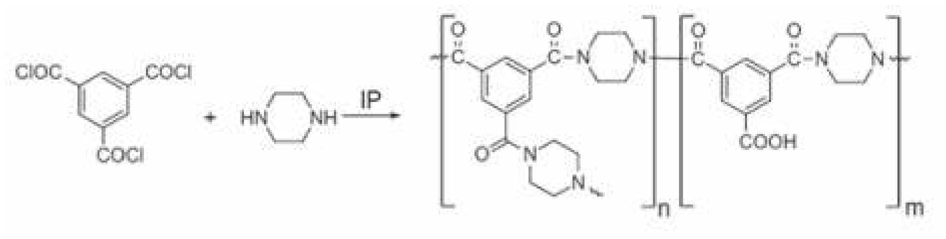
The RO membrane is an aromatic polyamide made from 1,3-phenylene diamine and the tri-acid chloride of benzene



RO/NF Membranes and Their Rejection Rules

Nanofiltration Membrane

The NF membrane is an aromatic/aliphatic polyamide with amine and carboxylates end groups.



As a general rule, membranes with a high water permeability also have a higher salt permeability compared to membranes with lower water permeability. The rejection of solutes increases with an increase in the:

1. **Ionic charge** – divalent ions are better rejected than monovalent ions
2. **Degree of hydration** – highly hydrated species, e.g., chloride, are better rejected than less hydrated ones, e.g., nitrate
3. **Molecular weight** – higher molecular weight species are better rejected
4. **Polarity** – More polar substances are rejected better
5. **Degree of dissociation** – weak acids, such as lactic acid, are rejected much better at higher pH when the dissociation is high
6. **Degree of molecular branching** – e.g., iso-propanol is better rejected than n-propanol

2.5 Polymex Membrane Characteristics

Versatility and Customization

Polymex thin film composite membranes give excellent performance for a wide variety of applications, including lowpressure tap water use, seawater desalination, brackish water purification, chemical processing and waste treatment. Customised membrane elements can be supplied for specific applications.

Precision and Consistency

Based on the self-developed integrated composite membrane manufacturing process, the membrane production is precisely controlled by a DCS with 4000+ process control points.

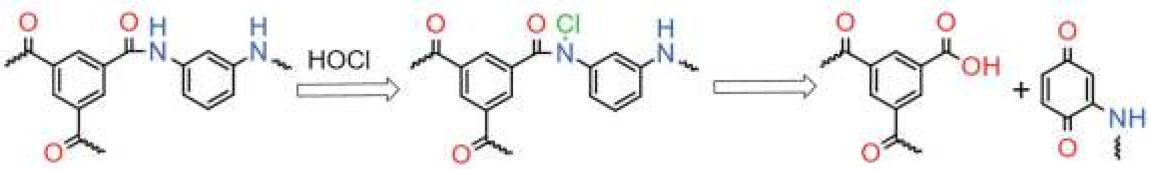
Enduring Stability

Non-chlorination treatment guarantees both short-term and enduring high performance.

High Resistance to Fouling and Chemical Cleaning

Based on the self-developed integrated composite membrane manufacturing process, the membrane production is precisely controlled by a DCS with 4000+ process control points.

The chemistry of membrane oxidation due to residual chlorine



Polymex membrane sheets and elements without any chlorination treatment for long-term stable desalination performance

Chlorine treatment may initially boost membrane performance, but it ultimately undermines its long-term viability. Chlorinated membrane elements have a number of long-term drawbacks: for example, membrane life is significantly reduced, they are highly sensitive to high pH cleaning conditions, desalination rates decay rapidly over time, they exhibit lower removal rates for difficult 'soft ions' such as ammonium, nitrate, boron, silica, arsenate and low molecular weight organics, and during operation, they are more sensitive to oxidizing chlorine in the water. The membrane is extremely sensitive to oxidizing chlorine in the water, etc.

2.6 Membrane Nomenclature

SW 400 HF

Features : FR: Fouling Resistant；HP: High Pressure； HR: High Rejection；HF: High FLux ；POS: Polar Organic Solvent

Active Area Or Membrane Size: 40 40

365 : 365 ft^2
400 : 400 ft^2
440 : 440 ft^2

Length
40 : 40 inches

Diameter
40 : 4.0 inches

SW : Seawater
SWFR : Seawater Fouling Resistant
BW : Brackish Water
BWLE : Brackish Water Low Energy
BWFR : Brackish Water Fouling Resistant
ULP : Ultra Low Pressure
LP : Low Pressure
HSRO : Heat Sanitizable Reverse Osmosis
AR : Acid Resistant
OR : Oxidation Resistant
DM : Amide Solvent Resistant
NF30 : Nanofiltration membrane for separation of divalent and monovalent anions
NF50 : Nanofiltration membrane for 50% salt removal
NF90 : Nanofiltration membrane for 90% salt removal
NFEP : NanoFiltration Electric Positive
DTRO : Disk Tube Reverse Osmosis

ULP, LP, BW, XFR, SW, HSRO, NF 4040 And 8040

POLYMEX MODEL	FLOW GPD(m^3/d)	REJECTION (%)	Area (ft^2)	Testing Condition
ULP-4040	2400 (9.08)	96.00	75	1500ppm NaCL, 150psi, 15%, 25°C, pH 8
LP-4040	2600 (9.8)	99.00	90	1500ppm NaCL, 150psi, 15%, 25°C, pH 8
LP-4040HR	2500 (9.44)	99.20	90	2000ppm NaCL, 225psi, 15%, 25°C, pH 8
LP-8040	8000 (30.3)	99.00	365	1500ppm NaCL, 140psi, 15%, 25°C, pH 8
BW-440 LE PRO	12650 (47.9)	99.70	440	2000ppm NaCL, 225psi, 15%, 25°C, pH 8
BW-400/34LF	11500 (43.5)	99.80	400	2000ppm NaCL, 225psi, 15%, 25°C, pH 8
LHR 4040	2900 (6.80)	99.50	94	2000ppm NaCL, 225psi, 15%, 25°C, pH 8
LHR 400	10500 (26.50)	99.50	400	2000ppm NaCL, 225psi, 15%, 25°C, pH 8
BW XFR 4040	2500 (9.4)	99.80	90	2000ppm NaCL, 225psi, 15%, 25°C, pH 8
BW XFR 400/34	10500 (39.7)	99.80	400	2000ppm NaCL, 225psi, 15%, 25°C, pH 8
LP-2540	750 (2.8)	99.00	28	1500ppm NaCL, 150psi, 15%, 25°C, pH 8
LP-4021	1000 (3.8)	99.00	36	1500ppm NaCL, 150psi, 15%, 25°C, pH 8

Sea Water or SW 4040 And 8040

POLYMEX MODEL	FLOW GPD(m^3/d)	REJECTION (%)	Area (ft^2)	Testing Condition
SW-4040	1600 (6.05)	99.80	90.00	32000ppm NaCl / 5ppm Boron , 800psi, 8% , 25°C, pH: 8
SW-8040	7500 (28.39)	99.80	400.00	
SW-XLE-440	9900 (37.47)	99.80	440.00	

Heat Sanitizable or HSRO 4040 And 8040

POLYMEX MODEL	FLOW GPD(m^3/d)	REJECTION (%)	Area (ft^2)	Testing Condition
HSRO 4040	1600 (6.0)	99.00	90.00	2000ppm NaCl, 225psi, 15%, 25°C, pH 8
HSRO 400	7500 (28.39)	99.00	390.00	

Nano Filtration or NF 4040 And 8040

POLYMEX MODEL	FLOW GPD(m^3/d)	REJECTION (%)	Area (ft^2)	Testing Condition
NF90-4040	2500 (9.4)	98.70	90.00	500 ppm NaCl, 2000ppm $MgSO_4$ 100psi, 15%, 25°C, pH 8
NF90-8040	10000 (37.85)	98.00	400.00	

Special Category Membranes

Model	Flow L/H (1.5 Kg/cm^2, 25°C)	REJECTION (%)	Effective Membrane Area (ft^2) m^2
AR-400	400 (37.16)	99.80	7500 (28.90)
AR-4040	90 (8.36)	99.80	1600 (6.10)
OR-400	400 (37.16)	99.80	8000 (30.30)
OR-4040	90 (8.36)	99.80	1800 (6.80)
DMAC-400	400 (37.16)	99.00	7500 (28.40)
DMAC-4040	90 (8.36)	99.00	1600 (6.10)
NFEP-400	400 (37.16)	< 35 > 97	9900 (28.40)
NFEP-4040	90 (8.36)	< 35 > 97	2400 (6.10)
NF50-400POS	400 (37.16)	45–55 >96	10500 (39.7)
NF95-400POS	400 (37.16)	> 95 > 99.5	9500 (36.0)
NF50-4040POS	100 (9.29)	45–55 >96	2600 (9.8)
NF95-4040POS	100 (9.29)	>95 >99.5	2300 (8.7)
DTRO-SW	101 (9.38)	99.00	2300 (8.70)
DTRO-HP	101 (9.38)	99.00	1800 (6.80)

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Ultrafiltration PVDF

Model	Effective Membrane Area, $ft^2(m^2)$	Flow Configuration	Flow L/H (1.5 Kg/cm^2, 25°C)
UF 2860	549 (51)	Outside in	2000-6000
UF 2880	829 (77)	Outside in	6000-9000

Ultrafiltration PVC

Model	Effective Membrane Area, $ft^2(m^2)$	Flow Configuration	Flow L/H (1.5 Kg/cm^2, 25°C)
UFC90 AL	51.66(4.8)	Inside Out	168-480
UFC160AL	172.22(16)	Inside Out	560-1600
UFC200AM	290.62(27)	Inside Out	945-2700
UFC200BL	365.97(34)	Inside Out	1190-3400
UFC250B	516.66(48)	Inside Out	1680-4800

Ultrafiltration PES

Model	Effective Membrane Area, $ft^2(m^2)$	Flow Configuration	Flow L/H (1.5 Kg/cm^2, 25°C)
DZ 0.9 80W	861 (80)	Inside Out	4000 - 9600

Ultrafiltration PVC

Model	Effective Membrane Area, $ft^2(m^2)$	Flow Configuration	Flow L/H (1.5 Kg/cm^2, 25°C)
Flex 40	430(40)	Inside Out	2000 – 4800
Flex 55	592(55)	Inside Out	2750 – 6600
Flex 64	700(65)	Inside Out	3250 – 7800
Flex 75	807(75)	Inside Out	3750 – 9000

Ultrafiltration PVC

Model	Effective Membrane Area, $ft^2(m^2)$	Flow Configuration	Flow L/H (1.5 Kg/cm^2, 25°C)
Mx 40	560(52)	Outside in	2600 – 6240
Mx 60	840(78)	Outside in	3900 – 9360
Mx 80	1130(105)	Outside in	5250 – 12600

Ultrafiltration PVDF

Model	Effective Membrane Area, $ft^2(m^2)$	Flow Configuration	Flow L/H (1.5 Kg/cm^2, 25°C)
ZW 700B	646(60)	Outside in	3000 - 7200

Part 3

RO Membranes

POLYMEX™

3.1 ULP & LP Series - Low Pressure Brackish Water RO

Product Highlights

- Significantly lower membranes system's operating pressure and power consumption.
- Cost-effective.

Key Features

- Low energy consumption
- High salt rejection
- High permeate flow rate
- Improved fouling resistance due to thicker feed spacer

Main Benefits

- A combination of high permeate water quality and energy efficiency

Ideal Applications

- Small industrial & commercial drinking water system requiring energy efficiency & moderate permeate water quality

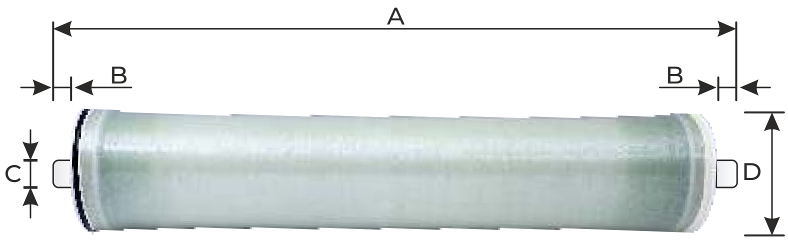
Notes

- Permeate flow for individual elements may vary ±15 percent from the value specified
- Active membrane area guaranteed ±4%.
- Stabilized salt rejection is generally achieved within 24-48 hours of continuous use; depending upon the feedwater characteristics & Operating conditions.

*At the Inlet of this membrane <5 μm Filter should be Provided to prevent blockage of membrane by large particles in Feed Water.

Product Description

POLYMEX LP & ULP series RO membrane elements are manufactured by adjusting the formula and process conditions of the supporting layer and thin film composite layer, therefore the membrane density and properties are altered. Compared with the traditional brackish water RO membranes, they provides 99% rejection rate, at a lower operating pressure. The application of this RO membrane element reduces the RO system's energy consumption, without compromising product water quality. These RO membranes are available in 4" and 8" sizes



Product Dimensions

Size	8040	4040	Unit
A Inch	40.0"(1016)	40.0"(1016)	Inch(mm)
B Inch		1.04"(26.5)	Inch(mm)
C Inch	1. 12"(28.5)	0.75"(19. 1)	Inch(mm)
D Inch	7.9"(201)	3.9"(99)	Inch(mm)

Performance Specifications

POLYMEX MODEL	FLOW GPD(m³/d)	REJECTION STABLE (%)	REJECTION (%) MIN.	Area ft² (m²)	Feed Spacer (mil)
ULP 4040	2400 (9.08)	99.00	98.50	75 (6.96)	32
LP 4040	2600 (9.8)	99.20	99.00	90 (8.36)	32
LP 4040 HR	2500 (9.44)	99.20	99.00	90 (8.36)	34
LP 8040	8000 (30.3)	99.00	98.80	365 (33.91)	38

Testing Conditions

Operating Pressure	150psi (10.6 Kg/cm²)
Tested at	1500ppm NaCL
Temperature	25°C
pH	8.0 ± 0.5
Recovery rate at	15%

Operating & Cleaning Limits

· Maximum Operating Pressure	600 psi (41 Kg/cm²)
· Maximum Operating Temperature	45°C (113°F)
· Maximum Element Pressure Drop	15 psi (1 Kg/cm²)
· pH Range Continuous Operation	2-11
· pH Range Short-Term Cleaning	1-13
· Maximum Feed SDI(SDI15)	5.0
· Free Chlorine Tolerance	< 0.1 ppm

Note : Each membrane element may have ± 15% variation of permeate flow.

Polymex RO, UF & NF Membranes

Product Highlights

- Stable performance and high rejection rate for organics
- Low operating pressures, high flux and cost saving
- Meets the demand for near zero discharge

Key Features

- Superior salt rejection
- High silica rejection
- High permeate flow rate
- Improved fouling resistance due to thicker feed spacer

Main Benefits

- A combination of high permeate water quality and energy efficiency

Ideal Applications

- Commercial & industrial drinking water system requiring energy efficiency & moderate permeate water quality.

Notes

- Permeate flow for individual elements may vary ±15 percent from the value specified
- Active membrane area guaranteed ±4%.
- Stabilized salt rejection is generally achieved within 24-48 hours of continuous use; depending upon the feedwater characteristics & Operating conditions.

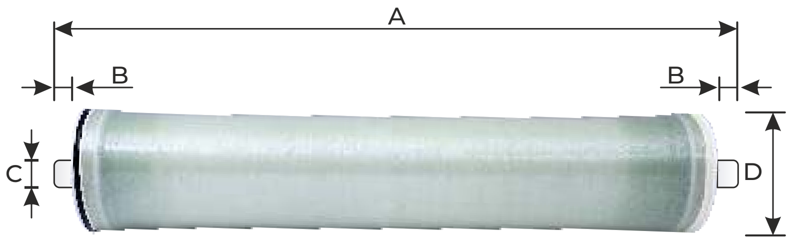
*At the Inlet of this membrane <5 μm Filter should be Provided to prevent blockage of membrane by large particles in Feed Water.

POLYMEX™

3.2 BW Series Brackish Water RO

Product Description

BW Series RO membrane elements are primarily used for brackish water desalination. They provide excellent, stable and consistent membrane performance for industrial & commercial water treatment systems. The elements operates at moderate pressure providing a more cost effective alternative for industrial-grade water treatment applications. They have high rejection rate for dissolved salts that are difficult to remove, such as TOC, SiO_2, etc., and therefore, applicable to near-zero discharge for oil and petrochemical industry waste water treatment and feed water for thermal power plant boilers. These RO membranes are available in 4"and 8" sizes.



Product Dimensions

Size	8040	4040	Unit
A Inch	40.0"(1016)	40.0"(1016)	Inch(mm)
B Inch		1.04"(26.5)	Inch(mm)
C Inch	1. 12"(28.5)	0.75"(19. 1)	Inch(mm)
D Inch	7.9"(201)	3.9"(99)	Inch(mm)

Performance Specifications

POLYMEX MODEL	FLOW GPD(m^3/d)	REJECTION STABLE (%)	REJECTION (%) MIN.	Area ft^2 (m^2)	Feed Spacer (mil)
BW 4040	2500 (9.4)	99.50	99.30	90 (8.36)	32
BW 400	10500 (39.7)	99.50	99.30	400 (37.16)	32
BW 400/34 LF	11500 (43.5)	99.80	99.70	400 (37.16)	34
BW 440 LE PRO	12650 (47.9)	99.70	99.40	440 (40.88)	28

Testing Conditions

Operating Pressure	225psi (15 Kg/cm^2)
Tested at	2000ppm NaCL
Temperature	25°C ± 2°C
pH	8.0 ± 0.5
Recovery rate at	15%

Operating & Cleaning Limits

· Maximum Operating Pressure	600 psi (41 Kg/cm^2)
· Maximum Operating Temperature	45°C (113°F)
· Maximum Element Pressure Drop	15 psi (1 Kg/cm^2)
· pH Range Continuous Operation	2-11
· pH Range Short-Term Cleaning	1-13
· Maximum Feed SDI(SDI15)	5.0
· Free Chlorine Tolerance	< 0.1 ppm

Note : Each membrane element may have ± 15% variation of permeate flow.

Polymex RO, UF & NF Membranes

Product Highlights

- Enhanced Fauling Resistance
- High Rejection Rate & Flux
-

Key Features

- Superior salt rejection
- High silica rejection
- High permeate flow rate
- Improved fouling resistance due to thicker feed spacer

Main Benefits

- High silica rejection

Ideal Applications

- Commercial & industrial water & waste water system requiring energy efficiency & moderate permeate water quality

Notes

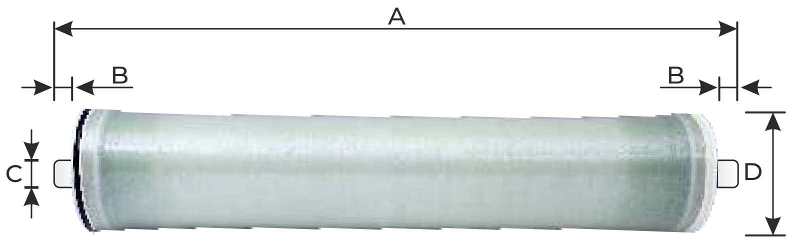
- Permeate flow for individual elements may vary ±15 percent from the value specified
- Active membrane area guaranteed ±4%.
- Stabilized salt rejection is generally achieved within 24-48 hours of continuous use; depending upon the feedwater characteristics & Operating conditions.

*At the Inlet of this membrane <5 µm Filter should be Provided to prevent blockage of membrane by large particles in Feed Water.

3.3 Polymex LHR Series

LHR Membrane

LHR Membranes are primarily used for brakish water desalination with high efficiency. They provide excellent, stable and consistent membrane performance for industrial & commercial water treatment systems. The elements operates at moderate pressure providing a more cost effective alternative for industrial-grade water treatment applications. They have high rejection rate for dissolved salts that are difficult to remove, such as TOC, SiO , etc., and are therefore, applicable to near zero discharge for oil and petrochemical industry wastewater treatment and feed water for thermal power plant boilers. These RO membranes are available in 4"and 8" sizes.



