COMPANY PROFILE

Vontron Technology Co., Ltd. is specialized in R&D, manufacture and technical service of RO and NF membrane elements. Owning the core technology and capability for fabrication of membrane sheet, Vontron is the biggest professional manufacturer of compound RO membranes in China, and is the provider of system design and applied service with powerful technical support.

Vontron operates its manufacturing plant in Guiyang, with a total capacity of 17 million square meters of RO and NF membrane sheet annually.

Based upon the absorption and renovation of the full-process RO membrane producing line and technologies imported from the United States in 2001, the product series produced by Vontron, including industrial-purpose element, seawater desalination element, fouling resistant element, oxidation resistant element and residential element, etc., have taken the leading position in quality and technological level in the world. Vontron has become the world's second supplier of dry-type membrane elements with capacity of mass production. Moreover, the oxidation-resistant membrane and fouling-resistant membrane with leading technical advantage under completely independent intellectual property developed by Vontron have been widely applied to the wastewater treatment field, and have surmounted the difficulty in the application of RO membranes, i.e. the organic contamination and biological contamination, and have been widely applied in foodstuff and hygiene industries such as pharmaceutical abstraction, germ-free drinking water, etc.

The company has been undertaking a number of state-level and province/ministry level projects, including National 863 Program, National Torch Program and National New Product Program, etc. The company applied for 11 state-level patents in 2001, including compound oxidation resistant RO membrane, laser thermal-melting equipment, etc. The R&D team, consisting mainly of doctorial researchers, has established four professionalized basic platforms separately of "design, research & development", "technological process control", "inspection and test", and "applied research", thus building a solid technical foundation for rapid growth in the future.

Vontron has accomplished developing various specifications of compound RO membranes covering 9 series and more than 50 models. All product series adopt the state-of-the-art fouling-resistant technology, and reach the international advanced level in quality. Certified to NSF Standards, VONTRON™ membranes have been broadly applied to seawater desalination, purification of drinking water, depuration of sewage and concentration/abstraction, and well sold to USA, India, Italy, Spain, Germany, Turkey, Korea, Japan, Vietnam, Malaysia, Thailand, Singapore, Brazil, etc., where Vontron has also set up its sales distributors and consistent customers.

Vontron will be, as always, carrying out the corporate spirit of "Surmounting ourselves and pursuing endlessly", bringing forth the new products from the old ones, and devoting ourselves to the establishment of elite products for the enviro-tech era.

www.famcocorp.com
E-mail: info@famcocorp.com
@famco_group
Tel:۰۲۱-۴۸۰۰۰۰۴۹
Fax:۰۲۱ - ۴۴۹۹۴۶۴۲
تهران، کیلومتر۲۱ بزرگراه لشگری (جاده مخصوص کرج)
روبـروی پالایشگاه نفت پارس، پلاک ۱۲

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PART ONE: TECHINICAL SPECIFICATIONS

Chapter I–Introduction to VONTRON™ RO Membranes

1–1 Major Membrane Product Series

◇ Residential Membrane Element: 1812-sized and 2012-sized

The 1812-sized and 2012-sized residential membrane elements are mainly applicable to various small-sized systems, such as household water purifier and other water purifying devices in hospital and laboratory.

◇XLP Series: Extremely Low Pressure Compound RO Membrane Element

Working under the conditions of extremely low operating pressure, XLP membrane series can achieve as high permeated flow and rejection rate as regular low-pressure membranes can. It runs under approximately half pressure of that of regular low pressure compound membranes, and can achieve a rejection rate of as high as 98.0%.

◇ ULP Series: Ultra-low Pressure Compound RO Membrane Element

Working under the conditions of ultra low operating pressure, ULP membrane series can achieve as high permeated flow and rejection rate as regular low-pressure membranes can. It runs under approximately two thirds pressure of that of regular low pressure compound membranes, and can achieve a rejection rate of as high as 98.0%.

◇ LP Series: Low Pressure Compound RO Membrane Element

Having the properties of low-pressure, high permeated flow and excellent desalination performance, LP membrane series is mainly applicable to brackish water desalination. Furthermore, with the excellent properties in removing soluble salts, TOC and SiO_2, it is particularly applicable to preparation of high-purity water for electronic and electrical power industries.

◇ SW Series: Compound RO Membrane Element for Seawater Desalination

Designed for sweater desalination, the SW series can increase the permeated flow by improving the structure of membrane elements, thus decreasing the number of membrane elements installed. It has the properties of high rejection rate, persistent performance, low operation cost and low investment in equipment, and can ensure that drinking water can be produced from seawater simply by one-pass RO treatment.

◇ FR Series: Fouling Resistant Compound RO Membrane Element

FR membrane series is mainly applied to reuse of wastewater and treatment of highpolluted surface water. For treatment of water with inferior quality grade, it adopts the design of wider feedwater inflow conduit net, which makes it easier to be cleaned. Furthermore, the membrane surface has been specially processed with special technology, thus changing the electric charge and the smoothness of membrane surface, increasing the hydrophilicity of membrane surface, reducing the contaminants and microbes adhering to the membrane surface, bringing about the performance of stronger resistant to scaling, organic contamination and microbe contamination, and therefore decreasing the contamination speed of membrane element and elongating its service life.

◇ HOR Series: High Oxidation Resistant RO Membrane Element

The HOR series, independently developed Vontron Technology Co., Ltd. upon years of research, is currently the sole oxidation resistant RO membrane in the world, and is mainly applied to treatment of wastewater reuse, surface water with high microbe contamination, and feedwater containing oxidative substances as well as applied to germ-free system, etc. Considering the shortcoming of regular polyamide RO membrane in weak resistance to oxidation, the HOR series has integrated special synthetic process to strengthen the oxidation resistance of membrane element, and allow the bactericide to be directly dispensed to the membrane element so as to keep the RO mainframe completely free of bacteria. The use of HOR membrane elements can simplify and optimize the pretreatment process of RO system (without filtration by activated carbon or dispensing of reductant), thus saving the investment cost and therefore reducing the microbial contamination of membrane element, saving the operational cost and elongating the service life.

◇ VNF Series: Nanofiltation Element

Nanofiltration element is used for purification of drinking water and industrial-purpose water, treatment of wastewater and concentration of valuable ingredients in industrial fluids. It can detain those substances with molecular weight between 200~1000 and separate those substances with molecular dimension of 1nm from the solution.

1–2 Nomenclature of VONTRON™ Membrane Elements

Nomenclature of Industrial Membrane Elements

HOR 1 2 – 80 40 L

L — Representing the Working Pressure of Membrane Element (Optional)
X: XLP Series U: ULP Series
L: LP Series S: SW Series

40 — Length of Membrane Element (in inch)

80 — Membrane Element Diameter in inch
(to be multiplied by 0.1)
8040: 8-inch diameter, 40-inch length
4040: 4-inch diameter, 40-inch length
4021: 4-inch diameter, 21-inch length
2540: 2.5-inch diameter, 40-inch length
2521: 2.5-inch diameter, 21-inch length
2514: 2.5-inch diameter, 14-inch length

2 — Active Membrane Area
1:85 ft2 (4040 element)
365ft2(8040 element)
2:400 ft2(8040 element)

1 — Rejection Rate
The sequence of 1~3 represents the gradual increase of rejection rate.

HOR — Membrane Type
XLP: Extremely Low Pressure Series
ULP: Ultra Loa Pressure Series
LP: Low Pressure Series
SW: Seawater Desalination Series
FR: Fouling Resistant Series
HOR:High Oxidation Resistant Series

Nomenclature of Residential Membrane Elements

ULP 18 12 – 50

- **50** — Permeate Flow in GPD (gallon per day)
  50 (50GPD)；75 (75GPD)；100 (100GPD)
- **12** — Length of Membrane Element in inch
- **18** — Diament of membrane element in inch
  (to be multiplied by 0.1)
  1812: 1.8-inch diameter, 12-inch length
  2012: 2.0-inch diameter, 12-inch length
  2812: 2.8-inch diameter, 12-inch length
  3012: 3.0-inch diameter, 12-inch length
  3020: 3.0-inch diameter, 20-inch length
- **ULP** — Membrane Type
  ULP: Regular ultra-low-pressure residential element
  HOR: High-oxidation-resistant residential element

Nonmenclature of Nanofiltration Element

VNF 1 —— 80 40 – 31

- **31** — Representing the width of channel spacer (optional), in mil)
- **40** — Length of element in inch
- **80** — Diament of membrane element in inch
  (to be multiplied by 0.1)
  1812: 1.8-inch diameter, 12-inch length
  2012: 2.0-inch diameter, 12-inch length
  2812: 2.8-inch diameter, 12-inch length
  3012: 3.0-inch diameter, 12-inch length
  3020: 3.0-inch diameter, 20-inch length寸
- **1** — Rejection Rate
  The sequence of 1~2 represents the gradual increase of rejection rate.
- **VNF** — Membrane Type
  VNF: Nanofiltration Membrane

1–3 Catalog and Selection of VONTRON™ Membrane Elements

1–3.1 Catalog of Industrial Membrane Elements

Type	Model	Reject. (%)	Average Permeate GPD (m³/d)	Working Pressure & Application Fields	Testing Conditions		
					Pressure psi (MPa)	Solution Concentr. NaCl(ppm)	Recovery Rate (%)
General-purpose Industrial Membrane Elements	LP21-8040	99.5	9600 (36.3)	Working under low pressure. Applicable to regular or high content brackish water.	225 (1.55)	2000	15
	LP22-8040	99.5	10500 (39.7)				
	LP21-4040	99.5	2400 (9.1)				
	XLP11-4040	98.0	2000 (7.6)	Working under extremely low pressure. Applicable to feedwater with low salinity that requires low rejection rate.	100 (0.69)	500	15
	ULP21-8040	99.0	11000 (41.6)	Working under ultra low pressure. Applicable to feedwater with fairly low salinity.	150 (1.03)	1500	15
	ULP12-8040	98.0	13200 (49.9)				
	ULP22-8040	99.0	12100 (45.7)				
	ULP32-8040	99.5	10500 (39.7)				
	ULP11-4040	98.0	2700 (10.2)				
	ULP21-4040	99.0	2400 (9.1)				
	ULP31-4040	99.4	1900 (7.2)				
	ULP11-4021	98.0	1000 (3.78)	Working under ultra low pressure. Applicable to commercial water purifier, and water purifying devices for hospital and laboratory.	150 (1.03)	1500	8
	ULP21-4021	99.0	950 (3.6)				
	ULP31-4021	99.4	850 (3.2)				
	ULP21-2521	99.0	300 (1.13)				
	ULP21-2540	99.0	750 (2.84)				15
Seawater Desalination Element	SW21-8040	99.7	5000 (18.9)	Working under high pressure. Applicable to seawater or quasi seawater.	800 (5.5)	32800	8
	SW22-8040	99.7	6000 (22.7)				
	SW21-4040	99.5	1400 (5.3)				
	SW11-2540	99.2	500 (1.89)	Working under high pressure. Applicable to small-sized system in military ship, marine ship, laboratory, etc. for desalination of seawater or high-content brackish water.			
	SW11-4021	99.2	750 (2.8)				4
	SW11-2521	99.2	200 (0.76)				
Fouling Resistant Element	FR11-8040	99.5	9600 (36.3)	Working under low pressure. Applicable to feedwater with small content of contaminants (organic substances, colloids).	225 (1.55)	2000	15
	PURO-I	99.5	10500 (39.7)				
	FR11-4040	99.5	2200 (8.3)				
High Oxidation Resistant Element	HOR21-8040	99.2	9000	Applicable to feedwater with oxidative substances or serious microbial contamination.	225 (1.55)	2000	15
	HOR21-4040	99.2	2200				

1–3.2 Catalog of Residential Membranes and Non–standard Membranes

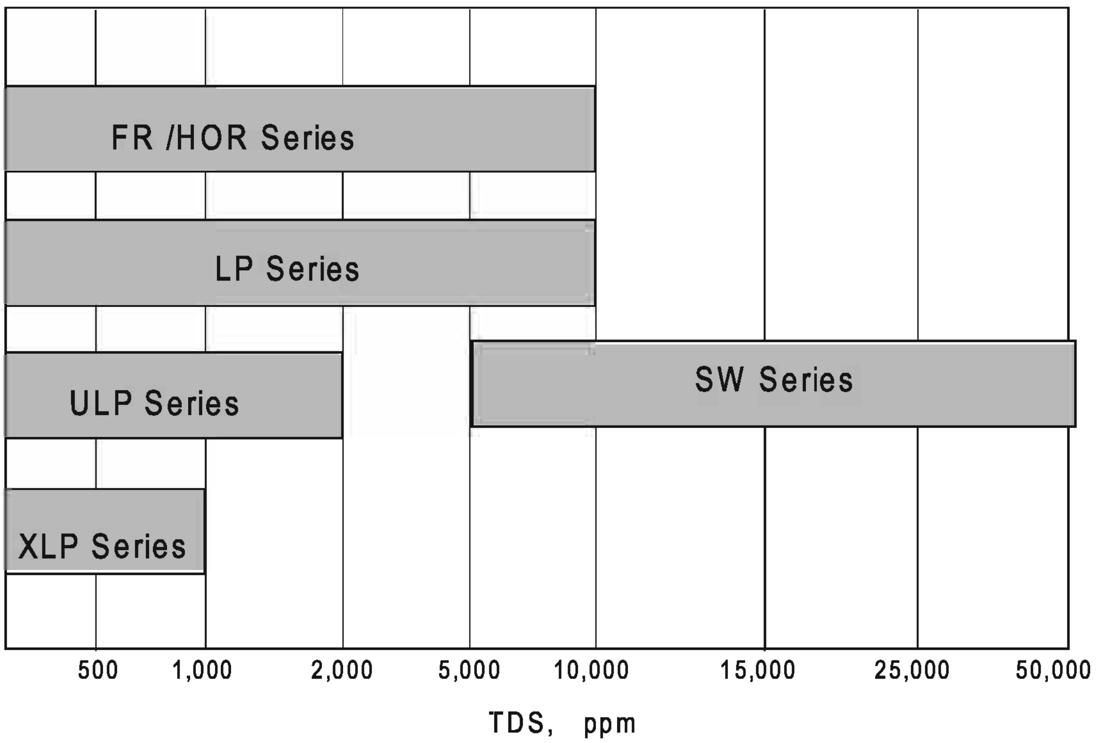
Type	Model	Reject. (%)	Average Permeate GPD (m^3/d)	Working Pressure & Application Fields	Testing Conditions		
					Pressure psi (MPa)	Solution Concentr. NaCl(ppm)	Recovery Rate (%)
Residential	ULP1810-40	97.0	40 (0.15)	Working under extremely low pressure. Applicable to residential water purifier and water purifying devices in hospital and laboratory for treatment of feedwater with TDS lower than 500 ppm.	60 (0.41)	250	15
	ULP1812-50	97.5	50 (0.19)				
	ULP1812-75	97.5	75 (0.28)				
	ULP2012-100	95.0	100 (0.38)				
Residential Oxidation Resistant Element	HOR2012	97.5	50 (0.19)	Applicable to water sources with oxidizing substance or high microbial pollution.	60 (0.41)	250	15
Non-standard	ULP2812	97.0	200 (0.76)	Working under extremely low pressure. Applicable to automatic water dispenser and residential drinking fountain.	100 (0.69)	500	15
	ULP3012	97.0	240 (0.91)				
	ULP3020	97.0	420 (1.60)				

1–3.3 Catalog of Nanofiltration Membranes

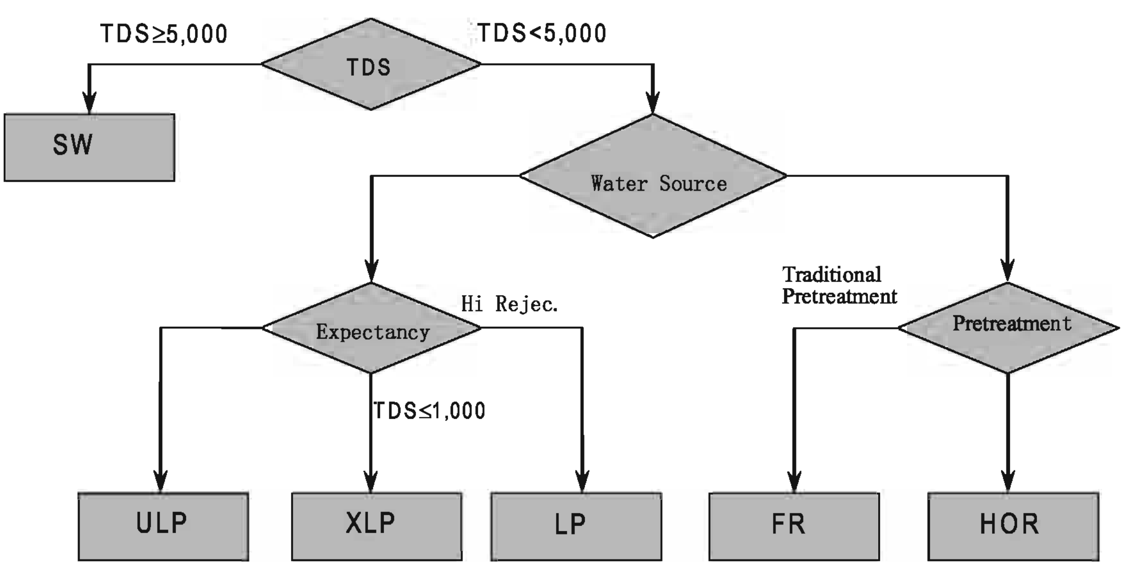
Type	Model	Reject. (%)	Average Permeate GPD (m³/d)	Working Pressure & Application Fields	Testing Conditions		
					Pressure psi (MPa)	Solution Concentr. (ppm)	Recovery Rate (%)
Residential NF Element	VNF1-1812	30~50	60 (0.22)	Working under extremely low pressure. Applicable to various home-drinking purifiers, mineralizing drinking machine, etc.	30 psi (0.2MPa)	250ppm (NaCl)	15%
		>60				250ppm ($CaCl_2$)	15%
	VNF2-1812	50~70	50 (0.19)		30 psi (0.2MPa)	250ppm (NaCl)	15%
		>80				250ppm ($CaCl_2$)	15%
	VNF1-2012	30~50	100 (0.38)		30 psi (0.2MPa)	250ppm (NaCl)	15%
		>60				250ppm ($CaCl_2$)	15%
	VNF2-2012	50~70	85 (0.32)		30 psi (0.2MPa)	250ppm (NaCl)	15%
		>80				250ppm ($CaCl_2$)	15%
Industrial Purpose NF Element	VNF1-8040	40~60	12000 (45.5)	Working under extremely low pressure. Applicable to production of drinking water and in separation and concentration/ purification processes for foodstuff, medicine, biological engineering and pollution treatment, etc.	70 psi (0.5Mpa)	2000ppm (NaCl)	15%
		>96	10000 (37.5)		70 psi (0.5Mpa)	2000ppm ($MgSO_4$)	15%
	VNF2-8040	80~95	7500 (28.4)		70 psi (0.5Mpa)	2000ppm (NaCl)	15%
		>96	9000 (33.9)		70 psi (0.5Mpa)	2000ppm ($MgSO_4$)	15%
	VNF1-4040	40~60	2400 (9.1)		70 psi (0.5Mpa)	2000ppm (NaCl)	15%
		>96	2000 (7.5)		70 psi (0.5Mpa)	2000ppm ($MgSO_4$)	15%
	VNF2-4040	80~95	1400 (5.3)		70 psi (0.5Mpa)	2000ppm (NaCl)	15%
		>96	1800 (6.8)		70 psi (0.5Mpa)	2000ppm ($MgSO_4$)	15%
	VNF1-2540	40~60	800 (3.03)		70 psi (0.5Mpa)	2000ppm (NaCl)	15%
		>96	650 (2.46)		70 psi (0.5Mpa)	2000ppm ($MgSO_4$)	15%
	VNF2-2540	80~95	525 (1.98)		70 psi (0.5Mpa)	2000ppm (NaCl)	15%
		>96	600 (2.27)		70 psi (0.5Mpa)	2000ppm ($MgSO_4$)	15%

1–3.4 Guide to Selection of Membrane Elements

1) Selection of Membrane Elements according to Salinity of Feedwater



2) Frame Diagram of Selection of Membrane Elements



1–4 Complete Series of VONTRON™ Dry Membrane Elements

Vontron Technology Co., Ltd. is capable of supplying complete series of dry-type membrane elements.

Compared with wet-type membrane elements, the dry-type elements have the advantages of easier transportation and installation as well as longer terms of preservation. Complete series of membrane elements are available in both dry type and wet type from Vontron technology Co., Ltd.

1–4.1 Comparison between Dry–type and Wet–type Membrane Elements

Items of Comparison	Dry-type Element	Wet-type Element
Preservative Solution	Not required	1.0%(W) sodium hydrogen sulfite required as preservative solution, which shall be replaced after 90 days of storage.
Preservative Temperature	Not higher than 45℃	0℃～45℃
Breeding of Microbe	Free from breeding of any microbe	Prone to breeding of microbes (in case the preservative solution is not replaced in time)
Transportation, etc.	Easier for transportation thanks to light weight, thus decreasing the delivery costs.	Not easy for transportation owing to heavy weight of preservative solution, thus increasing the delivery costs.

1–4.2 Precautions for Use of Dry–type Membrane Elements

● Storage of Dry-type Membrane Elements

1. The membrane elements must be stored in cool and dry place, and shall not be exposed to direct sunlight.

2. The dry-type elements shall be stored in the place with temperature not higher than 45, below which temperature the elements can be stored for unlimited period.

● General Information of Dry-type Membrane Elements

1. The dry-type membrane elements shall be always kept in wet condition once been moistened.

2. Only after being operated for at least 6 hours can the dry-type membrane elements be disinfected with formaldehyde.

3. The dry-type membrane elements work under the Operating Limits and Conditions and design guide identical to the wet-type elements of same specifications.

4. Once a dry-type membrane element is moistened to become a wet-type element, it shall be disposed of according to the methods of storage, preservation and cleaning indicated in this Manual corresponding to equivalent wet-type membrane element.

5.The initial adjustment and running of RO system shall be conducted in accordance with the procedures indicated in “Chapter 4 – Operation and Maintenance of RO System”, and the filtered water and rejected water produced in the first one hour shall be discarded.

Chapter II–General Technical Specifications of VONTRON™ RO Membranes

2–1 VONTRON™ Residential and Non–standard RO Element

Brief Introduction

The residential and non-standard RO elements are mainly applicable to various small-sized systems, such as household water purifier and other water purifying devices in hospital and laboratory.