Product Dimensions

Size	8040	4040	Unit
A Inch	40.0"(1016mm)	40.0"(1016)	Inch(mm)
B Inch		1.04"(26.5)	Inch(mm)
C Inch	1. 12"(28.5mm)	0.75"(19. 1)	Inch(mm)
D Inch	7.9"(201mm)	3.9"(99)	Inch(mm)

Performance Specifications

POLYMEX MODEL	FLOW GPD(m^3/d)	REJECTION STABLE (%)	REJECTION (%) MIN.	Area ft^2 (m^2)	Feed Spacer (mil)
LHR 4040	2900 (6.80)	99.70	99.50	94 (8.73)	38
LHR 400	10500 (39.70)	99.70	99.50	400 (37.16)	38

Testing Conditions

Operating Pressure	225psi (15 Kg/cm^2)
Tested at	2000ppm NaCL
Temperature	25°C
pH	8.0 ± 0.5
Recovery rate at	8%

Performance Specifications

POLYMEX MODEL	Salute Typical Rejection			
	NH4	NO3	SiO2	Boron
LHR 400 LHR 4040	99.80	98.20	99.80	80.00

Operating & Cleaning Limits

· Maximum Operating Pressure	600 psi (41 Kg/cm^2)
· Maximum Operating Temperature	45°C (113°F)
· Maximum Element Pressure Drop	15 psi (1 Kg/cm^2)
· pH Range Continuous Operation	2-11
· pH Range Short-Term Cleaning	1-13
· Maximum Feed SDI(SDI15)	5.0
· Free Chlorine Tolerance	< 0.1 ppm

Note : Each membrane element may have ± 15% variation of permeate flow.

Product Highlights

- Enhanced fouling resistance
- High performance and durability
- High rejection rate and flux

Key Features

- Superior salt rejection
- High silica rejection
- High permeate flow rate
- Improved fouling resistance due to thicker feed spacer

Main Benefits

- A combination of high permeate water quality and energy efficiency

Ideal Applications

- Commercial & industrial water & waste water treatment system requiring energy efficiency & moderate permeate water quality

Notes

- Permeate flow for individual elements may vary ±15 percent from the value specified
- Active membrane area guaranteed ±4%.
- Stabilized salt rejection is generally achieved within 24-48 hours of continuous use; depending upon the feedwater characteristics & Operating conditions.

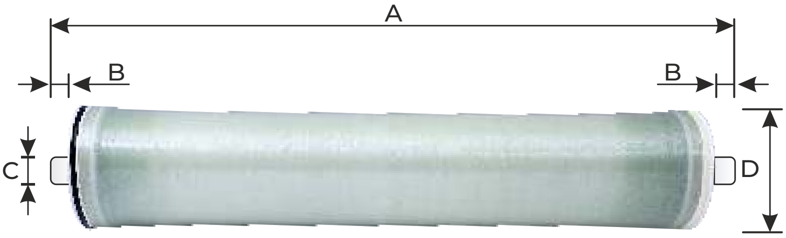
*At the Inlet of this membrane <5 µm Filter should be Provided to prevent blockage of membrane by large particles in Feed Water.

POLYMEX™

3.4 XFR Series - Extra Fouling Resistance RO

Product Description

Polymex XFR series RO membranes are manufactured with an optimized formula, reaction conditions, and post-treatment. The membrane's thin layer is denser, more hydrophilic, and the membrane surface is smoother. The membrane element is optimized in structure and manufactured with premium material. The membrane can effectively purify feed water with biological and organic pollution. POLYMEX XFR series adopts the latest membrane technology enabling the industry's first-class organic fouling resistance and cleanability. It provides membrane elements with excellent fouling resistance and super durability for difficult waste water treatment. POLYMEX XFR series are available in 8-inch and 4-inch sizes, which are suitable for systems with poor feed water quality.



Product Dimensions

Size	8040	4040	Unit
A Inch	40.0"(1016mm)	40.0"(1016)	Inch(mm)
B Inch		1.04"(26.5)	Inch(mm)
C Inch	1. 12"(28.5mm)	0.75"(19. 1)	Inch(mm)
D Inch	7.9"(201mm)	3.9"(99)	Inch(mm)

Performance Specifications

POLYMEX MODEL	FLOW GPD(m^3/d)	REJECTION STABLE (%)	REJECTION (%) MIN.	Area ft^2 (m^2)	Feed Spacer (mil)
XFR 4040	2500 (9.4)	99.80	99.50	90 (8.36)	34
XFR 400 / 34	10500 (39.7)	99.80	99.50	400 (37.16)	34
XFR 400 / 34 HF	11000 (41.6)	99.80	99.60	400 (37.16)	34

Testing Conditions

Operating Pressure	225psi (15 Kg/cm^2)
Tested at	2000ppm NaCL
Temperature	25°C
pH	8.0 ± 0.5
Recovery rate at	15%

Operating & Cleaning Limits

· Maximum Operating Pressure	600 psi (41 Kg/cm^2)
· Maximum Operating Temperature	45°C (113°F)
· Maximum Element Pressure Drop	15 psi (1 Kg/cm^2)
· pH Range Continuous Operation	2-11
· pH Range Short-Term Cleaning	1-13
· Maximum Feed SDI(SDI15)	5.0
· Free Chlorine Tolerance	< 0.1 ppm

Note : Each membrane element may have ± 15% variation of permeate flow.

Product Highlights

- Significantly lower membrane system's operating pressure and power consumption
- Cost-effective membrane system

Key Features

- Superior salt rejection
- High silica rejection
- High permeate flow rate
- Improved fouling resistance due to thicker feed spacer

Main Benefits

- A combination of high permeate water quality and energy efficiency

Ideal Applications

- Small industrial & commercial drinking water system requiring energy efficiency & moderate permeate water quality

Notes

- Permeate flow for individual elements may vary ±15 percent from the value specified
- Active membrane area guaranteed ±4%
- Stabilized salt rejection is generally achieved within 24-48 hours of continuous use; depending upon the feedwater characteristics & Operating conditions

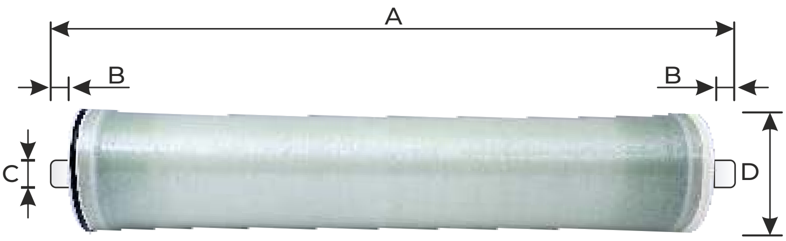
*At the Inlet of this membrane <5 μm Filter should be Provided to prevent blockage of membrane by large particles in Feed Water.

POLYMEX™

3.5 LP Series 2540 & 4021 Brackish Water RO

Product Description

POLYMEX LP series RO membrane elements are manufactured by adjusting the formula and process conditions of the supporting layer and thin film composite layer, therefore the membrane density and properties are altered. Compared with the traditional brackish water RO membranes, they provides 99% rejection rate, at a lower operating pressure. The application of this RO membrane element reduces the RO system's energy consumption, without compromising product water quality.



Product Dimensions

Size	8040	4040	Unit
A Inch	40.0"(1016mm)	21.0"(533)	Inch(mm)
B Inch		1.04"(26.5)	Inch(mm)
C Inch	1. 12"(28.5mm)	0.75"(19. 1)	Inch(mm)
D Inch	2.5"(63.5mm)	3.9"(99)	Inch(mm)

Performance Specifications

POLYMEX MODEL	FLOW GPD(m^3/d)	REJECTION STABLE (%)	REJECTION (%) MIN.	Area ft^2 (m^2)	Feed Spacer (mil)
LP 2540	750 (2.8)	99.00	98.50	28 (2.60)	28
LP 4021	1000 (3.8)	99.00	98.50	36 (3.34)	28

Testing Conditions

Operating Pressure	150psi (10.6 Kg/cm^2)
Tested at	1500ppm NaCL
Temperature	25°C
pH	8.0 ± 0.5
Recovery rate at	15%

Operating & Cleaning Limits

· Maximum Operating Pressure	600 psi (41 Kg/cm^2)
· Maximum Operating Temperature	45°C (113°F)
· Maximum Element Pressure Drop	15 psi (1 Kg/cm^2)
· pH Range Continuous Operation	2-11
· pH Range Short-Term Cleaning	1-13
· Maximum Feed SDI(SDI15)	5.0
· Free Chlorine Tolerance	< 0.1 ppm

Note : Each membrane element may have ± 15% variation of permeate flow.

Product Highlights

- Capacity to handle higher TDS water
- Enhanced fouling resistance
- High performance and durability
- High rejection rate and flux

Key Features

- Superior salt rejection
- High silica rejection
- High permeate flow rate
- Improved fouling resistance due to thicker feed spacer

Main Benefits

- A combination of high permeate water quality and energy efficiency

Ideal Applications

- Mainly used for desalination treatment of seawater & High-salt raw water which TDS more than 10000 mg / L, as well as waste water reuse and other application fields.

Notes

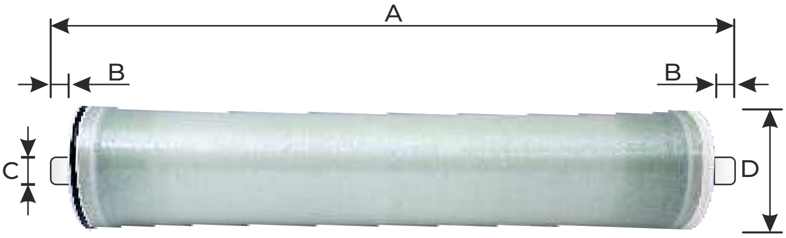
- Permeate flow for individual elements may vary ±15 percent from the value specified
- Active membrane area guaranteed ±4%.
- Stabilized salt rejection is generally achieved within 24-48 hours of continuous use; depending upon the feedwater characteristics & Operating conditions

*At the Inlet of this membrane <5 µm Filter should be Provided to prevent blockage of membrane by large particles in Feed Water.

3.6 SW Series - Sea Water RO

Product Description

Polymex SW series are high-end RO membranes featuring a thick, dense, flawless, thin film supporting layer with high compression resistance. They have good chemical degradation resistance. The membrane element does not need postprocessing during manufacturing. It tolerates a wide range of pH, which enables more efficient and thorough cleaning using regular acid and base, therefore it has high cleaning efficiency. The membrane system can operate long term under lower pressure due to thorough cleaning. Consequently the membrane performs better during its service life. It can significantly reduce operation costs, and bring the best long-term economy to the seawater desalination system.



Product Dimensions

Size	8040	4040	Unit
A Inch	40.0"(1016mm)	40.0"(1016)	Inch(mm)
B Inch		1.04"(26.5)	Inch(mm)
C Inch	1. 12"(28.5mm)	0.75"(19. 1)	Inch(mm)
D Inch	7.9"(201mm)	3.9"(99)	Inch(mm)

Performance Specifications

POLYMEX MODEL	FLOW GPD(m^3/d)	REJECTION STABLE (%) BORON	REJECTION (%) STABLE NaCl	REJECTION (%) MIN. NaCl	Area ft^2 (m^2)	Feed Spacer (mil)
SW 4040	1600 (6.0)	92.00	99.80	99.60	95 (9)	32
SW 400	7500 (28.4)	93.00	99.80	99.65	400 (37)	32
SW XLE 440	9000 (34.0)	92.00	99.80	99.65	440 (40.88)	28

Testing Conditions

Operating Pressure	800psi (55 Kg/cm^2)
Tested at	32000ppm NaCL / 5ppm Boron
Temperature	25°C
pH	8.0 ± 0.5
Recovery rate at	8%

Operating & Cleaning Limits

· Maximum Operating Pressure	1200 psi (83 Kg/cm^2)
· Maximum Operating Temperature	45°C (113°F)
· Maximum Element Pressure Drop	15 psi (1 Kg/cm^2)
· pH Range Continuous Operation	2-11
· pH Range Short-Term Cleaning	1-13
· Maximum Feed SDI(SDI15)	5.0
· Free Chlorine Tolerance	< 0.1 ppm

Note : Each membrane element may have ± 15% variation of permeate flow.

Polymex RO, UF & NF Membranes

Product Highlights

- Highest Active Area
- Designed for pharmaceutical, medical, and biotech applications.
- Permeate polishing in food and dairy processes.

Key Features

- Withstand high temperature
- High permeate flow rate
- No dependence on chemical cleaning agents

Main Benefits

- A combination of high permeate water quality and energy efficiency

Ideal Applications

- Small capacity commercial & industrial water treatment plant requiring energy efficiency & moderate permeate water quality in pharmaceutical industries

Notes

- Permeate flow for individual elements may vary ±15 percent from the value specified
- Active membrane area guaranteed ±4%.
- Stabilized salt rejection is generally achieved within 24-48 hours of continuous use; depending upon the feedwater characteristics & Operating conditions.

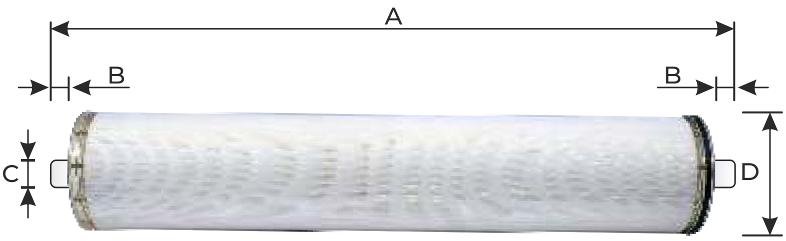
*At the Inlet of this membrane <5 μm Filter should be Provided to prevent blockage of membrane by large particles in Feed Water.

POLYMEX™

3.7 HSRO Series - Heat Sanitizable RO

Product Description

Polymex. HSRO membranes are specialty Hot Water sanitizable RO membranes that deliver outstanding quality water with the added capability to withstand the sanitization with hot water, eliminating the need for chemical sanitizers. They have the highest active membrane area, allowing system designs with either lower operating flux or cost savings from fewer membrane elements. The full-fit configuration minimizes stagnant areas and is optimal for applications requiring sanitary design.



Product Dimensions

Size	8040	4040	Unit
A Inch	40.0"(1016mm)	40.0"(1016)	Inch(mm)
B Inch		1.04"(26.5)	Inch(mm)
C Inch	1. 12"(28.5mm)	0.75"(19. 1)	Inch(mm)
D Inch	7.9"(201mm)	3.9"(99)	Inch(mm)

Performance Specifications

POLYMEX MODEL	FLOW GPD(m^3/d)	REJECTION STABLE (%)	REJECTION (%) MIN.	Area ft^2 (m^2)	Feed Spacer (mil)
HSRO 4040	1300 (4.9)	99.00	98.50	85 (7.90)	28
HSRO 400	9000 (34.0)	99.00	98.50	400 (37.20)	28

Testing Conditions

Operating Pressure	225psi (15 Kg/cm^2)
Tested at	2000ppm NaCl
Temperature	25°C
pH	8.0 ± 0.5
Recovery rate at	15%

Operating & Cleaning Limits

· Maximum Operating Pressure	600 psi (41 Kg/cm^2)
· Maximum Operating Temperature	45°C (113°F)
· Maximum Sanitisation Temp. @ 25psi	85°C (185°F)
· Maximum Element Pressure Drop	15 psi (1 Kg/cm^2)
· pH Range Continuous Operation	2-11
· pH Range Short-Term Cleaning	1-13
· Maximum Feed SDI(SDI15)	5.0
· Free Chlorine Tolerance	< 0.1 ppm

Note : Each membrane element may have ± 15% variation of permeate flow.

POLYMEX™

Product Highlights

- Excellent removal of salts
- Suitable for removing TOC and THM precursors
- Salt removal under ultra-low pressure & low energy consumption

Key Features

- High salt rejection
- High silica rejection
- High permeate flow rate

Main Benefits

- Cost effective alternative for softner
- Pre-treatment of RO
- Can work a low energy low salt rejection membane

Ideal Applications

- Small capacity commercial & industrial water treatment systems for softening, demineralisation and purification.
- For pretreatment for RO Water

Notes

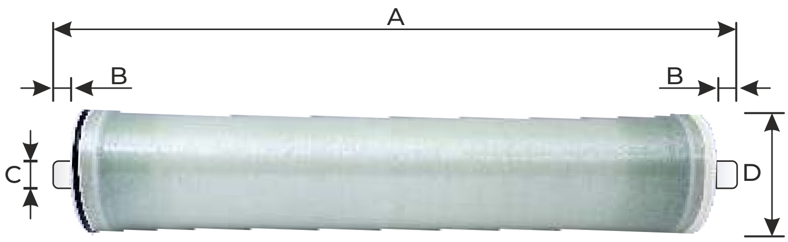
- Permeate flow for individual elements may vary ±15 percent from the value specified
- Active membrane area guaranteed ±4%.
- Stabilized salt rejection is generally achieved within 24-48 hours of continuous use; depending upon the feedwater characteristics & Operating conditions.

*At the Inlet of this membrane <5 µm Filter should be Provided to prevent blockage of membrane by large particles in Feed Water.

3.8 NF 90 Series - Nano Filtration Membranes

Product Description

Polymex NF 90 Series NF membranes provide high flux and excellent performance in removing monovalent and divalent salts. They also have a high removal rate for organic compounds, such as pesticides, herbicides, and THM precursors. Furthermore, they exhibit a high rejection rate for natural organic compounds like humic acid and other organic compounds. In addition, these membranes can also recover valuable multivalent salts and small molecular organics. They require low net driving pressure and can effectively remove impurities or recover valuable minerals. They can be operated by a very simple procedure with low energy consumption and cost. These membranes are suitable for the papermaking, printing and dyeing industries, and municipal water treatment systems. In the water treatment brocess, they can not only reduce water hardness but also effectively remove toxic and harmful substances from the water.



Product Dimensions

Size	8040	4040	Unit
A Inch	40.0"(1016)	40.0"(1016)	Inch(mm)
B Inch		1.04"(26.5)	Inch(mm)
C Inch	1. 12"(28.5)	0.75"(19. 1)	Inch(mm)
D Inch	7.9"(201)	3.9"(99)	Inch(mm)

Performance Specifications

POLYMEX MODEL	FLOW GPD(m^3/d)	REJECTION STABLE (%)	REJECTION (%) MIN.	Area ft^2 (m^2)	Feed Spacer (mil)
NF 4040	2500 (9.5)	= 98.00	85 - 95	90 (8.36)	28
NF 8040	10500 (39.8)	= 98.00	85 - 95	400 (37.16)	34

Testing Conditions

Operating Pressure	100psi (7 Kg/cm^2)
Tested at	2000ppm MgSO4 / 500 NaCl
Temperature	25°C
pH	8.0 ± 0.5
Recovery rate at	15%

Operating & Cleaning Limits

· Maximum Operating Pressure	600 psi (41 Kg/cm^2)
· Maximum Operating Temperature	45°C (113°F)
· Maximum Element Pressure Drop	15 psi (1 Kg/cm^2)
· pH Range Continuous Operation	2-11
· pH Range Short-Term Cleaning	1-13
· Maximum Feed SDI(SDI15)	5.0
· Free Chlorine Tolerance	< 0.1 ppm

Note : Each membrane element may have ± 15% variation of permeate flow.

Polymex RO, UF
& NF Membranes

Product Highlights

- Specifically designed to withstand and perform efficiently in highly acidic environments.
- Improved Permeability and Selectivity:
- Novel Material Compositions

Key Features

- Enhanced Acid Resistance Mechanisms
- Structural Stability in Acidic Conditions
- Dual Retention Mechanisms

Main Benefits

- Effective Acidic Wastewater Treatment
- Resource Recovery and Environmental Protection
- Reduced Operational Costs and Extended Lifespan.

Ideal Applications

- Industrial Acidic Wastewater Treatment
- Recovery of Valuable Resources
- Treatment of Acidic Dye Wastewater

Notes

- Maximum temperature for continuous operation above pH 10 is 35°C.
- Under certain conditions, the presence of residual chlorine and other oxidizing agents can lead to premature failure of the membrane. Polymex recommends removing residual free chlorine by pretreatment prior to membrane exposure.

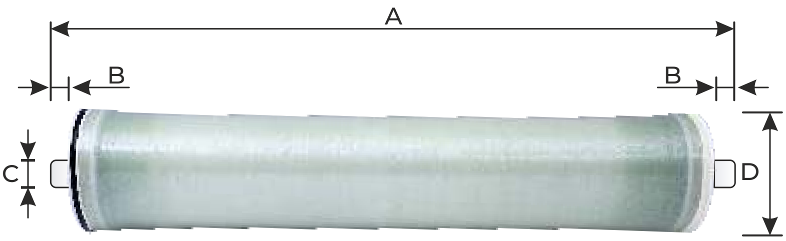
*At the Inlet of this membrane <5 μm Filter should be Provided to prevent blockage of membrane by large particles in Feed Water.

POLYMEX™

3.9 Polymex AR Series

Acid Resisting High Pressure RO Membrane

Polymex AR Series, acid-resistant high-pressure reverse osmosis membrane elements are suitable for the desalination of highly acidic and saline wastewater.



Product Dimensions

Size	8040	4040	Unit
A Inch	40.0"(1016)	40.0"(1016)	Inch(mm)
B Inch		1.04"(26.5)	Inch(mm)
C Inch	1. 12"(28.5)	0.75"(19. 1)	Inch(mm)
D Inch	7.9"(201)	3.9"(99)	Inch(mm)

Performance Specifications

POLYMEX MODEL	FLOW GPD(m^3/d)	REJECTION (%)	Area ft² (m²)
AR-4040	1600 (6.10)	99.80	90 (8.36)
AR-400	7500 (28.90)	99.80	400 (37.16)

Testing Conditions

Operating Pressure	800psi (55 Kg/cm²)
Tested at	3200ppm NaCl
Temperature	25°C
pH	8.0 ± 0.5
Recovery rate at	15%

Operating & Cleaning Limits

· Maximum Operating Pressure	1200 psi (82 Kg/cm²)
· Maximum Operating Temperature	45°C (113°F)
· Maximum Element Pressure Drop	15 psi (1 Kg/cm²)
· pH Range Continuous Operation	0-11
· pH Range Short-Term Cleaning	1-13
· Maximum Turbidity	1.0
· Maximum Feed SDI(SDI15)	5.0
· Free Chlorine Tolerance	< 0.1 ppm

Note : Each membrane element may have ± 15% variation of permeate flow.

POLYMEX™

Product Highlights

- High Oxidation Resistant RO Membrane Elements.
- Designed for Brackish Water with Micro-Oxidizing Substances.

Key Features

- Enhanced Oxidation Resistance.
- High Performance Metrics.
- Extended Working Life.

Main Benefits

- Overcomes Oxidation Vulnerability.
- Enables Effective Sterilization

Ideal Applications

- Broadly applicable where source water may contain microbial contaminants or oxidizing substances.
- Highly suitable for water reuse projects (including surface water reuse) and municipal water supply systems where source water quality might be variable or require rigorous purification and sterilization.
- Ideal for specialized applications such as power plant boiler make-up water, food and beverage industry water, electroplating wastewater treatment, and textile printing and dyeing water treatment, where high purity and resistance to oxidation are critical.

Notes

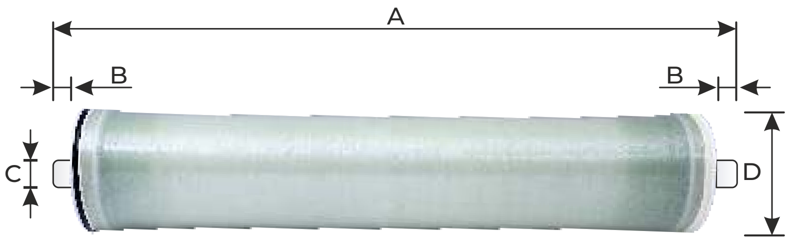
- Maximum temperature for continuous operation above pH 10 is 35°C.
- Under certain conditions, the presence of residual chlorine and other oxidizing agents can lead to premature failure of the membrane. Polymex recommends removing residual free chlorine by pretreatment prior to membrane exposure

*At the Inlet of this membrane <5 µm Filter should be Provided to prevent blockage of membrane by large particles in Feed Water.

3.10 Polymex OR Series

Oxidation Resistant High Pressure RO Membrane

The oxidation-resistant reverse osmosis membrane elements are suitable for the desalination and TOC removal from oxidative aqueous solutions, especially FOT he purification of high-concentration hydrogen peroxide. These membrane elements also feature high removal rates of TOC and boron, and can be applied in the preparation process electronic-grade hydrogen peroxide



Product Dimensions

Size	8040	4040	Unit
A Inch	40.0"(1016)	40.0"(1016mm)	Inch(mm)
B Inch		1.04"(26.5mm)	Inch(mm)
C Inch	1. 12"(28.5)	0.75"(19. 1mm)	Inch(mm)
D Inch	7.9"(201)	3.9"(99mm)	Inch(mm)

Performance Specifications

POLYMEX MODEL	FLOW GPD(m^3/d)	REJECTION (%)	Area ft^2 (m^2)
OR-4040	1800 (6.80)	99.80	90 (8.36)
OR-400	8000 (30.30)	99.80	400 (37.16)

Testing Conditions

Operating Pressure	400psi (27 Kg/cm^2)
Tested at	2000ppm NaCl
Temperature	25°C
pH	8.0 ± 0.5
Recovery rate at	15%

Operating & Cleaning Limits

· Maximum Operating Pressure	1200 psi (82 Kg/cm^2)
· Maximum Operating Temperature	45°C (113°F)
· Maximum Element Pressure Drop	15 psi (1 Kg/cm^2)
· pH Range Continuous Operation	2-11
· pH Range Short-Term Cleaning	1-13
· Maximum Turbidity	1.0
· Maximum Feed SDI(SDI15)	5.0
· Free Chlorine Tolerance	< 0.1 ppm

Note : Each membrane element may have ± 15% variation of permeate flow.

Product Highlights

- Novel Organic Solvent Membrane:
- High Performance in Organic Solvents

Key Features

- Unique Interfacial Polymerization (IP) with PNP:
- Optimized Structural Properties
- Stable Chemical Bonds .

Main Benefits

- Enhanced Organic Solvent Resistance.
- Improved Separation Efficiency.

Ideal Applications

- Primarily suited for applications requiring separation, purification, and concentration in various organic phases, particularly where catalyst regeneration or antibiotic separation is critical.
- Chemical and Petrochemical Industries:.
- Wastewater Treatment with Pollutant Utilization.

Notes

- 1.Maximum temperature for continuous operation above pH 10 is 35°C.
- 2. Under certain conditions, the presence of residual chlorine and other oxidizing agents can lead to premature failure of the membrane. Polymex recommends removing residual free chlorine by pretreatment prior to membrane exposure.

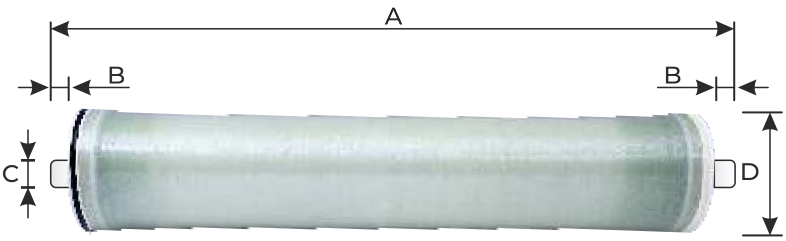
*At the Inlet of this membrane <5 µm Filter should be Provided to prevent blockage of membrane by large particles in Feed Water.

POLYMEX™

3.11 Polymex DM Series

Amide Solvent Resistant High Pressure RO Membrane

This membrane element is characterized by its resistance to amide solvents and is suitable for the concentration treatment of DMF, DMAc, and NMP aqueous solutions. It is widely used in the concentration treatment of wastewater and liquids containing related solvents. It is applicable for high-pressure and high-concentration organic wastewater treatment. Polymex DM XFR series are available in 8-inch and 4-inch sizes, which are suitable for systems with poor feed water quality.



Product Dimensions

Size	8040	4040	Unit
A Inch	40.0"(1016)	40.0"(1016mm)	Inch(mm)
B Inch		1.04"(26.5mm)	Inch(mm)
C Inch	1. 12"(28.5)	0.75"(19. 1mm)	Inch(mm)
D Inch	7.9"(201)	3.9"(99mm)	Inch(mm)

Performance Specifications

POLYMEX MODEL	FLOW GPD(m^3/d)	REJECTION (%)	Area ft^2 (m^2)
DMAC-4040	1600 (6.10)	99.00	90 (8.36)
DMAC-400	7500 (28.40)	99.00	400 (37.16)

Testing Conditions

Operating Pressure	600psi (41 Kg/cm^2)
Tested at	5000ppm DMAc Solution
Temperature	25°C
pH	8.0 ± 0.5
Recovery rate at	10%

Operating & Cleaning Limits

· Maximum Operating Pressure	1200 psi (82 Kg/cm^2)
· Maximum Operating Temperature	45°C (113°F)
· Maximum Element Pressure Drop	15 psi (1 Kg/cm^2)
· pH Range Continuous Operation	2-11
· pH Range Short-Term Cleaning	1-13
· Maximum Turbidity	1.0
· Maximum Feed SDI(SDI15)	5.0
· Free Chlorine Tolerance	< 0.1 ppm

Note : Each membrane element may have ± 15% variation of permeate flow.

POLYMEX™

Product Highlights

- High Selectivity Mg^{2+}/Li+ Separation Nanofiltration (NF) Membrane.
- Positively Charged Surface with Quaternary Ammonium Groups.

Key Features

- Dual Amine and Quaternary Ammonium Functionalization contributing to both initial positive charge and the introduction of stable quaternary ammonium groups.
- Enhanced Electrostatic Repulsion.
- Stable Performance and Tunable Properties.

Main Benefits

- Highly Efficient Lithium Recovery.
- Overcomes Limitations of Conventional NF Membranes.
- Long-Term Stability in Challenging Conditions.

Ideal Applications

- Lithium Extraction from Salt Lake Brines.
- Sustainable Resource Management.
- Industrial Water Treatment with Specific Ion Separation Needs.

Notes

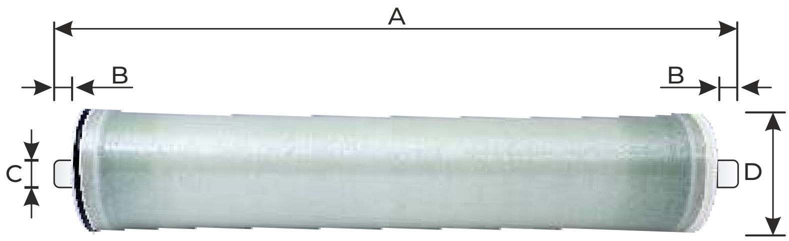
- Permeate flow and salt rejection based on the following standard conditions: 25°C, pH 7.5-8 and 15% recovery. Flow performance variation: ±15%

*At the Inlet of this membrane <5 µm Filter should be Provided to prevent blockage of membrane by large particles in Feed Water.

3.12 Polymex NFEP Series

Electric Positive Nanofiltration Membrane

The electric positive nanofiltration membrane, specially formulated to provide a positively charged surface, can be used for the separation bf monovalent and divalent cations, including ithium extraction from salt lakes, heavy metal ion removal, and in biochemical and pharmaceutical applications, water softening, and the dye ndustry, among other fields.



Product Dimensions

Size	8040	4040	Unit
A Inch	40.0"(1016)	40.0"(1016mm)	Inch(mm)
B Inch		1.04"(26.5mm)	Inch(mm)
C Inch	1. 12"(28.5)	0.75"(19. 1mm)	Inch(mm)
D Inch	7.9"(201)	3.9"(99mm)	Inch(mm)

Performance Specifications

POLYMEX MODEL	FLOW GPD(m^3/d)	REJECTION (%)	Area ft² (m²)
NFEP-4040	2400 (9.08)	< 35 > 97	90 (8.36)
NFEP-400	9900 (37.47)	< 35 > 97	400 (37.16)

Testing Conditions

Operating Pressure	100psi (7 Kg/cm²)
Tested at	500ppm NaCl, 2000 ppm MgCl2
Temperature	25°C
pH	8.0 ± 0.5
Recovery rate at	8%

Operating & Cleaning Limits

· Maximum Operating Pressure	800 psi (55 Kg/cm²)
· Maximum Operating Temperature	45°C (113°F)
· Maximum Element Pressure Drop	15 psi (1 Kg/cm²)
· pH Range Continuous Operation	2-11
· pH Range Short-Term Cleaning	1-13
· Maximum Turbidity	1.0
· Maximum Feed SDI(SDI15)	5.0
· Free Chlorine Tolerance	< 0.1 ppm

Note : Each membrane element may have ± 15% variation of permeate flow.

Polymex RO, UF
& NF Membranes

Product Highlights

- Newly fabricated Thin-Film Composite (TFC) SRNF membrane specifically designed for separating solutes from challenging polar aprotic organic solvents.
- PTFE Substrate with Enhanced Adhesion
- Reverse Flexible-Chain Binding Interfacial Polymerization (rFB-IP).

Key Features

- Three-Layered Interpenetrated Structure to ensure strong bonding and structural integrity.
- Excellent Polar Aprotic Solvent Resistance in aggressive polar aprotic solvents like DMSO, DMAC, and DMF, where other membranes typically fail.
- Optimized Fabrication Parameters.

Main Benefits

- Enables Separation in Harsh Organic Environments.
- High Stability and Delamination Resistance leading to a longer membrane lifespan.
- Improved Efficiency over ISA Membranes to offer higher permeance, reducing energy consumption in practical operations.

Ideal Applications

- Industrial Separations in Polar Aprotic Solvents:.
- Processes Requiring High Chemical and Solvent Resistance.
- Addressing Low Performance and Stability Issues in SRNF.

Notes

- Permeate flow and molecule rejection based on the following standard conditions : 25°C, pH 7.5-8 and 15% recovery. Flow performance variation: ±15%

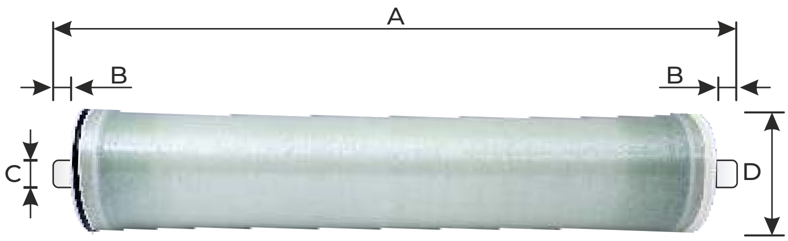
*At the Inlet of this membrane <5 μm Filter should be Provided to prevent blockage of membrane by large particles in Feed Water.

POLYMEX™

3.13 Polymex NF-POS Series

Polar-Organic-Solvent Resistant Nanofiltration Membrane

Highly resistant to polar organic solvents such as methanol, ethanol, and isopropanol, these membranes can be customized for different molecular weights of the retained material to meet various customer needs. They can be widely used for the purification and recovery of polar organic solvents, such as chromatographic solutions, and for the concentration and separation of pharmaceutical intermediates and APIs.



Product Dimensions

Size	NF50-4040POS	NF95-4040POS	NF50-400POS	NF95-400POS	Unit
A Inch	40.0"(1016)	40.0"(1016)	40.0"(1016)	40.0"(1016)	In(mm)
B Inch	1.04"(26.5)	1.04"(26.5)			In(mm)
C Inch	0.75"(19. 1)	0.75"(19. 1)	1. 12"(28.5)	1. 12"(28.5)	In(mm)
D Inch	3.9"(99)	3.9"(99)	7.9"(201)	7.9"(201)	In(mm)

Performance Specifications

POLYMEX MODEL	FLOW GPD(m^3/d)	REJECTION (%) Glucose Sucrose	Area ft^2 (m^2)
NF50-4040POS	2600 (9.8)	45–55 >96	90 (8.36)
NF95-4040POS	2300 (8.7)	>95 >99.5	90 (8.36)
NF50-400POS	10500 (39.7)	45–55 >96	400 (37.16)
NF95-400POS	9500 (36.0)	>95 >99.5	400 (37.16)

Testing Conditions

Operating Pressure	225psi (15.5 Kg/cm^2)
Tested at	Glucose in Methanol: 2000 ppm, Sucrose in Methanol: 2000 ppm
Temperature	25°C
pH	8.0 ± 0.5
Recovery rate at	15%

Operating & Cleaning Limits

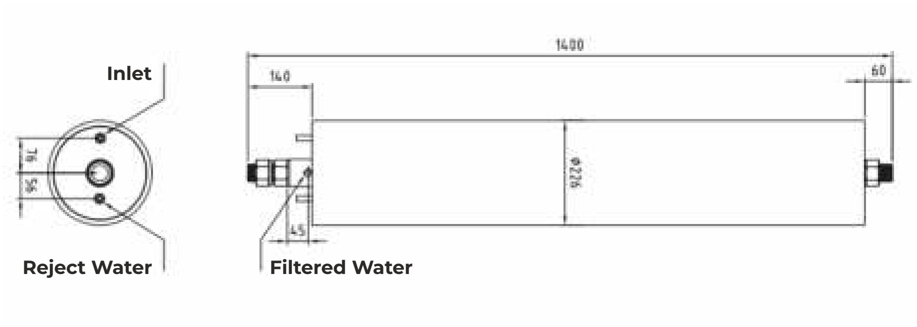
· Maximum Operating Pressure	600 psi (41 Kg/cm^2)
· Maximum Operating Temperature	45°C (113°F)
· Maximum Element Pressure Drop	15 psi (1 Kg/cm^2)
· pH Range Continuous Operation	6-9
· pH Range Short-Term Cleaning	2-12
· Maximum Turbidity	1.0
· Maximum Feed SDI(SDI15)	5.0
· Free Chlorine Tolerance	< 0.1 ppm

Note : Each membrane element may have ± 15% variation of permeate flow.

3.14 Polymex DTRO Series

Disk Tube RO Membrane

The DTRO system can be operated flexibly and can be selected as primary or secondary treatment according to the discharge standard required by leachate. The treated water can be guaranteed to meet the primary discharge standard of the water reuse standard. It is primarily used in projects such as land fill leachate, waste composting leachate, and deep salt concentration with zero discharge.



Performance Specifications

POLYMEX MODEL	FLOW GPD(m^3/d)	REJECTION (%)	Area ft^2 (m^2)
DTRO-SW	2000 (7.60)	99.80	101 (9.38)
DTRO-HP	1800 (6.80)	99.80	101 (9.38)

Testing Conditions

Operating Pressure	800psi (55 Kg/cm^2)
Tested at	32000ppm NaCl
Temperature	25°C
pH	8.0 ± 0.5
Recovery rate at	8%

Operating & Cleaning Limits

· Maximum Operating Pressure	2320 psi (160 Kg/cm^2)
· Maximum Operating Temperature	45°C (113°F)
· Maximum Element Pressure Drop	130psi (9.0 Kg/cm^2)
· pH Range Continuous Operation	6-9
· pH Range Short-Term Cleaning	2-12
· Maximum Turbidity	1.0
· Maximum Feed SDI(SDI15)	5.0
· Free Chlorine Tolerance	< 0.1 ppm

Note : Each membrane element may have ± 15% variation of permeate flow.

Product Highlights

- Disk Tube Reverse Osmosis (DTRO) Technology for challenging wastewater treatment.
- Designed for High-COD & High TDS Wastewater.
- Pioneering Application in Landfill Leachate.

Key Features

- Robust, Fouling-Resistant Design.
- High Pressure Tolerance for Increased Recovery.
- Versatile for Complex Water Qualities.

Main Benefits

- Improved Water Recovery and Reduced Discharge: crucial for water reuse, reclamation, and achieving stringent zero liquid discharge (ZLD) requirements
- Lower Operational Challenges and Costs.
- Effective for Difficult-to-Treat Wastewaters.

Ideal Applications

- Landfill Leachate Treatment.
- High COD and High TDS Industrial Wastewater such as flue gas desulfurization (FGD) wastewater from coal-fired power plants, digestate, acid wastewater, metallurgical wastewater, petrochemical, and coal chemical wastewater.
- Water Reuse and Zero Liquid Discharge (ZLD) Systems

Notes

- Permeate flow and salt rejection based on the following standard conditions: NaCl solution, 25°C, pH 7.5-8 and 8% recovery. Flow performance variation: ±15%

*At the Inlet of this membrane <5 μm Filter should be Provided to prevent blockage of membrane by large particles in Feed Water.

Part 4

UF Membranes

4.1 UF PVDF Series - Ultra Filtration Membranes

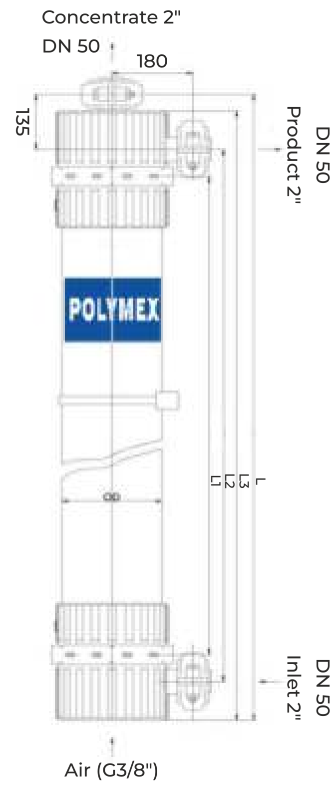
Product Description

Polymex PVDF Series UF Membranes offer superior resistance to fouling and chlorine, along with a high removal rate of colloidal particulates, bacteria, and viruses. They provide excellent filtration permeability and is designed for easy cleaning and wettability. The module features an optimized, open platform design that integrates seamlessly with customer-built skids, while its large active filtration area enhances productivity. It supports high operational recovery and withstands intensive air scouring. Additionally, the system reduces chemical consumption through efficient maintenance cleaning protocols, and its robust materials ensure a long service life. Easy to install and requiring minimal maintenance, it delivers both reliability and convenience.