Specifications and Major Properties

Model	Active Membrane Area ft²(m²)	Average Permeated Flow GPD (m³/d)	Stable Rejection Rate (%)	Minimum Rejection Rate (%)
ULP1810-40	3.3 (0.31)	40（0.15）	97.0	96.0
ULP1812-50	4.4 (0.41)	50（0.19）	97.5	96.0
ULP1812-75	5.0 (0.46)	75（0.28）	97.5	96.0
ULP2012-100	6.0 (0.56)	100（0.38）	95.0	93.0
HOR2012	6.0 (0.56)	50（0.19）	97.5	96.0
ULP2812	11.2 (1.04)	200 (0.76)	97	95.5
ULP3012	13.2 (1.23)	240 (0.91)	97	95.5
ULP3020	24.1 (2.24)	420 (1.60)	97	95.5

Testing Conditions:

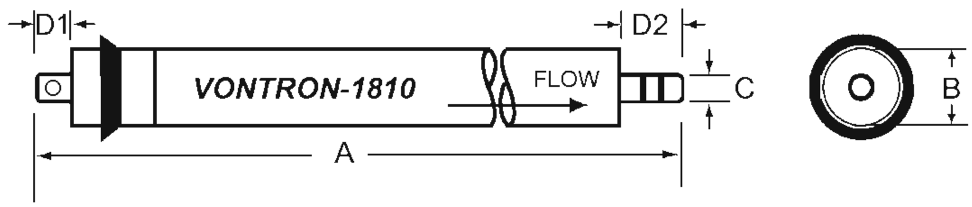
Testing Pressure.. 60psi（ULP1810-40,ULP1812-50,ULP1812-75, ULP2012-100, HOR2012）
100 psi (ULP2812, ULP3012, ULP3020)
Testing Solution Temperature.......................... 25℃
Testing Solution Concentration(NaCl) .... 250ppm (ULP1810-40,ULP1812-50,ULP1812-75,ULP2012-100, HOR2012）
.... 500 ppm (ULP2812, ULP3012, ULP3020)
pH Value of Testing Solution 7.5
Recovery Rate of Single Element .... 15℃

Operation limits and conditions

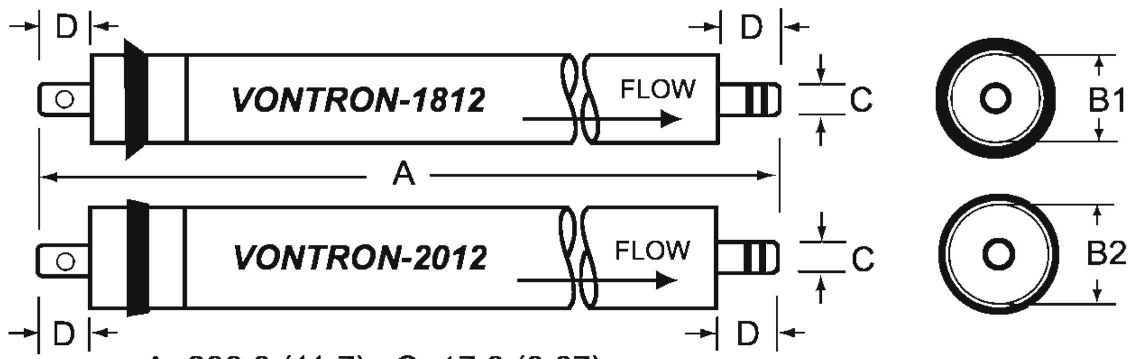
Max. Working Pressure.. 300psi(2.07Mpa)
Max. Feedwater Temperature.................................... 45℃
Max. Feedwater SDI.. 5
Residual chlorine Concentration of Feedwater............... <0.1ppm
.... <0.5 ppm (HOR2012)
pH Range of Feedwater during Continuous Operation......... 3~10
pH Range of Feedwater during Chemical Cleaning............ 2~12
Max. Pressure Drop of Single Membrane Element............ 10psi (0.07Mpa)

Dimensions of Membrane Element

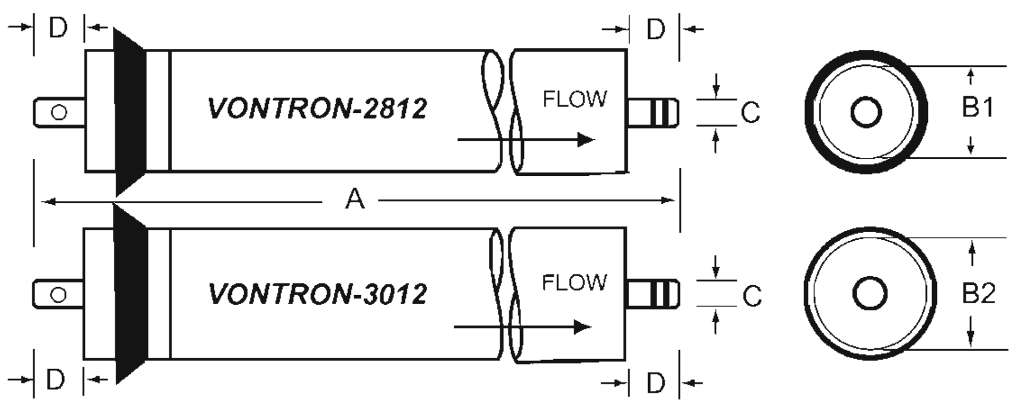
All dimensions are shown in: millimeter (inch)



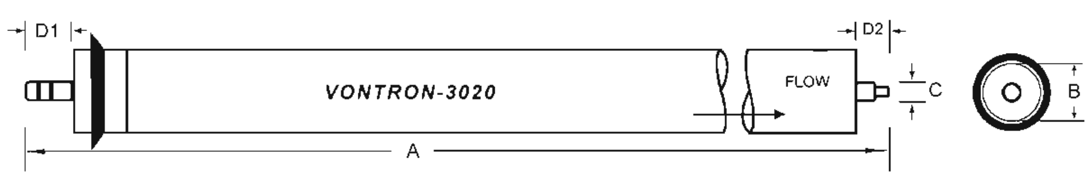
A=256.0mm (10.08") B=44.5mm (1.75")
C=17.0mm (0.67") D1=15.0mm(0.59") D2=25.0mm(0.98")



A=298.0 (11.7) C=17.0 (0.67)
B1=44.5 (1.75) B2=48.2 (1.9) D=21.0(0.83)



A=298.0mm (11.7") C=17.0mm (0.67")
B1=71.1mm (2.8") B2=76.2mm (3.0") D=21.0mm(0.83")



A=513.8mm (20.23") B=77 (3.0")
C=26.1mm (0.85") D1=26.5mm(1.04") D2=23.3mm(0.92")

www.famcocorp.com
E-mail: info@famcocorp.com
@famco_group
Tel:۰۲۱-۴۸۰۰۰۰۴۹
Fax:۰۲۱ - ۴۴۹۹۴۶۴۲
تهران، کیلومتر۲۱ بزرگراه لشگری (جاده مخصوص کرج)
روبـروی پالایشگاه نفت پارس، پلاک ۱۲

Important Information

1. Any specific application must be limited within the Operating Limits and Conditions. We strongly recommend you to refer to the latest edition of technology manual and design guide prepared by Vontron Technology Co., Ltd., or consult experts proficient in membrane technology. In case the customer fails to follow the operating conditions as specified in this manual, Vontron technology Co., Ltd. will assume no liability for all results.

2. The permeate flow listed in the table is the average value. The permeate flow of single membrane element is within a tolerance not exceeding ±20% of the nominal value.

3. All wet-type membrane elements have been strictly tested before leaving the factory, and have been treated with the solution of 1.0% sodium hydrogen sulfite (an antifreeze solution of 10% propanediol required in winter) for storage purpose, then sealed with plastic bag in vacuum, and further packed in carton boxes. In order to prevent the breeding of microbes during short-time storage, transportation and system standby, we recommend you to soak the membrane elements with protective solution (prepared with RO filtered water) containing 1.0% sodium hydrogen sulfite (foodstuff-purpose).

4. Discard the RO-filtered water produced during the first one hour after system start-up.

5. During storage time and run time, it is strictly prohibited to dose any chemical medicament that may be harmful to membrane elements. In case of any violation in using this kind of chemical medicament, Vontron Technology Co., Ltd. assumes no liability for any outcome incurred herefrom.

Points of Attention

1. All data and information provided in this manual have been obtained from long-term experiment by Vontron Technology Co., Ltd. We truly believe that these data and information are accurate and effective. Vontron Technology CO., Ltd. assumes no liability for any aftermath caused by user's failure in abiding by the conditions specified in this manual in use or maintenance of membrane products. It is strongly recommended that the user shall strictly abide by the requirements for design, use and maintenance of products and keep relevant records.

2. Along with technical development and product renovation, the information contained herein will be subject to modification without prior notification. Please keep an eye on the website of Vontron Technology Co., Ltd. for any update of product.

2–2 VONTRON™ General–purpose Industrial Membrane Elements

2–2.1 LP Series: Low Pressure Membrane Element

Brief Introduction

The LP (low pressure) series of aromatic polyamide compound membrane element developed by Vontron Technology Co., Ltd. has the properties of low-pressure operation, high permeate flow and excellent desalination and are applicable to desalination of brackish water. Besides, it is particularly applicable to fabrication of high-purity water for electronic industry and electric power industry owing to its excellent performance in removing soluble salts, TOC, SiO2, etc.

Being suitable for desalting such water sources as surface water, underground water, tap water and municipal water, etc., LP series is mainly applicable to treatment of various industrial water such as industrial-purpose pure water, boiler water replenishment in power plant, and can be also applied to such brackish water applications as treatment of high-concentrated saline wastewater and production of beverage-purpose water.

Specifications and Major Properties

Model	Active Membrane Area $ft^2(m^2)$	Average Permeated Flow GPD (m^3/d)	Stable Rejection Rate (%)	Minimum Rejection Rate (%)
LP21-8040	365（33.9）	9600（36.3）	99.5	99.3
LP22-8040	400（37.0）	10500（39.7）	99.5	99.3
LP21-4040	90（8.4）	2400（9.1）	99.5	99.3

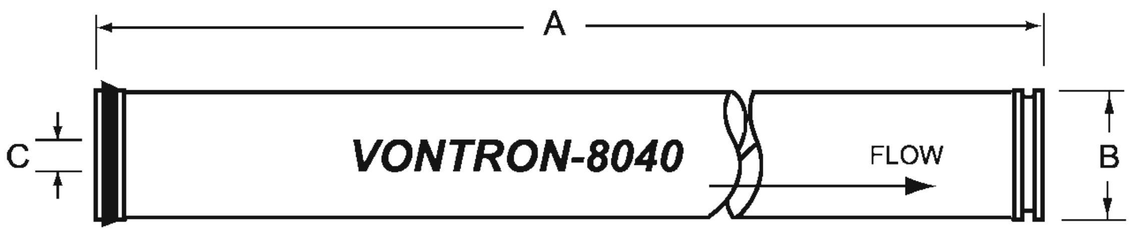
Testing Conditions:
- Testing Pressure... 225 psi (1.55Mpa)
- Temperature of Testing Solution.......................... 25 ℃
- Concentration of Testing Solution (NaCl).................. 2000ppm
- pH Value of Testing Solution.................................. 7.5
- Recovery Rate of Single Membrane Element.............. 15%

Operation limits and conditions

Max. Working Pressure.. 600psi (4.14Mpa)
Max. Feedwater Flow... 75gpm (17 m^3/h) (for 8040)
16gpm (3.6 m^3/h) (for 4040)
Max. Feedwater Temperature................................... 45 ℃
Max. Feedwater SDI... 5
Residual chlorine Concentration of Feedwater.................. <0.1ppm
pH Range of Feedwater during Continuous Operation......... 3~10
pH Range of Feedwater during Chemical Cleaning........... 2~12
Max. Pressure Drop of Single Membrane Element............ 15psi (0.1Mpa)

Dimensions of Membrane Element

All dimensions are shown in: millimeter (inch)



A=1016.0mm (40") B=201.9mm (7.95") C=28.6mm (1.125")

A=1016.0mm (40") B=99.7mm (3.9")
C=19.1mm (0.75") D=26.7mm (1.05")

Important Information

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2. The permeate flow listed in the table is the average value. The permeate flow of single membrane element is within a tolerance not exceeding ±20% of the nominal value.

3. All wet-type membrane elements have been strictly tested before leaving the factory, and have been treated with the solution of 1.0% sodium hydrogen sulfite (an antifreeze solution of 10% propanediol required in winter) for storage purpose, then sealed with plastic bag in vacuum, and further packed in carton boxes. In order to prevent the breeding of microbes during short-time storage, transportation and system standby, we recommend you to soak the membrane elements with protective solution (prepared with RO filtered water) containing 1.0% sodium hydrogen sulfite (foodstuff-purpose).

4. Discard the RO-filtered water produced during the first one hour after system start-up.

5. During storage time and run time, it is strictly prohibited to dose any chemical

medicament that may be harmful to membrane elements. In case of any violation in using this kind of chemical medicament, Vontron Technology Co., Ltd. assumes no liability for any outcome incurred herefrom.

Points of Attention

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2–2.2 ULP Series: Ultra Low Pressure Membrane Element

Brief Introduction

ULP series of ultra-low pressure aromatic polyamide compound membrane element newly developed by Vontron Technology Co., Ltd. can work under ultra low pressure to reach as high permeate flow and salt rejection as regular low-pressure membrane element can, and is applicable to desalination of surface water and underground water. It operates under approximately 2 thirds of the operating pressure of regular low-pressure composite membrane, and achieves a salt rejection rate of up to 99.5%, which can decrease the investment costs for such relevant facilities as pump, piping, and container, etc. and the operating cost for the RO system, thus increasing the economic efficiency.

Being suitable for the desalting treatment of those water sources with salt concentration lower than 2000 ppm, such as surface water, underground water, tap water and municipal water, etc., ULP series membrane elements are mainly applicable to numerous applications of various scales, such as pure water, boiler water replenishment, foodstuff processing, and pharmaceutical production, etc.

Specifications and Major Properties

Model	Active Membrane Areaft²(m²)	Average Permeated Flow GPD (m³/d)	Stable Rejection Rate (%)	Minimum Rejection Rate (%)
ULP21-8040	365（33.9）	11000（41.6）	99.0	98.5
ULP12-8040	400（37.0）	13200（49.9）	98.0	97.5
ULP22-8040	400（37.0）	12100（45.7）	99.0	98.5
ULP32-8040	400（37.0）	10500（39.7）	99.5	99.0
ULP11-4040	90（8.4）	2700（10.2）	98.0	97.5
ULP21-4040	90（8.4）	2400（9.1）	99.0	98.5
ULP31-4040	90（8.4）	1900（7.2）	99.4	99.0
ULP11-4021	36（3.3）	1000（3.78）	98.0	97.5
ULP21-4021	36（3.3）	950（3.6）	99.0	98.5
ULP31-4021	36（3.3）	850（3.2）	99.4	99.0
ULP21-2540	30（2.8）	750（2.84）	99.0	98.5
ULP21-2521	14（1.3）	300（1.13）	99.0	98.5

Testing Conditions:

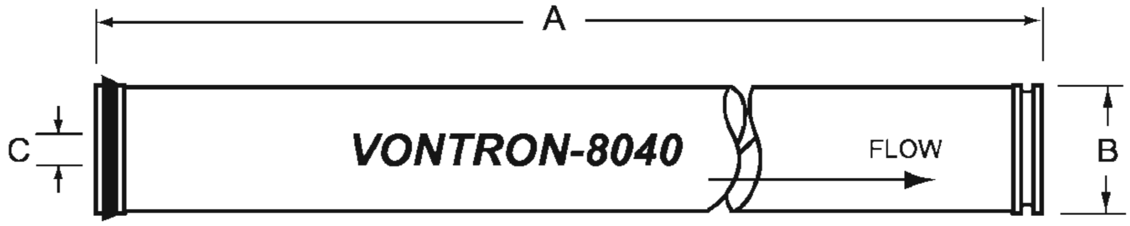
Testing Pressure.. 150 psi (1.03Mpa)
Temperature of Testing Solution............................. 25℃
Concentration of Testing Solution (NaCl).................. 1500ppm
pH Value of Testing Solution................................ 7.5
Recovery Rate of Single Membrane Element.............. 15% (8040-size, 4040-size and 2540-size)
.... 8% (4021-size and 2521-size)

Operation limits and conditions

Max. Working Pressure... 600psi (4.14Mpa)
Max. Feedwater Flow... 75gpm (17 m3/h) (8040-size)
.... 16gpm (3.6 m3/h) (4040-size)
Max. Feedwater Temperature.. 45℃
Max. Feedwater SDI.. 5
Residual chlorine Concentration of Feedwater....................... <0.1ppm
pH Range of Feedwater during Continuous Operation............ 3~10
pH Range of Feedwater during Chemical Cleaning............... 2~12
Max. Pressure Drop of Single Membrane Element................. 15psi (0.1Mpa)

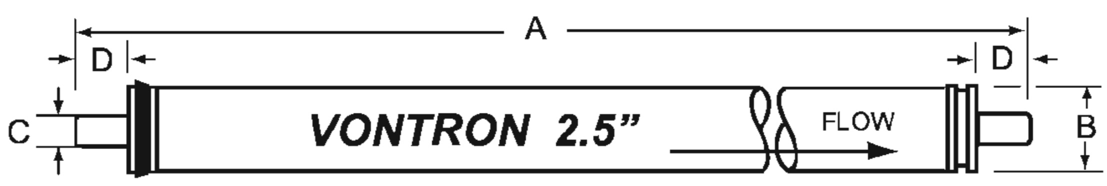
Dimensions of Membrane Element

All dimensions are shown in: millimeter (inch)

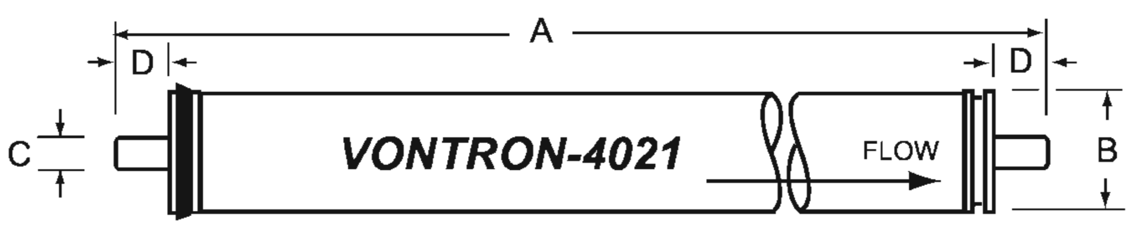


A=1016.0mm (40”) B=201.9mm (7.95”) C=28.6mm (1.125”)

A=1016.0mm (40”) B=99.7mm (3.9”)
C=19.1mm (0.75”) D=26.7mm (1.05”)



2540:	A=1016.0mm (40”)	B=61.0mm (2.4”)	C=19.1mm (0.75”)	D=30.2mm (1.19”)
2521:	A=533.4mm (21”)	B=61.0mm (2.4”)	C=19.1mm (0.75”)	D=30.2mm (1.19”)



A=533.4mm (21”) B=99.7mm (3.9”)
C=19.1mm (0.75”) **D=30.2mm (1.19”)**

www.famcocorp.com
E-mail: info@famcocorp.com
@famco_group
Tel:۰۲۱-۴۸۰۰۰۰۴۹
Fax:۰۲۱ - ۴۴۹۹۴۶۴۲
تهران، کیلومتر ۲۱ بزرگراه لشگری (جاده مخصوص کرج)
روبـروی پالایشگاه نفت پارس، پلاک ۱۲

Important Information

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2. The permeate flow listed in the table is the average value. The permeate flow of single membrane element of ULP 31 series and ULP32 series is within a tolerance not exceeding ± 15% of the nominal value, while the single membrane element of other series has a minimum permeate flow with a tolerance not exceeding 20% of nominal value.

3. All wet-type membrane elements have been strictly tested before leaving the factory, and have been treated with the solution of 1.0% sodium hydrogen sulfite (an antifreeze solution of 10% propanediol required in winter) for storage purpose, then sealed with plastic bag in vacuum, and further packed in carton boxes. In order to prevent the breeding of microbes during short-time storage, transportation and system standby, we recommend you to soak the membrane elements with protective solution (prepared with RO filtered water) containing 1.0% sodium hydrogen sulfite (foodstuff-purpose).

4. Discard the RO-filtered water produced during the first one hour after system start-up.

5. During storage time and run time, it is strictly prohibited to dose any chemical medicament that may be harmful to membrane elements. In case of any violation in using this kind of chemical medicament, Vontron Technology Co., Ltd. assumes no liability for any outcome incurred herefrom.

Points of Attention

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www.famcocorp.com
E-mail: info@famcocorp.com
@famco_group
Tel:۰۲۱-۴۸۰۰۰۰۴۹
Fax:۰۲۱ - ۴۴۹۹۴۶۴۲
تهران، کیلومتر ۲۱ بزرگراه لشگری (جاده مخصوص کرج)
روبـروی پالایشگاه نفت پارس، پلاک ۱۲

2–2.3 XLP Series: Extremely Low Pressure Membrane Element

Brief Introduction

XLP series of extremely low pressure aromatic polyamide compound membrane element newly developed by Vontron Technology Co., Ltd. can work under ultra low pressure to reach as high permeate flow and salt rejection as regular low-pressure membrane element can, and is applicable to desalination of surface water and underground water. It operates under approximately half the operating pressure of regular low-pressure composite membrane, and achieves a salt rejection rate of up to 99.0%, which can decrease the investment costs for such relevant facilities as pump, piping, and container, etc. and the operating cost for the RO system, thus increasing the economic efficiency.

Being suitable for the desalination treatment of those water sources with low salinity not requiring high salt rejection such as surface water, underground water, tap water and municipal water, etc. which have a salt concentration lower than 1000 ppm, XLP series of membrane element is particularly applicable to the second-pass desalination with two-pass RO system, and is mainly applied to numerous applications of various scales, such as pure water production, boiler water replenishment, foodstuff processing and pharmaceutical production, etc.

Specifications and Major Properties

Model	Active Membrane Areaft²(m²)	Average Permeated Flow GPD (m³/d)	Stable Rejection Rate (%)	Minimum Rejection Rate (%)
XLP11-4040	90（8.4）	2000（7.6）	98.0	97.5

Testing Conditions:

Testing Pressure...100 psi (0.69Mpa)
Temperature of Testing Solution............................. 25℃
Concentration of Testing Solution (NaCl).................. 500ppm
pH Value of Testing Solution................................ 7.5
Recovery Rate of Single Membrane Element.............. 15%

Operation limits and conditions

Max. Working Pressure.. 600psi (4.14Mpa)
Max. Feedwater Flow... 16gpm (3.6 m3/h)
Max. Feedwater Temperature... 45℃
Max. Feedwater SDI... 5
Residual chlorine Concentration of Feedwater......................... <0.1ppm
pH Range of Feedwater during Continuous Operation............ 3~10
pH Range of Feedwater during Chemical Cleaning................. 2~12
Max. Pressure Drop of Single Membrane Element.................. 15psi (0.1Mpa)

Dimentions of Membrane Element

All dimentions are shown in: millimeter (inch).

A=1016.0mm (40") B=99.7mm (3.9")
C=19.1mm (0.75") D=26.7mm (1.05")

Important Information

1. Any specific application must be limited within the Operating Limits and Conditions. We strongly recommend you to refer to the latest edition of technology manual and design guide prepared by Vontron Technology Co., Ltd., or consult experts proficient in membrane technology. In case the customer fails to follow the operating conditions as specified in this manual, Vontron technology Co., Ltd. will assume no liability for all results.

2. The permeate flow listed in the table is the average value. The permeate flow of single membrane element is within a tolerance not exceeding ±20% of the nominal value.

3. All wet-type membrane elements have been strictly tested before leaving the factory, and have been treated with the solution of 1.0% sodium hydrogen sulfite (an antifreeze solution of 10% propanediol required in winter) for storage purpose, then sealed with plastic bag in vacuum, and further packed in carton boxes. In order to prevent the breeding of microbes during short-time storage, transportation and system standby, we recommend you to soak the membrane elements with protective solution (prepared with RO filtered water) containing 1.0% sodium hydrogen sulfite (foodstuff-purpose).

4. Discard the RO-filtered water produced during the first one hour after system start-up.

5. During storage time and run time, it is strictly prohibited to dose any chemical medicament that may be harmful to membrane elements. In case of any violation in using this kind of chemical medicament, Vontron Technology Co., Ltd. assumes no liability for any outcome incurred herefrom.

Points of Attention

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2–3 VONTRON™ SW Series: Seawater Desalination Membrane Element

Brief Introduction

SW series of aromatic polyamide compound membrane element developed by Vontron Technology Co., Ltd. is applicable to desalination of seawater. By optimizing the structure of membrane element, the SW series increases the permeate flow, and requires fewer elements for same permeate flow. It is characterized by low operating pressure, low investment in equipment, excellent rejection rate and reliable performance, and its high salt rejection can ensure producing the drinking water from seawater simply through one-pass RO design.

Applicable to treatment of seawater and high-concentration brackish water, the SW series of membrane element is designed for various industrial water treatment, such as seawater desalination, high-concentration brackish water desalting, boiler water replenishment for power plant, etc., and is also applicable to various fields such as recycling of wastewater, concentration and reclamation of such substances with high additional value as foodstuff, pharmaceuticals, etc.

Specifications and Major Properties

Model	Active Membrane Area ft^2 (m^2)	Average Permeated Flow GPD (m^3/d)	Stable Rejection Rate (%)	Minimum Rejection Rate (%)
SW21-8040	330（30.6）	5000（18.9）	99.7	99.5
SW22-8040	380（35.2）	6000（22.7）	99.7	99.5
SW21-4040	85（7.9）	1400（5.3）	99.5	99.2
SW11-4021	33（3.1）	750（2.8）	99.2	99.0
SW11-2521	12（1.1）	200（0.76）	99.2	99.0
SW11-2540	28（2.6）	500（1.89）	99.2	99.0

Testing Conditions:

Testing Pressure……………………………………… 800 psi (5.5Mpa)

Temperature of Testing Solution…………………… 25℃

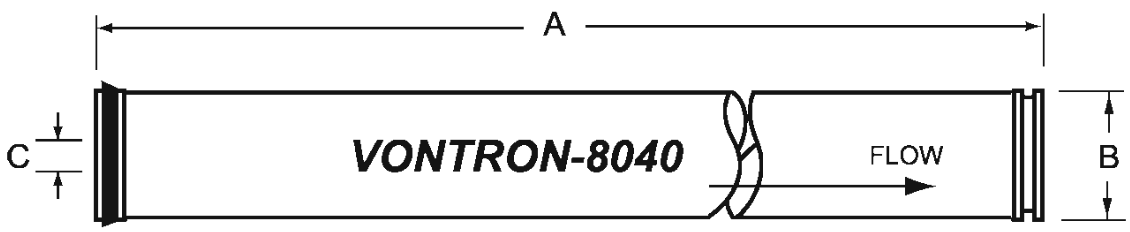
Concentration of Testing Solution (NaCl).................. 32800ppm
pH Value of Testing Solution.................................. 7.5
Recovery Rate of Single Membrane Element............... 8% (8040-size, 4040-size and 2540-size)
4% (4021-size and 2521-size)

Operating Limits and Conditions

Max. Working Pressure.. 1000psi (6.9Mpa)
Max. Feedwater Flow.. 75gpm (17 m3/h) (8040-size)
16gpm (3.6 m3/h) (4040 and 4021)
6.0gpm (1.4 m3/h) (2521 and 2540)
Max. Feedwater Temperature... 45℃
Max. Feedwater SDI... 5
Residual chlorine Concentration of Feedwater....................... <0.1ppm
pH Range of Feedwater during Continuous Operation.......... 3~10
pH Range of Feedwater during Chemical Cleaning............... 2~12
Max. Pressure Drop of Single Membrane Element................ 15psi (0.1Mpa)
(8040, 4040 and 2540)
10psi (0.07Mpa) (2521 and 4021)

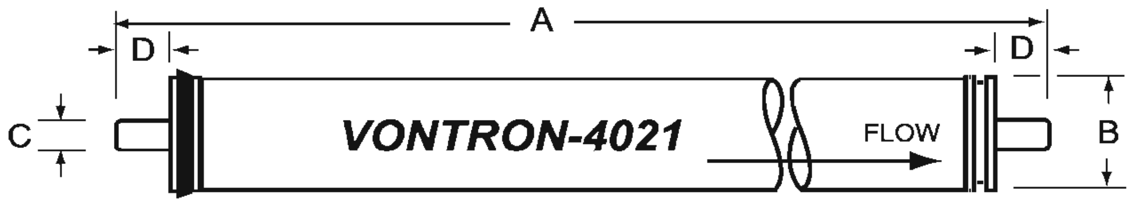
Dimensions of Membrane Element

All dimensions are shown in: millimeter (inch)

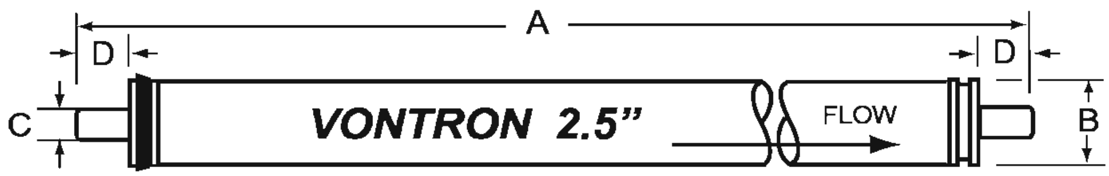


A=1016.0mm (40”)   B=201.9mm (7.95”)   C=28.6mm (1.125”)

A=1016.0mm (40”)   B=99.7mm (3.9”)
C=19.1mm (0.75”)   D=26.7mm (1.05”)



A=533.4mm (21”) B=99.7mm (3.9”)
C=19.1mm (0.75”) D=30.2mm (1.19”)



2540:	A=1016.0mm (40”)	B=61.0mm (2.4”)	C=19.1mm (0.75”)	D=30.2mm (1.19”)
2521:	A=533.4mm (21”)	B=61.0mm (2.4”)	C=19.1mm (0.75”)	D=30.2mm (1.19”)

Important Information

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2. The permeate flow listed in the table is the average value. The permeate flow of single membrane element is within a tolerance not exceeding ±20% of the nominal value.