Product Highlights

High recovery and large size filtration in:

- Industrial utility water
- Industrial wastewater reuse.
- Municipal wastewater filtration
- RO pretreatment.



Product Dimensions

Model	Length L, L1 inch (mm)	Length L2, L3 Inch(mm)	Diameter D Inch(mm)	Width W1 , W2
UF 2860	73.22 (1860); 59.05 (1500)	64.13 (1630); 71.65 (1820)	8.9 (225)	7.1 (180); 13.5 (342)
UF 2880	92.90 (2360); 78.90 (2000)	83.90 (2130); 91.30 (2320)	8.9 (225)	7.1 (180); 13.5 (342)

Product Specifications

Model	Effective Membrane Area, ft^2 (m^2)	Flow Configuration	Flow L/H (1.5 Kg/cm^2, 25°C)
UF 2860	549 (51)	Outside in	2000-6000
UF 2880	829 (77)	Outside in	6000-9000

Operating & Cleaning Limits

Filtration Performance	
Ingredient	Effect
SS, Particles > 1μm	Removal Rate = 99%
SDI	≤ 3
Bacteria, Viruses	> 4 log
Turbidity	< 1NTU
TOC	Removal Rate: 0-25%

Technical Parameters	
Filtering Type	Outside-in
Membrane Material	Modified PVDF
MWCO	200K Dalton
Membrane Area	$51m^2$ & $77m^2$

Raw Water Pre-Requisits	
Turbidity	≤ 15NTU
Oil & Grease	≤ 2mg/L
SS	≤ 10mg/L
Total Iron	≤ 1mg/L
Continuous Residual Chlorine	≤ 5ppm
COD	< 500mg/L

Application Dataz	
Operating Flux	40-120L/m^2.hr (1.5 Kg/cm^2, 25°C)
Backwash Flux	100-150L/m^2.hr (1.5 Kg/cm^2, 25°C)
Suggested Working Pressure	≤ 2 Kg/cm^2, 25°C
Maximum Transmembrane Pressure	1.5 Kg/cm^2
Maximum Backwashing Pressure	1.5 Kg/cm^2
Air Washing Volume	0.1-0.15N m^3/m^2.hr
Air Washing Pressure	≤ 1 Kg/cm^2
Maximum Working Temperature	45°C
PH Range	Working: 4-10; Washing: 2-12
Operating Mode	Cross Flow or Dead End

Operating Parameters	
Backwashing Frequency	Every 30-60min.
Backwashing Duration	30-60s
CEB Frequency	0-4 times per day
CEB Duration	5-10min.
CIP Frequency	Every 1-3 months
Sterilization	15ppm Sodium Hypochlorite
Organic Pollution Washing	0.2% Sodium Hypochlorite + 0.1% Sodium Hydroxide
Inorganic Pollution Washing	1-2% Citric Acid/0.2% Hydrochloric Acid

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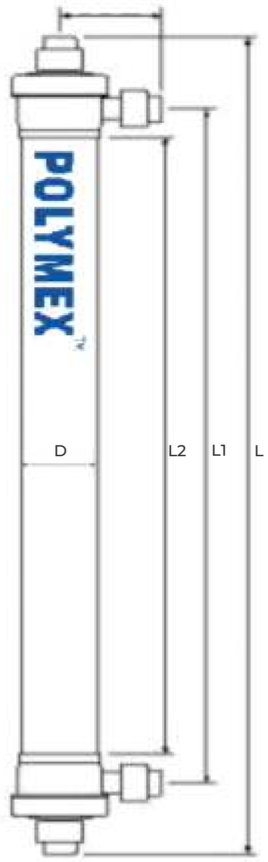
4.2 UF PVC Series - Ultra Filtration Membrane

Product Description

Polymex PVC Series UF Membranes are capillary hollow fiber membranes, which are made up of a high polymer material that does not undergo any phase change. The modified PVC material used in this product offers a good permeation rate, strong mechanical properties, and excellent chemical and pollution resistance. The membrane has a molecular weight cut-off (MWCO) of 100K Daltons, with an inner/outer diameter (ID/OD) of 1.0 mm/1.8 mm, and operates with an inside-out filtration type.

Product Highlights

- Unique central tube water distribution process
- UPVC housing offers excellent resistance to aging, acids, and alkalis
- Anti-degumming structure
- Improved split-charging technology



Product Dimensions

Model	Length L, inch (mm)	Length L1 Inch(mm)	Length L2 Inch(mm)	Diameter D Inch(mm)
UFC90 AL	46.85(1190)	38.97(990)	35.82(910)	3.54(90)
UFC160AL	55.70(1415)	41.33(1050)	35.43(900)	6.29(160)
UFC200AM	58.26(1480)	41.96(1066)	35.03(890)	7.87(200)
UFC200BL	67.32(1710)	62.79(1595)	46.77(1188)	7.87(200)
UFC250B	67.32(1710)	62.99(1600)	46.45(1180)	9.84(250)

Product Specifications

Model	Effective Membrane Area, ft^2 (m^2)	Flow Configuration	Flow L/H (1.5 Kg/cm^2, 25°C)
UFC90 AL	51.66(4.8)	Inside Out	168-480
UFC160AL	172.22(16)	Inside Out	560-1600
UFC200AM	290.62(27)	Inside Out	945-2700
UFC200BL	365.97(34)	Inside Out	1190-3400
UFC250B	516.66(48)	Inside Out	1680-4800

Operating & Cleaning Limits

Filtration Performance	
Ingredient	Effect
SS, Particles > 1µm	Removal Rate = 99%
SDI	≤ 3
Bacteria, Viruses	> 4 log
Turbidity	< 1NTU
TOC	Removal Rate: 0-25%

Technical Parameters	
Filtering Type	Inside-Out
Membrane Material	Modified PVDF
MWCO	100K Dalton
Membrane Area	$4.8m^2$ - $48m^2$

Raw Water Pre-Requisits	
Turbidity	≤ 15NTU
Oil & Grease	≤ 2mg/L
SS	≤ 10mg/L
Total Iron	≤ 1mg/L
Continuous Residual Chlorine	≤ 5ppm
COD	< 500mg/L

Application Data	
Operating Flux	35-100L/m^2.hr (1.5 Kg/cm^2, 25°C)
Backwash Flux	100-150L/m^2.hr ((1.5 Kg/cm^2, 25°C)
Suggested Working Pressure	≤ 2 Kg/cm^2
Maximum Transmembrane Pressure	1.5 Kg/cm^2
Maximum Backwashing Pressure	1.5 Kg/cm^2
Maximum Working Temperature	35°C
PH Range	Working: 4-10; Washing: 2-12
Operating Mode	Cross Flow or Dead End

Operating Parameters	
Backwashing Frequency	Every 30-60min.
Backwashing Duration	30-60s
CEB Frequency	0-4 times per day
CEB Duration	5-10min.
CIP Frequency	Every 1-3 months
Sterilization	15ppm Sodium Hypochlorite
Organic Pollution Washing	0.2% Sodium Hypochlorite + 0.1% Sodium Hydroxide
Inorganic Pollution Washing	1-2% Citric Acid/0.2% Hydrochloric Acid

4.3 Polymex DZ Series - Ultra Filtration Membrane

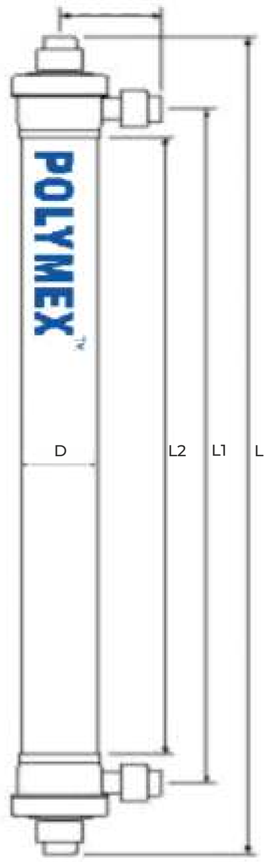
Product Description

Polymex DZ series UF Membrane is a pressurized PES UF module for open platform installation, which offers outstanding physical strength and chemical resistance, effectively eliminating colloidal particulate, bacteria, and viruses. Furthermore, all components in contact with water are corrosion-free, ensuring optimal efficiency throughout the module's lifetime.

Product Highlights

Proven PES Fibers:

- Exceptional physical strength and chemical resistance
- High colloidal particulate, bacteria and virus log removal rate.
- Unique design for high solids loads.
- Optional coagulation can enhance the removal of algae and organics



Product Dimensions

Model	Length L, inch (mm)	Length L1 Inch(mm)	Length L2 Inch(mm)	Diameter D Inch(mm)
DZ 0.9 80W	75.35(1914)	72.20(1834)	67.72(1720)	9.84(250)

Product Specifications

Model	Effective Membrane Area, ft^2 (m^2)	Flow Configuration	Flow L/H (1.5 Kg/cm^2, 25°C)
DZ 0.9 80W	861(80)	Inside Out	4000 - 9600

Operating & Cleaning Limits

Filtration Performance	
Ingredient	Effect
SS, Particles > 1μm	Removal Rate = 99%
SDI	≤ 3
Bacteria, Viruses	> 4 log
Turbidity	< 1NTU
TOC	Removal Rate: 0-25%

Technical Parameters	
Filtering Type	Inside-Out
Membrane Material	PES
MWCO	100K Dalton
Membrane Area	$80m^3$ (861 ft^2)

Raw Water Pre-Requisits	
Turbidity	≤ 15NTU
Oil & Grease	≤ 2mg/L
SS	≤ 10mg/L
Total Iron	≤ 1mg/L
Continuous Residual Chlorine	≤ 5ppm
COD	< 500mg/L

Application Data	
Operating Flux	50-120L/m^2.hr (1.5 Kg/cm^2, 25°C)
Backwash Flux	100-200L/m^2.hr (1.5 Kg/cm^2, 25°C)
Suggested Working Pressure	≤ 3 Kg/cm^2
Maximum Transmembrane Pressure	1.5 Kg/cm^2
Maximum Backwashing Pressure	2 Kg/cm^2
Air Washing Volume	0.1-0.15N m^3/m^2.hr
Air Washing Pressure	≤ 1 Kg/cm^2
Maximum Working Temperature	35°C
PH Range	Working: 4-10; Washing: 2-12
Operating Mode	Cross Flow or Dead End

Operating Parameters	
Backwashing Frequency	Every 30-60min.
Backwashing Duration	30-60s
CEB Frequency	0-4 times per day
CEB Duration	5-10min.
CIP Frequency	Every 1-3 months
Sterilization	15ppm Sodium Hypochlorite
Organic Pollution Washing	0.2% Sodium Hypochlorite + 0.1% Sodium Hydroxide
Inorganic Pollution Washing	1-2% Citric Acid/0.2% Hydrochloric Acid

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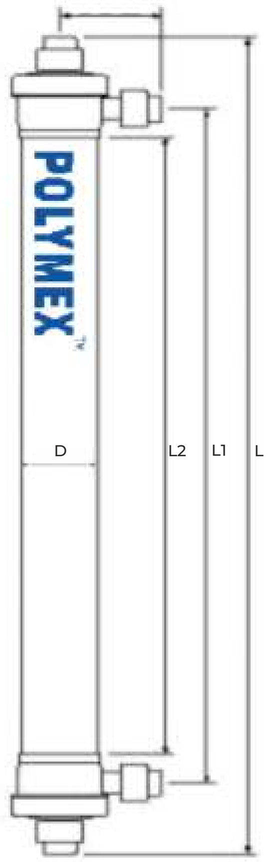
4.4 Polymex Flex Series - Ultra Filtration Membrane

Product Description

Polymex Flex Series UF Membrane Elements are based on hydrophilic hollow-fiber ultrafiltration membranes composed of a PES/PVP blend. They have high mechanical and chemical strength, making them suitable for a wide range of applications. The pressurized membrane elements are the industry's choice for the removal of bacteria, viruses, suspended solids, and colloids.

Product Highlights

- Membrane filtration provides 99.9999% reduction of bacteria and 99.99% reduction of viruses by mechanical means
- High membrane packing density
- Individual fiber repair
- Wide pH range: 2 – 12
- Typical high permeability: low energy consumption



Product Dimensions

Model	Length L, inch (mm)	Length L1 Inch(mm)	Length L2 Inch(mm)	Diameter D Inch(mm)
Flex 40	74.84(1901)	68.42(1738)	60.51(1537.5)	8.66(200)
Flex 55	74.84(1901)	68.42(1738)	60.51(1537.5)	8.66(200)
Flex 65	74.84(1901)	68.42(1738)	60.51(1537.5)	8.66(200)
Flex 75	74.84(1901)	68.42(1738)	60.51(1537.5)	8.66(200)

Product Specifications

Model	Effective Membrane Area, ft^2 (m^2)	Flow Configuration	Flow L/(1.5 Kg/cm^2, 25°C)
Flex 40	430(40)	Inside Out	2000 – 4800
Flex 55	592(55)	Inside Out	2750 – 6600
Flex 65	700(65)	Inside Out	3250 – 7800
Flex 75	807(75)	Inside Out	3750 - 9000

Operating & Cleaning Limits

Filtration Performance	
Ingredient	Effect
SS, Particles > 1µm	Removal Rate = 99%
SDI	≤ 3
Bacteria, Viruses	> 4 log
Turbidity	< 1NTU
TOC	Removal Rate: 0-25%

Technical Parameters	
Filtering Type	Inside-Out
Membrane Material	PES
MWCO	100K Dalton
Membrane Area	40 - 75m^3 (430 - 807 ft^2)

Raw Water Pre-Requisits	
Turbidity	≤ 15NTU
Oil & Grease	≤ 2mg/L
SS	≤ 10mg/L
Total Iron	≤ 1mg/L
Continuous Residual Chlorine	≤ 5ppm
COD	< 500mg/L

Application Data	
Operating Flux	50-120L/m^2.hr (1.5 Kg/cm^2, 25°C)
Backwash Flux	100-200L/m^2.hr (1.5 Kg/cm^2, 25°C)
Suggested Working Pressure	≤ 3 Kg/cm^2
Maximum Transmembrane Pressure	3 Kg/cm^2
Maximum Backwashing Pressure	3 Kg/cm^2
Air Washing Volume	0.1-0.15N m^3/m^2.hr
Air Washing Pressure	≤ 1 Kg/cm^2
Maximum Working Temperature	35°C
PH Range	Working: 4-10; Washing: 2-12
Operating Mode	Cross Flow or Dead End

Operating Parameters	
Backwashing Frequency	Every 30-60min.
Backwashing Duration	30-60s
CEB Frequency	0-4 times per day
CEB Duration	5-10min.
CIP Frequency	Every 1-3 months
Sterilization	15ppm Sodium Hypochlorite
Organic Pollution Washing	0.2% Sodium Hypochlorite + 0.1% Sodium Hydroxide
Inorganic Pollution Washing	1-2% Citric Acid/0.2% Hydrochloric Acid

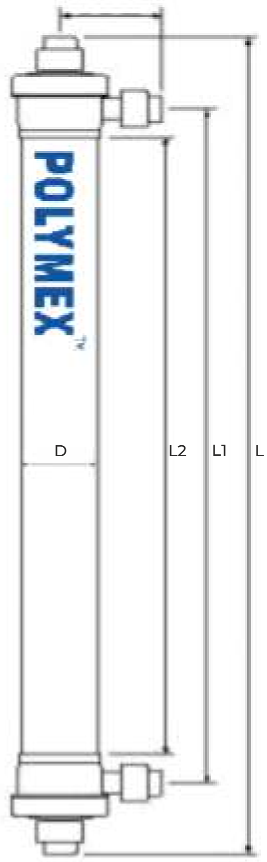
4.5 Polymex MX Series - Ultra Filtration Membrane

Product Description

Polymex Mx Series UF Membranes are used to treat a wide range of highly variable waters as either primarytreatment or as pretreatment to reverse osmosis (RO) and nanofiltration (NF). Comparedto conventional pretreatment and other UF membrane pre-treatment, Polymex Mx Series UF Membranesoffer the combined benefits of high recovery and low footprint requirement due to itsoptimized membrane area and novel cleaning regimes. High strength TIPS PVDFmembrane minimizes fiber breakage rate and ensures consistently superior filtrate quality,which enables RO and NF systems to be operated at higher fluxes, while maintaininglonger intervals between cleanings.

Product Highlights

- - Increased tensile and fatigue strength
- Increased chemical resistance
- Increased tolerance to chlorine, peroxide, ozone and other oxidants
- Air scour replaces traditional backwash
- No backwash pump nor ancillary equipment required.



Product Dimensions

Model	Length L, inch (mm)	Length L1 Inch(mm)	Length L2 Inch(mm)	Diameter D Inch(mm)
Mx 40	1365.00	1257.30	1135.50	250
Mx 60	1832.20	1724.70	1602.90	250
Mx 80	2340.60	2232.70	2110.90	250

Product Specifications

Model	Effective Membrane Area, ft^2 (m^2)	Flow Configuration	Flow L/H (1.5 Kg/cm^2, 25°C)
Mx 40	560(52)	Outside In	2600 – 6240
Mx 60	840(78)	Outside In	3900 – 9360
Mx 80	1130(105)	Outside In	5250 - 12600

Operating & Cleaning Limits

Filtration Performance	
Ingredient	Effect
SS, Particles > 1µm	Removal Rate = 99%
SDI	≤ 3
Bacteria, Viruses	> 4 log
Turbidity	< 1NTU
TOC	Removal Rate: 0-25%

Technical Parameters	
Filtering Type	Inside-Out
Membrane Material	PES
MWCO	100K Dalton
Membrane Area	$80m^3$ (861 ft^2)

Raw Water Pre-Requisits	
Turbidity	≤ 15NTU
Oil & Grease	≤ 2mg/L
SS	≤ 10mg/L
Total Iron	≤ 1mg/L
Continuous Residual Chlorine	≤ 5ppm
COD	< 500mg/L

Application Data	
Operating Flux	50-120L/m^2.hr (1.5 Kg/cm^2, 25°C)
Backwash Flux	100-200L/m^2.hr (1.5 Kg/cm^2, 25°C)
Suggested Working Pressure	≤ 3 Kg/cm^2
Maximum Transmembrane Pressure	3 Kg/cm^2
Maximum Backwashing Pressure	3 Kg/cm^2
Air Washing Volume	0.1-0.15N m^3/m^2.hr
Air Washing Pressure	≤ 1 Kg/cm^2
Maximum Working Temperature	35°C
PH Range	Working: 4-10; Washing: 2-12
Operating Mode	Cross Flow or Dead End

Operating Parameters	
Backwashing Frequency	Every 30-60min.
Backwashing Duration	30-60s
CEB Frequency	0-4 times per day
CEB Duration	5-10min.
CIP Frequency	Every 1-3 months
Sterilization	15ppm Sodium Hypochlorite
Organic Pollution Washing	0.2% Sodium Hypochlorite + 0.1% Sodium Hydroxide
Inorganic Pollution Washing	1-2% Citric Acid/0.2% Hydrochloric Acid

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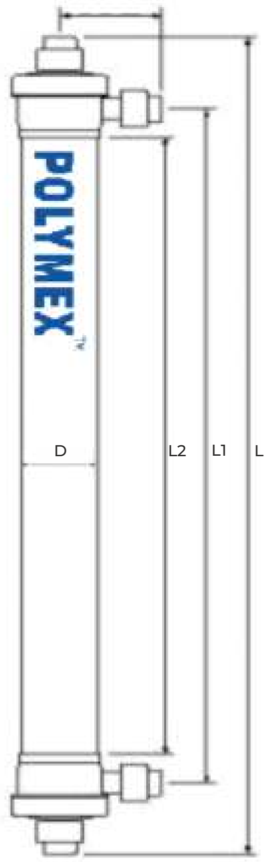
4.6 Polymex ZW Series - Ultra Filtration Membrane

Product Description

Polymex ZW Series UF Membranes are used to treat a wide range of highly variable waters as either primarytreatment or as pretreatment to reverse osmosis (RO) and nanofiltration (NF). Comparedto conventional pretreatment and other UF membrane pre-treatment, Polymex Mx Series UF Membranesoffer the combined benefits of high recovery and low footprint requirement due to itsoptimized membrane area and novel cleaning regimes. High strength TIPS PVDFmembrane minimizes fiber breakage rate and ensures consistently superior filtrate quality,which enables RO and NF systems to be operated at higher fluxes, while maintaininglonger intervals between cleanings.