3. All wet-type membrane elements have been strictly tested before leaving the factory, and have been treated with the solution of 1.0% sodium hydrogen sulfite (an antifreeze solution of 10% propanediol required in winter) for storage purpose, then sealed with plastic bag in vacuum, and further packed in carton boxes. In order to prevent the breeding of microbes during short-time storage, transportation and system standby, we recommend you to soak the membrane elements with protective solution (prepared with RO filtered water) containing 1.0% sodium hydrogen sulfite (foodstuff-purpose).

4. Discard the RO-filtered water produced during the first one hour after system start-up.

5. During storage time and run time, it is strictly prohibited to dose any chemical medicament that may be harmful to membrane elements. In case of any violation in using this kind of chemical medicament, Vontron Technology Co., Ltd. assumes no liability for any outcome incurred herefrom.

Points of Attention

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2–4 VONTRON™ FR Series: Fouling Resistant Membrane Element

Brief Introduction

Vontron's fouling resistant elements include FR series and PURO series.

FR (fouling resistant) series of aromatic polyamide RO membrane element developed by Vontron Technology Co., Ltd. is applicable to desalination of brackish water. It is characterized by low-pressure operation, higher water productivity and excellent desalting performance. Moreover, special treatment has been made to the surface of membrane with unique technology to change its electrical charge and smoothness, increasing the hydrophilicity of membrane surface, thus decreasing the adhesion of contamination and microbe so as to lessen the pollution and extend the service life of elements.

Newly developed by Vontron, the PURO-I is specially designed for treatment of water reclamation and surface water treatment where the water source contains high contamination. This brand-new element contains a new fouling resistant coating, and the membrane surface is treated with special technology to modify the electrical charge and smoothness of membrane surface so as to increasing the hydrophilicity of membrane surface, thus decreasing the adhesion of contamination and microbe so as to lessen the pollution and extend the service life of elements. Besides, the wider 34mil feed spacer channel can provide better fouling resistance and washability.

Vontron's fouling resistant products are designed for desalting treatment of such water with salt concentration less than 10,000 ppm as surface water, underground water, tap water and municipal water, etc. It is mainly applied to treatment of various industrial water applications, such as reuse of industrial reclaimed water and boiler water replenishment for power plant, etc., and is particularly applicable to treatment of those water containing slight organic pollutants such as industrial wastewater, municipal sewage and other slightly contaminated water.

Specifications and Main Properties

Model	Active Membrane Area ft^2 (m^2)	Average Permeated Flow GPD (m^3/d)	Stable Rejection Rate (%)	Minimum Rejection Rate (%)
FR11-8040	365（33.9）	9600（36.3）	99.5	99.3
PURO-I	400（37.0）	10500（39.7）	99.5	99.3
FR11-4040	90（8.4）	2200（8.3）	99.5	99.3

Testing Conditions:

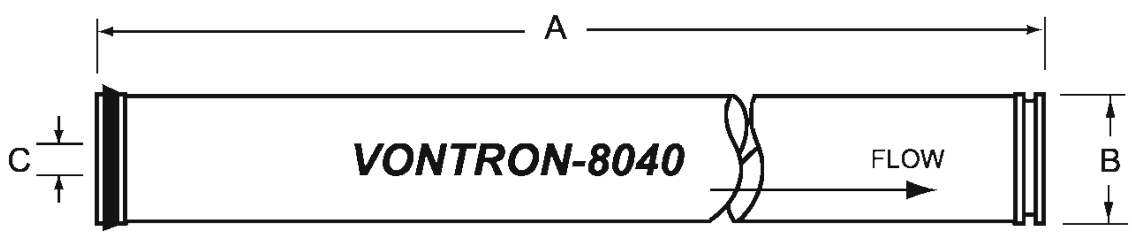
Testing Pressure.. 225 psi (1.55Mpa)
Temperature of Testing Solution............................. 25℃
Concentration of Testing Solution (NaCl).................. 2000ppm
pH Value of Testing Solution................................ 7.5
Recovery Rate of Single Membrane Element............... 15%

Operating Limits and Conditions

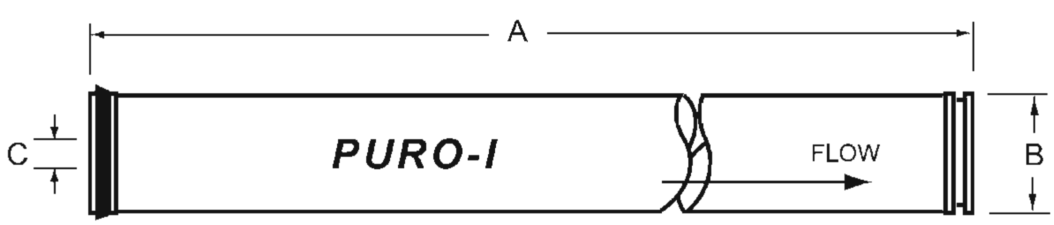
Max. Working Pressure.. 600psi (4.14Mpa)
Max. Feedwater Flow.. 75gpm (17 m3/h) (8040-size)
16gpm (3.6 m3/h) (4040-size)
Max. Feedwater Temperature.. 45℃
Max. Feedwater SDI.. 5
Residual chlorine Concentration of Feedwater........................ <0.1ppm
pH Range of Feedwater during Continuous Operation............ 3~10
pH Range of Feedwater during Chemical Cleaning................. 2~12
Max. Pressure Drop of Single Membrane Element.................. 15psi (0.1Mpa)

Dimensions of Membrane Element

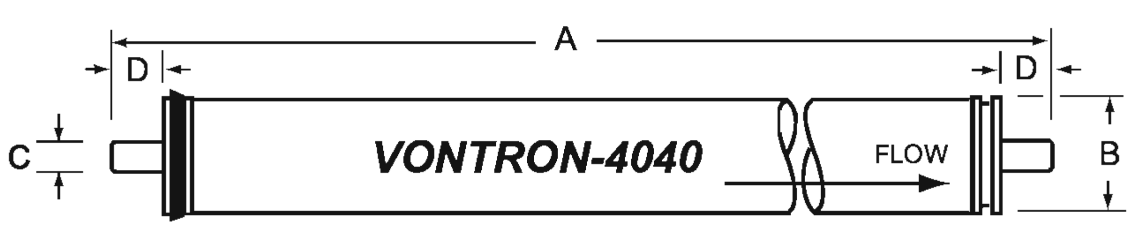
All dimensions are shown in: millimeter (inch)



A=1016.0mm (40”) B=201.9mm (7.95”) C=28.6mm (1.125”)



A=1016.0mm (40”) B=201.9mm (7.95”) C=28.6mm (1.125”)



A=1016.0mm (40”) B=99.7mm (3.9”)
C=19.1mm (0.75”) D=26.7mm (1.05”)

Important Information

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2. The permeate flow listed in the table is the average value. The permeate flow of single membrane element is within a tolerance not exceeding ±15% of the nominal value.

3. All wet-type membrane elements have been strictly tested before leaving the factory, and have been treated with the solution of 1.0% sodium hydrogen sulfite (an antifreeze solution of 10% propanediol required in winter) for storage purpose, then sealed with plastic bag in vacuum, and further packed in carton boxes. In order to prevent the breeding of microbes during short-time storage, transportation and system standby, we recommend you to soak the membrane elements with protective solution (prepared with RO filtered water) containing 1.0% sodium hydrogen sulfite (foodstuff-purpose).

4. Discard the RO-filtered water produced during the first one hour after system start-up.

5. During storage time and run time, it is strictly prohibited to dose any chemical medicament that may be harmful to membrane elements. In case of any violation in using this kind of chemical medicament, Vontron Technology Co., Ltd. assumes no liability for any outcome incurred herefrom.

Points of Attention

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2–5 VONTRON™ HOR Series: High Oxidation Resistant Membrane Element

Brief Introduction

HOR (high oxidation resistant) series of aromatic polyamide compound membrane element newly developed by Vontron Technology Co., Ltd. has the properties of low operating pressure, high permeate flow and excellent rejection performance, etc. Besides, the use of special synthesizing process enhances the oxidation property of membrane element and enables the membrane element to endure the impact by certain magnitude of oxidative substance, thus simplifying and optimizing the pretreatment process of RO system, decreasing the microbial contamination of membrane element, saving the operating cost and elongating the service life.

Industrial HOR series is designed for the desalting treatment of those water sources with salinity lower than 10000ppm such as surface water, underground water, tap water and municipal water, etc., and is especially applicable to reuse treatment of those water sources that contain microbial contamination or oxidative substance, such as municipal-purpose or industrial-purpose reclaimed water, electroplating wastewater, etc. The residential HOR-2012 element is mainly applied to various miniature systems such as household water purifier, water purifying devices for hospital and laboratory, etc.

Specifications and Main Properties

Model	Active Membrane Area $ft^2(m^2)$	Average Permeated Flow GPD (m^3/d)	Stable Rejection Rate (%)	Minimum Rejection Rate (%)
HOR21-8040	365（33.9）	9000（34.1）	99.2	99.0
HOR21-4040	90（8. 4）	2200（8.3）	99.2	99.0

Testing Conditions:

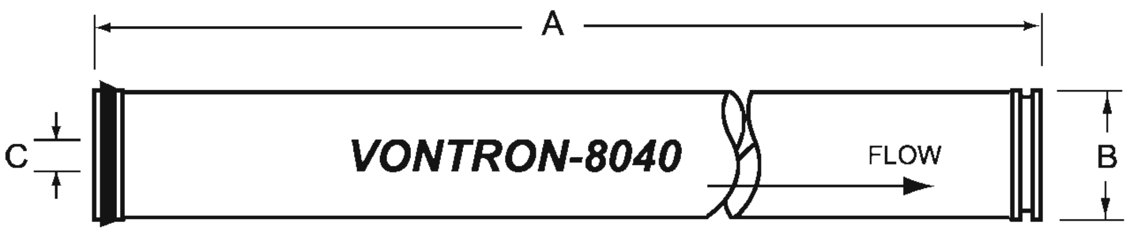
Testing Pressure.. 225 psi (1.55Mpa)
Temperature of Testing Solution.............................. 25 ℃
Concentration of Testing Solution (NaCl)................. 2000ppm
pH Value of Testing Solution................................ 7.5
Recovery Rate of Single Membrane Element.............. 15%

Operating Limits and Conditions

Max. Working Pressure.. 600psi (4.14Mpa) (for 8040 and 4040)
Max. Feedwater Flow.. 75gpm (17 m3/h) (for 8040) 16gpm (3.6 m3/h) (for 4040)
Max. Feedwater Temperature.. 45℃
Max. Feedwater SDI.. 5
Residual chlorine Concentration of Feedwater........................ ＜0.5ppm
pH Range of Feedwater during Continuous Operation............ 3～10
pH Range of Feedwater during Chemical Cleaning................. 2～12
Max. Pressure Drop of Single Membrane Element.................. 15psi (0.1Mpa) (for 8040 and 4040)

Dimensions of Membrane Element

All dimensions are shown in: millimeter (inch)



A=1016.0mm (40")   B=201.9mm (7.95")   C=28.6mm (1.125")

A=1016.0mm (40")   B=99.7mm (3.9")
C=19.1mm (0.75")   D=26.7mm (1.05")

Important Information

1. When hypochlorite is dosed, the catalytic and oxidative metallic ions in the feedwater, such as Cu^{2+}, Ni^{2+}, etc. shall be completely removed.

2. When hypochlorite is dosed, the pH value and temperature of Feedwater shall be kept under careful control to make sure that the feedwater temperature doesn't exceed 30℃ and the pH value is preferably between 6~8. Higher feedwater temperature or improper pH value may quicken the oxidation.

3. The salt permeation rate shall not exceed 4 times of the initial value within 3 years of service life.

4. It would be best to use the feedwater pipe made of high-pressure PVC or stainless with high resistance to corrosion, the membrane housing made of FRP, the pump and instrument made of FRP with high resistance to corrosion and containing no bronze component.

5. Since there is residual chlorine in the side of permeated water, the customer shall choose to carry out dechlorination treatment as per the practical application. Post carbon is recommended for this purpose.

6. When it is required to carry out impact disinfection, the hypochlorite solution with 2ppm concentration can be selected.

7. Any specific application must be limited within the Operating Limits and Conditions. We strongly recommend you to refer to the latest edition of technology manual and design guide prepared by Vontron Technology Co., Ltd., or consult experts proficient in membrane technology. In case the customer fails to follow the operating conditions as specified in this manual, Vontron technology Co., Ltd. will assume no liability for all results.

8. The permeate flow listed in the table is the average value. The permeate flow of single membrane element is within a tolerance not exceeding ±20% of the nominal value.

9. All wet-type membrane elements have been strictly tested before leaving the factory, and have been treated with the solution of 1.0% sodium hydrogen sulfite (an antifreeze solution of 10% propanediol required in winter) for storage purpose, then sealed with plastic bag in vacuum, and further packed in carton boxes. In order to prevent the breeding of microbes during short-time storage, transportation and system standby, we recommend you to soak the membrane elements with protective solution (prepared with RO filtered water) containing 1.0% sodium hydrogen sulfite (foodstuff-purpose).

10. Discard the RO-filtered water produced during the first one hour after system start-up.

11. During storage time and run time, it is strictly prohibited to dose any chemical medicament that may be harmful to membrane elements. In case of any violation in using this kind of chemical medicament, Vontron Technology Co., Ltd. assumes no liability for any outcome incurred herefrom.

Points of Attention

1. All data and information provided in this manual have been obtained from long-term experiment by Vontron Technology Co., Ltd. We truly believe that these data and information are accurate and effective. Vontron Technology CO., Ltd. assumes no liability for any aftermath caused by user's failure in abiding by the conditions specified in this manual in use or maintenance of membrane products. It is strongly recommended that the user shall strictly abide by the requirements for design, use and maintenance of products and keep relevant records

2. Along with technical development and product renovation, the information contained herein will be subject to modification without prior notification. Please keep an eye on the website of Vontron Technology Co., Ltd. for any update of product.

Chapter III– General Technical Specifications of VONTRON™ NF Membranes

3.1 Nanofiltration Membranes – Residential Element

Brief Introduction

Applicable to various small-sized drinking systems, such as home drinking water purifiers, mineralized drinking fountain, etc., the residential 1812-type and 2012-type NF elements are designed for removing from water various organics, microbes, viruses and most metallic ions with two or higher valence while retaining part of the sodium, potassium, calcium and magnesium ions, etc., thus improving the mouthfeel of purified water and maintaining the content of mineral nutrition.

VNF1: Moderate rejection rate; Moderate passage of calcium

VNF2: Higher rejection of calcium

Specifications and Major Properties

Model	[Active Membrane Area] ft²(m²)	Solution Type	[Average Permeate] GPD(m³/d)	[Stable Rejection] %
VNF1-1812	4.4 (0.41)	NaCl	60 (0.22)	30~50
		$CaCl_2$		>60
VNF2-1812	4.4 (0.41)	NaCl	50 (0.19)	50~70
		$CaCl_2$		>80
VNF1-2012	5.0 (0.46)	NaCl	100 (0.38)	30~50
		$CaCl_2$		>60
VNF2-2012	5.0 (0.46)	NaCl	85 (0.32)	50~70
		$CaCl_2$		>80

Notes: The permeate flow of single membrane element may vary within (-15%) ~ (25%)

Testing Conditions

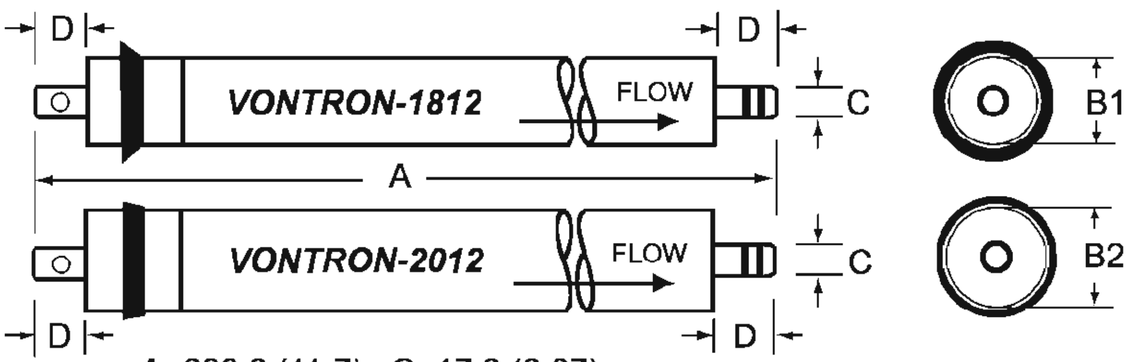
Testing Pressure...................................... 30 psi (0.2Mpa)
Temperature of Testing Solution.................. 25 ℃
Concentration of Solution (NaCl).................. 250ppm
Concentration of Solution ($CaCl_2$).................. 250ppm
pH Value of Solution................................ 7.5
Single Element Recovery........................... 15%

Operating Limits and Conditions

Max Working Pressure.. 300psi（2.07Mpa）
Max Feedwater Temperature.. 45℃
Max Feedwater SDI.. 5
Max Feedwater Hardness.. 400 ppm
Free Chlorine Concentration of Feedwater...................... ＜0.1ppm
pH range of feedwater during cont. oper........................ 3～10
pH range of feedwater during chem. cleaning................. 2～12
Max Pressure Drop of Single Element........................... 10 psi（0.07Mpa）

Dimensions

All dimensions are shown in millimeter (inch)



A=298.0 (11.7) C=17.0 (0.67)
B1=44.5 (1.75) B2=48.2 (1.9) D=21.0(0.83)

Important Information

1. Any specific application must be limited within the Operating Limits and Conditions. We strongly recommend you to refer to the latest edition of technology manual and design guide prepared by Vontron Technology Co., Ltd., or consult experts proficient in membrane technology. In case the customer fails to follow the operating conditions as specified in this manual, Vontron technology Co., Ltd. will assume no liability for any result.

2. The permeate flow listed in the table is the average value. The permeate flow of single membrane element is within a tolerance not exceeding ±25% of the nominal value.

3. The wet-type membrane elements have been strictly tested before leaving the factory, and have been treated with the solution of 1.0% sodium hydrogen sulfite (an antifreeze solution of 10% propanediol required in winter) for storage purpose, then sealed with plastic bag in vacuum, and further packed in carton boxes. In order to prevent the breeding of microbes during short-time storage, transportation and system standby, we recommend you to soak the membrane elements with protective solution (prepared with RO filtered water) containing 1.0% sodium hydrogen sulfite (foodstuff-purpose).

4. Discard the RO-filtered water produced during the first one hour after system start-up.

5. During storage time and run time, it is strictly prohibited to dose any chemical medicament that may be harmful to membrane elements. In case of any violation in using this kind of chemical medicament, Vontron Technology Co., Ltd. assumes no liability for any outcome incurred herefrom.

Points of Attention

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3.2 Nanofiltration Membranes–Industrial Element

Brief Introduction

The industrial nanofiltration element is designed for removing from water various organics, microbes, viruses and most metallic ions with two or higher valence while retaining part of the sodium, potassium, calcium and magnesium ions, etc. Nanofiltration, free of chemical reaction, heating and transformation, can keep the biological activity undamaged and maintain the primary flavor or fragrance of substance unchanged, and is increasingly applied in production of drinking water and in separation and concentration/purification processes for foodstuff, medicine, biological engineering and pollution treatment, etc.

VNF1: Moderate rejection rate; Moderate passage of calcium; High removal of TOC

VNF2: Higher rejection rate; Satisfactory removal of insecticide, herbicide, TOC and transition metals.

Specifications and Major Properties

Model	[Active Membrane Area] ft²(m²)	Solution Type	[Average Permeate] GPD(m³/d)	[Stable Rejection] %
VNF1-8040	400（37.2）	NaCl	12000（45.5）	40～60
		$MgSO_4$	10000（37.5）	＞96
VNF2-8040	400（37.2）	NaCl	7500（28.4）	80～95
		$MgSO_4$	9000（33.9）	＞96
VNF1-4040	80（7.4）	NaCl	2400（9.1）	40～60
		$MgSO_4$	2000（7.5）	＞96
VNF2-4040	80（7.4）	NaCl	1400（5.3）	80～95
		$MgSO_4$	1800（6.8）	＞96
VNF1-2540	28（2.6）	NaCl	800（3.03）	40～60
		$MgSO_4$	650（2.46）	＞96
VNF2-2540	28（2.6）	NaCl	525（1.98）	80～95
		$MgSO_4$	600（2.27）	＞96

Notes: Minimum rejection of MgSO4 is 94%. The permeate flow of single element may vary within ±25%.

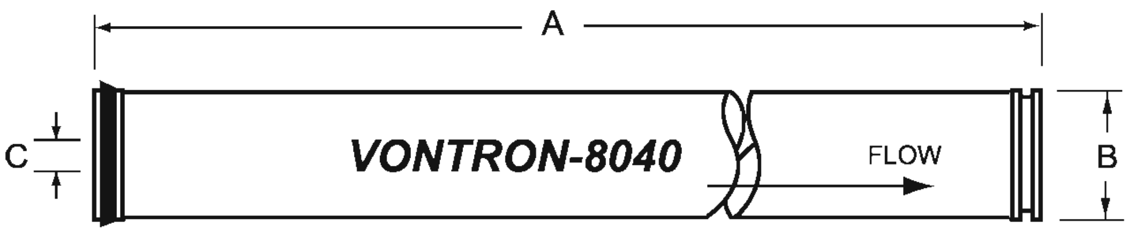
Testing Conditions
- Testing Pressure...................................... 70 psi (0.5Mpa)
- Temperature of Testing Solution.................. 25 ℃
- Concentration of Solution (NaCl).................. 2000ppm
- Concentration of Solution (MgSO4)............... 2000ppm
- pH Value of Solution................................. 7.5
- Single Element Recovery........................... 15%

Operating Limits and Conditions

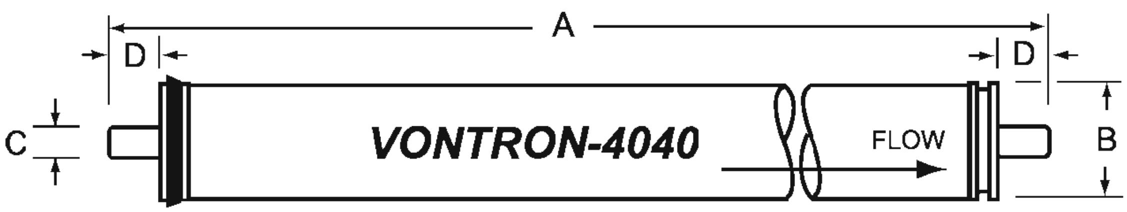
Max Working Pressure.. 600psi（4.14Mpa）
Max Feedwater Flow.. 75gpm（17 m3/h） （8040）
.... 16gp（3.6 m3/h） （4040）
Max Feedwater Temperature.................................. 45℃
Max Feedwater SDI.. 5
Free Chlorine Concentration of Feedwater................ ＜0.1ppm
pH range of feedwater during cont. oper.................... 3～10
pH range of feedwater during chem. cleaning............ 2～12
Max Pressure Drop of Single Element....................... 15 psi（0.1Mpa）

Dimensions of Membrane Element

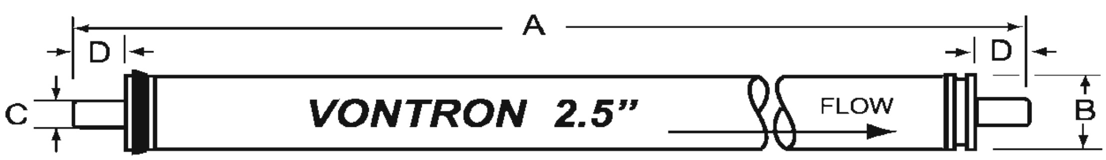
All dimensions are shown in: millimeter (inch)



A=1016.0mm (40") B=201.9mm (7.95") C=28.6mm (1.125")



A=1016.0mm (40") B=99.7mm (3.9")
C=19.1mm (0.75") D=26.7mm (1.05")



2540:	A=1016.0mm (40")	B=61.0mm (2.4")	C=19.1mm (0.75")	D=30.2mm (1.19")
2521:	A=533.4mm (21")	B=61.0mm (2.4")	C=19.1mm (0.75")	D=30.2mm (1.19")

Important Information

1. Any specific application must be limited within the extreme operating conditions. We strongly recommend you to refer to the latest edition of technology manual and design guide prepared by Vontron Technology Co., Ltd., or consult experts proficient in membrane technology. In case the customer fails to follow the operating conditions as specified in this manual, Vontron technology Co., Ltd. will assume no liability for any result.

2. The permeate flow listed in the table is the average value. The permeate flow of single membrane element is within a tolerance not exceeding ±25% of the nominal value

3. The wet-type membrane elements have been strictly tested before leaving the factory, and have been treated with the solution of 1.0% sodium hydrogen sulfite (an antifreeze solution of 10% propanediol required in winter) for storage purpose, then sealed with plastic bag in

vacuum, and further packed in carton boxes. In order to prevent the breeding of microbes during short-time storage, transportation and system standby, we recommend you to soak the membrane elements with protective solution (prepared with RO filtered water) containing 1.0% sodium hydrogen sulfite (foodstuff-purpose).

4. Discard the RO-filtered water produced during the first one hour after system start-up.

5. During storage time and run time, it is strictly prohibited to dose any chemical medicament that may be harmful to membrane elements. In case of any violation in using this kind of chemical medicament, Vontron Technology Co., Ltd. assumes no liability for any outcome incurred herefrom.

Points of Attention

1. All data and information provided in this manual have been obtained from long-term experiment by Vontron Technology Co., Ltd. We truly believe that these data and information are accurate and effective. Vontron Technology CO., Ltd. assumes no liability for any aftermath caused by user's failure in abiding by the conditions specified in this manual in use or maintenance of membrane products. It is strongly recommended that the user shall strictly abide by the requirements for design, use and maintenance of products and keep relevant records.

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Chapter IV–Guide to Design of RO System

A complete set of RO system consists of 4 parts: pretreatment; RO section (membrane filtration); post-treatment; system cleaning section. An RO is reasonably designed according to specific feedwater quality and various requirements for product water quality so as to decrease the contamination speed, elongate the cleaning cycle of system, reduce the cleaning frequency, improve the long-term stability of system and decrease the operating costs of system.

The system is designed generally according to the following steps:

1) Completely analyzing the quality of water source

2) Designing a reasonable and efficient pretreatment solution in line with the water sources.

3) Designing a reasonable RO system in accordance with permeate flow and product water quality, etc.

4) Designing the post-treatment section (such as mixed bed or EDI system) to produce the water with higher quality.

5) Designing a reasonable system of chemical cleaning.

6) Determining the designing parameters for pilot test of large-sized system.

4–1 Design of Pretreatment Section of RO System

4–1.1 Analysis of Type and Quality of Raw Water

4-1.1.1 Type of Raw Water

The type of water is determined by the total dissolved solids (TDS) and the organic content of the raw water:

① RO filtered water, with TDS generally less than 50 mg/L.

② Tap water, with TDS generally less than 500 mg/L

③ Brackish water, with TDS generally lower than 5000mg/L, classified as surface water and underground water.

④ Quasi seawater, with TDS generally between 5,000~15,000 mg/L.

⑤ Seawater, with TDS generally at 35,000 mg/L

⑥ Grade-III wastewater (reclaimed water), with organic substance at comparatively high content (high values of TOC and BOD).

Different types of water source require different processes of pretreatment and different models of membrane element. For designing small-sized engineering projects without the conditions for water quality analysis or test, please refer to the pretreatment system of those projects that have been put into operation for similar water sources. Nevertheless, full analysis of water quality must be done for large-scale engineering project.

4-1.1.2 Items of Analysis of Raw Water Quality

The water quality of raw water determines the process flow of pretreatment, and the complete parameters of water quality analysis is the important guaranty for designing the reasonable pretreatment system and ensuring the long-term stable operation of RO system. Table 1 shows the items for analysis of water quality of RO system recommended by Vontron Technology Co., Ltd.

Table 1–Analysis of Raw Water Quality in RO System

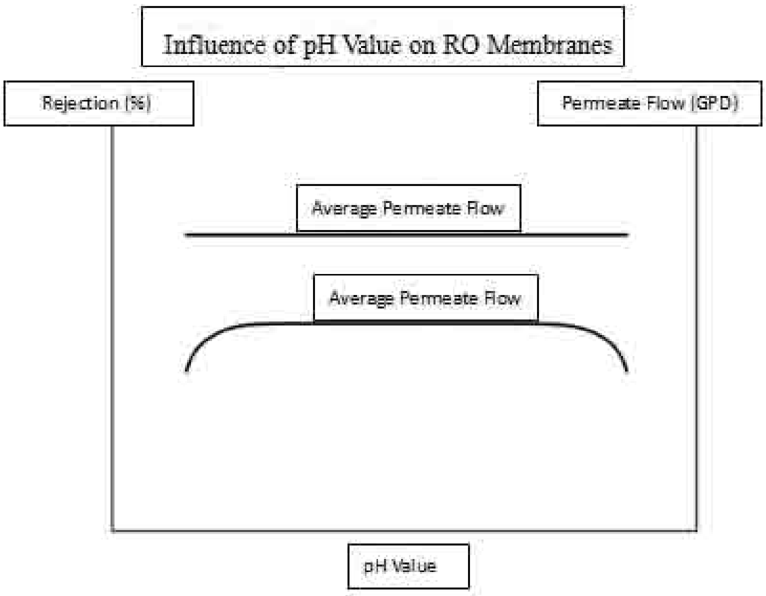
Project Name _____ Sampling Time _____ Sampling Position _____ Source of Raw Water_____ Time of Analysis _____ Analyzed by _____					
pH		Turbidity (NTU)		Water Temp. (℃)	
SDI		Conductivity (μS/cm)		ORP(mV)	
Ionic Compositions	ppm	meq/L	Ionic Compositions	ppm	meq/L
Calcium Ion (Ca^{2+})			Chlorine Ion (Cl^-)		
Magnesium Ion (Mg^{2+})			(SO_4^{2-})		
Sodium Ion (Na^+)			(CO_3^{2-})		
Barium Ion (Ba^{2+})			(HCO_3^-)		
Strontium Ion (Sr^{2+})			(PO_4^{3-})		
Potassium Ion (K^+)			(F^-)		
Ferrous Ion (Fe^{2+})			(NO_3^-)		
Ferric Ion (Fe^{3+})			(SiO_2)		
Aluminum Ion (Al^{3+})			OtherIons (such as boron ion)		
Total Cations			Total Anions		
TDS (ppm)			BOD(ppm)		
Total Hardness ($CaCO_3$ppm)			COD(ppm)		
Total Alkalinity (mL)			Number of Microbes, per Liter		
Phenolphthalein Alkalinity (mL)			Residual chlorine Concentration (ppm)		

Where Ba2 + and Sr2 + must be tested to the magnitude of 1 μ g/L(ppb) and1mg/L(ppm).

4-1.1.3 Descriptions of Each Item of Water Quality Analysis and Its Significance

(1) pH

The pH value of raw water reflects the acidity/alkalinity of raw water, i.e., to be neutral with pH at 7, to be acid with pH at 0~7, to be alkaline with pH at 7~14. Since the variation of pH can influence the rejection of ions and cause the variation of rejection rate of system, the optimal pH value of RO system is within 6~8, and pH value is a critical parameter in pretreatment design. In addition, lowering the pH value of feedwater is an effective means to restrict the deposition and separation of calcium carbonate. The pH value has the influence on rejection rate of RO membrane element, as shown in the following figure:



(2) Turbidity

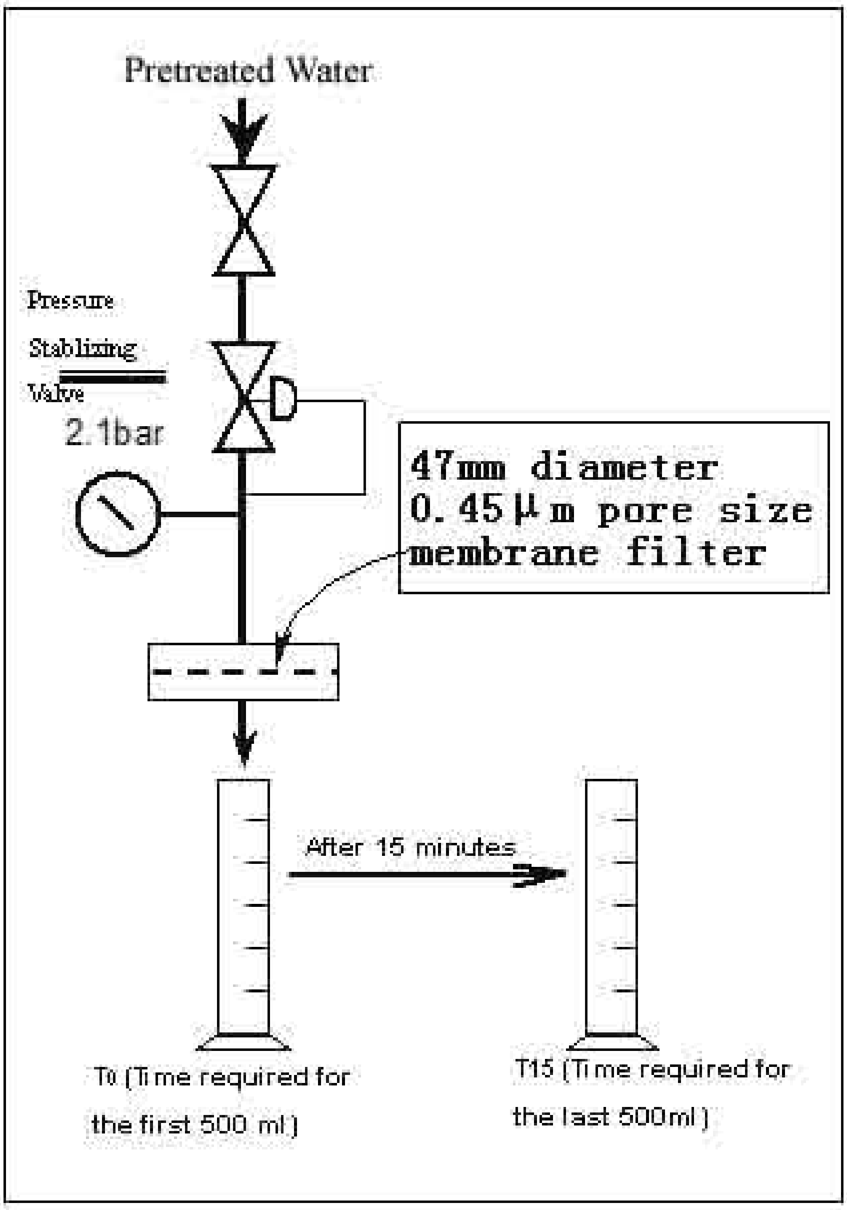
According to ISO, turbidity is defined as the decrease of transparency of liquids caused by the existence of insoluble substances. Based upon the differences in turbidity standard solutions, the turbidity values and measurements obtained may vary from each other. Currently, the solution produced from the reaction of hexamethylenetetramine and hydrazine sulfate is universally used as the turbidity standard solution, and the turbidity measured by using the scattered –light turbidimeter is indicated in NTU. The RO system requires the feedwater with turbidity less than 1 NTU.

(3) Temperature

As a critical parameter in design of RO system, the temperature must be specified. Temperature has direct influence upon the system operating pressure (thus influencing the selection of high-pressure pump), the number of membrane elements and quality of product water as well as the solubility of crystals that may be deposited or separated. In general case, each temperature drop by 3℃ will cause a 10% decrease of RO system yield; each temperature drop by 5℃ will require a 15% increase of water pump pressure. If the temperature rises, the salt permeation of RO system increases and the conductivity of product water also rises. If the temperature drops, the salt permeation of RO system decreases and the conductivity of product water decreases.

(4) SDI

SDI (Silt Density Index), also known as fouling index (FI), is an important index representing the feedwater quality of RO system, and is the best way for determining the colloidal and granular contamination in the feedwater of RO system. The standard method for inspecting the SDI is specified in ASTM TEST (D189-82).



Above is the diagram of an SDI Tester.

The test shall be carried out in the following steps:

1. First, take a piece of tested membrane sheet with 47mm diameter and 0.45μm hole diameter and put it into the testing box (pay attention to the correct front and reverse faces of membrane sheet). Tighten and seal the box, and keep it in vertical position.

2. Regulate the feedwater pressure to 2.1bar (30psi) and measure immediately the T0, i.e. the time required for 500 (250) ml of water to permeate the filtration membrane. Maintain the pressure consistently at 2.1bar, and continue the filtration for 15 minutes, then measure the T1, i.e. the time required for 500 (250) ml of water to permeate the filtration membrane.

3. After obtaining T0 and T1, calculate the SDI of feedwater according the following formula::

SDI15=[1-TO/T1]*100/15

In practical application, the RO system always requires an SDI value less than 5. When T1 is equal to 4 times of T0, the SDI is 5. With the SDI at 6.7, the water can completely foul the tested membrane and T1 cannot be obtained, in which case the RO pretreatment system needs to be regulated so as lower the SDI to below 5.0.

Generally, when the feedwater SDI of RO system is less than 3, the membrane system will suffer a much low risk of contamination, and the membrane system can be free from excessively quick contamination during the equipment operation. When the SDI is greater than 5, it represents that serious contamination of membrane may occur during the running of RO system.

（5）Conductivity and Total Dissolved Solids (TDS)

Conductivity is an index representing the electrical conductibility of the ions dissolved in water, and is measured by a conductivity meter and generally shown in μS/cm. Conductivity is a convenient and effective method for measuring the ion concentration of water, but is unable to accurately reflect the composition of ions. The conductivity rises along with the increase of ionic concentration.

TDS (total dissolved solids) is the inorganic substances remaining after the suspended substances are filtered and the colloids are evaporated. The TDS can be measured directly by using a TDS meter, or can be calculated through the conversion of water conductivity measured. A rough calculation is as follows: For the reference solution of sodium chloride, the conductivity of 2μS/cm corresponds to the TDS of 1 ppm.

（6）Oxidation-Reduction Potential (ORP)

The oxidation-reduction potential (ORP) is an index representing the amount of oxidative substances and reductive substances, and is indicated generally in millivolt (mV). When the ORP is a positive figure, it represents that there is oxidative substance in the water, while it represents that there is reductive substance in water when the ORP is a negative figure. In general, the RO system requires the ORP of feedwater to be less than 200 mV.

The oxidative substances in water generally include residual chlorine, ozone, etc. Since compound polyamide membrane has an inferior resistance to oxidation, VONTRON membrane series require the residual chlorine content of feedwater not to exceed 0.1 ppm. For the water sources with high ORP, the oxidative substances must be removed by using the activated carbon adsorption or dosing the reductant.

Sometimes the water in the nature may appear to be negative in ORP, which means that there is H_2S, SO_3^{2-}, or Fe^{2+}, etc. in the water. The RO system is also sensitive to H_2S and Fe^{2+}, because tthese two substances may cause colloidal and microbic contamination. A number of methods, such as activated carbon adsorption, oxidative deposition, flocculation filtration, ionic exchange, etc., can be adopted to get rid of these substances in pretreatment system.

（7）Composition of Ions

Of the inorganic salts dissolved in water, the hardly or slightly soluble salts formed from the combination of cations and anions may become some soluble at certain temperature, and may foul on the surface of RO membrane when the Feedwater of RO system has been continuously concentrated to exceed the solubility limit. The hardly soluble salts frequently seen include $CaCO_3$ and $CaSO_4$, and other compounds that may result in scaling include CaF_2, $BaSO_4$, $SrSO_4$ and $Ca_3(PO_4)_2$. In case it's possible that the cations and anions form the hardly or slightly soluble salts as mentioned above, measures must be taken to control the fouling in pretreatment and to avoid deposition or fouling caused by the situation that the concentration of hardly or slightly soluble salts exceed their solubility. Vontron's RODesign or other design software can be utilized to determine whether the hardly or slightly soluble salts can deposit under the designed recovery conditions.

（8）Hardness

Hardness of water means the concentration of calcium and magnesium ions in the water, measured in mg/L as $CaCO_3$. For the water sources with high hardness and alkalinity, special importance should be attached to the prevention of $CaCO_3$ scaling in pretreatment process.

	Hardness	
	Meq/L	mg/L as $CaCO_3$
soft	<1	<50
moderately hard	1～3	50～150
hard	3～6	150～300
very hard	>6	>300

(9) Alkalinity

Alkalinity refers to the content of alkaline substances that can react with strong acid (generally the standard HCL solution with 0.1mol/L concentration) in the water. Alkalinity is mainly for representing the content of bicarbonate (HCO_3^-), carbonate (CO_3^{2-}) and hydroxide ions, and is classified into phenolphthalein alkalinity and total alkalinity. When in titration, the alkalinity measured by using phenolphthalein as indicator (pH = 8.3 at the end point indicated) is called "phenolphthalein alkalinity". The alkalinity measured by using orange methyl orange as indicator (pH = 4.4~4.5 at the end point indicated) is called "methyl-orange alkalinity" or "total alkalinity". Therefore, phenolphthalein alkalinity is simply part of the total alkalinity. The relationship between "phenolphthalein alkalinity" and "total alkalinity" is shown in the following table:

Table 2–Relationship between Alkalinity and Part of the Ions Contained in Water

Relation between M and P	Content of Various Alkalinities of Water		
	HCO_3^-	CO_3^{2-}	OH^-
M=0, namely A=P	0	0	A
A>2P, Namely M>P	M−P	2P	0
A<2P, Namely M<P	0	2M	P−M
A=2P, Namely M=P	0	A	0
P=0, Namely A=M	A=M	0	0

Notes

1. The concentration of standard solution HC1 is 0.1 mol/L.
2. P is the volume of standard solution consumed where phenolphthalein is used as the indicator; M is the volume of standard solution consumed where methyl orange is used as the indicator subsequently after titration is conducted with phenolphthalein as the indicator.
3. A = M + P, i.e. the total consumption of standard solution.

（10）COD、BOD、TOC

In water treatment, three indexes, i.e. chemical oxygen demand (COD), biochemical oxygen demand (BOD) and total organic carbon (TOC) are generally used for representing the content of organic substances in water. There are great varieties of organic substances in the nature, and the organic constituents contained in water mainly consists of humic acid, surfactant, oil, microbes, agricultural chemicals, etc.

1）Chemical oxygen demand (COD) refers to the consumption of oxidant when strong oxidant is used for treating the sampled water under certain conditions. It is an index representing the amount of reductive substances contained in water. Though also containing nitrite, sulphide and ferrous salt, etc., the reductive substances in water consist mainly of organic substances. Therefore, the chemical oxygen demand (COD) is usually used as an index representing the amount of organic substances in water. There are two reagents for determining the COD, i.e. potassium bichromate (CODCr) and acid potassium permanganate (CODMn), of which the former is mostly applied to the test of industrial waste water and the latter is applied to the test of natural water. Since potassium bichromate has a stronger oxidizability than potassium permanganate, the CODCr is generally greater than CODMn.

Biochemical oxygen demand (BOD) is the total amount of oxygen dissolved in water consumed for the inorganic transformation and gasification of organic substances owing to oxidation and decomposition caused by the biochemical action of microbes. It is indicated in ppm (mg/L). Currently in both domestic and abroad, the amount of oxygen consumed in five days of breeding at temperature of 20℃ is used as the index of BOD, called BOD5.

The biochemical property, i.e. the ratio of BOD5 to CODCr, represents the content of organic matters contained in the water that can be biologically decomposed. The higher the ratio is, the better the biochemical capability is, and the lower is the content of organic substances contained in the water produced from biochemical treatment, or vice versa with the lower ratio.

2) Total Organic Carbon (TOC): It is a comprehensive index indicating the total organic matters contained in water body by means of carbon content. The firing method is used for measuring the TOC, which can completely oxidize the organic matters. It can represent the total amount of organic matters in a more direct way than the oxygen consumption can; therefore it is frequently used for evaluating the degree of pollution on the organic matters contained in the water. However, the TOC measuring method is comparatively complicated and has strict requirements for the testing equipment, and moreover, it cannot accurately measure the content of organic substances in the water.

（11）Silicon Dioxide

In most water sources, the content of soluble silicon dioxide (SiO_2) is mainly between 1~100 mg/L. If being excessively saturated, the SiO_2 may automatically gather together, and form the insoluble colloidal silicon, thus resulting in the fouling of membrane. The fouling of SiO_2 is one of the serious contaminations in RO membrane elements, and is extremely difficult to be removed once being deposited on membranes. A number of treatment processes are recommended for the water containing SiO_2, such as dosing of anti-scalant, regulating the pH value (SiO_2 has the minimal solubility when the pH value is between 7~7.8), lime-soda softening, decreasing of recovery, increasing of feedwater temperature, etc.

4–1.2 Water Treatment Processes Frequently Used in RO Pretreatment

In most cases, the original water cannot be allowed to enter the RO element, because the impurities contained in water may contaminate the element, which will affect the stable running of system and the service life of membrane element. Pretreatment is a process treating the impurities contained in the raw water according to their properties by using proper technologies so that the requirements of feedwater can be satisfied for the RO membrane elements. It is called pretreatment simply because it occurs in the position prior to the reverse osmosis in the whole technological process of water treatment.

For the RO system, the feedwater is habitually classified as underground water, tap water, surface water, seawater, and wastewater (reclaimed water), etc. Since the water bodies are influenced by various factors, the differences in geographical conditions and seasonal weather can cause the properties of the water bodies and the impurities contained herein to be somewhat different, and therefore the technologies of RO treatment may vary to some extent. The reasonable pretreatment should satisfy the following requirements

1. The pretreatment must be capable of removing most of the impurities in the raw water to satisfy the feedwater requirements for membrane elements.

2. The variation of water quality (such as seasonal variation in water volume and temperature, etc.) must be taken into consideration in pretreatment so as to prevent the stable operation of the entire system from being influenced by the fluctuation of raw water quality.

3. The pretreatment process must be able to run stably in high efficiency; besides, it must simplify the processing flow so as to reduce the investment and the operating costs.

The indexes of feedwater quality requirements are as shown in Table 3.

www.famcocorp.com
E-mail: info@famcocorp.com
@famco_group
Tel:۰۲۱-۴۸۰۰۰۰۴۹
Fax:۰۲۱ - ۴۴۹۹۴۶۴۲
تهران، کیلومتر ۲۱ بزرگراه لشگری (جاده مخصوص کرج)
روبروی پالایشگاه نفت پارس، پلاک ۱۲

Table 3–Indexes of Feedwater Quality for RO Membrane

Items		RO Membrane (Spiral Wound Compound Polyamide Membrane)	Type of Possible Contaminations in Over-limit Operation
1	Turbidity (degree)	<1	Contamination of Silt and Sludge
2	Silt Density Index (SDI)	<5	Contamination of Silt, Sludge and Colloid
3	pH Value	3～10	Hydrolization of Membrane Element
4	Water Temperature（℃）	5～45	Excessively low temperature results in excessively high pressure and therefore in uneconomic operation of system. Excessively high temperature may cause irreversible attenuation of membrane performance.
5	Hardness (Ca、Mg)(mg/L)		Scaling of Inorganic Salts
6	Alkalinity (HCO_3)(mg/L)		Scaling of Carbonate
7	BOD(mg/L)	<10	Organic Contamination
8	COD_{Mn}(O_2,mg/L)	<15	Organic Contamination
9	TOC(mg/L)	<2	Organic Contamination
10	Residual chlorine (mg/L)	Less than 0.1 for regular membrane. No limit for oxidation-resistant membrane.	Oxidation of Membrane Element
11	Iron (total irons) (mg/L)	<0.05	Contamination of Iron
12	Manganese (mg/L)	<0.1	Contamination of Manganese
13	Cations, amphoteric and neutral surfactants (mg/L)	Not detected.	Irreversible attenuation of permeated flow.
14	Detergent, oil, H_2S, etc. (mg/L)	Not detected.	Contamination of organic substances and oil
15	Precipitates, salts, etc. (mg/L)	No deposition caused by rejected water	Scaling of inorganic salts

4-1.2.1 Flocculation and Flocculating Filtration

Flocculation treatment is for the purpose of treating the suspended granular and colloidal substances. According to the principle of flocculation, chemical reagents are dosed so as for the impurities in water to form large-granule floccule, deposit under the action of gravity, and then separate from the water. For flocculating filtration, the flocculant is dosed to the water so that the water and the flocculant can repeatedly keep in mutual contact while flowing through the sand filter so as to bring about flocculating reaction between each other, then the produced floc, after growing into specific volume, is retained inside the spaces between sand columns. The retained floc will further adsorb the fine alumen ustum contained in the water flowing by, thus purifying the water quality. Flocculation treatment has also an effect on the colloidal silicon.

Flocculant

There are various flocculants commonly used, among which most are the aluminum-salt flocculant, molysite flocculant or organic flocculant. When the use of simply one flocculant cannot obtain the satisfactorily good effect, the coagulant aids can be added in. The adding of coagulant aids is for two purposes: first, to improve the flocculent structure so as to enlarge its granules, which will be better for precipitation; second, to adjust the pH value of raw water in order to obtain the effect of best flocculation. Table 4 shows the flocculants and coagulant aids commonly available.

Flocculating filtration can be used only in the raw water with turbidity less than 70 degree, which is mostly the tap water or underground water. For the water sources with high turbidity (such as surface water, wastewater, etc.), the combined process with other treatment technologies is required, and only by this means can the feedwater satisfy the requirement of reverse osmosis system.

In order to properly select the flocculant types most suitable for the water body and to determine the most appropriate dosage, certain experiments may be properly carried out. Excessive dosing of flocculant may cause the contamination of membrane element. Especially when using the two flocculants of bivalent molysite and aluminum salt, it is necessary to detect the concentration of $Fe2+$ and $Al3+$ periodically for the purpose of preventing the membrane elements from colloidal contamination. When using the flocculant of ionic polymer, be sure to prevent the cationic polymer from influencing the regular electronegative membrane elements and prevent the anionic polymer from influencing the electropositive membrane elements. It must be also ensured that the use of flocculant will not react with other chemicals added to the system, such as antiscaling agent, etc. For the specific compatibility, please consult relevant chemical manufacturers.