Product Highlights

- - Increased tensile and fatigue strength
- Increased chemical resistance
- Increased tolerance to chlorine, peroxide, ozone and other oxidants
- Air scour replaces traditional backwash
- No backwash pump nor ancillary equipment required.



Product Dimensions

Model	Length L, inch (mm)	Length L1 Inch(mm)	Length L2 Inch(mm)	Diameter D Inch(mm)
ZW 700B	66.22(1682)	62.83(1596)	59.05(1500)	9.84(250)

Product Specifications

Model	Effective Membrane Area, ft^2 (m^2)	Flow Configuration	Flow L/H (1.5 Kg/cm^2, 25°C)
ZW 700B	646(60)	Outside in	3000 - 7200

Operating & Cleaning Limits

Filtration Performance	
Ingredient	Effect
SS, Particles > 1µm	Removal Rate = 99%
SDI	≤ 3
Bacteria, Viruses	> 4 log
Turbidity	< 1NTU
TOC	Removal Rate: 0-25%

Technical Parameters	
Filtering Type	Inside-Out
Membrane Material	PVDF
MWCO	100K Dalton
Membrane Area	80m^3 (861 ft^2)

Raw Water Pre-Requisits	
Turbidity	≤ 15NTU
Oil & Grease	≤ 2mg/L
SS	≤ 10mg/L
Total Iron	≤ 1mg/L
Continuous Residual Chlorine	≤ 5ppm
COD	< 500mg/L

Application Data	
Operating Flux	50-120L/m^2.hr (1.5 Kg/cm^2, 25°C)
Backwash Flux	100-200L/m^2.hr (1.5 Kg/cm^2, 25°C)
Suggested Working Pressure	≤ 3 Kg/cm^2
Maximum Transmembrane Pressure	1.5 Kg/cm^2
Maximum Backwashing Pressure	2 Kg/cm^2
Air Washing Volume	0.1-0.15N m^3/m^2.hr
Air Washing Pressure	≤ 1 Kg/cm^2
Maximum Working Temperature	35°C
PH Range	Working: 4-10; Washing: 2-12
Operating Mode	Cross Flow or Dead End

Operating Parameters	
Backwashing Frequency	Every 30-60min.
Backwashing Duration	30-60s
CEB Frequency	0-4 times per day
CEB Duration	5-10min.
CIP Frequency	Every 1-3 months
Sterilization	15ppm Sodium Hypochlorite
Organic Pollution Washing	0.2% Sodium Hypochlorite + 0.1% Sodium Hydroxide
Inorganic Pollution Washing	1-2% Citric Acid/0.2% Hydrochloric Acid

Part 5

Basics of RO, NF & UF Membranes

5.1 Separation Technologies and Filtration Processes

The main difference among these four membranes is their pore size. The pore sizes of the RO membrane, NF membrane, UF membrane, and MF membrane are 0.1-1μm, 1-10μm, 10-100μm, and 100-1000μm, respectively. Reverse osmosis is mainly used for desalination, while nanofiltration is mainly used to trap divalent ions and separate larger molecules. Microfiltration is mainly used to trap suspended particles, bacteria, viruses, etc.. All four membranes allow water molecules to pass through.

Microfiltration (MF)

Microfiltration removes particles in the range of approximately 0.1-5 microns. In general, suspended particles and large colloids are effectively removed. Microfiltration membranes are typically used to remove bacteria, flocculated materials, or TSS (total suspended solids). Transmembrane pressures are typically 10-70 psi (0.7-4.8 Kg).

Ultrafiltration (UF)

Ultrafiltration is a low-pressure molecular separation for particles ranging in size from approximately 20-1,000 Angstroms (0.002-0.1 micron). All dissolved salts and smaller molecules pass through the membrane. Items rejected by the membrane include viruses, proteins, pyrogens, colloids, and macromolecules. Transmembrane pressures are typically 15-100 psi (1-7 Kg)

Nanofiltration (NF)

Nanofiltration (NF) is a specialty membrane process which rejects particles in the approximate size range of 1 nanometer (10 Angstroms), hence the term "nanofiltration". NF operates in the realm between UF and reverse osmosis. Organic molecules with molecular weights greater than 200-400 are rejected by nanofiltration membranes. Compared to UF, NF membranes have a high rejection rate for inorganic salts. Compared to RO membranes, NF membranes can be operated at lower pressure. They (e.g., calcium and magnesium sulphate) have higher rejections of 90-99%. Typical applications include removal of color and total organic carbon (TOC), softening (removal of hardness), removal of heavy metals, removal of pesticides, removal of nitrate, removal of soluble salt, food concentration and separation of useful medical substances. Transmembrane pressures are typically 50-200 psi (3.4-13.8 Kg).

Reverse Osmosis (RO)

Reverse osmosis is the most sophisticated membrane liquid separation technology. It can block all soluble salts and organics with a molecular weight greater than 100. RO membranes are typically thin-film composite membranes. They have a separation ability of 99% and can be applied in seawater and brackish water desalination, boiler feed water, industrial pure water, and electronic grade water production, as well as pharmaceutical concentration separation and special separation processes.

5.2 Principles of Reverse Osmosis and Nanofiltration

How Reverse Osmosis (RO) Works

The phenomenon of osmosis occurs when pure water flows from a dilute saline solution through a membrane into a higher concentration saline solution. This flow continues until the chemical potential equilibrium is reached. If a pressure greater than the membrane is permeable to some species, and not permeable to others, assume that this membrane is permeable to water, but not to the dissolved salts, and that there is a higher concentration on one side of the membrane. This pressure is the force which causes water to flow through it to the other side. But salt cannot pass through the membrane.

Osmotic Pressure

Water diffuses through a semi-permeable membrane toward the region of higher concentration until the pressure of the two solutions balances the osmotic pressure difference. The osmotic pressure is the pressure that stops water from flowing. Reverse osmosis is the reverse process of this natural phenomenon. If a pressure greater than the osmotic pressure is applied to the side of the membrane with the higher concentration, the water molecules in the concentrated side move to the dilute side in the opposite direction under the pressure, and enter the low-concentration side, leaving ions and suspended solid matter. The purified water thus passes through the membrane. Reverse osmosis separation is a physical process that uses membrane technology to separate dissolved solids and other side of the membrane together with dissolved solids and suspended solids in called concentrated water, brine, or wastewater.

The Principles of Reverse Osmosis

Reverse osmosis operating pressure is applied on the feed water (high concentration solution) to overcome the natural osmotic pressure. When the operating pressure is higher than the natural osmotic pressure, water is applied to the high concentration side and starts to move toward the low concentration side (dilute solution). The water molecules in the feed water pass through the membrane to become purified water on the side of the dilute solution.

How Nanofiltration Works

There is no obvious boundary between nanofiltration and reverse osmosis. Nanofiltration membranes are not a perfect barrier to dissolved salts or solutes. The level of penetration of these solutes through the nanofiltration membrane depends on the salt or solute and the properties of the nanofiltration membrane. The higher the solute penetration, the higher the osmotic pressure is on the nanofiltration membrane. The higher the solutes' penetration, the closer it is to the reverse osmosis process. On the contrary, if the penetration is higher, the osmotic pressure on the nanofiltration membrane is lower, and the influence of osmotic pressure on the nanofiltration process is smaller.

Definitions

Recovery

Recovery is the percentage of feedwater that emerges from the membrane system as product water or "permeate." Membrane system design is based on the feedwater quality, and recovery can be set by adjustment controlling of concentrate stream. Recovery is often fixed at the highest level that maximizes permeate flow while preventing precipitation of super-saturated salts within the membrane system.

Rejection

The percentage of solute concentration removed by the membrane from the feedwater. In reverse osmosis, a high rejection of total dissolved solids (TDS) is important, while in nanofiltration, the solutes of interest are specific, e.g., low rejection for hardness and high rejection for organic matter.

Flow Rate

Feed flow rate is the rate of feedwater introduced to the membrane element or membrane system, usually measured in gallons per minute (gpm) or cubic meters per hour (m^3/h). Concentrate flow is the rate of flow of non-permeated feedwater that exits the membrane element or membrane system. The concentrate contains most of the dissolved constituents originally fed into the element or into the system from the feed source. It is usually measured in gallons per minute (gpm) or cubic meters per hour (m^3/h)

Flux

The flow rate of permeate per unit membrane area is usually expressed in liters per square meter per hour (L/m^2h) or gallons per square foot per day (gfd).

Impact from Pressure

Water molecules pass through the flux and rejection rate of RO and NF membranes. We know that permeation refers to the flow of water molecules from the dilute solution side to the concentrated side through the membrane. Reverse osmosis and nanofiltration overcome natural osmotic pressure by applying pressure on the concentrated side. When the operating pressure is higher, the osmotic pressure is applied to the concentration side, the natural permeation flow direction of water molecules will be reversed, and part of the concentration will pass through the membrane to become purified water on the filtration side. Both RO and NF membranes cannot completely intercept the soluble salts in the feedwater; there is always a certain amount of permeation. With the increase of pressure, the rate of water permeation is faster than the rate of salt transfer through the membrane. The increase in salt permeability is only very obvious. However, there is an upper limit for increasing the salt rejection rate by increasing the inlet water pressure. If the pressure exceeds a certain value, the salt rejection rate will no longer increase, and some salt will also pass through the membrane together with water molecules.

5.3 Factors affecting RO, NF & UF Performance

Temperature

The water conductivity of the membrane system is very sensitive to changes in the temperature of the feedwater. With the increase of water temperature, the water flux increases almost linearly, which is mainly due to the decrease of the viscosity of the water molecules passing through the membrane and the increase of the diffusion capacity. Increasing the water temperature will cause the salt rejection rate of the membrane permeate rate to increase. This is mainly because the salt diffusion rate through the membrane will be accelerated due to the increase in temperature.

pH

The pH value also has a certain effect on the conductivity of the product water. This is because the reverse osmosis membrane itself mostly contains some active groups. The pH value can affect the electric field on the membrane surface and thus the migration of ions. In addition, the pH value has a direct effect on the form of impurities in the feedwater. For example, the rejection rate of dissociable organic matter decreases with the decrease of pH value. The dissolved CO_2 in water is greatly affected by the pH value. When the pH value is low, it will be in the form of CO_2 gas, and it will be easy to permeate the reverse osmosis membrane. When the pH is low, the rejection rate will be lower. When the pH increases, the dissolved CO_2 will be converted into HCO_3 and Co_3, and the rejection rate will gradually increase. When the pH is between 7.5 and 8.5, the rejection rate reaches the highest.

Feedwater Salt Concentration

Osmotic pressure is a function of the concentration and type of salt or organic matter in the water. As the salt concentration increases, the osmotic pressure also increases. Therefore, the driving pressure of the feedwater that needs to reverse the direction of natural osmotic flow also depends on the salt content of the feedwater. If the pressure is kept constant, the higher the salt content, the lower the flux. The increase in osmotic pressure offsets the driving force of the feed flow, resulting in a decrease in water flux and an increase in salt permeate through the membrane.

Recovery

The reverse osmosis process is realized by applying pressure to the feedwater when the natural osmotic flow direction between the concentration side and the dilute side is reversed. If the recovery rate increases (constant inlet pressure), the residual salt content in the membrane will be higher, and the natural osmotic pressure will continue to increase until it is the same as the applied pressure, which will offset the push of the inlet pressure and slow down or stop reverse osmosis. The process reduces or even stops the membrane flux.

The concentrated water must have a large flow enough to take away impurities and prevent mechanical blockage or precipitation on the feedwater side of the membrane. In order to facilitate system operation, the ratio between product water and feedwater is usually used as an important operating parameter.

This ratio is called the "recovery rate" and is usually expressed as a percentage. For example, if the feedwater flow rate of the RO system is 100m^3/hr and the product water flow rate is 75m^3/hr, the recovery rate is 75%. The remaining 25m^3/hr that has not passed through the membrane is the concentrated water, which is usually discharged.

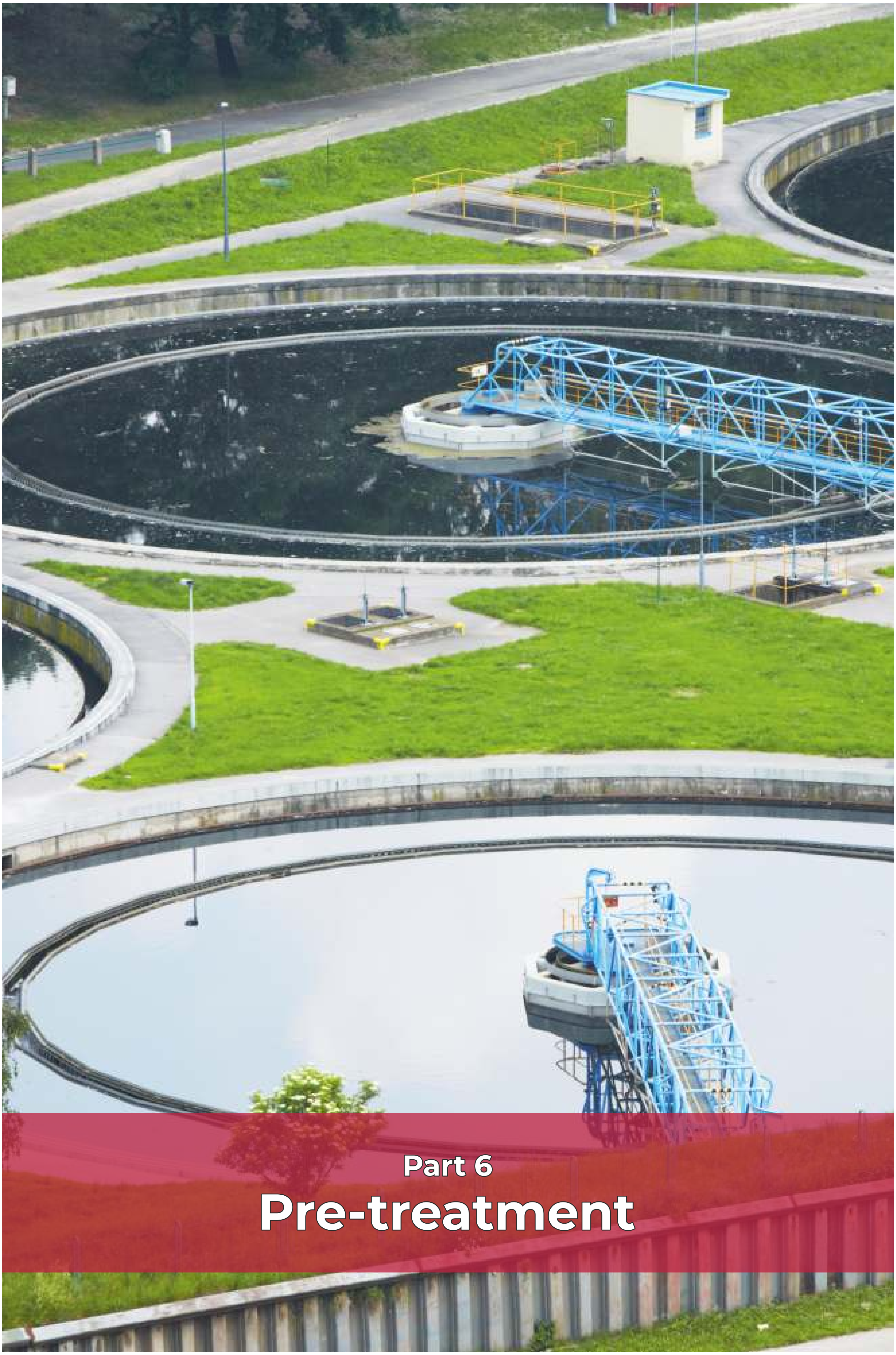
The recovery rate is defined mathematically as:

Recovery rate (%) = {Permeate water flow} X 100 / {Feedwater flow}

The sum of permeate water flow and concentrated water flow equals the feedwater flow:

{Feedwater flow} = {Permeate water flow} + {Concentrated water flow}

Depending on the specific application, the recovery rate of the reverse osmosis system is usually between 70% and 80%. If the feedwater TDS is high, a lower recovery rate is required. On the contrary, if the feedwater TDS is low, a higher recovery rate can be used.



Part 6

Pre-treatment

RO or NF membrane elements are mainly used to remove dissolved solids, such as salts. If the feedwater contains suspended solids, these suspended solids will be trapped by the cartridge filter and some of them will accumulate inside the element. If the feedwater contains dissolved solids, these solids will be deposited in the membrane element during normal operation. The membrane itself may also be susceptible to contamination and chemical attack. Therefore, proper pretreatment is extremely important to improve the efficiency of membrane filtration and extend the service life of the membrane. The purpose of pretreatment is to remove or prevent fouling of membrane elements, prevent membrane performance degradation, and reduce membrane cleaning frequency as much as possible.

6.1 Definition

Scaling

When the concentration of the dissolved solids exceeds its solubility limit, the impurities will be deposited on the surface of the membrane. This phenomenon is fouling. In natural water bodies, the impurities most likely to lead to scaling are calcium carbonate ($CaCO_3$), calcium sulphate ($CaSO_4$), barium sulphate ($BaSO_4$), strontium sulphate ($SrSO_4$), and silicates. Scaling usually occurs first on the downstream membrane elements, due to the higher salt content in the downstream concentrated stream.

Water Analysis

Laboratory Name				**Inspector**			
Sampling time				Date			
Item		mg/L	mmol/L	Item		mg/L	mmol/L
Cation	K+			Anion	Cl^-		
	Na^+				SO_4^{2-}		
	Ca^{2+}				HCO_3^-		
	Mg^{2+}				CO_3^{2-}		
	NH^{4+}				NO_2^-		
	Fe^{3+}				NO_3		
	Al^{3+}				F^-		
	Fe^{2+}				OH^-		
	Ba^{2+}						
	Sr^{2+}						
	Total				Total		
Item		Content		Item		Content	
Total hardness		mmol/L		Total Solids		mg/L	
Non-carbonate hardness		mmol/L		Dissolved Solids		mg/L	
Carbonate hardness		mmol/L		Suspended Matter		mg/L	
Total alkalinity (Methyl Orange Alkalinity)		mmol/L		All Silicon		mg/L	
Phenolphthalein alkalinity		mmol/L		Active Silicon		mg/L	
Turbidity (NTU)				COD(O_2)		mg/L	
Conductivity (25°C)		μS/cm		pH			
Other		Odor, Colour, Biological Activity, Number of Bacteria, Specifications (such as boron ion), etc.					

Membrane Degradation

The degradation of membrane performance, caused by the change of membrane chemical properties, is called membrane degradation. Oxidizing agents such as hypermanganate, persulfate, and hexavalent chromium, or high or low pH during the cleaning process may cause membrane degradation.

Fouling

Fouling refers to the degradation of membrane performance caused by the deposition or adsorption of impurities on the membrane surface. This type of pollution is usually more serious in upstream membrane elements. Fouling is manifested as a moderate to severe decrease in flux, an increase in salt permeability, and an increase in system pressure drop.

6.2 Feedwater Types and Analysis

The major water types being treated by RO/NF can be roughly characterized by the total dissolved solids (TDS) content and the organic load (Total organic carbon, TOC):

- Very-low-salinity, high-purity water (HPW) coming from the first RO systems (double-pass RO system) or the polishing stage in ultrapure water (UPW) systems with TDS of 0-50mg/L.
- Low-salinity groundwater with TDS up to 500mg/L.
- Medium-salinity groundwater with high natural organic matter (NOM) and TDS up to 5,000mg/L.
- Medium-salinity high TDS water with TDS up to 5,000mg/L.
- Medium-salinity tertiary wastewater with high TDS and biological oxygen demand (BOD) level; TDS up to 5,000mg/L.
- High-salinity brackish waters with TDS in the range of 5,000-15,000mg/L.
- Seawater with TDS in the range of 35,000mg/L.
- Special feedwater.

Different types of water sources correspond to different pre-treatments and different types of membrane elements. For small engineering projects that do not have water quality analysis or test conditions, the design can be made with reference to the pre-treatment of the same type of water source that has been put into operation. Medium- or large-scale engineering projects must have a full analysis of the feedwater quality.

6.3 Feed Water Quality Index

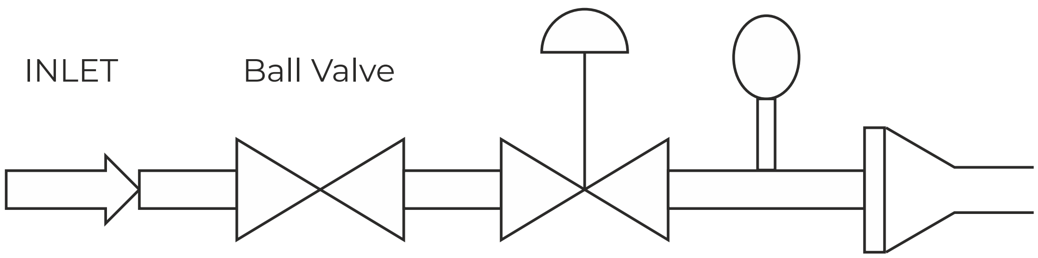
SDI

The steps to measure SDI are:

- Place the membrane filter carefully on its support.
- Load the microfiltration membrane into the test filter and stabilize the pressure of the feedwater within 2kg/cm^2 (30psi).