Conditions of Flocculating Filtration Design and Selection of Equipment

Design Conditions: For the raw water with turbidity less than 70 degrees, multi-media filtration is generally selected, where gravity-type filter or pressure-type filter can be utilized. Different from double filter-material filter chamber commonly used, it requires the filter materials with larger granules, as shown in the following table:

Type of Filtration Material	(mm) Granular Diameter	Non-uniformity Coefficient	(mm) Thickness of Filtration Layer	(m/h) Filtration Velocity
Anthracite Coal	1.2～1.8	1.3	400～600	6～10
Quartz Sand	0.5～1.0	1.5	400～600	6～10

Rinsing intensity of filter chamber: 15—17L/(S•M2)

Rinsing Time: 5—10min

Maximum gravity or filter-chamber head loss: 2.5—3m

Maximum pressure or filter-chamber head loss: 10m, or 5m in general case.

The quartz-sand filter should be put into rinse for 10~15 hours before being used.

Among the filter materials, the anthracite coal is required to be stable in both acidity and alkalinity, while the quartz is required to be acid resistant and slightly dissolved out in alkaline solution. In flocculating filtration, better effect can be obtained by using molysite as the flocculant than using the aluminum salt. The designed water yield of filter should include the water consumption in subsequent treatment processes and the water consumed by the filter itself, i.e. the water for rinsing.

Table 4–Commonly Used Flocculants and Coagulant Aids and Their Flocculation Effect

Type of Flocculants		Applicable pH Values	Flocculation Effect
Flocculant of inorganic-salt type	Aluminum sulphate $Al_2(SO_4)_3 \cdot 18H_2O$	6～8	At low feedwater temperature, the floccules are light and loose, with considerably inferior treatment results obtained.
	Aluminum potassium sulphate (alum) $K_2SO_4 \cdot Al_2(SO_4)_3 \cdot 24H_2O$	6～8	The composite salt of aluminum sulphate and potassium sulphate, among which the latter exerts no action on the coagulation, therefore more of this flocculant is added than aluminum sulphate
	Ferrum trichloride $FeCl_3 \cdot 6H_2O$	4～11	Obvious effect of coagulation is obtained for treating the raw water with quite high turbidity and quite low water temperature. However, it is moisture-sensitive thus causing corrosion of metal and concrete.
	Ferrous sulphate $FeSO_4 \cdot 7H_2O$	4～11	It produces the weighty floccules with quick sedimentation and stable effect, and is little influenced by the water temperature. Yet it can produce $Fe(OH)_2$ of high solubility, which requires to be removed by oxidation.

Inorganic high-molecular coagulant	Alkaline aluminum chloride (PAC) $[Al_2(OH)_nCl_{6-n}]_m$ where n⩽5, m⩽10	6～8	It is high adaptable to various kinds of water quality, and enjoys a wide range of pH values. It also has comparatively satisfactory effect on the low-temperature water, where it quickly forms the floccules with large and weighty granules, and causes only little reduction of raw water alkalinity after being added in. Less quantity of it needs to be added in than aluminum sulphate does.
	Polymerized ferric sulphate $[Fe_2(OH)_n(SO_4)_{3-n/2}]_m$ where n<2,m>10	4～11	Enjoying the properties of small consumption, excellent effect (especially the effect of decoloration), low causticity, a wide range of applicable pH values, and small quantity of iron residues.
	Polymerized aluminum sulphate (PAS) $[Al_2(OH)_n(SO_4)_{3-n/2}]_m$ where 1⩽n⩽6， m<10	6～8	Having the flocculation characteristics similar to polymerized aluminum chloride, enjoying the comparatively good properties of decoloration, defluorination and turbidity reduction of the high-turbidity water. The water contains small quantity of aluminum residues after PAS treatment, and enjoys powerful filterability.
Organic high-molecular flocculant	Polyacrylamide (PAM)	8 and above; also applicable to water solution with the acidity not so strong	It is a synthetic high-molecular organic flocculant used most extensively. Its hydrolysis degree is limited generally within 30%~40%, and excellent effect can be obtained when jointly used with aluminum salt or molysite.
	Anionic polymer	6 and above	It owns the excellent flocculation effect but is expensive, and cannot be used in pretreatment of the low-fouling electropositive elements.
	Cationic polymer	6 and above	It owns the excellent flocculation effect but is expensive, and cannot be used in pretreatment of the low-fouling electronegative elements.
Coagulant aids	Silicic acids, such as activated silicic-acid clay, etc.	Less than 9	It has high effectiveness as the coagulant aids, but it is not easy to put its preparation under control and owns only a limited service life.
	PH and alkalinity regulator		Commonly using the muriatic acid, sulphate, lime, and sodium hydroxide, etc.
	Redox catalyst		Used for the oxidation of iron, manganese and ammonia nitrogen, and for the deodorization, etc.

4-1.2.2 Adsorption

Adsorption is a treatment method where porous solid substances are utilized to adsorb certain contaminants in the water onto surfaces of said substances so as to purify the water body. The contaminants that can be removed by adsorption method include organic substance, colloidal substance and residual chlorine, which have the functions of decoloration and odor removal, etc. The adsorbents frequently used include activated carbon, macroporous adsorbent, etc., classified as powder type and granule type according to their shapes. Granular activated carbon is currently the most frequently used adsorbent.

Activated carbon Adsorption

Activated carbon is a kind of black porous granule made from various black coal, anthracite coal, fruit shell or wood dust, etc. through carbonization and activation treatment. The physical property of activated carbon refers mainly to the structure and distribution of pores. The pores of various shapes and sizes are formed in the course of activation, which creates an enormous specific surface area and a large contacting area with water, thus bringing about a strong adsorbability. The activated carbon can not only adsorb various contaminants in the water, but also adsorb those contaminants such as SO2 in the waste gases, and therefore owns a wide range of applications in the fields of environmental protection and water treatment, etc.

The high-quality activated carbon generally has a specific surface area of above 1000m2/g, the total pore volume as high as 0.6 ~ 1.18cm3/g and the pore diameter of 0.001~10μm. According to their sizes, the pores can be classified as macropore, transitional pore and micropore, which have different adsorbability as shown in the following table. There are many indexes for the active-carbon products, as shown in the following table, which is based upon the national standard of GB/T7701.4-1997 of the People’s Republic of China. Please refer to this table for all applications.

Design of Activated carbon Column (Filter)

There are various kinds of activated carbon columns, such as pressure type and gravity type, etc. The pressure-type activated carbon column is frequently used in RO pretreatment system, with its shape and structure similar to the mechanical filter.

Activated carbon filter can be shaped simply into active column, or combined with quartz sand to form the quartz-sand active-carbon filtering column, which can not only adsorb the residual chlorine and organic matters but also get rid of the suspended solids.

In a quartz-sand active-carbon filter, a supporting layer and a quartz-sand filtering material layer with combined thickness of 0.2~0.5m are loaded on the bottom of filter, and a layer of activated carbon with 1.0~1.5m thickness is loaded atop. It has a filtration velocity of 6~12m/h, but owing to the small thickness of filling layer, however, it can be used only in the applications of comparatively good water quality and low contents of suspended substances and residual chlorine.

In a simplex active-carbon filter, no quartz sand is placed on the supporting layer but a layer of activated carbon fillings with 2.0~3.0m height, and the filter works at the filtrating velocity of 3~10m/h and the reverse flushing intensity of 4~12L/(s×m2).

Table 5: Technical Indexes of Coal–granule Activated carbon for Water Purification

Items		Indexes		
		Super-grade Products	First-grade Product	Acceptable Product
Pore Volume (cm^3/g)		⩾0.65		
Specific Surface Area (m^2/g)		⩾900		
Flotation Rate (%)		⩽2		
pH value		6~10		
Adsorption Value of Phenol (mg/g)		⩾140		
Water content (%)		⩽5.0		
Intensity (%)		⩾85		
Adsorption Value of Iodine (mg/g)		⩾1050	900~1049	800~899
Adsorption Value of Methylene Blue (mg/g)		⩾180	150~179	120~149
Ash Content (%)		⩽10	11~15	—
Filling Density (g/L)		380~500	450~520	480~560
Granularity (%)	>2.50mm	⩽2		
	1.25~2.50mm	⩾83		
	1.00~1.25mm	⩽14		
	<1.00mm	⩽1		

Points for attention when using the activated carbon

1) The activated carbon should be soaked in clean water before being filled into the filter in order to get rid of the contaminants. After being filled in the filter, it should be treated for 1~3 times alternately by using the 5% HCl solution and the 4% NaOH solution in the filtrating velocity of 10~21m/h, with the consumption being three times as much as the volume of activated carbon, then the filter should be rinsed for 8~10 hour.

2) Before running, the suspended matters and colloidal matters in the water should be removed as much as possible so as to prevent the micropore of activated carbon from being blocked. For general feedwater, it is required that the suspended substances shall be less than 3~5mg/L.

3) The adsorption end of activated carbon filter should be determined upon the nature of

the substances to be removed. Since the activated carbon in RO treatment is mainly purposed for eliminating the residual chlorine, the residual chlorine content in the permeated water should be limited to less than 0.1mg/L. Once this limit is exceeded, the activated carbon shall be replaced or regenerated immediately.

4-1.2.3 Precision Filter (Safety Filter)

Precision filtration, also known as micropore filtration or safety filtration, utilizes the machine-shaped filtration materials, such as filter fabric, filter paper, filter mesh and filter element, etc. to remove the extremely fine granules.

Ordinary sand filtration can remove the very tiny solid granules, and cause the permeated water to reach the turbidity of approximately 1 degree; nevertheless, the permeated water still contains a great quantity of granules with 1~5μm grain diameter, which cannot be removed by sand filtration. Though being very tiny in diameter, these granules, if directly entering the host machine of RO system, can still cause the contamination of membrane elements with the concentrating action of RO membrane. In order to get rid of these granules, precision filtration must be adopted.

The precision filter is usually mounted following the pressure filter, or installed at the end of the pretreatment process for the purpose of preventing the broken filtration materials, activated carbon and resin, etc. from entering the RO system, thus preventing as far as possible the granules produced in the preceding process from being conveyed to the next process. The diameter of filtration pore should match the granular phase of the impurities contained in water, and excessively large or small diameter should be avoided.

A pressure gauge should be mounted respectively at the water inlet and outlet of precision filter, and the difference can give judgment on the pollution degree of filter element in the precision filter. In general case, the filter element inside it needs to be replaced when the difference is greater than 15psi (0.1MPa).

Table 6: Filtration Precision of Precise Filtering Materials Frequently Used

Materials	Minimum grain diameter of granules removed (μ m)	Materials	Minimum grain diameter of granules removed (μ m)
Woven fabrics of natural and synthetical fiber	100~10	Foam plastic	10~1
Ordinary mesh filtration	10000~10	Fiberglass paper	8~0.03
Filter element of woven nylon mesh	75~1	Sintered ceramic (or sintered plastic)	100~1
Fiber paper	30~3	Microporous filtration membrane	5~0.1

4-1.2.4 Oxidation

Oxidation is a kind of chemical treatment method for oxidizing and decomposing the contaminants in water by utilizing strong oxidant. For RO system pretreatment, oxidation is usually for the purpose of removing the following two kinds of substances

① Organic substances

② Iron, manganese

Furthermore, oxidation can also get rid of the color, taste, odor and microorganisms, etc. in the water. The use of oxidation combined with such treating methods as flocculation, filtration and adsorption, etc. can achieve an excellent pretreatment effect. There are two kinds of oxidants frequently used, i.e., chlorine series and oxygen series. Besides, such oxidants as KMnO4, etc. can also be used.

Chlorine series: Cl2, ClO2, NaClO, etc.

Oxygen series: O3, H2O2, etc.

1）Removal of Organic Substances

The RO feedwater requires the TOC to be less than 2mg/L, because excessive organic matters will cause the contamination of elements, which must be removed in the pretreatment process. Theoretically, as soon as enough quantity of strong oxidants such as O3, ClO2, Cl2, etc. is added in, most of the organic matters can be thoroughly transferred to inorganic matters through oxidation; however, it requires considerably large quantity of oxidants to be added, long time of reaction and comparatively high cost, and may produce harmful byproducts. Usually in RO pretreatment, only the strong oxidant is required to break the long chain of organic matters, and convert them to micro-molecular organic matters, which shall then be removed by using such processes as adsorption, etc.

2）Removal of Fe2+ and Mn2+, etc.

Usually in the nature, the water body, especially the underground water, appears in the state of reduction because the water contains such reductive substances as Fe2+, Mn2+ and H2S, etc. Fe2+ is one of the reasons that cause the ferric contamination and colloidal contamination to membrane elements. In RO feedwater, ferric contaminant is still possibly caused even if the content of Fe2+ is less than 0.1mg/L. Therefore, when treating this kind of water source, the oxidation method is most frequently adopted to convert Fe2+ and Mn2 into the hardly soluble Fe3+ and MnO2 and then to remove them through filtration. ClO2 , O2 and Cl2 are frequently used for oxidation, with the reaction formula as follows:

2ClO2+5Mn2++6H2O=5MnO2+12H++2Cl-

ClO2+5Fe(HCO3)2+3H2O=5Fe(OH)3+10CO2+ Cl-+H+

ClO2 has a higher capacity of removing the iron and manganese than Cl2 does, therefore the utilization of ClO_2 is recommended for treating the water sources with high contents of iron and manganese.

It's necessary to notice that common polyamide composite membrane has an inferior oxidation resistance, and in terms of residual chlorine, the maximum concentration of residual chlorine in feedwater that Vontron membrane element can endure is 0.1mg/L, and therefore, relevant process must be set up to eliminate the residual oxidant in the pretreatment where oxidant is added in, in which case the method of active-carbon adsorption and the dosing of reductant ($NaHSO_3$) are usually adopted.

4-1.2.5 Sterilization and Disinfection

All of the water bodies contain such microorganisms as bacteria, fungus, algae, virus and protozoan, etc. If the water containing microorganisms enters directly the RO element without being treated by sterilization, the microorganisms will, under the RO concentration effect, gather on the surface of membrane, and form a microorganism film, which seriously influence the water permeate and rejection rate of element, cause the increase of pressure difference and result in the telescoping of the elements. Moreover, the rinse of element doesn't always obtain a satisfactorily good effect when it is contaminated with microorganisms, and therefore, the sterilization action must be taken in pretreatment process for the raw water, especially for the surface water, seawater and waste water, which contain microorganisms. For these water sources, we recommend you to select the oxidation-resistant RO membrane element which can simplify the pretreatment and prevent the risk of oxidation of membrane element. The sterilization process frequently used includes physical sterilization and chemical sterilization.

1）Physical Sterilization – UV Device

The UV with 254-nm wavelength has the best effect of sterilization. When UV irradiates on the bacteria, the energy of UV is absorbed by the nucleic acid of bacteria and thus changes the vitality of bacteria, and the synthesis of protein and enzyme inside the bacteria body becomes obstructed, thus causing the variation or death of microorganisms.

2）Chemical Sterilization – Germicide

Chemical germicide is generally classified as oxidative germicide and non oxidative germicide. The oxidative germicide includes Cl_2, ClO_2 and O_3, etc. The non oxidative germicide refers mainly to certain organic matters, such as DBNPA, isothiazolinone, formaldehyde, etc.

When oxidative germicide is used, it must be noticed that common compound membrane has an inferior resistance to oxidation, and the maximum content of residual chlorine in water that Vontron elements can endure is 0.1mg/L, and therefore, relevant process must be set up to eliminate the residual oxidant in the pretreatment where oxidant is added in, in which case the method of active-carbon adsorption and the addition of reductant ($NaHSO_3$) are usually adopted.

4-1.2.6 Prevention of Scaling Caused by Hardly Soluble Salt

The scaling of inorganic salt is a kind of contamination most commonly seen in RO element. Most of the water bodies in the nature contain hardly soluble saturated salts, such as calcium carbonate, etc. If directly entering the element without being treated before, the saturated salts will, upon the concentrating action of RO system, reach the oversaturated concentration, and form crystals that deposit on the membrane surface, thus causing contamination to the elements.

Regarding the scaling of CaCO3 , the indexes of LSI or S&DSI can be employed to represent the scaling tendency. For the rejected water with salt concentration less than 10000ppm, LSI is used as the index to indicate the scaling tendency of CaCO3, while S& DSI is used as the index to indicate the scaling tendency of CaCO3 for the rejected water with salt concentration greater than 10000 ppm. These two indexes are calculated according to the formulas as follows:

$$LSI = pHc - pHs \qquad TDS \leq 10000ppm$$

$$S\&DSI = pHc - pHs \qquad TDS > 10000ppm$$

where pHc refers to the pH value of rejected water, and pHs refers to the pH value of water saturated with calcium carbonate.

When LSI or S&DSI is ≥0, the scaling of CaCO3 will occur. Unless the antiscaling agent is dosed in the RO system, it must be guaranteed that both of LSI and S&DSI indexes be negative.

For the scaling of sulphates including those hardly soluble substances such as CaSO4, BaSO4, SrSO4, such methods as softening method, dosing of antiscaling agent or reducing of system recover rate is usually used for preventing the scaling. There are mainly three kinds of antiscaling agents, i.e. sodium hexametaphosphate, micromolecular organic phosphate and polyacrylate, with their merits and shortcomings shown in Table 7. Table 8 shows the solubility product constant of hardly soluble compounds.

Table 7: Comparison of Properties of Antiscaling Agents Commonly Used

Ingredients of Antiscaling Agent	Antiscaling Effects	Merits	Shortcomings
Sodium Hexametaphosphate	Inferior effect. It can ensure that the scaling of $CaCO_3$ will not occur only when the LSI is ⩽0.8	Inexpensive	Limited and unsteady effect of antiscaling; highly hydrolyzable; having the scaling risk caused by calcium phosphate.
Micro-molecular Organic Phosphate	Good effect. Being free from scaling of calcium carbonate when the LSI is ⩽2.0.	Good effect of antiscaling	Comparatively expensive
Polyacrylate	Good effect. No scaling of calcium carbonate will occur when the LSI is ⩽2.0.	Good effect of antiscaling	Comparatively expensive

Table 8: Solubility Product Constant of Hardly Soluble Salts (291 ~ 298K)

Descriptions	Molecular Formula	K_{sp}	pK_{sp}	Descriptions	Molecular Formula	K_{sp}	pK_{sp}
Barium Carbonate	$BaCO_3$	5.1×10^{-9}	8.29	Nickel carbonate	$NiCO_3$	6.6×10^{-9}	8.18
Barium fluoride	BaF_2	1.0×10^{-6}	6.00	Lead carbonate	$PbCO_3$	7.4×10^{-14}	13.13
Barium sulphate	$BaSO_4$	1.1×10^{-10}	9.96	Lead chloride	$PbCl_2$	1.6×10^{-5}	4.79
Calcium carbonate	$CaCO_3$	2.9×10^{-9}	8.54	Zinc carbonate	$ZnCO_3$	1.4×10^{-11}	10.84
Calcium fluoride	CaF_2	2.7×10^{-11}	10.57	Zinc hydroxide	$Zn(OH)_2$	1.2×10^{-17}	16.92
Calcium phosphate	$Ca_3(PO_4)_2$	2.0×10^{-29}	28.70	Zinc phosphate	$Zn_3(PO_4)_2$	9.1×10^{-33}	32.04
Calcium sulphate	$CaSO_4$	9.1×10^{-6}	5.04	Zinc sulphide	ZnS	1.2×10^{-23}	22.92
Calcium hydroxide	$Ca(OH)_2$	1.55×10^{-6}	5.81	Ferrous carbonate	$FeCO_3$	3.2×10^{-11}	10.50
Copper hydroxide	$Cu(OH)_2$	5.6×10^{-20}	19.25	Ferrous hydroxide	$Fe(OH)_2$	1.6×10^{-14}	13.80
Copper sulphide	CuS	8.5×10^{-45}	44.07	Ferrous sulphide	FeS	6.3×10^{-18}	17.20
Copper chloride	$CuCl_2$	1.2×10^{-6}	5.92	Iron hydroxide	$Fe(OH)_3$	1.1×10^{-36}	35.96
Magnesium carbonate	$MgCO_3$	3.5×10^{-8}	7.46	Ferrous phosphate	$FePO_4$	1.3×10^{-22}	21.89
Magnesium fluoride	MgF_2	6.4×10^{-9}	8.19	Lead sulphate	$PbSO_4$	1.6×10^{-8}	7.80
Magnesium hydroxide	$Mg(OH)_2$	1.2×10^{-11}	10.92	Strontium carbonate	$SrCO_3$	1.1×10^{-10}	9.96
Ammoniated magnesium phosphate	$MgNH_4PO_4$	2.0×10^{-13}	12.70	Strontium sulphate	$SrSO_4$	3.2×10^{-7}	6.49
Manganese carbonate	$MnCO_3$	1.8×10^{-11}	10.74	Strontium fluoride	SrF_2	2.4×10^{-9}	8.61
Manganese hydroxide	$Mn(OH)_2$	4.0×10^{-14}	13.40	Aluminum hydroxide	$Al(OH)_3$	2.0×10^{-33}	32.70

4-1.2.7 Softening

Softening refers to the treatment method where the chemical method is adopted to remove the hardness in the water. It is classified as ion-exchange softening and chemical-reagent softening.

Chemical-reagent softening is the process where, based upon the principle of solubility product, the hardness contained in the water is converted into the hardly soluble salts under proper conditions and then removed. In chemical-reagent softening, lime softening technology is usually adopted, which can effectively reduce the concentration of such ions as Ca2+, Mg2+ and Ba2+, etc., and which, however, is generally applied to large-scale brackish water system owing to that it needs to use the special-purpose reactor, that the pH value of permeated water may go up and that its operational cost is comparatively high. At present, ion-exchange softening is the softening method frequently used in RO pretreatment.

Ion-exchange softening is a softening treatment where ion exchanging agent is used in order for the hardness compositions of water body such as ions of Ca2+ and Mg2+, etc. to react with the effective exchange group (mainly the sodium ion) so that the water quality can be softened. It works as shown in the following formula

Exchange

$$2\,RNa + \begin{cases} Ca(HCO3)2 \\ CaCO3 \\ CaSO4 \end{cases} = R2Ca + \begin{cases} 2\,NaHCO3 \\ Na2CO3 \\ Na2SO4 \end{cases}$$

$$2\,RNa + \begin{cases} Mg(HCO3)2 \\ MgCO3 \\ MgSO4 \end{cases} = R2Mg + \begin{cases} 2\,NaHCO3 \\ Na2CO3 \\ Na2SO4 \end{cases}$$

Regeneration

$$R2Ca + 2NaCl = CaCl2 + 2RNa$$

$$R2Mg + 2NaCl = MgCl2 + 2RNa$$

Since ion exchange softening requires the regeneration of resin, which will consume the regenerative liquid and produce high-concentrated saline wastewater, it is economically inferior for the high-hardness water, and therefore, its utilization is restricted by certain conditions. Presently, it is adopted only in the small-scale system, while the middle-scale and large-scale systems generally use the method of dosing the antiscaling agent to prevent the contamination of inorganic-salt scaling.

4-1.2.8 Typical Pretreatment Processes on Various Contaminants

Pretreatment Processes	$CaCO_3$	$CaSO_4$	$BaSO_4$	$SrSO_4$	CaF_2	SiO_2	SDI	Fe	Bacteria	Oxidant	Organic Matters
Acidifying the pH value	▲							△			
Dosing the anti-scalant	△	▲	▲	▲	▲	△					
Softening with ion resin	▲	▲	▲	▲	▲						
Multimedia filtration						△	△	△			
Flocculation – Aided Coagulation						△	▲	△			▲
MF/ UF						▲	▲	△	△		▲
Filtration with Precision Filtering Element						△	△	△	△		
Filtration with Granular Activated carbon										▲	▲
Dosing of Reductant										▲	
Disinfection with chlorination / oxidation									▲		
Shock Disinfection									△		
Oxidation - filtration							△	▲			
Lime softening	△	△	△	△	△	△	△	△			△
Preventive cleaning	△					△	△	△	△		△
Regulation of operating parameters (pH, recovery rate)		△	△	△	△	▲					

△ regularly effective ▲ High effective

4–1.3 Comparison of Common Pretreatment Processes for Regular RO Membrane and Oxidation Resistant RO Membrane

Regular RO membrane can endure the impact of residual chlorine at 1000ppm•h, and the membrane element requires the residual chlorine in feedwater to be less than 0.1 ppm and the feedwater shall be free of oxidative substances, otherwise the membrane element will be oxidized. The oxidation-resistant membrane element can endure the impact of residual chlorine at 26000ppm•h (with rejection rate greater than 98%), which means that the membrane element can maintain a rejection rate of above 98% after 3 years of service in case the residual chlorine in feedwater is equal to 0.5 ppm. Since oxidation-resistant membrane has a much higher resistance to oxidation by residual chlorine than regular membrane, the unit for removing residual chlorine (or other oxidative substances) can be omitted from the pretreatment process, thus reducing the investment.