Note: Place the membrane in the filter in a positive direction, and use a small amount of clean water to completely wet the diaphragm. No air bubbles are allowed under the membrane, and the tester should avoid affecting the test results.

- Place a 500ml graduated cylinder under the test, ready to collect filtered water.
- Open the valve, measure the time it requires to collect a 500ml water sample, and keep the water flowing.
- After 15 minutes, measure the time required to collect a 500ml water sample (T15). If the time to collect a 100ml water sample exceeds 60 seconds, it indicates that the membrane surface is blocked, and no further testing is required. Close the valve and remove the membrane from the test filter for further analysis. Calculation formula: SDI = [1-(T1/T15)] X100 / T1.



Apparatus for measuring the silt density index

Temperature

The temperature of the feedwater is an important factor that affects the water production of the reverse osmosis/nanofiltration system. For feedwater with a lower temperature, appropriate measures can be taken to adjust it. According to requirements, feedwater with too high a temperature is not conducive to operating the membrane system. High temperatures can cause serious harm to the performance of the membrane elements. In the daily operation of the system, the maximum temperature of reverse osmosis/nanofiltration feedwater is required to be ≤45°C

pH

Adjusting pH is the easiest way to control calcium carbonate scaling. By measuring and calculating the L.I. (Langelier Index) value or S.I. (Saturation Index) value, the scaling of calcium carbonate can be judged. Scaling of calcium carbonate is a major concern; too low or too high pH can cause membrane damage. In the daily operation of the system, the reverse osmosis membrane continuously operates in the pH range of 2-11, and the nanofiltration membrane continuously operates in the pH range of 3-10.

COD & BOD

In water treatment, two indicators, chemical oxygen demand (COD) and biochemical oxygen demand (BOD), are generally used to express the content of organic matter in the water. There are many types of organic species in nature, and the organic components in water are mainly humic acid, surfactants, microorganisms, pesticides, etc.

Chemical oxygen demand (COD) is the amount of oxidant consumed when a certain strong oxidant is used to treat water samples.

under certain conditions. it is an indicator of the amount of reducing substances in the water. The reducing substances in water include organic substances, nitrites, sulfides, ferrous salts, etc. But the main ones are organic substances. Chemical oxygen demand (COD) is often used as an indicator to measure the amount of organic matter in the water. Biochemical Oxygen Demand (BOD) is the total amount of dissolved oxygen consumed in the water when organic matter in water undergoes oxidative decomposition by the microorganisms. BOD is an indicator to measure microorganisms (bacteria, etc.) in water (mg/L). At present, the oxygen consumed by the culture time at 20°C for 5 days is generally used as an indicator, which is called BOD5.

BOD is a nutrient source for the growth of microorganisms. When microorganisms enter the membrane system, they will be adsorbed or multiplied on the membrane surface, especially on the concentration side due to the large accumulation of organic matter and trace nutrients.In the daily operation of the membrane system, it is recommended that the COD in the reverse osmosis membrane system feedwater is less than 15ppm.

Oxidant

Since the reverse osmosis/nanofiltration membrane material itself cannot withstand oxidants, free chlorine, perchlorate, persulfate, hexavalent chromium, peroxide, ozone, and other oxidizing substances must be removed from the feedwater. The feedwater can be added with sodium bisulfite to remove oxidizing substances.

Chemical Pollutants

The feedwater of the reverse osmosis/nanofiltration membrane must not contain cationic polymer flocculants, cationic surfactants, epoxy resin coatings, and anion exchange resins. These chemicals will form chemical pollution on the membrane surface and cause the membrane elements to be fouled. Before the water enters into reverse osmosis/nanofiltration membrane system, such chemical pollutants need to be removed by pretreatment.

Water Quality Index of Reverse Osmosis / Nanofiltration Membrane

	Item	RO	NF
1	Turbidity	<1NTU	<1NTU
2	SDI	<5	<5
3	pH	2-11	2-11
4	Temperature	5-45°C	5-45°C
5	COD	<15ppm	<15ppm
6	Free chlorine	<0.1ppm, 0	<0.1ppm, 0
7	Iron	<0.05ppm	<0.05ppm
8	Manganese	<0.1ppm	<0.1ppm
9	Surface activity, detergent, oil, etc	Not detectable	Not detectable

6.4 Common Pre-treatment Methods

Due to different water sources, the pretreatment methods are different. In order to ensure the quality of the feedwater, different treatment units must be effectively combined for different water qualities to form a technically feasible and economically reasonable pretreatment system.

Chemical Oxidation

The chemical oxidation pretreatment method is usually a chemical treatment method that uses strong oxidants to oxidize and decompose organic pollutants in water. At the same time, some oxidants can remove color, taste, odor, iron, phenol, algae, and other substances in the water. Certain oxidants can also remove fungicides. The chemical oxidation treatment process can be combined with treatment units such as coagulation, filtration, and adsorption to achieve good treatment effects.

The majority of oxidants commonly used in industrial water treatment include chlorine, sodium hypochlorite, chlorine dioxide, potassium permanganate, ozone, hydrogen peroxide, and other inorganic permanganate. Reverse osmosis membranes and polypiperazine nanofiltration membranes are easily oxidized by oxidants. If the oxidation process is used in the pretreatment, it is necessary to use a corresponding reduction means to prevent residual oxidants from entering the membrane system and causing oxidative damage to the membrane.

Chemical Pollutants

Chemical softening is the process of using the principle of chemical precipitation to remove the hardness contained in the water under the action of an appropriate medication to form insoluble compounds and be removed according to the principle of solubility product. The most commonly used method in water treatment is the combined precipitation of calcium and magnesium ions. However, the application of other methods or medications, agents, and other means can also be combined with coagulation, precipitation, or clarification processes at the same time.

Softening agents used in water treatment plants are mainly lime, soda ash, caustic soda, trisodium phosphate, disodium hydrogen phosphate, etc. According to different types of feedwater quality, different agents can be used for treatment. Generally, the lime softening method is used for water with high hardness and high alkalinity, and the lime-soda ash method is used for water with high hardness and low alkalinity. The lime-gypsum method is used for water with negative hardness (where the total alkalinity is greater than the total hardness).

When chemical agents are used to soften, the dosage of agents must be correct. After the water is softened with the agent, the pH value of the water will generally increase. The pH value must be restored to its appropriate value; over-dosing may cause scaling. The simple lime softening method mainly removes the hardness of carbonate in the water and reduces the alkalinity of the water. It is worth noting that excessive addition of lime will increase the hardness of the water. The lime-soda method can simultaneously remove carbonate hardness and non-carbonate hardness. The further it removes carbonate hardness and the latter removes non-carbonate hardness. This method is suitable for water with hardness greater than alkalinity.

Ion Exchange Softening

This method is based on the principle of ion exchange, which matches the calcium and magnesium ions in the water react with the cations (Na+, H+) in the exchanger to remove the hardness. These preventing calcium and magnesium scaling. During the exchange process, the structure of the resin itself does not change. The ion in the solution diffuses into the molecular structure of the resin for exchange, and the exchanged ions diffuse into the solution in the same way.

Ion exchange resins are divided into cation exchange resins and anion exchange resins. The resin used to remove calcium and magnesium hardness includes Na-type and Na-type strong acid cation exchange resins.

Na-type ion exchange softening is suitable for occasions where the alkalinity of the raw water is low, and the alkalinity removal is not required for softening. At this time, the alkalinity remains unchanged and the salt content of the soft water slightly increases. The strong acid sodium exchange system is generally for raw water with a total hardness of less than 5mol/L. When the hardness of the softened effluent exceeds the limit, it needs to be regenerated in time to avoid hardness leakage. H-type weak acid resin can only remove the hardness of carbonate, and the softening is not complete. In order to remove both hardness and alkalinity, H-Na ion exchange system can be used for joint treatment.

Coagulation Flocculation

Coagulation refers to the addition of a certain amount of chemical agents to the water. These chemical agents are hydrolyzed in the water to form colloids, which are particles in the water and electrically neutralize, produce adsorption, bridging, and net trapping, whereby coagulating small suspended solids and colloidal particles and settlements from the water are achieved. When the coagulant alone cannot achieve the expected effect, an auxiliary agent can be added to improve the coagulation effect. This is because auxiliary coagulation aids improve the hydrophobicity and aggregation of the floc, thus improving the structure of the flocs and making the flocs larger, stronger, and heavier. Therefore, the use of coagulant alone cannot achieve good results. There are many types of coagulants commonly used in industry. Generally, inorganic salt coagulants and organic polymer coagulants are commonly used in industrial wastewater treatment, and mainly include ferric chloride and ferrous sulfate, inorganic polymer coagulants mainly include basic aluminum chloride (PAC), polyferric sulfate (PFS) and polyaluminium sulfate (PAS), among them, ferric chloride and basic aluminum chloride are the most commonly used.

The coagulation of the feedwater will be affected by many factors such as pH, water temperature and water quality. The selection of the appropriate coagulant and dosage should be determined in conjunction with a small-scale ring-burning experiment.

Since the surface of most aromatic polyamide reverse osmosis membranes and polyperazine nanofiltration membranes is negatively charged as a whole, if an excessive amount of cationic coagulant or coating is added in the pretreatment process, then the excess cationic coagulant will enter the membrane surface, causing ion pollution of the membrane. At this time, the reverse osmosis/nanofiltration system will result in a drop in water production, and a rise in pressure drop, and ionic fouling can be difficult to reverse. Therefore, effective measures must be taken to monitor the accurate dosage of coagulant and coagulant aid and the control of the pH range.

Media Filtration

Media filtration refers to the use of quartz sand, garnet, or anthracite as the media to allow water to pass through the bed composed of these media under gravity or pressure, while the particulate pollutants in the water are blocked by the media to achieve the process of separation from the water. Granular media filtration is based on the "filtration-clarification" working process to remove particles, suspended solids, and other impurities in water.

Common types of filtration in water treatment include co-current single filter filtration and counter-current filtration. In order to improve the performance of media filtration, the following methods can usually be used. First of all, a variety of media layered filtration is adopted. In downward filtration, the media layer from top to bottom is usually arranged as anthracite, quartz sand, and pebbles with particle size. This form of filtration can increase the filtration flow rate and the efficiency of the filter, and also effectively reduce the frequency of backwash. Secondly, the filter material and water must be able to mutually backwash and react as they flow through the gaps of the sand column. When the floc generated reaches a certain volume, they are trapped in the sand column gaps. These trapped flocs will adhere to the sand surface and increase the water clarity. Next, it is necessary to clean the impurities of the filter material. After running this for certain time, flocculated pollutants are flushed with reverse flushing.

Activated Carbon Absorption

Activated carbon adsorption is a method that uses the porous nature of activated carbon to adsorb one or more harmful substances in water to the solid surface and remove it. The activated carbon adsorption has a good effect on removing organic colloids, microorganisms, residual chlorine, odor, etc., in water. At the same time, activated carbon absorption has certain reduction effect; it also has a good effect on removing oxidants in water.

Commonly used activated carbon includes powdered and granular activated carbon, and granular activated carbon is more commonly used as a reverse osmosis membrane pretreatment.

Because the adsorption of activated carbon has a certain saturation value, when the adsorption is saturated, the adsorption capacity of the activated carbon will be greatly reduced, so it is necessary to pay attention to the timeliness of the adsorption capacity of activated carbon, timely replacement of activated carbon or high-pressure steam for disinfection and recovery. But at the same time, the organic matter adsorbed on the surface of activated carbon may become a nutrient source or hotbed for bacterial reproduction. Therefore, the reproduction of microorganisms in the activated carbon filter is also worthy of attention. Regular disinfection is necessary to control the growth of bacteria.

Disc Filter

The disc filter is a parallel combination of filter units, which are composed of a group of ring-shaped reinforced plastic filter discs with grooves or ribs. When filtering, sewage enters from the outside, and the rim formed by the edge of the groove on the adjacent filter disc intercepts the solid in the water. When backwashing, the water flows from the inside of the annular filter disc to the outside, which rinses down the trapped dirt on the filter disc and discharges through the sewage outlet. The disc filter has the characteristics of large processing capacity, stable operation, and easy control.

At present, it is mostly used in the pretreatment of ultrafiltration to ensure the security for the ultrafiltration.

MF/UF

Microfiltration/ultrafiltration is a separation process driven by pressure, which can remove almost all suspended substances and some dissolved organic substances in water. The specific removal effect depends on the molecular weight of organic substances and the cut-off molecular weight of the ultrafiltration membrane.

Microfiltration/ultrafiltration not only has good equipment quality (SDI value can generally be controlled below 3), but also can greatly improve the stability of system operation and reduce the frequency of the chemical cleaning of reverse osmosis/nanofiltration.

Cartridge Filtration

A cartridge filter, with an absolute pore size of less than 10μm, is the suggested minimum pretreatment required for every RO system. It is a safety device to protect the membrane and the high-pressure pump from suspended solids. Usually it is the last step of a pretreatment sequence. A pore size of 5μm is recommended. Backwashable filters as final safety filters are generally not recommended because of their risk of breakthrough in case of a malfunction during backflush mechanism, their lower efficiency, and the higher soluble impurity volume when fine particles must be upstream of the membrane filters to protect them. They are, however, suitable for disposable cartridge filters. The cartridge filter should be made of a synthetic non-degradable material (e.g., nylon or polypropylene) and equipped with a pressure gauge to indicate the differential pressure, thereby indicating the extent of fouling. Regular inspections of inlet cartridges provide useful information regarding fouling mode and cleaning requirements.

6.5 Common Water Source Pre-treatment System

Surface Water

Surface water is usually complex in composition, especially in suspended matter, colloidal matter, organic matter, and microorganisms. The usual pretreatment process for this kind of water source is:

- For suspended solids content in raw water >10mg/L, pre-treatment usually adopts coagulation, clarification & direct filtration.
- For suspended solids content in raw water 1-10mg/L, pre-treatment usually adopts coagulation.
- For suspended solids content in raw water <1mg/L, pre-treatment usually adopts direct filtration.

Ground Water

Groundwater generally has higher hardness and alkalinity; less colloids and suspended solids; lower color and turbidity; but such water sources may contain ferrous, manganese ions, and silicic acid compounds.The conventional treatment process of this kind of water source pre-treatment system is:

- When the iron content in the raw water is less than 0.1mg/L, the pre-treatment is usually direct filtration + coagulation.
- When the iron content in the raw water is greater than 0.3mg/L, the pre-treatment is usually aeration + oxidation + coagulation + filtration.
- When the raw water contains a large amount of SiO_2, which can be removed by adding acid to remove CO_2 and adding a scale inhibitor to prevent the scaling of slightly soluble salts on the membrane surface;
- When the content of silica in the raw water is above 20mg/L, removal measures must be considered. Silica scale can be prevented by adjusting pH and temperature, etc.

Reuse Water

Reclaimed water generally has higher COD, BOD, colloids, and suspended solids. Sometimes the alkalinity and hardness are also higher. The water quality is generally complicated. Generally, a corresponding treatment process is selected according to the type of reclaimed water. After the adoption of RO, it is necessary to further remove organic matter in the water before entering reverse osmosis/nanofiltration. Generally, aerated biological filter, activated carbon filtration, ultrafiltration and other treatment processes are commonly used.

For the recycled water with high colloidal and suspended solids, coagulation, clarification, direct filtration and other treatment processes are generally used.

Due to the complexity of the water quality of the recycled water, there are many potential pollution factors to the membrane. If there is no experience in similar water quality operation, it is recommended to conduct a pilot or small test first.

Sea Water

The salt content in seawater is various and relatively high. There are much suspended matter, organic matter, microorganisms, colloids, and other substances, and the turbidity and color are relatively high. The treatment process of the usually selected pretreatment system is:

- Chlorine or sodium hypochlorite sterilization and algae killing.
- Coagulation, clarification, filtration to remove suspended solids and colloidal substances.
- Add acid and scale inhibitor to prevent carbonate and sulphate from scaling on the membrane surface.
- When the raw water contains more microorganisms and microorganisms, chlorination, coagulation, clarification, filtration, and activated carbon adsorption filtration are usually used.

6.6 Insoluble Salt Prevents Scaling

Inorganic salt fouling is the most common type of pollution for reverse osmosis/nanofiltration membrane elements. Most water bodies in nature contain saturated insoluble salts, such as calcium carbonate, etc. If they enter the membrane element directly without treatment, the saturated salts will reach a supersaturated concentration under the action of reverse osmosis/nanofiltration concentration, forming scaling on the membrane surface. The LSI (Langelier Saturation Index) value and SDI (Silt Density Index) value can be used to indicate its fouling tendency. For concentrated water with a salt content of less than 10000ppm, the Langelier Index LSI is used to indicate the tendency of $CaCO_3$ scaling. For concentrated water with a salt content greater than 10000ppm, the Stiff and Davis saturation index method is used to indicate the tendency of $CaCO_3$ scaling. The index is calculated as follows: LSI = pHc - pHs; for TDS < 10000ppm, SDI = pHc - pHs; for TDS > 10000ppm

Compound	Molecular formula	Ksp	-LogKsp	Temperature
Aluminum hydroxide	$Al(OH)_3$	$3X10^{-34}$	33.5	25
Phosphoric acid	$AlPO_4$	$9.84x10^{-21}$	20	25
Barium carbonate	$BaCO_3$	$2.58x10^{-9}$	8.6	25
Barium sulfate	$BaSO_3$	$1.1x10^{-10}$	10	25
Calcium carbonate	$CaCO_3$	$3.36x10^{-9}$ / $6x10^{-9}$	8.5/8.2	25
Calcium fluoride	CaF	$3.45x10^{-11}$	10.5	25
Calcium phosphate	$Ca_3(PO_4)_2$	$2.07x10^{-33}$	32.7	25
Calcium sulfate	$CaSO_4$	$4.93x10^{-5}$	4.3	25
Ferrous hydroxide	$Fe(OH)_2$	$4.87x10^{-17}$	16.3	25
Ferrous sulfide	FeS	$8x10^{-19}$	18.1	25
Ferric hydroxide	$Fe(OH)_3$	$2.79x10^{-39}$	38.6	25
Hydrated iron phosphate	$FePO_4$ $2H_2O$	$9.91x10^{-16}$	15	25
Lead carbonate	$PbCO_3$	$7.4x10^{-14}$	13.1	25
Lead fluoride	PbF_2	$3.3x10^{-8}$	7.5	25
Lead sulfate	$PbSO_4$	$2.53x10^{-8}$	7.6	25
Magnesium Ammonium Phosphate	$MgNH_4PO_4$	$2.5x10^{-13}$	12.6	25
Magnesium carbonate	$MgCO_3$	$2.6x10^{-5}$ / $6.82x10^{-6}$	4.56/5.17	12/25
Magnesium fluoride	MgF_2	$7.1x10^{-9}$ / $5.16x10^{-11}$	8.15/10.3	18/25
magnesium hydroxide	$Mg(OH)_2$	$1.2x10^{-11}$/ $5.61x10^{-12}$	10.9/11.25	18/25
Magnesium Phosphate	$Mg_3(PO_{4)2}$	$1.04 x10^{-24}$	24	25
Manganese Hydroxide	$Mn(OH)_2$	$4x10^{-14}$/ $2x10^{-13}$	13.4/12.7	18/25
Strontium Carbonate	$SrCO_3$	$5.6x10^{-10}$	9.25	25
Strontium Sulfate	$SrSO_4$	$3.8x10^{-7}$	6.42	17.4
Zinc carbonate	$ZnCO_3$	$1.43x10^{-10}$	9.84	25

Note: pHc refers to the pH value of concentrated water while pHs refers to the pH value when $CaCO_3$ is saturated.

Add Scale Inhibitor

Adding scale inhibitor to raw water is a commonly used method of scale inhibition, which can effectively control the formation of scales such as carbonate, sulfate, and calcium fluoride. Most RO scale inhibitors from reputable manufacturers are organic acid and polyacrylate, and are effective in preventing scale. Some manufacturers have reported that the allowable feedwater SiO_2 in SiO_2 type scale inhibition can reach more than 50mg/L. The addition amount and its scale inhibition effect can be calculated according to the design software provided by the scale inhibitor manufacturer. Organic scale inhibitors may precipitate with the cationic polymer flocculants used for coagulation in pretreatment, causing fouling. All users in industrial treatment must pay attention, so excessive use should be avoided. When adding anionic scale inhibition, avoid adding or excessive addition of cationic polymer in the pre-treatment to prevent precipitation.