1. Pretreatment of Tap Water as Feedwater

Regular Membrane: Multimedia Filtration / Ultrafiltration + Activated carbon / Dosing of Reductant + Softening / Dosing of Anti-scalant + Reverse Osmosis

Oxidation-Resistant Membrane: Multimedia Filtration / Ultrafiltration + Softening / Dosing of Anti-scalant + Reverse Osmosis

2. Pretreatment of Underground Water as Feedwater

Regular Membrane: Multimedia Filtration / Ultrafiltration + Softening / Dosing of Anti-scalant + Reverse Osmosis

Oxidation-resistant Membrane: Multimedia Filtration / Ultrafiltration + Softening / Dosing of Anti-scalant + Reverse Osmosis

3. Pretreatment of Surface Water as Feedwater

Regular Membrane: Dosing of NaClO + Multimedia Filtration / Ultrafiltration + Activated carbon / Dosing of Reductant + Softening / Dosing of Anti-scalant + Reverse Osmosis

Oxidation Resistant Membrane: Dosing of NaClO + Multimedia Filtration / Ultrafiltration + Softening / Dosing of Anti-scalant + Reverse Osmosis

4. Seawater Desalination

Regular Membrane: Disinfection + Multimedia Filtration / Ultrafiltration + Activated carbon / Dosing of Reductant + Dosing of Anti-scalant + Reverse Osmosis

Oxidation Resistant Membrane: Disinfection + Multimedia Filtration / Ultrafiltration + Dosing of Anti-scalant + Reverse Osmosis

5. Reuse of Biological and Chemical Sewage

Regular Membrane: Disinfection + Multimedia Filtration / Ultrafiltration + Activated carbon / Dosing of Reductant + Reverse Osmosis

Oxidation Resistant Membrane: Disinfection + Multimedia Filtration / Ultrafiltration + Reverse Osmosis

6. Reuse of Industrial Wastewater (Electroplating Wastewater, etc.)

Regular Membrane: Chemical Deposition + Oxidation Treatment + Flocculation Deposition + Multimedia Filtration + Activated carbon Adsorption + Reverse Osmosis

Oxidation Resistant Membrane: Chemical Deposition + Oxidation Treatment + Flocculation Deposition + Multimedia Filtration + Reverse Osmosis

> **Notes:**
> 1. All data and information provided in this manual have been obtained from long-time experiment by Vontron Technology Co., Ltd. We believe the data and information contained herein to be accurate and effective. However, since the conditions and methods for use of our products are beyond our control, Vontron Technology Co., Ltd. assumes no liability for any result obtained or damages incurred through the application of the presented data and information. Regardless of separate use or working with other products, it is strongly recommended that the users shall carry out experiment to determine the safety of Vontron's products and their applicability to customers' specific end uses
> 2. Along with technical development and product renovation, the information contained herein will be subject to modification without prior notification. Please keep an eye on the website (www.vontron.com) of Vontron Technology Co., Ltd. for any update of product.

4–2 Design of RO Filtration System

The design of RO filtration system covers membrane element, arrangement of pressure vessels, high-pressure pump, pipe, instrument and meters, etc. It is the responsibility of the designer to lower the operating pressure and the cost of membrane element as much as possible and to raise the permeate flow and recovery rate as well as the long-term consistency of system and therefore reduce the expenses for cleaning and maintenance (low failure rate makes it practical to use cheap medicines for efficient cleaning).

4–2.1 Guide to Design of VONTRON Membrane Element

Fouling tendency of feedwater is the biggest factor influencing the design of membrane system, and fouling of membrane element is due to that there exist granules, colloidal substances and organic substances which deposits on the membrane surface, and the deposition speed of fouling substances rises along with the increase of average system permeate flow rate (permeate water load of specific membrane area) and recovery rate of membrane element (influencing the concentration polarization). Therefore, excessively high average system permeate flow rate and system recovery rate can be apt to bring about higher fouling speed and more frequent chemical cleaning.

This design guide contains the experiential parameters summarized from lots of engineering design and operating data for various types of water sources. The system designed according to this guide may have a longer running duration and a lower cleaning frequency. Please be aware that this guide is simply a reference for design, but not a commitment for quality guarantee.

Guide to Design of VONTRON Membrane Element

Feedwater Type		RO Permeate Water	Tap Water	Surface Water		Seawater		Wastewater	
				MF	Conventional Treatment	MF	Conventional Treatment	MF	Conventional Treatment
Feedwater SDI_{15}		<1	<3	<3	<5	<3	<5	<3	<5
Recomm System Permeate Flow (GFD)		25~30	16~20	14~18	12~16	8~12	7~10	8~13	7~12
Max Recovery of Single Element (%)		30	20	17	15	13	10	13	10
Max Permeate Flow (gpd(m^3/d))	2540-size	800 (3.0)	700(2.6)	600(2.3)	500(1.9)	500(1.9)	400(1.5)	500(1.9)	400(1.5)
	4040-size	2400 (9.1)	2000(7.6)	1600(6.1)	1500(5.7)	1400(5.3)	1200(4.5)	1400(5.3)	1200(4.5)
	8040-size ($365ft^2$)	10000(38)	8300(31)	7200(27)	6500(25)	5900(22)	5200(20)	5900(22)	5200(20)
	8040-size ($400ft^2$)	11000(42)	9100(34)	7900(30)	7200(27)	6400(24)	5700(22)	6400(24)	5700(22)
Min. Concentrate Flow gpm(m^3/h)	2540-size	0.7(0.16)	1(0.2)	1(0.2)	1(0.2)	1(0.2)	1(0.2)	1(0.2)	1(0.2)
	4040-size	2(0.5)	3(0.7)	3(0.7)	3(0.7)	3(0.7)	4(0.9)	4(0.9)	5(1.1)
	8040-size (365ft2)	10(2.3)	13(3.0)	13(3.0)	15(3.4)	13(3.0)	15(3.4)	16(3.6)	18(4.1)
	8040-size (400ft2)	10(2.3)	13(3.0)	13(3.0)	15(3.4)	13(3.0)	15(3.4)	18(4.1)	20(4.6)
Ma.x Feedwater Flow gpm(m^3/h)	2540-size	6(1.4)	6(1.4)	6(1.4)	6(1.4)	6(1.4)	6(1.4)	6(1.4)	6(1.4)
	4040-size	16(3.6)	16(3.6)	16(3.6)	16(3.6)	16(3.6)	16(3.6)	16(3.6)	16(3.6)
	8040-size (365ft2)	65(15)	65(15)	63(14)	58(13)	63(14)	56(13)	52(12)	52(12)
	8040-size (400ft2)	75(17)	75(17)	73(16.6)	67(15)	70(16)	62(14)	61(14)	61(14)

4–2.2 Design Steps for RO System

(1) Collect relevant data and get aware of the information concerning the nature and quality of water source as well as its variation. Select the type of membrane element and determine the average system permeate flow (in GFD or L/m2•h).

Select proper model of membrane element in accordance with the quality and feature of feedwater. Select ULP series for the application with feedwater conductivity less than 1000μs/cm while ULP series can provide satisfactory rejection rate. Select LP series for brackish water as feedwater. Select HOR (High Oxidation Resistant) series for feedwater containing oxidative substances. Select FR (Fouling Resistant) or HOR series for wastewater reuse. Select SW series for seawater desalination. Select 4040-size or smaller membrane element for those applications with system permeate flow less than 3 tons per hour, or select 8040-size membrane element for those applications with system permeate flow at or above 3 tons per hour.

"Average System Permeate Flow Rate" can be determined according to the data obtained from field experiment and experience, or can be figured out according to the design guide corresponding to the type of feedwater.

(2) Determining the quantity of membrane elements in series and the number of passes and stages

Pass: It refers to the number of permeation times of raw water, i.e. the number of times for which the filtered water permeates through the membrane. Multi-pass system can increase the quality of finished water product but decrease the system recovery rate. One-pass RO can reach a rejection rate of 98%~99%, and multi-pass can reach a rejection rate of above 99.5%.

Stage: It refers to the number of times for which the feed water flows through the pressure vessel, or in other words, the number of times for which the rejected water flows through different pressure vessels.

The use of multi-stage system can avoid the deterioration of contamination caused by low flow rate of rejected water of the membrane element at the terminal and the excessively high recovery rate. The configuration of stage is not as distinct and identifiable as that of pass. Flowing through multiple pressure vessels doesn't definitely mean the multiple stages. For example, in case longer pressure vessel cannot be installed in certain location, a number of shorter pressure vessels can be installed in series. Therefore, in order to identify the number of stages of RO system, make sure whether the feedwater mixes again after being divided and separately entering the pressure vessel. Every remixing of feedwater (rejected water) means the end of a stage.

The number of membrane elements in series shall be determined according to the recovery rate of expected design. However, excessive membrane elements in series will bring about the final rise of recovery rate of membrane element, which may increase the risk of scaling by inorganic salt, and in rare case is a pressure vessel utilized that can contain more than 6 membrane elements in series, but multi-stage design is applied in most cases. Currently, most RO membrane systems adopt double-stage design, and a system with 3 or more stages is adopted only in those applications requiring much high recovery rate or in concentrating application. In those applications requiring high recovery rate and few membrane elements, the backflow of rejected water is an applicable option. The relationship between recovery rate and number of membrane elements in series is as follows:

Number of Membrane Elements in Series	Maximum System Recovery Rate (%)
1	15～20%
2	28～33%
3	38～43%
4	43～48%
5	43～52%
6	50～60%
12	70～80%
18	85～90%

(3) Figure out the required number of membrane elements [$N_{\text{Membrane Elements}}$] and Pressure Vessels

[Number of Membrane Elements] = [Designed Permeate Flow] / ([Average System Recovery Rate] × [Membrane Area])

[Number of Pressure Vessels] = [Number of Membrane Elements] / [number of membrane elements in a pressure vessel], with the result rounded off

(4) Determination of Array of Membrane Element

For a multi-stage system in regular operation, when the feedwater flows into every membrane element, part of the feedwater permeates the membrane element and become the product water, which means that less volume of feedwater flows into next membrane element. Therefore, for the purpose of maintaining enough feedwater flow in every stage (to ensure enough flushing force on membrane surface) so as to prevent the deposition of contaminants on membrane surface, the number of pressure vessel in following stage is less than that in preceding stage, and the numbers of pressure vessels in two neighboring stages is at the ratio from 4:3 through 3:1. Higher ratio can effectively increase the feedwater flow in the following stage, while lower ratio can decrease the recovery rate of each membrane element in the preceding stage. The arrangement between 3:2 and 2:1 is frequently seen.

(5) Analog by Using Design Software

Input into VONTRON RO-Design Software the data figured out as mentioned above and carry out proper analogical calculation, then conduct relevant optimization and adjustment according to the results of calculation.

Taking the following as example

Assuming that tap water is used as feedwater, with SDI15<5, water yield required to be 100m3/h, recovery rate to be 75%, and feedwater conductivity to be 500μs/cm while product water conductivity to be in conformity with standard of purified water.

Step1: Since that the feedwater is from tap water with conductivity at 500μs/cm and that the product water conductivity to be in conformity with standard of purified water, the system rejection rate is required to be greater than 98%. ULP series of membrane elements (ULP21-8040, for example) can be selected for this application.

Regarding water productivity, with tap water used as feedwater and SDI_{15} less than 5, it can be found in the Guide to Design that the water productivity shall be between 16~20GFD with tap water as feedwater and SDI_{15} less than 3. For SDI_{15} less than 5, a water productivity of 16GFD or less shall be selected hereof.

Step2: With system recovery rate required to be 75% and system rejection rate to be greater than 98%, a number of 12 membrane elements in series are required, and a one-pass two-stage RO system can satisfy the requirements.

Step3: Select ULP21-8040 (effective membrane area to be 365 ft2 or 33.9m2). With the water productivity of system to be 100m3/h (or 440.92gpm), the number of membrane elements shall be 440.92×60×24gpd/(16×365) = 108 pieces.

Number of vessel pressure shall be 108/6 = 18 pcs.

Step4: The 18 pressure vessels shall be arrayed with the ratio of 2:1 (12:6).

Step5: Use the RODesign software of VONTRON to conduct analogical system arithmetic. This software can figure out the feedwater pressure, water quality indexes and the running parameters of each membrane element, and can conveniently optimize the system design by changing the number of membrane elements, models and array.

4–2.3 Other Considerations in Design of Membrane System

1）The pressure vessel of RO system shall be mounted alone on a specially made stand, and the two ends of the pressure vessel must be provided with enough room for the purpose of installation and replacement of membrane elements.

2）Since the pressure vessel will be elongated to some extent as being kept under pressure during the running of RO system, the regular deformation of pressure vessel must be kept unrestricted when the pressure vessel and its piping are fastened. Furthermore, after the pressure vessel is elongated as being kept under pressure, the membrane element may move forth and back inside the pressure vessel when the system is powered on or off or when the feedwater flow fluctuates. For this reason, it is advisable to use special cushion to fasten the membrane elements at the time of installation to prevent them from being damaged by shifting.

3）Startup and shutdown of the high-pressure pump will produce hydraulic impact (water hammer), which, if being exerted directly on the membrane element, will cause such phenomena as the breakage of glue line of membrane bag. Therefore, relevant devices must be designed for the RO system in order to prevent or reduce the impact of water hammer on the membrane element. Large-scale RO device generally uses frequency converting pump, soft start or electric butterfly valve for preventing the hydraulic impact. We recommend the use of frequency converting pump or the soft startup.

4）The pressure drop of single membrane element is not allowed to exceed 15 psi. Excessive pressure drop will cause the membrane element to extend along the direction of water flow, which will bring about the telescoping phenomenon and damage the membrane elements. For this reason, it must be ensured that the pressure drop of single membrane element will not exceed 15 psi and that of a single pressure vessel will not exceed 60 psi during the running of RO system. In case of any exceeding, please clean appropriately the membrane elements in time.

5）In no case is the membrane elements allowed to bear any backpressure greater than 5psi, because excessive backpressure can cause the polyamide desalting layer to peel off, thus resulting in irretrievable damage of the membrane elements. The maximum backpressure that the membrane elements produced by Vontron technology Co., Ltd. can bear is 5 psi.

6）Vontron Technology Co., Ltd. recommends that the design of RO system should ensure the low-pressure cleaning of membrane elements at every time when the system is started and shut down, and that the membrane elements should be rinsed everyday by using the RO-filtered water when the system is in downtime for short period (not exceeding 7 days). Please note that at any time of rinsing, the rinsing water must be able to satisfy the feedwater requirements of RO membrane elements, and the volume of rinsing water flow cannot exceed the maximum feedwater flow of single membrane element.

7）Measurement of temperature. In the RO system, the feedwater temperature will have influence on various parameters, such as electrical conductivity, permeate flow, feedwater pressure, etc., and it is therefore recommended that an on-line temperature tester be installed in the system as part of the recording of routine running parameters in order to standardize the running parameters and to give proper judgment on the running of system. For the water source with quite high feedwater temperature, a temperature alarm must also be mounted, which can raise the alarm when the feedwater temperature exceeds 45℃ and stop the running of RO system as necessary.

8）Measurement of Electrical Conductivity. The on-line conductivity meter mounted on the RO system must be able to implement temperature compensation, i.e. to rectify the measured conductivity as compensated for the temperature of 25℃ in order to figure out the rejection rate of system. In addition, calibration of electrodes must be conducted according to the operational procedures specified by the equipment supplier before the conductivity meter is used. Only after correct calibration can the conductivity meter be put into use. The conductivity meter measuring the feedwater shall be installed at the position following the dosing of chemical substances and immediately preceding the high-pressure pump, and the one for permeated water should be installed at the position preceding the post-treatment process. In case of available condition, multiple conductivity meters may be installed to measure the conductivity of permeated water at different positions to obtain more detailed running parameters of system. Each pressure vessel must be equipped with an independent valve for sampling of permeated water for the purpose of determining the position where the conductivity of permeated water of system rises abnormally.

9）Calculation of Rejection Rate

[Rejection Rate] = (1- [TDS of Permeated Water] / [TDS of Feedwater]) ×100%

Accurate rejection rate can be calculated only after conducting chemical analysis on permeated water and feedwater and measuring the TDS. However, this method is comparatively troublesome, and in general case, the rejection rate is calculated by converting the conductivity to TDS, as shown specifically in the following formula:

TDS = K × EC25

TDS is shown in the unit of mg/L, namely in ppm. EC25 is the conductivity when the temperature is rectified to be at 25℃, with the unit in μs/cm. All salts of EC25 are regarded as NaCl, and the permeability of CO_2 is not taken into consideration.

Table–Converting Coefficient between Conductivity and Salt Content

Solution	Conductivity EC_{25}（μs/cm）	K
Permeated Water	0～300	0.50
Brackish Water	300～4000	0.55
	4000～20000	0.67
Seawater	40000～60000	0.70
Rejected Water	60000～85000	0.75

10）Measurement of pH Value. It refers mainly to the measurement of pH value of feedwater, which is an important index for calculating the LSI index and judging the scaling tendency. Furthermore, the pH value of cleaning fluid can also be monitored at the time of chemical cleaning.

11）Measurement of ORP. For the RO pretreatment system which in its pretreatment process adopts oxidative disinfection or other treatment technology with the use of oxidant, the reductive agent is generally added subsequently to get rid of the residual oxidant for the purpose of protecting the membrane elements. At that moment, the measurement ORP of feedwater can make it available to judge whether there is enough quantity of reductant added in and whether there is any oxidant entering the RO membrane elements.

12）Installation of Pressure Gauge. The pressure gauge must be calibrated before use, and the positions for installing the pressure gauge should satisfy the following requirements of measurement:

◆ Be able to measure the pressure of feedwater and permeate at every section of the system.

◆ Be able to measure the pressure of raw water, feedwater and product water

◆ Be able to measure the pressure of feedwater and filtered water from sand filter, carbon filter and safety filter and to judge whether it's necessary to clean the filter or replace the filtering element.

◆ A pressure switch shall be installed apiece in the inlet and outlet of high-pressure pump, which can be adjusted in case of excessively low pressure at inlet or excessively high pressure at outlet so as to protect the high-pressure pump and membrane element from being damaged.

13）Regarding the selection of piping of RO system and the materials for making the high-pressure pump, since it is required that the piping for permeate will not contaminate the product water, we recommend PPR or AL-PE composite pipe which is extremely low soluble in the water.. The inlet water piping requires to be made from stainless steel pipe that doesn't pollute the feedwater. It is advisable to use the pipe made of regular polymeric materials as the low-pressure water inlet pipe and the rejected water discharge pipe. With regard to the materials for high-pressure piping and high-pressure pump, stainless steel of various specifications can be selected according to the salt concentration of feedwater. (As shown in the following table.)

Type of Feedwater	Pressure (Mpa)	(ppm) Salinity	Materials of Piping
Product Water	＜0.3	5～200	PPR, Al-PE, etc.
Feedwater	＜0.5	1000～50000	UPVC、PVC、PE、ABS, etc.
	0.5～1.5	1000～5000	304 stainless steel
	1.5～2.0	5000～7000	316L stainless steel
	2.0～3.0	7000～25000	904L stainless steel
	＞3.0	25000以上	254SMO stainless steel
Rejected Water	＜0.5	1000～50000	UPVC, PVC, PE, ABS, etc.

4–3 Instructions for Use of RO Design Software

1. Configuration Requirements

(1) IBM-PC compatible Computer

(2) Pentium II Processor (586 and above)

(3) Memory: 32MB and above

(4) Operating System: Windows 98 and above

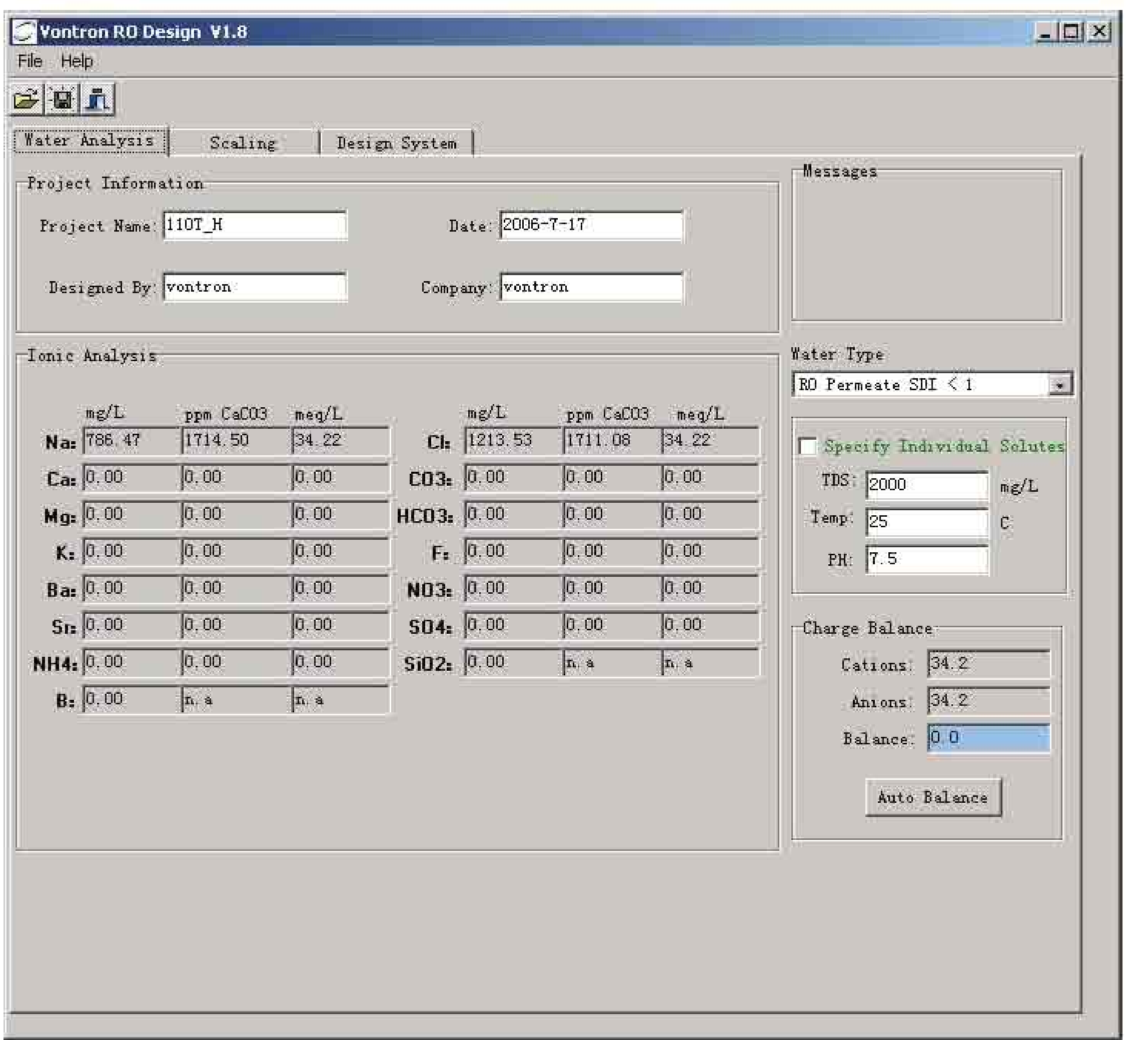
2. Considerations for Installation of Software

(1) Any exclusive program (such as anti-virus software) shall be closed before installation of the design software.

(2) The users of Windows NT shall conduct the installation with the status of Administrator or the user with administrator authority

3. Steps for Installation

Running the VONTRON RODesign, you will see an image as shown below:



1. The Page of "Water Analysis"

First Step: Fill in the "Project Information": Input the project name, date of design, name of designer, and name of design company.

Second Step: Select the type of feedwater

Selection of the feedwater type is very critical to the design of RO system. Specific feedwater quality corresponds to different alarming value for design.

Type of Water Source: RO permeate water: SDI<1; Tap water: SDI<3; Surface water (microfiltration):SDI<3; Surface water (conventional filtration): SDI<5; Wastewater (microfiltration): SDI<3; Wastewater (regular treatment): SDI<5; Seawater (deep well water / microfiltration): SDI<3; Seawater (conventional treatment): SDI<5.

Corresponding (or similar) feedwater type shall be selected according to the actual feedwater in your design.

Third Step: Input the complete water analysis data

If the complete feedwater quality data are not available, you can simply input the value of feedwater TDS (refer to following description for the conversion between TDS and conductivity), and estimate the array arrangement of RO system. In case the complete data of feedwater quality are not available, the software will neglect the calculation of scaling. Then a warning window will appear as follows when you click the "scaling" page:

The rejection rate is calculated upon converting conductivity to TDS, as per the following conversion formula:

TDS = K × EC25

(TDS in mg/L, or namely ppm)

EC25 refers to the conductivity at 25℃ temperature, in μs/cm.

In term of EC25, all salts are considered as NaCl, neglecting the permeability of CO_2.

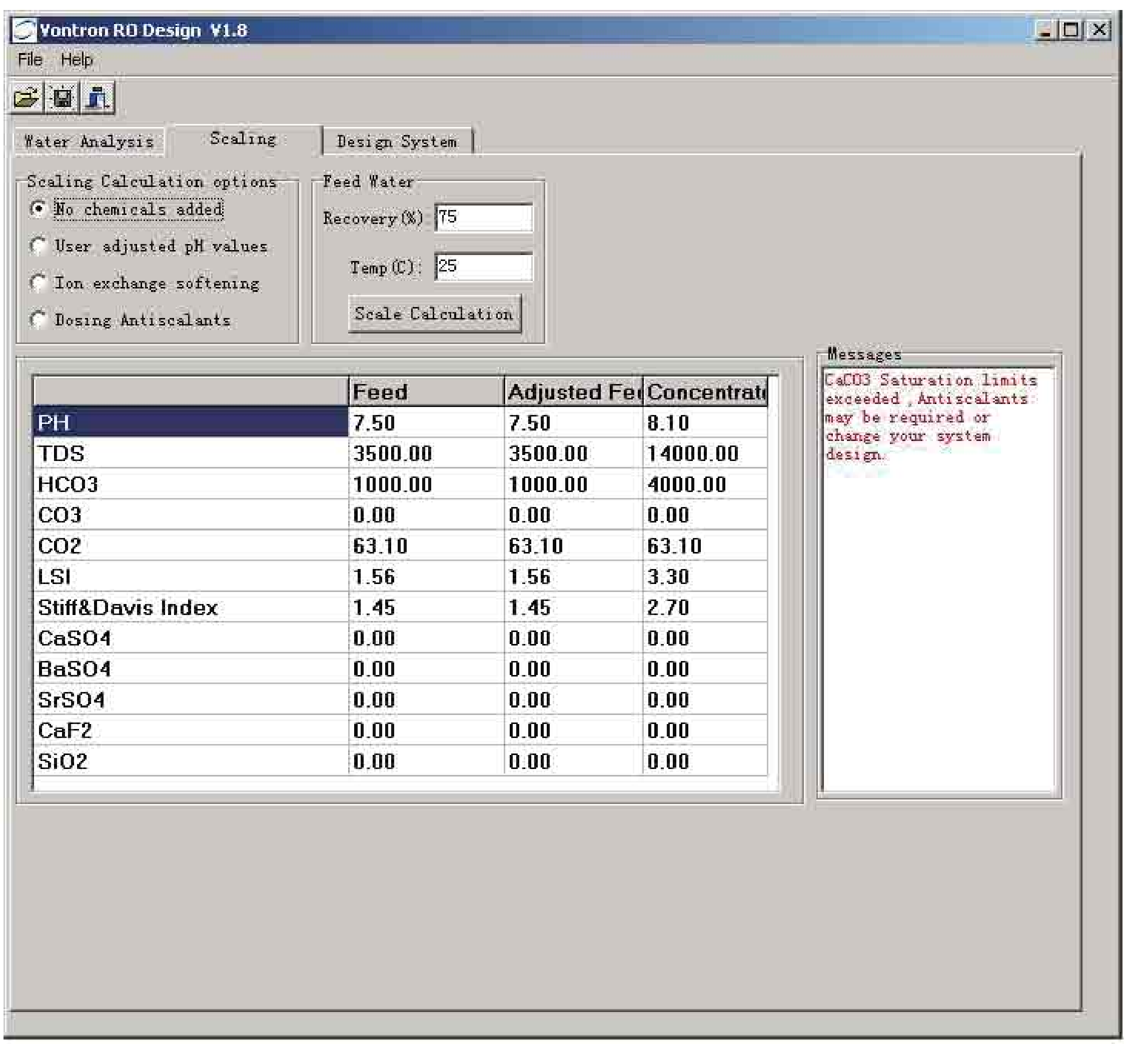
Conversion Coefficient between Conductivity and Salinity

Solution	Conductivity EC_{25} (μs/cm)	K
Permeate Water	0~300	0.50
Brackish Water	300~4000	0.55
	4000~20000	0.67
Seawater	40000~60000	0.70
Concentrate	60000~85000	0.75

If you choose to "input the complete data of water analysis", you will be required to input the content of relevant ions, then the software will execute the calculation of scaling.

If you input different values of "total cations" and "total anions", you can click the button "Auto Balance" to make them balanced.

2. The Page of "Scaling"



First Step: Input the required system recovery rate and the feedwater temperature. Observe the column of [Messages] to make sure whether the warning information appears.

Second Step: In case no warning information appears in the column of [Messages], go directly to the page of “Design System”. If warning information appears, make a proper selection from “Scaling Calculation Options”: “No chemicals added”; “Use adjusted pH values” , “Ion exchange softening”; “Dosing Antiscalants”.

LSI (Langelier Saturation Index) and SDI (Stiff&Davis Index): They are frequently used for judging whether there is scaling of CaCO3. Following are the rules for judging:

（1）When TDS<10000mg/l and LSI<0, there is no sedimentation of CaCO3; When LSI ≥0, there is sedimentation of CaCO3.

（2）When TDS≥10000mg/l and [Stiff&Davis Index] <0, there is no sedimentation of CaCO3; when [Stiff&Davis Index] ≥0, there is sedimentation of CaCO3.

In case of CaCO3 sedimentation, following measurements shall be taken to avoid the sedimentation

◆ Decrease the pH value of feedwater;

◆ Use the ion exchange for softening;

◆ Dose the antiscaling agent.

Saturation of calcium sulphate (%) – cannot be greater than 100% without the addition of antiscaling agent, otherwise the sedimentation of calcium sulphate will result.

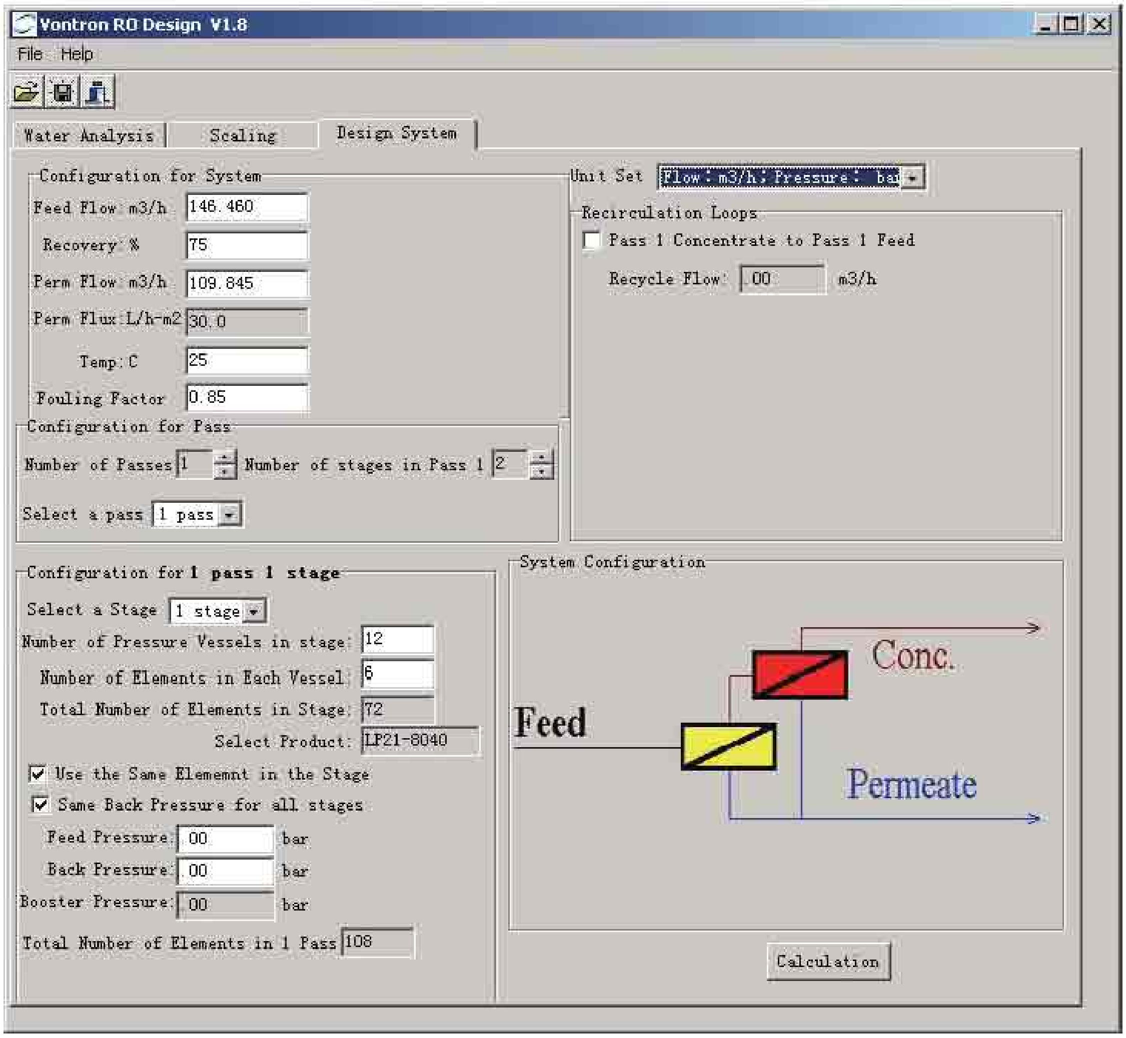
Saturation of barium sulphate (%) – cannot be greater than 100% without the addition of antiscaling agent, otherwise the sedimentation of barium sulphate will result.

Saturation of strontium sulphate (%) – cannot be greater than 100% without the addition of antiscaling agent, otherwise the sedimentation of strontium sulphate will result.

Saturation of calcium fluoride (%) – cannot be greater than 100% without the addition of antiscaling agent, otherwise the sedimentation of calcium fluoride will result.

Saturation of silicon dioxide (%) – cannot be greater than 100% without the addition of antiscaling agent, otherwise the sedimentation of silicon dioxide will result.

3. The Page of “Design System”



First Step: Select the relevant unit as per your habit.

Second Step: Set the parameters as shown in the column of "Configuration for System" , including Feed Flow, Recovery, Permeate Flow, Permeate Flow, Permeate Flux, Temperature, and Fouling Factor.

Fouling Coefficient: It refers to the proportion of "A" to "B" after the membrane surface is partially fouled (Where "A" refers to the effectively permeating area of membrane surface that hasn't been fouled, and "B" refers to the total effective area of membrane surface.). For example, when the ULP series membranes are used for tap water, the recommended value of fouling factor shall be 0.85 after three years of operation, which means that the fouled area amounts to 15% of total effective area while the fouling-free area amounts to 85%. The average fouling area is 5% of total effective area annually, which means that the permeated flow decreases by 5% annually. The actual fouling factor, however, is not a fixed value in practical applications, and may be greater or smaller than the recommended value for a specific water quality. The recommended value is given only on the basis of experience. The more perfect the pretreatment is and the smaller the value of SDI is, then the smaller the fouled area is and the greater the value of fouling factor is.

Recommended fouling coefficients are as follows

Duration of Running (year)	1 year	3 year	5 year
RO-filtered Water (SDI<1)	0.95	0.90	0.90
Tap Water (SDI<3)	0.90	0.85	0.70
Surface Water (Conventional Filtration)	0.85	0.80	0.70
Surface Water (Microfiltration or Ultra Filtration)	0.90	0.85	0.80
Seawater (Deep Well Water / Microfiltration)	0.85	0.80	0.70
Seawater (Conventional Treatment)	0.75	0.70	0.60
Wastewater (Microfiltration or Ultrafiltration)	0.80	0.75	0.70
Wastewater (Conventional Treatment)	0.75	0.65	0.55

"Recovery Rate": it refers to the percentage of permeated water to total feedwater. The recovery rate of system is relevant to number of membrane elements in series and to the fact whether there is backflow of concentrated water. Following is the range of recovery rate in common situations:

System Recovery Rate (%)	No. of Membrane Elements in Series	No. of Stages with Pressure Vessel Containing 6 Elements
40～60	6	1
70～80	12	2
85～90	18	3

Third Step: Set the Arrangement and Combination of RO System

"Backflow of Rejected Water": For the purpose of saving the costs, the backflow of rejected water is used for appropriately increasing the recovery rate of RO system. The backflow of rejected water cannot be excessively large, otherwise the concentration of rejected water will continuously rise and the concentration of ions in rejected water will also rise, thus causing the sedimentation.

- How to Set the Pass and Stage of RO System

Firstly, the user shall determine the number of passes of RO system according to the actual conductivity of feedwater and the desired conductivity of permeated water, and input the permeated flow rate and feedwater flow rate as well as recovery rate in each pass, then determine the number of stages of the RO system according to the recovery and number of membrane elements.

- How to Select the Model of Membrane Element?

A properly designed RO system requires the proper selection of membrane element models.

Following are the principles for selection of membrane element.

(1) Select reasonable sizes of membrane element as per the required permeate flow rate:

-When the permeate flow is less than <0.2m3/h, select the 2.5-sized or the residential membrane element.

-When the permeate flow is less than 3 m3/h, select the 4040-sized membrane element.

-When the permeate flow is 3 m3/h and above, select the 8040-sized membrane element.

(2) Selection based upon the Quality of Permeated Water or Feedwater

-When comparatively high quality of permeate water is required, select the high-rejection LP (low pressure) series.

-When comparatively low quality of permeate water is required, select the ULP (ultra-low pressure) series.

-When the feedwater is of wastewater or is with inferior quality, select the enhanced FR (fouling resistant) series.

-When the feedwater is of quasi-seawater or regular seawater, select the SW (seawater desalination) series.

(3) TDS of Feedwater

When TDS is less than 500mg/l, select the XLP (extreme low pressure), ULP (ultra low pressure) or LP (low pressure) series.

When TDS is less than 2000mg/l, select the ULP (ultra low pressure) or LP (low pressure) series.

When TDS is less than 8000mg/l, select the LP (low pressure) series.

When TDS is 8000mg/l or above, select the SW (seawater desalination) series.

● When to Set the Inter-stage Pressure Rise

When the outlet water pressure from preceding stage is quite lower than the required pressure for next stage, an inter-stage pressure increasing pump shall be installed. When the permeate water yields are quite uneven among different stages and the water blending proportion approaches to the critical value, the inter-stage pressure increasing pump is required so as to optimize the running conditions of preceding and subsequent membrane elements at the same time and to decrease the parameters of high-pressure pump in the first stage.

● The Time to Set the Pressure Suppression of Permeated Water; Relevant Considerations

The setting of pressure suppression of permeated water is for the purpose of more uniform distribution of permeate yield among stages so as to optimize the operating conditions of preceding and subsequent membrane elements. In a system with ULP membrane elements, comparatively high temperature of feedwater or recycled water, etc. where the product water yields are quite uneven among different stages, it is often required to set the pressure suppression at the first one or several stages. In setting of the pressure suppression, following points shall be taken into consideration:

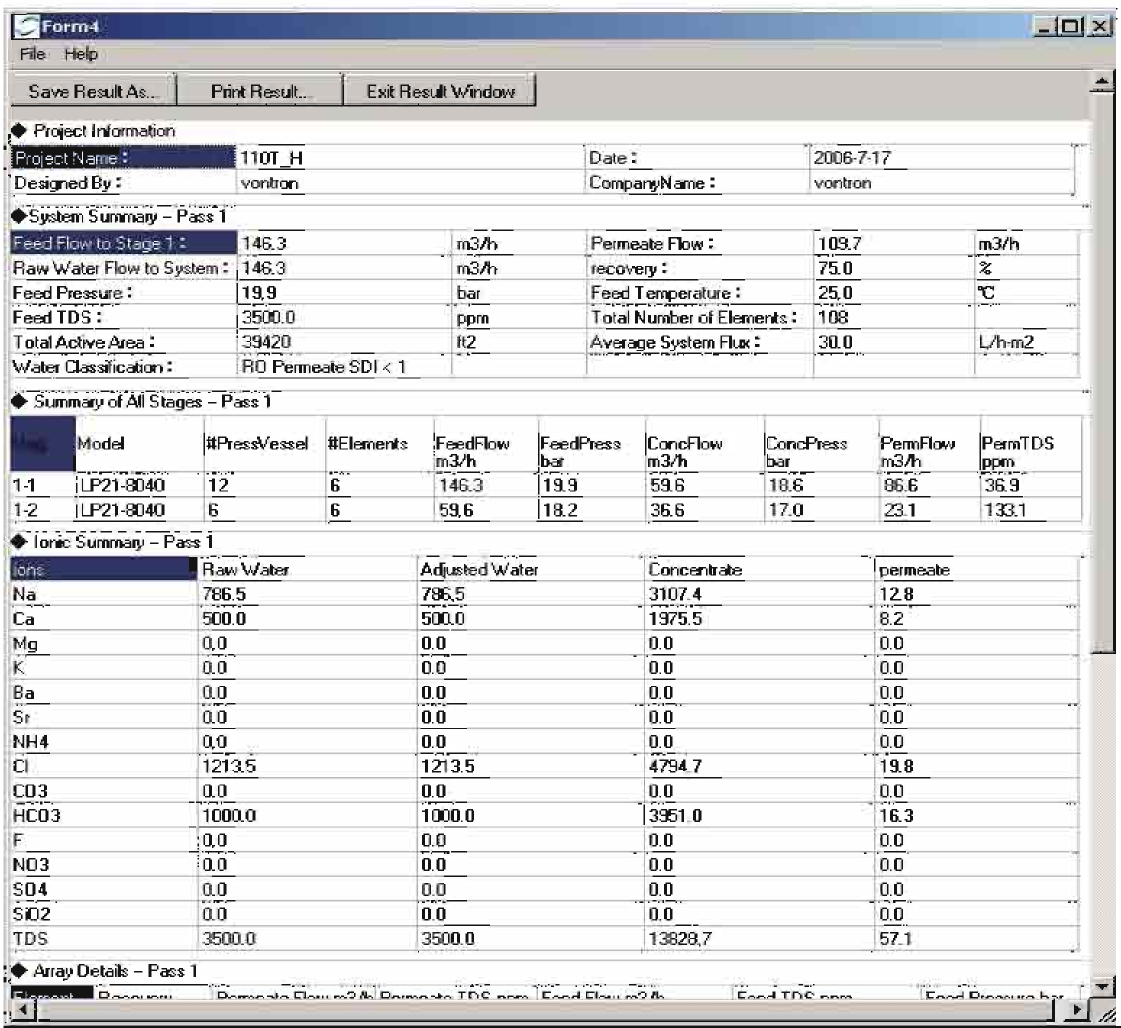
(1) The maximum pressure of product water after suppression shall not exceed the pressure of rejected water by 0.3bar in any case.

(2) When the system is started, be sure "to increase the feedwater pressure first then to retain the pressure expression of product water". When the system is shut down, "release the suppressed pressure of product water first, and then decrease the feedwater pressure" so as to avoid the backpressure ("backpressure" is defined as the difference between the pressure of product water and the pressure of feedwater / rejected water.), which may cause the peeling of compound membrane sheet thus damaging the properties of membranes.

(3) The RO system shall be equipped with a check valve to prevent the backpressure destruction and a passageway to release the pressure of product water.

Fourth Step: By clicking the button of "Calculation", the software will calculate the simulative operation of RO system, and a window of calculation results will appear.

4. The Page of Calculation Results


Form4

File Help

Save Result As... | Print Result... | Exit Result Window

◆ Project Information

Project Name :	110T_H	Date :	2006-7-17
Designed By :	vontron	CompanyName :	vontron

◆ System Summary – Pass 1

Feed Flow to Stage 1 :	146.3	m3/h	Permeate Flow :	109.7	m3/h
Raw Water Flow to System :	146.3	m3/h	recovery :	75.0	%
Feed Pressure :	19,9	bar	Feed Temperature :	25,0	℃
Feed TDS :	3500.0	ppm	Total Number of Elements :	108	
Total Active Area :	39420	ft2	Average System Flux :	30.0	L/h-m2
Water Classification :	RO Permeate SDI < 1				

◆ Summary of All Stages – Pass 1

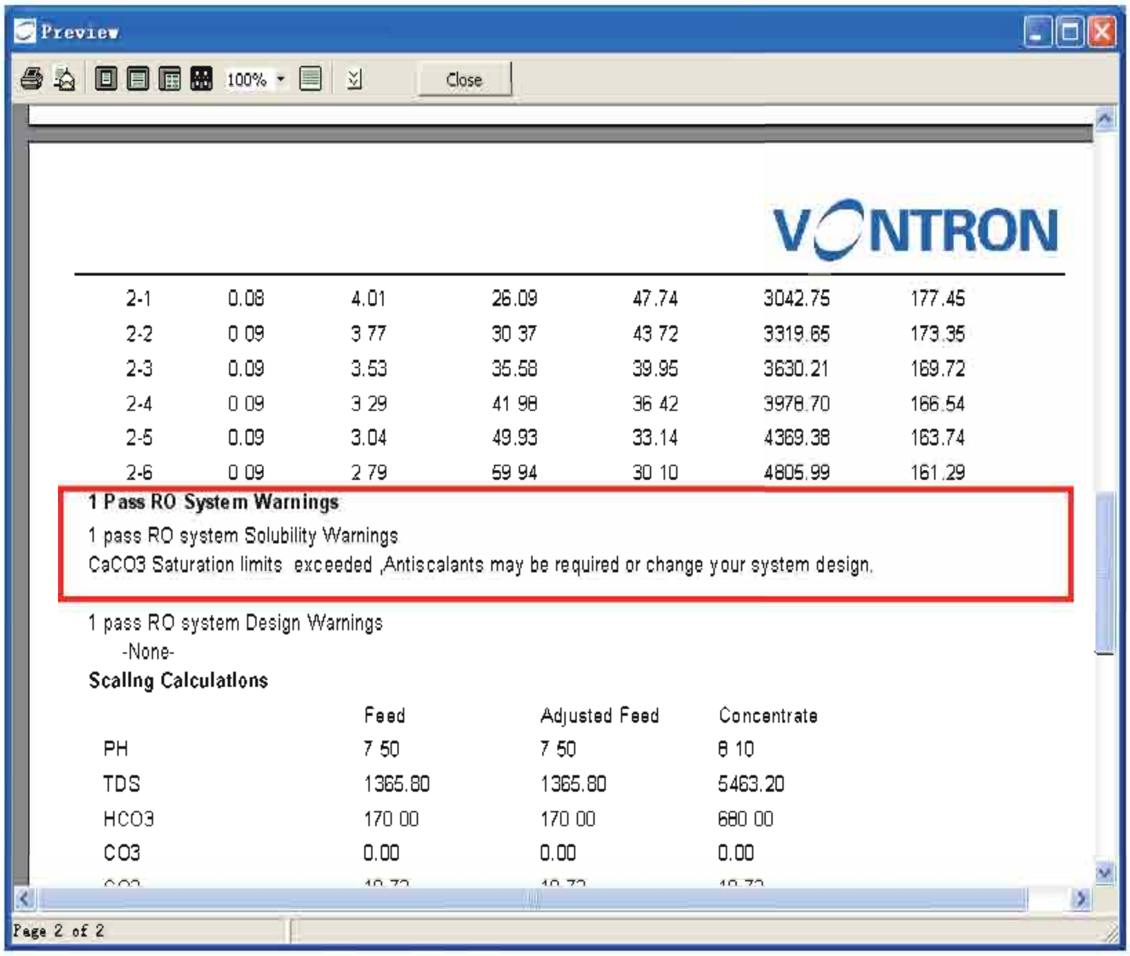
[illegible]	Model	#PressVessel	#Elements	FeedFlow m3/h	FeedPress bar	ConcFlow m3/h	ConcPress bar	PermFlow m3/h	PermTDS ppm
1-1	LP21-8040	12	6	146.3	19.9	59.6	18.6	86.6	36.9
1-2	LP21-8040	6	6	59,6	18.2	36.6	17.0	23.1	133.1

◆ Ionic Summary – Pass 1

Ions	Raw Water	Adjusted Water	Concentrate	permeate
Na	786.5	786,5	3107.4	12.8
Ca	500.0	500.0	1975.5	8.2
Mg	0,0	0.0	0.0	0.0
K	0.0	0.0	0.0	0.0
Ba	0.0	0.0	0.0	0.0
Sr	0.0	0.0	0.0	0.0
NH4	0,0	0.0	0.0	0.0
Cl	1213.5	1213.5	4794.7	19.8
CO3	0.0	0.0	0.0	0.0
HCO3	1000.0	1000.0	3951.0	16.3
F	0,0	0.0	0.0	0.0
NO3	0.0	0.0	0.0	0.0
SO4	0.0	0.0	0.0	0.0
SiO2	0.0	0.0	0.0	0.0
TDS	3500.0	3500.0	13828,7	57.1

◆ Array Details – Pass 1

You can click the button of "Printing" to directly print the results, or savethe results by exporting into the file formats of PDF, HTML or JPG.



2-1	0.08	4.01	26.09	47.74	3042.75	177.45
2-2	0 09	3 77	30 37	43 72	3319.65	173.35
2-3	0.09	3.53	35.58	39.95	3630.21	169.72
2-4	0 09	3 29	41 98	36 42	3978.70	166.54
2-5	0.09	3.04	49.93	33.14	4369.38	163.74
2-6	0 09	2 79	59 94	30 10	4805.99	161.29

1 Pass RO System Warnings

1 pass RO system Solubility Warnings

CaCO3 Saturation limits exceeded ,Antiscalants may be required or change your system design.

1 pass RO system Design Warnings

-None-

Scaling Calculations

	Feed	Adjusted Feed	Concentrate
PH	7 50	7 50	8 10
TDS	1365.80	1365.80	5463.20
HCO3	170 00	170 00	680 00
CO3	0.00	0.00	0.00

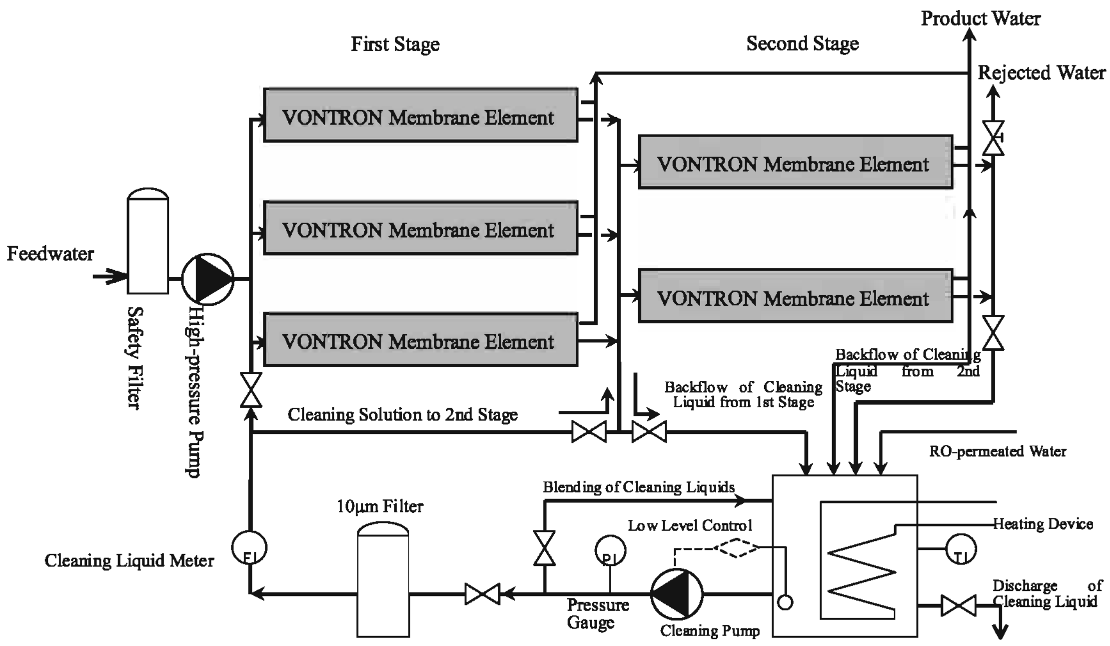
Page 2 of 2

In case the warning information appears, return to the interface of "Design System" and adjust the parameters of system design till the warning information no longer exists.