Add Acid

There is a tendency of $CaCO_3$ scaling in most water. For brackish water, Langelier Saturation Index (LSI) is used to judge, and for seawater, Stiff-Davis Stability Index (SDSI). Adding acid can remove CO_2 and HCO_3 in water. Acid is very effective in controlling calcium carbonate scaling. Hydrochloric acid and sulfuric acid are generally used, but the use of sulfuric acid will increase sulfate scaling. When the scale inhibitor is not used and only acid is used to prevent calcium carbonate from scaling, the LSI must be guaranteed to be negative. In practical engineering applications, a combination of acid addition and scale inhibitors is often used to prevent the generation of scales.

Sodium Ion Softening

Sodium ion exchange resin is used to soften Ca^{2+} , Ba^{2+}, and Sr^{2+}. This is suitable for small and medium brackish water treatment, but not suitable for seawater desalination systems. After the resin is saturated, it needs to be regenerated with NaCl to remove Ca^{2+}, Ba^{2+} and Sr^{2+}.This treatment does not change the pH of the feedwater; however, the CO_2 in the raw water will increase the conductivity of the product water through the RO membrane. Adding NaOH after softening to convert the CO_2 into carbonate that can be removed by the RO membrane can reduce the conductivity of the product water. Using strong cation exchange resins for softening can avoid carbonate scale and sulfate scale. However, regeneration consumes NaCl, and there is an environmental pollution problem. In addition, traditional ion exchange softening is used to remove Si, Ba, Sr, Ca, Mg, etc. from the water body, but it is not economical for treatment systems to treat large amounts of water.

Weak Acid Cation for Alkali

Weak acid cation resin is used to remove the bicarbonate (temporary hardness) of Ca^{2+}, Ba^{2+} and Sr^{2+} by H+ exchange. This method can achieve partial softening and is suitable for high-carbonate raw water. The chemical formula is HCO_3 + H = H_2O + CO. In order to improve the desalination rate, the raw water or RO product water can be degassed. The alkalinity of weak acid cation resin has the problem of residual hardness, and the pH value of the effluent varies widely, which affects the desalination effect of the membrane system.

Part 7

Membrane System Design

7.1 Guidelines for Membrane Element Design

The following design guidelines for membrane elements are based on empirical values summarized on the operation data of a large number of engineering projects with different types of water sources. The system design in accordance with these guidelines has a longer operating cycle and lower cleaning frequency. Note that these guidelines are a reference for designing the system and cannot be used as a promised warranty.

Feedwater Type		**RO Permeate Water**	**Tap Water**	**Ground / Softened Water**	**Surface Water**		**Waste Water**	
					MF/UF	Routine Treatment	MF/UF	Routine Treatment
Feedwater SDI		<1	<3	<3	<3	<5	<3	<5
Maximum Recovery Rate		30	20	19	17	15	13	10
Average Flux	GFD	21-25	16-20	14-20	13-18	12-16	8-13	7-12
	L/m^2h	36-43	27-34	24-34	22-28	20-27	13-21	11-20
Maximum Permeate Water Flux, GPD (m3/d)	4040 Membrane Elements	2400 (9.1)	2000 (7.6)	2000 (7.6)	1600 (6.1)	1500 (5.7)	1400 (5.3)	1200 (4.5)
	8040 Membrane Elements ($400ft^2$)	11000 (42)	9100 (34)	9100 (34)	7900 (30)	7200 (27)	6400 (24)	5700 (22)
	8040 Membrane Elements ($440ft^2$)	12000 (45)	10000 (38)	10000 (38)	8700 (33)	7900 (30)	7100 (27)	6300 (24)
Maximum Permeate Water Flux, GPD (m3/d)	4040 Membrane Elements	2 (0.5)	3 (0.7)	3 (0.7)	3 (0.7)	3 (0.7)	4 (0.9)	5 (1.1)
	8040 Membrane Elements ($400ft^2$)	10 (2.3)	13 (3.0)	13 (3.0)	13 (3.0)	15 (3.4)	18 (4.1)	20 (4.6)
	8040 Membrane Elements ($440ft^2$)	10 (2.3)	13 (3.0)	13 (3.0)	13 (3.0)	15 (3.4)	18 (4.1)	20 (4.6)
Maximum Permeate Water Flux, GPD (m3/d)	4040 Membrane Elements	16 (3.6)	16 (3.6)	16 (3.6)	16 (3.6)	16 (3.6)	16 (3.6)	16 (3.6)
	8040 Membrane Elements ($400ft^2$)	75 (17)	75 (17)	75 (17)	73 (16.6)	67 (15)	61 (14)	61 (14)
	8040 Membrane Elements ($440ft^2$)	75 (17)	75 (17)	75 (17)	73 (16.6)	67 (15)	61 (14)	61 (14)

7.2 Steps for Membrane System Design

Consider the Source and Quality of Feedwater, the Flow of Feedwater and Product Water, and the Required Product Water Quality

The design of the membrane system depends on the raw water to be treated and the purpose of the treated water. Therefore, it is necessary to first collect system design data and raw water analysis reports in detail.

Select System Arrangement and Number of Stages

The conventional water treatment system arrangement is the one-pass feedwater, while the concentrated water circulation arrangement is often used in the treatment of more difficult feedwater. Systems with a certain size and a large number of elements can adopt this arrangement. For systems with various feedwater qualities, especially with one-pass arrangement, in special applications such as process material concentration and wastewater treatment, the concentrated water recirculation arrangement is usually adopted.

RO/NF systems usually adopt continuous operation mode, in which the operating conditions of each membrane element in the system do not change over time. However, in some applications, such as wastewater treatment or concentration of process materials, it may be necessary to operate under intermittent operating conditions. Any changes in the mode must first collect the raw water tank and then be treated. Some of the batch operations are improved ones, during which the raw water tank is continuously mixed with water.

The multi-treatment (multi-pass) system is a combined process of two-traditional RO/NF systems. The produced water from the first pass is used as the feedwater of the second pass. Each pass can be either single-pass or multi-pass. It can be either a one-stage arrangement or a two-stage arrangement with recirculation of concentrated water. Pharmaceutical and medical processes often benefit from multi-purity membrane systems. If you want to replace the second pass membrane system, you can consider using ion exchange technology.

Selection of Membrane Elements

The selection of the membrane elements is based on the salt content of the feedwater, the possibility of feedwater pollution, the required system desalination rate, the water production, and the energy consumption requirements, etc. When the system water production is less than 3 m^3/hr, 4040 membrane elements are selected. When the system water production is ≥ 3 m^3/hr, 8040 membrane elements are selected.

Determination of the Average Flux of the Membrane

The selection of the average flux design value (gfd or L/m^2h) can be selected based on field test data, past experience, or the typical design flux value recommended by the design guidelines.

Calculation on the Number of Components Required

Divide the design volume of water production by the design flux value and then divide by the membrane area of the selected element to get the number of element

Calculation on the Number of Pressure Vessels Required

Dividing the number of membrane elements needed by the number of elements that can be installed in each pressure vessel, the number of pressure vessels rounded to an integer N.B. can be obtained. For large systems, pressure vessels with 6 to 7 elements are often used. For small or compact systems, select shorter pressure vessels.

Determination of the Number of Stages

The number of stages is determined by how many pressure vessels are connected in series, and each stage consists of a certain number of pressure vessels in parallel. The number of stages is a function of the system design recovery rate. The number of elements contained in each pressure vessel, and the quality of feedwater. The higher the system recovery rate, the poorer the feedwater quality, the longer the system will be, i.e., the more elements should be connected in series. For example, if the first stage uses four 6-element vessels, and the second stage uses two 6-element vessels, there are 12 elements connected in series; generally, the number of series elements is related to the system recovery rate and the number of stages as follows:

Number of elements in series	Maximum system recovery rate	Number of elements in series	Maximum system recovery rate
1	15-20%	5	43-52%
2	28-33%	6	50-60%
3	38-43%	12	70-80%
4	43-4%	18	85-90%

Determine the Arrangement Ratio

The ratio of the number of pressure vessels in the adjacent two stages is called the arrangement ratio. For example, if the first stage consists of 4 pressure vessels, and the second stage consists of 2 pressure vessels, then the arrangement ratio is 2:1. When using a conventional 6-element vessel, the arrangement ratio between two adjacent stages is usually close to 2.

Part 8

Installation Operation & Maintainance

8.1 Installation and Removal of the Membrane Elements

Preparations Before Membrane Element Installation

- Prepare the following before loading and unloading membrane elements: lubricated glycerin, safety glasses, a stable work platform, waterproof rubber boots, rubber gloves, and clean cloths.
- Have a table ready to record the position, installation, and operating data for each membrane element.
- Carefully inspect the upstream water inlet pipe and remove any dust, grease, or metal debris. Flush the water inlet pipe and pressure vessel if necessary to ensure no foreign objects remain. Remove the pressure vessel's end plate and thrust ring, and check for cleanliness. If dust or sediment is present, clean thoroughly with a cloth.

Membrane Element Installation

- Carefully take out the first membrane element from the packing box; record the number of the membrane element, and check whether the sealing ring and the brine seal on the water outlet pipe on the element's o-ring match the direction of the water flow (you must face the direction of water inlet). Apply a small amount of glycerine to the inner wall of the centre tube at both ends of the first membrane element.
- The membrane element must be installed from the water inlet end of the pressure vessel, and the end of the first membrane element without the brine seal shall be pushed into the pressure vessel in parallel until the membrane element is exposed to the outside of the pressure vessel by about 1/5 length (20cm). Coat the brine seal and the O-ring on the connector, and insert the connector into the centre tube of the first membrane element.
- Take out the second membrane element, check the position and direction of the brine seal, apply a small amount of glycerine to the inner wall of the centre tube at both ends of the second membrane element, push the membrane element in parallel, then bring it to be pushed into the pressure vessel, and make the second membrane element parallel. Hold it up and insert the other end of the connector in the central tube of the first membrane element into the centre tube of the second membrane element. At that time, it should be parallel and not allow the connector to bear the weight of the membrane element. Push the second membrane element in. Press the pressure vessel until it is exposed to the outside of the pressure vessel about 1/5 length (20cm), apply a small amount of glycerine to the brine seal and the O-ring on the connector, and insert the connector into the center tube of the second membrane element.
- Repeat the previous step until all the membrane elements are installed in the pressure vessel. Note that the last membrane element does not need to be inserted into the central tube connector.
- At the water outlet of the pressure vessel, install the thrust ring, and install the pressure vessel outlet end plate seal assembly.
- At the water inlet of the pressure vessel, push the membrane element completely into the pressure vessel, make the end plate seal assembly fit the water outlet and closely contact the first membrane element, and then install the pressure vessel inlet end plate seal assembly.
- Repeat the above steps to install other pressure vessels.
- After all the membrane elements in all pressure vessels are installed, install the external water inlet, concentrated water, and pure water pipelines.

Membrane Element Disassembly

- First, remove the external pipelines at both ends of the pressure vessel, remove the end plate seal assembly at both ends of the pressure vessel, and number all the removed parts and put them in order.
- Push out the membrane elements one by one from the water inlet of the pressure vessel. Only one element is allowed to be ejected at a time. When the element is pushed out of the pressure vessel, the element should be upright in time, and the membrane element should be levelled to prevent damage to the central tube connector by gravity force. The membrane element can be properly rotated to separate the membrane element from the central tube connector.

8.2 Start-Up Of the System for the First Time

First Start Check

- All piping, equipment, and connections should meet the design pressure. A clean filter has been installed in the safeguard filter. The pre-treatment equipment has been backwashed and cleaned to ensure that the effluent meets the design requirements, where SDI < 5, turbidity < 1 NTU, residual chlorine < 0.1 ppm, temperature < 45°C, and pH 2-10.
- Adjust the opening of the outlet valve of the high-pressure pump and the regulating valve to control the water flow of the membrane system to be less than 50% of the inlet water during operation.
- The chemical and their concentrations in each chemical tank are accurate and reliable. The settings and operating status of each chemical dosing pump are correct, and the interlock and alarm volume are correctly set. All meters are installed and calibrated correctly.
- The safety pressure relief valve is installed, the setting is correct, and measures are taken. The product water pressure will not exceed the inlet water or concentrated water pressure by 0.3 Kg. The settings of the high voltage and low voltage protection devices are correct.
- When oxidants are used for sterilization during pre-treatment, ensure that these oxidants are completely removed before entering the reverse osmosis/nanofiltration membrane system.

Steps for the First Start-up

Operate according to the correct start-up sequence to ensure that the system operating parameters meet the design parameters, and the system feedwater quality and water production reach the design goals, while preventing the membrane damage due to excessive pressure and excessive water hammer.

- Before starting the system, the premise of ensuring that the raw water does not enter the elements, check item by item according to the content of the start-up inspection table; thoroughly flush the raw water pre-treatment system, flush out impurities and other pollutants preventing them from entering the membrane elements, especially for SDI≤5 value of the pre-treated influent water should be tested to be qualified. If the influent water does not contain contaminants as residual chlorine.
- Check all valves and ensure that all settings are correct. The system product water discharge valve, water inlet control valve and concentrated water control valve must be fully opened.
- During pressure, low-flow colloidal pretreatment, effluent to drive away the air in the membrane elements and the pressure vessels. The flow rate of each 4-inch pressure vessel is 0.6-3.0m^3/h, the flow rate of each 8-inch pressure vessel is 7.2-12.0 m^3/h, and all product water and concentrated water during the flushing process should be discharged to sewer.
- During the flushing operation, check all valves and pipeline connections for leaks, tighten or repair leaks.
- The system with the membrane is flushed for at least 30 minutes before testing the membrane first control valve. The system with the film should be rinsed continuously with pre-filtered water for more than 30 minutes, or for 1 to 2 hours, then rinsed for about one hour, soaking overnight. During low-pressure and low-flow flushing, it is not allowed to add antiscalent in the pretreatment part.
- Start the high-pressure pump. Slowly adjust the bypass control valve of the high-pressure pump to gradually increase the water flow of the reverse osmosis/nanofiltration pressure vessel; at the same time, slowly close the concentrated water control valve and increase the pressure until the system recovery rate and water production volume reach the design value. The time duration for increasing the pressure is not less than 30-60 seconds, and the time duration for increasing the water flow rate is not less than 20-30 seconds; check whether the system operating pressure and membrane element pressure drop exceed the limit value.
- Check whether the dosage of various chemicals in the system is consistent with the design value.
- Measure the conductivity of the reverse osmosis/nanofiltration feedwater, product water for each pressure vessel and the total product water; compare the conductivity of the product water of each pressure vessel, and judge whether there is leakage in other failures in the membrane elements, the connectors and the pressure vessel seals. Measure the pH value, conductivity, calcium hardness, alkalinity, etc. of the concentrated water, calculate the LSI and SDI index of the concentrated water, and judge whether the reverse osmosis/nanofiltration system has $CaCO_3$ fouling under these operating conditions.
- Let the system run continuously for 1 hour. Once the product water is qualified, first open the qualified product water delivery valve and then close the product water discharge valve to supply water to the subsequent equipment.
- Record all operating parameters of the first group.
- After 24 to 48 hours of continuous operation, view all recorded system performance data, including feedwater pressure, pressure difference, temperature, flow rate, recovery rate, conductivity; at the same time, the feedwater, concentrated water and total system product water are sampled and their ion composition is analyzed. At this time, the system operating parameters are used as the benchmark of system performance.
- Compare design parameters with actual system performance parameters.
- It takes a certain time for the reverse osmosis/nanofiltration membrane elements newly put into use to transition from the initial performance to the stable state. Among them, the wet membrane elements reach stable performance after 72 hours of continuous operation, while the dry membrane elements can only reach stability after 5 days of continuous operation

8.3 System Shutdown Precautions

When the membrane system is shut down, the entire membrane system must be flushed with pre-qualified feedwater or product water to replace the concentrated water with high salt content. First, the pressure vessel and membrane elements until the conductivity of the concentrated water approaches the inlet water conductivity. Flushing should be carried out at a low pressure of about 3.0 Kg (43.5psi). High flow is good for improving the flushing effect, but the pressure difference between the two ends of the membrane or pressure vessel should not exceed the maximum specified value.

The low-pressure flushing feedwater should not contain chemicals used for pretreatment, nor should it contain antiscalent. After the flushing is complete, close the inlet valve. The reverse osmosis/nanofiltration system should be completely filled with water. If it is not emptied for a long time, it is preferable to store it in a solution to prevent microbial growth. The membrane is a U-shaped pipeline higher than the highest pressure vessel, and a siphon destruction device.

If the water production pipeline is higher than the water level of the water tank, a device to prevent siphon damage should also be installed.

When the system must be shut down for more than 48 hours, care must be taken to prevent the membrane elements from drying out. After the elements are dried, there will be an irreversible drop in water production. Take appropriate protective measures to prevent the growth of microorganisms or perform regular flushing every 24 hours during shut-down.

8.4 Daily Maintenance of the System

Once the membrane system is put into operation, ideally, it should be operated continuously under stable operating conditions. In fact, the operation of the membrane system must be started and stopped frequently. Each start and stop involves sudden changes in the system's current and the force which causes mechanical stress on the membrane elements. Therefore, the number of starting and stopping of the system should be minimized. The normal starting and stopping process should be as smooth as possible. The starting method should be the same as the first commissioning procedure in principle.

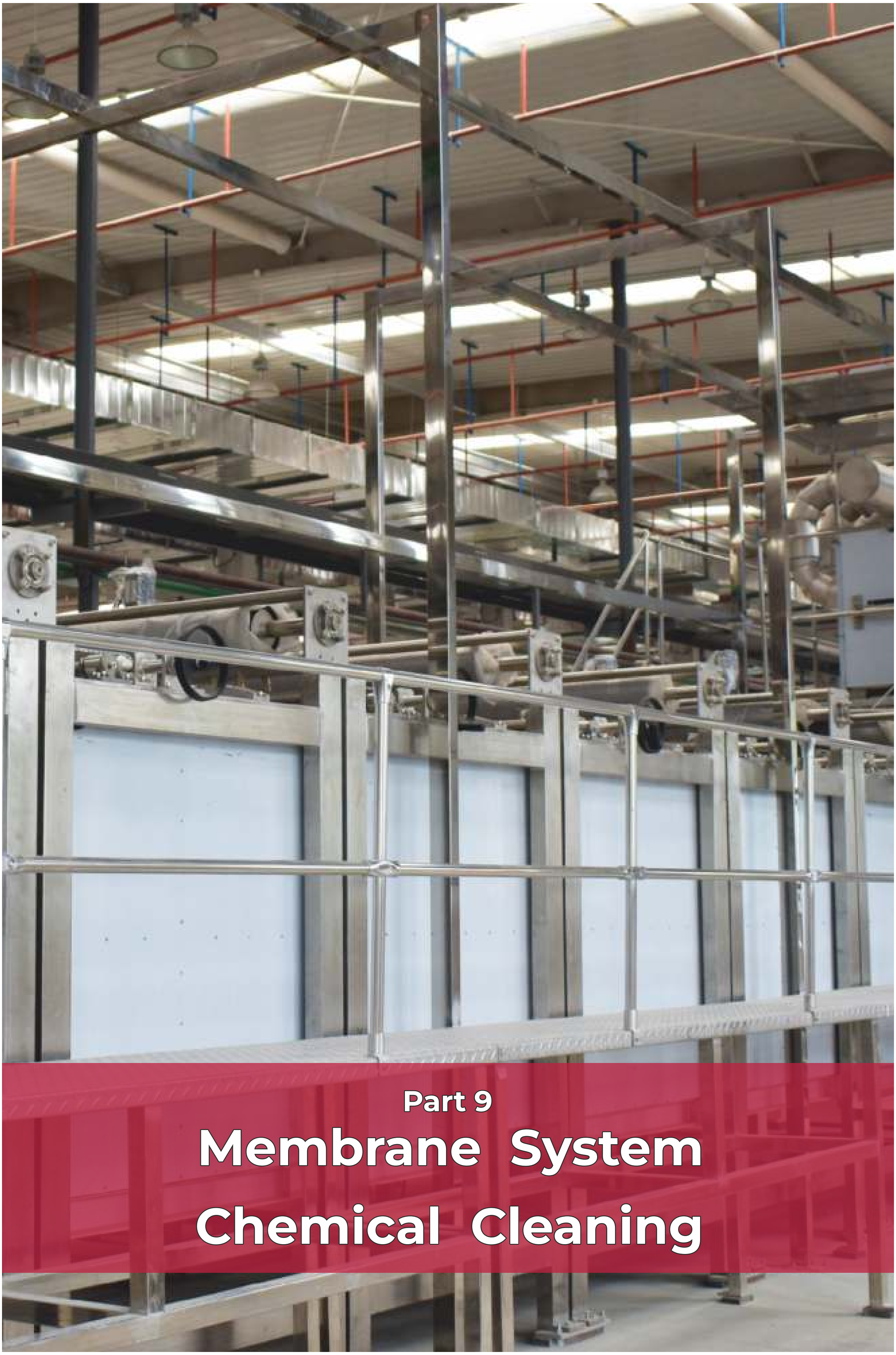
The regular pretreatment operation record contains the following contents, at least once per shift:

- The pressure drop of all filters is used to judge whether backwashing and air washing are needed.
- Feedwater pressure, residual chlorine concentration, pH value, and temperature should be monitored.
- After backwashing, forward washing, air washing time should be recorded.
- Effluent pH value, residual chlorine, turbidity, pH value, microorganisms.
- Consumption of chemicals (such as flocculants, coagulants, acids, etc.).
- Any failure or downtime, etc.

System Operation Record

Conventional membrane system operation records include the following contents, at least once per shift:

- Operation date, time, and system operating hours.
- The pressure drop before and after the safeguard filter and each pressure vessel (membrane module).
- Pressure of feedwater, product water, and concentrated water in each stage.
- The flow of product water and concentrated water in each stage.
- The conductivity of the feedwater, product water, and concentrated water of each stage shall be measured. The conductivity of the product water of each pressure vessel should be measured once a week.
- The salt content TDS of feedwater, product water, and concentrated water for each stage.
- Feedwater temperature.
- When the concentrated water TDS is less than 10,000mg/L, the Langelier saturation index LSI value of the concentrated water for $CaCO_3$ scaling.
- When the concentrated water TDS is greater than 10,000mg/L, the Stiff-Davis stability index SDSI value of concentrated water for the last stage.
- Calibrate the meter periodically, at least once every three months.



Part 9

Membrane System Chemical Cleaning

Suspended substances, colloids, organic matter, microorganisms, and salt precipitated out after concentration will cause pollution to membrane elements. The pretreatment of the reverse osmosis/nanofiltration system can remove these pollutants, reduce the pollution to the membrane, and extend the running life of the system. However, if the feedwater contaminants are not completely removed by the above-mentioned pollutants in the water, membrane element pollution will occur after a period of operation, resulting in a decrease in the performance of the system.

The performance degradation of the membrane system is mainly manifested as: a decrease in the water production, a decrease in the desalination rate (increased conductivity), and an increase in the pressure difference between the feedwater and the concentrated water.

9.1 Chemical Cleaning Conditions

During normal operation, the membrane of the reverse osmosis/nanofiltration element will be contaminated by inorganic salt scale, microorganisms, suspended particles, and insoluble organic substances, resulting in a decrease in the standardized feed water rate and system desalination rate or deterioration at the same time. When the following situations occur, the membrane elements need to be cleaned:

- Reduction in the permeate flow by 10%
- Delta P increased by 15%
- Salt penetration increased by 5%

Chemical cleaning must be carried out in time after the chemical cleaning conditions are reached. Under normal circumstances, the initial performance can be basically restored after cleaning; but if it is not cleaned in time, it will cause deep pollution of the membrane system, resulting in little chemical cleaning effect, and it is difficult to restore the system with good performance.

9.2 Steps for the Cleaning

Prepare Cleaning Solution

Prepare the cleaning liquid with reverse osmosis product water, accurately weigh the reagents, and mix them evenly in the cleaning tank, and check whether the pH value, temperature, and reagent content of the cleaning liquid meet the requirements.

Inject & Re-circulate Low Pressure & Low Flow Cleaning Liquid

Replace the water in the element with the cleaning solution at the lowest possible pressure. The pressure only needs to be enough to compensate the pressure loss from the feedwater to the concentrated water. The initial return water is drained to prevent the cleaning solution from being diluted. Let the cleaning liquid circulate for 30 minutes to 1 hour, observe its turbidity and pH value of the returned solution. If it becomes turbid obviously or the pH value changes more than 0.5, you can add an appropriate amount of chemical or reconstitute the cleaning solution and perform the above operation.

Membrane element model	pH range @ 45°C Maximum Temperature	pH range @ 35°C Maximum Temperature	pH range @ 25°C Maximum Temperature
Regular ULP, LP, BW, FR, XFR series, HR series and SW series	1 – 10.5	1 – 12	1 – 13
NF & HSRO Series	3 – 10	1 – 11	1 - 12

Cycling

Stop the cleaning pump cycling to prevent the cleaning solution from flowing out of the pressure vessel, and may close the cleaning solution inlet valve, cleaning solution concentrated water return valve, and cleaning solution product water return valve, depending on the contamination of the products. All membrane modules are soaked in the cleaning solution for about 1 hour or longer (10-15 hours overnight). During this period, the circulation pump can be turned on intermittently to maintain a constant cleaning solution temperature (25-30°C).

Circulation with the High Flow Water Pump

Circulate for 30-60 minutes at the flow rate listed in the table below. The high flow rate can flush out the contaminants washed down by the cleaning solution. If the pollution is serious, you can use a flow rate higher than the 50% specified in the table below to improve the cleaning effect.

Size of Membrane Element In	Flow rate of each Pressure Vessel gpm (m3/h)
4	10 (2.3)
5	40 (9.1)

Rinse

Rinse the system with product water for about 5 minutes, and then rinse the system with pretreatment qualified product water for 20-30 minutes. To prevent precipitation, the minimum flushing temperature is 20°C, and the cleaning solution is completely flushed out without residue.

9.3 Symptoms of Fouling & Choice of Cleaning Agent Symptoms After Membrane System Contamination

Symptoms After Membrane System Contamination

- **Symptoms of Inorganic Salt Scaling Pollution:** First of all, the conductivity of the second stage of the membrane system is abnormal (conductivity rises), and the water production is greatly reduced, the pressure gradually increases, and the pressure drop in the second stage also gradually increases. The most significant symptom is that water production has decreased significantly. The most common issue in membrane systems is calcium carbonate and calcium sulfate scaling. For membrane systems with serious inorganic scale, a high recovery rate, insufficient dosage of scale inhibitor, and failure to regenerate ion exchange softening resin in time are the main reasons for severe scaling.
- **Symptoms of Colloidal Contamination:** The colloids in the feedwater of the membrane system include sludge, inorganic colloids, colloidal silicon, and some organic substances, etc., which are usually removed by flocculation filtration and activated carbon adsorption. The colloidal pollution first appears in the first stage of the membrane system. The water production gradually decreases, the pressure difference gradually increases, and the conductivity of the produced water rises slightly; the main symptom of colloidal pollution is the slow change of water production and pressure difference.
- **Symptoms of Organic Pollution:** The main symptom of organic pollution is a sharp drop in water production and a basically unchanged salt rejection rate.
- **Symptoms of Microbial Contamination :** Microbial contamination usually occurs during the shutdown period of the reverse osmosis/nanofiltration system, and in the reverse osmosis/nanofiltration system that uses surface water, reclaimed water (tertiary wastewater), seawater, etc., as the feedwater source. Microbial contamination is usually accompanied by organic pollution.
- **Fouling occurs in all stages:** the pressure difference between the first and second stages increases rapidly, the water production decreases, and the conductivity of the water is basically unchanged. The main symptom is a rapid increase in pressure difference.
- **Symptoms of Metallic Fouling:** Metal compound pollution is mainly metal oxides, metal hydroxides, etc., especially iron pollution. The symptoms are decreased water production and desalination rate, and increased membrane element pressure difference.

Selection of Cleaning Agent After Membrane System Fouling

Pollutants	Preferred chemical cleaning agent	Cleaning conditions	Alternative chemical cleaning fluid
Inorganic salt scale ($CaCO_3$)	0.2%HCl Solution	pH: 1-2 Temperature< 38°C	(1) 2.0% Citric acid (preferably soaked overnight) (2) 1.0% $Na_2S_2O_4$ (3) 0.5% Phosphoric acid
Sulfate scale ($CaSO_4$,$BaSO_4$)	0.1%(W) NaOH or 1.0%(W)Na_4EDTA	p: H11-12 Temperature< 30°C	SHMP concentration1%
Metal oxide (such as iron, aluminum, etc.)	1.0% $Na_2S_2O_4$ Solution	Temperature< 35°C	(1) 0.5% Phosphoric acid (2) 0.2% Citric acid
Inorganic colloid (such as sludge)	0.1%NaOH Solution +0.025%Na-SDS	p: H 11-12	Temperature< 30°C
Silica scale	0.1%NaOH Solution + 0.025%Na-SDS	p: H11-12 Temperature< 30°C	0.1% NaOH solution + 1.0% Na_4EDTA solution
microorganism	0.1%NaOH Solution + 0.025%Na-SDS	pH: 11-12 Temperature< 30°C	0.1% NaOH solution + 1.0% Na_4EDTA solution
Organics	0.1%NaOH Solution + 0.025%Na-SDS is usually used as the first step of washing	pH: 11-12 Temperature< 30°C	0.2% HCl solution is usually used as the second step after alkaline washing

Notes:

1.(W) denotes weight percent of active ingredient.

2.Foulant chemical symbols in order used: $CaCO_3$ is calcium carbonate; $CaSO_4$ is calcium sulfate; $BaSO_4$ is barium sulfate.

3.Cleaning chemical symbols in order used: NaOH is sodium hydroxide; Na_4EDTA is the tetra-sodium salt of ethylene diamine tetraacetic acid; Na-DSS is sodium salt of dodecylsulfate; sodium Laurelsulfate; HCl is hydrochloric acid; H_3PO_4 is phosphoric acid; SHMP is sodium hexametaphosphate.

4.For effective sulfate scaling cleaning, the condition must be caught and treated early. Adding NaCl to the cleaning solution of NaOH and Na_4EDTA may help sulfate solubility increases with increasing salinity.

5.Citric acid is another cleaning alternative for metal oxides and calcium carbonate scale. It is less effective. It may contribute to biofouling, especially when it is not properly rinsed out.

The decline in desalination rate and water production is the most common failure in reverse osmosis and nanofiltration systems. If the desalination rate and water production drop relatively smoothly, this indicates that the system has normal fouling, which can be dealt with by proper and regular cleaning. However, rapid or sudden performance degradation indicates that the system has defective membrane elements, and corresponding corrective measures must be taken as soon as possible. Delay in treatment may cause irreversible damage to the membrane elements.

9.4 Troubleshooting

Analysis & Solutions for Common Phenomenon

Phenomenon			The Possible Cause of Bug	Solution
Rejection Rate	**Permeate Flow**	**Pressure Difference**		
↓	↗	→	Oxidation: Oxidant of Residual Chlorine, etc.	Replacing Membrane Element, Improving the Pretreatment
↓	↗	→	Membrane Element Damage: Back Pressure, Water Hammer	Replacing Membrane Element
↓	↗	→	Connector not tightly sealed	Replacing Membrane Element
↘	↓	↗	Scaling or Colloidal Contamination	Improving the Pretreatment, Chemical Cleaning
↘	↓	↗	Scale Formation of $CaCO_3$, SiO_2, etc.	pH Value/Recovery Rate Adjustment, Chemical Clean
→	↓	↗	Microbial Contamination	Disinfection, Chemical Cleaning
→	↓	→	Attachment: Surfactant, Oil	Avoiding Mixing the Same Substance in Raw Water
→↘	↗↘	→	High Temperature	Adjust within the Allowable Range
→↘	↗↘	→	High Pressure	Adjust within the Allowable Range

Note: ↓ Decreased ↘ Reducing ↗ Increasing → Unchanged

Methods Of Membrane Element Analysis

Method	Deterioration	Scale Layer	Suction Layer	Blockage	Flow Blockage
Appearance of Membrane Element, Weight Test	X	√	X	√	√
Dyeing Test of Membrane Elements	√	X	X	X	X
Membrane Observation (visual, microscope)	√	√	Δ	√	√
Raw Water Survey, Analysis	√	√	√	X	X
Performance Check of Membrane Elements	√	Δ	Δ	√	√
Quantitative Analysis of Attachments	X	√	X	X	√
Scanning Electron Microscope, SEM	√	√	X	√	√
X-ray Analysis, XMA X	X	√	X	√	√
X-ray Diffraction Analysis X	X	√	X	√	√
Fourier Infrared Analysis, FT-IR	√	√	√	X	X
Chemical Cleaning Test	X	√	X	X	X

Note: √ indicates applicable ; Δ indicates basically applicable ; X indicates not applicable

Methods Of Membrane Element Analysis

Low Desalination Rate, High Water Conductivity

- **Error in Instrument Reading**
- **Seal Leakage of Membrane Element Connector or Pressure Vessel End Plate Connection Adapter**
- During the installation of the membrane element, the O-ring on the connector was sprained or fell off, causing high salt water to enter the product water. First, measure the conductivity of the produced water of each pressure vessel. If the conductivity of a certain pressure vessel is too high, use the 'probe method' to judge if the salt leakage point is at the junction of the membrane element, which can be corrected by reinstalling the membrane element.
- **Feedwater pH**
- The ideal pH range of reverse osmosis/nanofiltration membrane is 6-8, and the pH value that is too low or too high has an impact on the desalination rate of the entire system.
- **Defect of the Membrane Element Itself**
- Due to the defects of the membrane element itself, if the glue line is not sealed, the water desalination rate of a single pressure vessel will be low, and the conductivity of the produced water will be high. Then use the 'probe method' to judge that the salt leakage point is at the membrane element and must be replaced if it is problematic.

Low Permeate & High Pressure

- **Error in Instrument Reading**
- **Temperature**
  The feedwater temperature is lower than the initial design, and the water output will decrease by about 10% for every 3°C decrease in the water temperature.
- **Feedwater Conductivity (or TDS) Deviation**
  The feedwater conductivity (or TDS) is much higher than the design value. For NaCl solution, the osmotic pressure increases by about 11.4 psi (0.8 Kg) for every 1000 ppm increase in TDS. Under the same feedwater pressure, the water production will decrease.
- **Pressure on the Product Water Side**
  Under the same water inlet pressure, due to the setting of holding pressure on the water production side or the small and long delivery port of the water production pipeline, the resistance is large, which leads to a decrease in net pressure and water production.
- **Wet Elements Are Not Kept in Place**
  The new membrane elements are not stored in place or protective measures are not taken after the wet membrane elements are installed in the system, which causes the membrane elements to dry out, resulting in a large flux attenuation or no flux, resulting in no water production in the system.
- **Feedwater Contains Surfactant**
  The quality of the feedwater was not confirmed during the initial operation of the system, and the membrane elements were soaked and rinsed with feedwater containing cationic, neutral, amphoteric surfactants or other chemicals that are incompatible with the membrane, which causes the flux of the membrane elements to attenuate, resulting in low system production water volume.

9.5 Troubleshooting in a normally running System

Decrease in Water Production and Desalination Rate

- **Colloidal Fouling:**
- To distinguish colloidal fouling;
- Determine the SDI value of the raw water;
- Analyze the leachate on the surface of the SDI test membrane;
- Check and analyze the deposits on the end surface of the first membrane element in the first stage.
- **Metal Oxide Fouling:**
- Methods to identify metal oxide fouling:
- Examine the pollutants trapped in the safeguard filter, the end face of the first membrane element, and the inner wall of the pressure vessel;
- Take out the first membrane element and analyze the metal ion composition on the membrane surface.
- **Scaling:**
- How to identify scaling on the membrane surface:
- Check whether there is fouling on the concentrated water side of the system; the inner wall and end plate of the pressure vessel will feel rough to the touch;
- Take out the last membrane element and weigh it. The membrane element with serious fouling generally gains significant weight.

Decrease in Water Production and Increase in Desalination Rate

- **Organic Pollution**
- Methods to identify organic pollution:
- Analyze the retentate on the filter element of the safeguard filter;
- Analyze the oil and organic pollutants in the feedwater;
- Take out the first membrane element and weigh it. The membrane element with organic contamination generally gains significant weight.
- **Membrane Compaction**
- The method of distinguishing membrane compaction: dissecting membrane elements and doing a membrane analysis test.

The Water Production is Abnormal and the Desalination Rate is Reduced

- **O-ring Leakage**

  The method of identifying O-ring leakage: Use the "probe method" to determine that the salt leakage point is at the connection portion of the membrane element.
- **Product Water Back Pressure**

  The back pressure of the product water exceeds the allowable value, causing physical damage to the peeling of the reverse osmosis/nanofiltration composite membrane desalination layer. The method to distinguish the back pressure of the produced water: dissect the membrane element and do the membrane sheet test.
- **Damage to the Membrane Surface**

  The components at the front end of the system are damaged by the combined action of sharp particles, crystals, and water hammer in the water. The method to distinguish the back pressure of the produced water: dissect the membrane element and do the membrane sheet test.

Decrease in Desalination Rate and Increase in Water Production

- **Membrane Oxidation**

  The residual chlorine or other oxidizing substances in the feedwater of the membrane system exceed the standard. When cleaning and disinfection, if the requirements are not strictly followed, and the cleaning time or temperature exceeds the standard and the membrane is oxidized. The method of distinguishing membrane oxidation: dissecting membrane elements and doing a membrane pressure dye test.
- **Leak**

  Severe damage to the O-ring or rupture of the center tube will cause feedwater or concentrated water to penetrate into the product water. The method of identifying leakage: disassemble the pressure vessel, take out the membrane elements, and check them one by one.

  Increase in Pressure Drop Results in A Decrease in Water Production or A Decrease in Desalination Rate

Increase in Pressure Drop Results in A Decrease in Water Production or A Decrease in Desalination Rate

- **Microbial Contamination**
- Methods to identify microorganisms:
- Examine the filter element of the safeguard filter and the end face of the membrane element to see if there is a sticky layer on the surface and it emits a fishy smell.
- Test the COD and BOD content of the feedwater.
- **Scaling**
- How to identify scaling on the membrane surface:
- Check whether there is fouling on the concentrated water side of the system; the inner wall and end plate of the pressure vessel will feel rough to the touch;
- Take out the last membrane element and weigh it. The membrane element with serious fouling generally gains significant weight.

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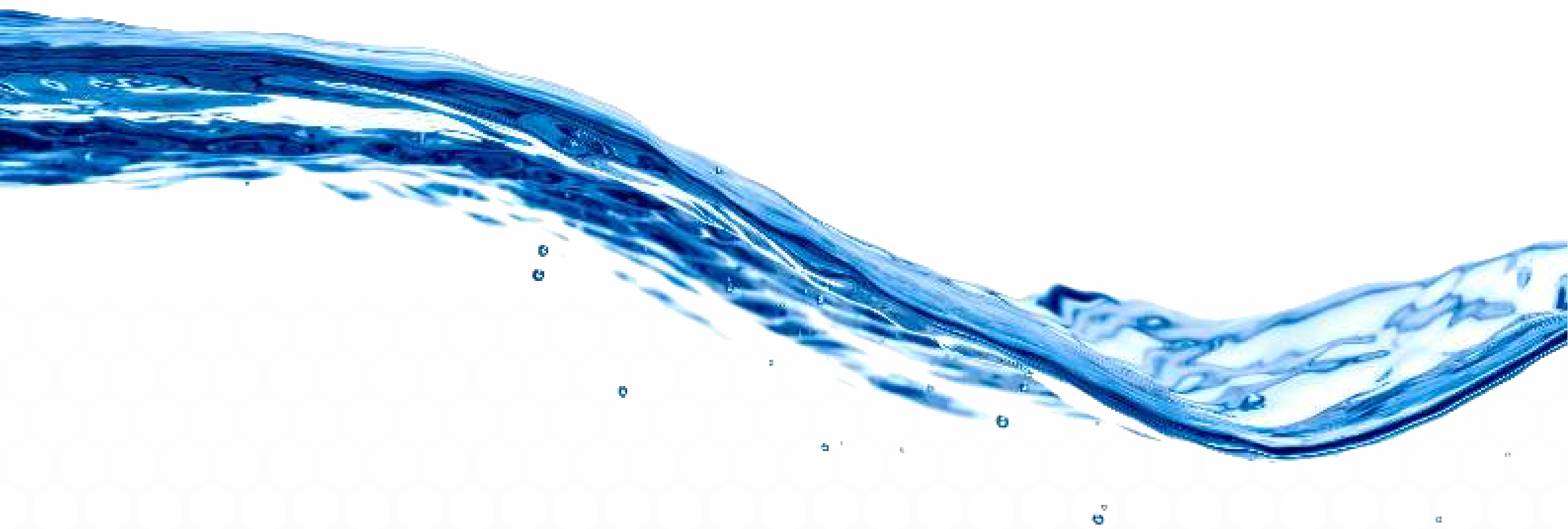

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