4–4 Design of Chemical Cleaning Section of RO Membrane System

After long period of running, the RO system will be fouled by the contaminants in the feedwater which can decrease the permeate flow and rejection rate of system, and it is necessary to carry out proper chemical cleaning so as to restore the initial performance of system.

（1）Technological Process Flow of Typical Online Cleaning System of RO System



（2）Composition of Cleaning System

The cleaning system is generally composed of cleaning water tank, cleaning pump, safety pressure device, heating device, flowmeter, pressure gauge, etc. Since the pH value of cleaning liquid is within 2~12, all components of the cleaning system shall be made of the materials resistant to acid and alkaline corrosion. The capacity of cleaning water tank can be calculated and determined according to the volume of cleaning liquid specified in "Guide to Cleaning of RO System". The pressure of cleaning pump is generally within 3bar~5bar, and the flow rate of pump can be determined by [the flow rate of single pressure vessel] multiplied by [the number of pressure vessels in a stage].

（3）Considerations for Cleaning

1. When using any cleaning chemical, you must be familiar with and abide by relevant safety operation procedure.

2. The pH value of cleaning liquid shall be within 2~12. For pH=2, the cleaning temperature shall not exceed 45℃, while for pH=12, the cleaning temperature shall not exceed 35℃.

3. After cleaning, use high-grade water (RO-filtered water is recommended) that contains no such oxidants as residual chlorine, etc. to rinse the membrane elements (at the temperature higher than 20℃). The cleaning shall begin at low flow rate and low pressure, and gradually restore to regular operating pressure and flow rate after a certain period. In addition, the cleaning solution may also enter the permeated flow, therefore the permeated water at the beginning must be discarded until being clear.

Chapter V–Guide to Use and Maintenance of RO System

The three critical factors that ensure the long-term consistent operation include: RO membrane element with superior performance; proper design of RO system; and correct operation and maintenance of system.

The operation and maintenance of RO system include: the initial adjustment of system, the routine operation and maintenance; and cleaning of system.

5–1 Initial Adjustment of RO System

5–1.1 Installation and Disassembly of Membrane Element

5-1.1.1 Items for Inspection before Installation of Membrane Element

For any new engineering project, following items must be inspected before the membrane elements are fixed into pressure vessel:

☆ Glycerin for lubrication, fixing tools, water-proof rubber shoes, gloves and other safety devices are ready for use.

☆ All tables and charts for recording the position, adjustment and operation of membrane element are ready for use.

☆ Make sure that the pretreatment device in preceding position (quartz sand or activated carbon filter) has been rinsed cleanly.

☆ Inspect the feedwater piping preceding RO membrane element, and make sure that it is free from any sludge, oil or metal scrap, etc. and that the preceding pipe, pressure vessel and high-pressure piping have been rinsed cleanly.

☆ Check and make sure that the pretreatment system runs normally and that the SDI, turbidity, residual chlorine, temperature, pH value and ORP, etc. of pretreated water satisfy the feedwater requirements for membrane element.

☆ A clean filtering element has been installed inside the safety filter preceding the high pressure pump.

5-1.1.2 Installation of Membrane Element

☆ Take out a membrane element carefully from the package, record its serial number, check to make sure that the Y-seal (brine water seal) of it is in correct position and direction (the opening of Y-seal must be directed toward the feedwater), and apply a little bit of glycerin to the internal wall of central pipe of the first membrane element.

☆ Installation of the membrane element must start from the water inlet end of pressure vessel, where the first membrane element must be pushed horizontally into the pressure vessel, with the end without Y-seal going first until 1/5 of membrane length (20 cm) left outside. Apply a little bit of glycerin to the Y-seal and O-ring of connector, and insert the connector into the central pipe of the first membrane element.

☆ Take out the second membrane element, and inspect the position and direction of Y-seal. Apply a little bit of glycerin to the internal wall of central pipe at both end of the second membrane element. Fasten the first membrane element to prevent it from being pushed into the pressure vessel. Support and lift up the second membrane horizontally so that another end of the connector inside the central pipe of the first membrane element can be inserted into the central pipe of the second membrane element, while the connector and the central pipe shall be kept in parallel so that the connector bears no weight of the membrane element, and the second membrane element shall be pushed into the pressure vessel until 1/5 of membrane length (20 cm) left outside. Apply a little bit of glycerin to the Y-seal and O-ring of connector, and insert the connector into the central pipe of the second membrane element.

☆ Repeat the above-mentioned step till all membrane elements are installed inside the pressure vessel. Be careful that it is not required to insert a central pipe connector to the last membrane element.

☆ Return to the product water side of pressure vessel, install the thrust ring, and install the sealing assembly of end plate at product water side of pressure vessel.

☆ Return to the feedwater side of pressure vessel, push the membrane fully into the pressure vessel so that the sealing assembly of end plate at product water side keeps in tight contact with the first membrane element, then install the sealing assembly of end plate at feedwater side of pressure vessel.

☆ Repeat the above mentioned steps, and install other pressure vessels.

☆ After all membrane elements have been installed in all pressure vessels, install the outside pipes for feedwater, rejected water and pure water.

5-1.1.3 Dismantling of Membrane Element

☆ First dismantle the external pipings connected to both ends of pressure vessel, then dismantle the end plate sealing assemblies at both ends of pressure vessel, number all the components dismantles, and keep them in orderly place.

☆ Push one by one the membrane element out of the feedwater end of pressure vessel. Only one membrane element is allowed to be pushed out at one time. When the membrane element is pushed out of the pressure vessel, receive the membrane element carefully and keep it in horizontal to prevent the central pipe connector from being damaged owing to gravity. It is advisable to rotate the membrane element so as to make it separate from central pipe connector.

5–1.2 Operating Steps and Methods for Initial Running of RO System

(1) Inspection Items before Startup

☆ All pipings, equipment and connectors shall be in conformity with designed pressure.

☆ The pretreatment equipment has been rinsed and backwashed cleanly to ensure that the product water can reach the designed requirement, with SDI less than 5, turbidity less than 1 NTU, residual chlorine less than 0.1 ppm, temperature lower than 45℃, pH value within 3~10, containing no other oxidant (ORP less than 200).

☆ Make sure that all valves used in the system are in correct status of opening or closing, and the product water discharge valve, the rejected water discharge valve, the rejected water pressure regulating valve and the bypass valve for regulating the flow rate of high-pressure pump shall be fully opened.

☆ All dosing boxes contain correct chemicals with accurate concentration. All dosing devices are set in correct conditions and kept in correct running state.

☆ All pipings and equipment shall be in conformity with the pH range of 2~12 (including that in cleaning) as designed.

☆ All meters have been installed and calibrated correctly.

☆ The device for preventing the occurrence of back pressure has been installed and set correctly.

☆ The device for preventing hydraulic shock (electrical slow door) has been installed and set correctly.

☆ The high-pressure and low pressure protection devices have been set correctly.

☆ The RO vessel and relevant pipings have been fixed on machine as per the manufacturer's requirements.

☆ When oxidant is used for disinfection purpose in pretreatment, be sure that the oxidant has been completely removed before entering the mainbody of RO system.

☆ Check and make sure that the automatic controlling electrical components of RO systems work properly.

(2) Steps of Initial Startup

1) Before starting the high-pressure pump, inspect item by item according to the contents of pre-start inspection so as to make sure that the pretreated water contains no other oxidant (ORP less than 200), with SDI less than 5, turbidity less than 1 NTU, residual chlorine less than 0.1 ppm, temperature lower than 45℃ and pH to be within 3~10.

2) Check all valves and make sure that all of them are in correct position and the product

water discharge valve, the feedwater bypass control valve, rejected water control valve and rejected water discharge valve have been fully opened.

3) Fill the RO pressure vessel with qualified pretreated water in low pressure and low flow rate, and then flush the membrane element. The feedwater pressure shall be restricted within 30~60 psi in this moment, and the flow rate shall be equal to 60~70% of maximum feedwater flow rate for relevant membrane element. The rejected water and product water shall be discharged completely. No antiscalant shall be added in flushing.

4) Observe carefully to make sure there is no seepage in piping and connected components of system, especially in the high-pressure section.

5) For initial flushing of membrane element, whether dry type or wet type, it is recommended that the membrane element shall be flushed for 4~6 hours under low pressure, or be flushed for 1~2 hours, immersed in flush liquid and then flushed again for 1 hour. It is not allowed to add any antiscalant during flushing.

6) For the small-sized RO system without electrical slowly-opened gate, the pressure vessel shall be filled with pretreated water (for air exhausting) before the high-pressure pump is started in order to prevent the membrane element from being impacted by water hammer. For large-sized RO system, electrical slowly-opened gate (electrical butterfly valve) or frequency-variation startup is generally used.

7) Start the high-pressure pump. Slowly regulate the bypass control valve of high-pressure pump, and gradually increase the feedwater flow rate of RO pressure vessel. In the meantime, slowly close the rejected water control valve to increase the pressure till the system recovery rate and water yield reach the designed values. The duration of pressure increase shall not be shorter than 30~60 seconds, and the duration for increase of feedwater flow rate shall not be shorter than 20~30 seconds. Check and make sure whether the operating pressure of system and pressure drop of membrane elements exceed the limits.

8) Check and make sure whether the amount of chemicals dosed is in conformity to the designed value.

9) Measure the conductivity respectively of the RO feedwater, the product water of each pressure vessel and the total product water, and compare the conductivity of product water among the pressure vessels in parallel to determine whether there is leakage or other failure in membrane element, connector and sealing ring of pressure vessel. Detect the pH value, conductivity, calcium hardness and alkalinity, etc. of rejected water, calculate the LSI and S&DSI indexes of rejected water, and judge whether the $CaCO_3$ fouling will be formed in RO system under this condition.

10) Keep the system in continuous running for 1~2 hours, and record all running data.

After the system is put into regular running continuously for 24~72 hours, record again all the running data and keep them on file. Said data include feedwater pressure, pressure difference, temperature, flow rate and conductivity of feedwater, flow rate and conductivity of rejected water, flow rate and conductivity of product water, and system recovery rate, and are the basis for future standardized comparison of operating parameters of system.

11) Refer to the operating parameters and the data for analysis of water quality, inspect the equipment to make sure that it works regularly, and determine whether the designed requirements are satisfied.

12) Within the first week after the system is put into operation, inspect periodically the performance of system and record carefully the operating parameters so as to ensure the regular running of equipment.

(3) Determination of Steadiness of Initial Performance of Membrane Element

It requires a certain period for the RO membrane elements newly used to progress from initial performance to stable condition. For wet-type membrane element, it requires 12 hours of continuous running to reach stable performance. For dry-type membrane element, it requires two days or longer period of continuous operation to reach stable performance.

5–2 Routine Operation and Maintenance of RO System

5–2.1 Records of Running of RO System

All information and data relating to the operation of system covering the adjustment and stable running of system shall be recorded and kept on file for the purpose of analyzing the running conditions of the whole system. Besides, the records of operating data is one of the effective means for seeking and solving the system failure, and is one of evidences to apply for quality guarantee.

Following data must be kept in record:

Operation of pretreatment; operation of membrane system; operation of reagent dosing system; chemical cleaning.

5-2.1.1 Records of Operation of Pretreatment System

Different water sources require different pretreatment, therefore there is no uniform form to record the data. However, following contents shall be included in the records of regular pretreatment:

☆ Pressure drop of all filters, in order to determine whether it requires backwash, flush or air cleaning.

☆ Pressure, residual chlorine concentration, pH value, temperature and microbe of feedwater.

☆ Time recording of backwash, flush and air cleaning of filter.

☆ SDI value, residual chlorine, turbidity, pH value and microbe of product water

☆ Consumption of chemical substances (such as flocculant, coagulant aid, acid, etc.)

☆ Any failure or breakdown.

5-2.1.2 Records of Running of RO System

For most RO systems, the following form can be referred to in recording the data, where the normalized data refer to those calculated by using the normalization software. VONTRON Normalization Software can be downloaded from Vontron's website (www.vontron.com) or is available by asking for a CD.

Record Table of Running of RO System							
Date	Date						
	Time						
Feedwater	Temp (℃)						
	SDI$_{15}$						
	Turbidity (NTU)						
	Residual chlorine (mg/L)						
Pressure (bar)	First-stage Feedwater						
	Second-stage feedwater						
	Concentrate						
	Product Water						
Pressure Difference (psi)	Safety Filter						
	First Stage						
	Second Stage						
Flow Rate (m3/h)	Feedwater						
	Product Water						
	Concentrate						
	Recovery						
Conductivity (ms/cm)	Feedwater						
	1st-stage product						
	2nd-stage product						
	Total product						
	Concentrate						
pH Value	Feedwater						
	Product Water						
Corrected Data	Permeate						
	Rejection						
	Operating Pressure						
Remarks	(Explanations of system failure, shutdown, chemical cleaning, etc.)						
Recorded by:	Shift No.:			Reviewed by:			

5-2.1.3 Records of Running of Chemicals Dosing System and Chemical Cleaning

Refer to the following table in preparing the records of running of chemicals dosing system.

Working Records of Chemicals Dosing System						
Date	Date					
	Time					
Flocculant	Liquid Level of Chemicals Tank					
	Quantity Added					
	Concentration					
	Measuring Pump Knob					
	Quantity Dosed (ppm)					
Acid added	Liquid level of chemicals tank					
	Quantity Added					
	Concentration					
	Measuring Pump Knob					
	Quantity Dosed (ppm)					
Reductant	Liquid level of chemicals tank					
	Quantity Added					
	Concentration					
	Measuring Pump Knob					
	Quantity Dosed (ppm)					
Anti-scalant	Liquid level of chemicals tank					
	Quantity Added					
	Concentration					
	Measuring Pump Knob					
	Quantity Dosed (ppm)					
Remarks	(Explanations of system failure, shutdown, etc.)					
Recorded by:		Shift No.:		Reviewed by:		

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@famco_group
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Fax:۰۲۱ - ۴۴۹۹۴۶۴۲
تهران، کیلومتر۲۱ بزرگراه لشگری (جاده مخصوص کرج)
روبـروی پالایشگاه نفت پارس، پلاک ۱۲

Refer to the following table in preparing the records of chemical cleaning.

Records of Chemical Cleaning							
Date	Composition and Concentration of Cleaning Solution	Volume of Cleaning Solution	pH of Cleaning Solution	Temp of Cleaning Solution	Time Cleaning starts	Time cleaning ends	Remarks
Recorded by:		Shift No.:			Reviewed by:		

5–2.2 Routine Startup and Shutdown of RO Membrane System

Once the RO system is put into running and in stable condition, it shall be kept in stable running as far as possible. In fact, however, most RO systems need to be switched on and off frequently. Each time when the system is switched on or off, the flow rate and pressure are involved and impose mechanical stress upon membrane element. Therefore, the frequency of system startup and shutoff shall be minimized as necessary, and the regular startup and shutoff shall be conducted in a stable and consistent manner. The routine startup shall be conducted according to the steps identical to those for initial startup, where the increase of pressure and flow rate shall be in a slow manner.

Considerations for Shutdown of RO System

☆ The whole membrane system must be rinsed with product water or pretreated water at low pressure to clean out the concentrate from membrane surface so as to prevent the precipitation and fouling of salts.

☆ In low-pressure cleaning, anti-scalant or other chemicals shall not be dosed. (In case the pretreated water is used for flushing the system, keep dosing the flocculant and reductant.)

☆ In order to prevent the generation of back pressure, the product water discharging valve shall be opened first.

☆ The decrease of flow rate and pressure shall be in a slow manner. During the decrease of pressure, be sure that the feedwater flow rate shall not exceed the maximum feedwater flow rate of membrane elements, and the pressure difference between both ends of pressure vessel shall not exceed the limit.

Steps for Shutoff of Membrane System

First, open the product water discharging valve, and open the bypass control valve of high pressure pump to decrease the feedwater flow rate of system while slowly opening the concentrate control valve so as to decrease the pressure to about 30~40psi. Close relevant chemical dosing system. Higher flow rate is beneficial to improve the flushing effect; however, the flow rate shall not exceed the maximum feedwater flow rate of single element, and the pressure difference between both ends of pressure vessel shall not exceed the limit. Keep flushing under such low pressure till the conductivity of concentrate is equivalent to that of feedwater (around 10~20 minutes for flushing).

The increase or decrease of flow rate and pressure shall be conducted in a slow manner, and completed within 30 ~ 60 seconds, or longer for seawater desalination system. Automatic control of system startup and shutoff can be realized by using the PLC (programmable logistic controller), while periodical inspection of the running conditions of relevant electrical equipment is required.

5–3 Management of RO System during Shutdown Period

5–3.1 Management for Routine Shutdown (0~48 hours)

Management of system during routine shutdown (0~48 hours) shall be conducted with reference to normal shutoff procedure, and it is critical that the system must be flushed under low pressure once every 24 hours in order to prevent the breeding of microbes.

5–3.2 Management for System Shutdown (2~25 Days)

☆ The shutoff of membrane system shall be conducted according to the shutoff steps described in “Section 4-2: Routine Operation and Maintenance of RO System” of this Chapter.

☆ After the system is switched off, be sure that the pressure vessel is full of RO-filtered water. Close all valves of feedwater, concentrate and product water in order to prevent the aridity of membrane element and the breeding of microbe.

☆ When the temperature is higher than 20℃, flushing shall be repeated once every 12 hours; when the temperature is lower than 20℃, flushing shall be repeated once every 24 hours.

☆ For the surface water or other water sources containing high contamination of microbes, the RO system shall be flushed with the solution made of RO-filtered water and containing1.0%

sodium hydrogen sulfite. Better effect can be obtained if the membrane elements are immersed in this solution, and the cycle of repeated flushing can be elongated correspondingly.

☆ During system shutdown, the temperature shall be maintained within 5℃～45℃. Low temperature is beneficial to the preservation of membrane element, but the system shall be prevented from icing or freezing.

5–3.3 Management for Long–term Shutdown of System (more than 25 days)

☆ The system shall be shut off according to normal shutoff procedure, and shall be flushed with product water under low pressure.

☆ It is advisable to carry out a treatment of chemical cleaning and disinfection, followed by low-pressure flushing of system with RO-filtered water till the conductivity of concentrate is identical to that of feedwater.

☆ A preservative solution made of RO-filtered water and containing sodium hydrogen sulfite shall be used for circulative flushing of membrane element as driven by the chemical cleaning system so as to rule out the air from the pressure vessel and to fully immerse the membrane element inside the preservative solution for preventing the aridity of membrane element. Close all valves of feedwater, concentrate and product water to prevent the air from entering the system which may cause the invalidity of preservative solution.

☆ Inspect weekly the pH value of preservative solution. When the pH value is less than 3, the preservative solution shall be replaced immediately.

☆ During system shutdown, the temperature shall be maintained within 5℃～45℃. Low temperature is beneficial to the preservation of membrane element, but the system shall be prevented from icing or freezing.

5–3.4 Preservation and Management of Membrane Element Taken out from System during Shutdown

During the system shutdown, if the membrane element is taken out from the system, such membrane element shall be preserved and treatment according to relevant requirements for preservation and storage of wet-type membrane element stated in “General Specifications of VONTRON Membrane”.

5–4 Guide to Cleaning of RO System

5–4.1 Brief Introduction of Fouling of Membrane Element

The membrane element can be possibly contaminated by the suspended substances, colloids, organic substances and microbes as well as salts deposited and separated out after concentration. The pretreatment of RO system can remove said contaminants to reduce the fouling on membrane and elongate the running time of system. However, since the pretreatment cannot completely remove said contaminants from the water, the membrane element always suffers fouling after a period of running, thus causing the decrease of system performance. The decrease of performance of RO system is featured by the decrease of permeate flow, the decrease of rejection rate (conductivity rising) and the increase of pressure difference between feedwater and concentrate.

5–4.2 Judgement of Cleaning Time for RO System

Since the performance of RO system varies with the change of such factors as temperature, pressure, pH value, feedwater TDS, etc., (for example, the permeate flow is reduced by 10% for every temperature drop of 3℃, while the considerable variation of pH value has an influence on the conductivity of product water). Therefore, it was sometimes not the fouling of RO membrane that causes the change of performance of RO system. In order to exactly determine the proper time for cleaning of system, the operating data shall be put into standardized calculation by using the normalization software provided by the RO membrane manufacturer. In case of any of the following occurrences upon normalization of operating data, the RO system shall be put into chemical cleaning immediately:

- System permeate flow decreases by more than 15% comparing with the initial value after normalization of operating data.
- Salt passage increases by more than 10% comparing with the initial value after normalization of operating data.
- Pressure difference between feedwater and concentrate increases by more than 15% comparing with the initial value after normalization of operating data.

Chemical cleaning must be done immediately after the condition of chemical cleaning is met. In general case, the initial performance can be basically restored after chemical cleaning. In case the chemical cleaning is not performed in time, however, the RO system will suffer serious fouling, thus causing the chemical cleaning have little effect, and it's difficult to restore the performance of system.

5–4.3 Steps of Cleaning of RO System

First Step: Low-pressure Flushing

It's better to use RO-filtered water to flush the system, or pretreated water can be used (in case the raw water contains special chemical substances that can possibly react with cleaning solution, such water cannot be used).

Step 2: Preparation of Cleaning Solution

Use the RO-filtered water for preparing the cleaning solution, accurately weigh the medicaments and mix them uniformly. Check the cleaning solution to make sure the pH value and temperature (not lower than 25℃), etc. meet the relevant requirements.

Step 3: Feed in the cleaning solution with low pressure and low flow rate, and then make it circulate in the system.

Feed the cleaning solution into the RO system with 1/3 of regular cleaning flow rate (see Table 1) under the pressure of 20~40psi, discard the backwater at the beginning to avoid the dilution of cleaning solution. Keep the cleaning solution circulating in the pipe for 5~10 minutes. Observe the turbidity and pH value of the backflow solution. If the cleaning solution become obviously turbid or the pH value varies by more than 0.5, it is advisable to add proper dosage of medicaments or to prepare a new solution and then to repeat the steps mentioned above.

Table 1: Recommended Cleaning Flow Rate for RO Membrane Elements

Washing Flow Rate	
Dia. of Membrane Element (in)	Flow Rate of Individual gpm(m^3/h)
2.5	5（1.2）
4	10（2.3）
8	40（9.1）

Step 4: Soaking and Intermittent Circulation

Stop the circulation of cleaning pump to prevent the cleaning solution from flowing out of the pressure vessel. It is advisable to close the cleaning solution feeding pump, the permeated cleaning solution return valve and the rejected cleaning solution return valve. The complete membrane module shall be soaked in the cleaning solution for about 1 hour or longer (10~15 hours or overnight), depending on the fouling situation of membrane module, during which period the circulating pump can be intermittently started to maintain constant temperature of cleaning solution (25～30℃).

Large Flowrate Circulation

Increase the flow rate of cleaning solution to 1.5 times regular flow rate and then start cleaning. Circulate the cleaning for 30~60 minutes. The pressure shall not be too high at this moment, as limited to the extent that there is no or little filtered water produced. Be careful that the pressure difference among membrane elements and that among pressure vessels cannot exceed the limits.

Step 6: Flushing

Firstly use the product water to flush the system for around 5 minutes (with minimum temperature at 20℃), then use the suitably pretreated water to flush the system for 20~30 minutes. In order to avoid precipitation, the temperature for flushing shall be 20℃ at least, and the cleaning solution shall be completely flushed out, without any residual remained. Start the system and run it. Inspect the cleaning effect and discard the product water. If the system is scheduled for shutdown, the membrane modules shall be preserved properly in accordance with relevant procedures.

5–4.4 Fouling Symptoms of RO System and Cleaning Method

The routine running records of RO system are the major basis for determining whether fouling will occur with the system and what reasonable cleaning method shall be taken after fouling. Special importance must be attached to the recording of data in the management of RO system.

1. Fouling by Organic Salt Scaling and Its Cleaning

Symptom of Fouling by Organic Salt Scaling

At the beginning, the conductivity of product water from the second stage of RO system becomes abnormal (the conductivity rises), the permeate flow decreases obviously, the pressure becomes higher gradually, and the pressure difference in the second stage also increases gradually. The most obvious symptom is that the permeate flow decreases obviously.

The fouling of RO system most frequently seen involves in scaling by calcium carbonate and calcium sulphate. The situation that the permeate flow of RO system decreases by a large margin within several hours or several days relates mostly to said fouling.

Scaling by inorganic salt is generally caused by such reasons as excessively high recovery rate, insufficient dosing of antiscalant and untimely regeneration of ionic exchange softening resin, etc.

Cleaning of Carbonate Scaling

The carbonate scaling can be cleaned out by using the following formula:

Major Contaminants	Cleaning Solution Recommended	Remarks
Precipitation of Carbonate	0.2% hydrochloric acid / (HCl)	Preferential choice. Maximum temperature at 45℃, and pH = 2
	2.0% Citric Acid ($C_6H_8O_7$)	Acceptable choice. Maximum temperature at 45℃, and pH > 2

Cleaning shall be implemented as per the aforesaid steps.

Cleaning of Sulphate Scaling

Of the inorganic salt scaling, the sulphate scaling is the one that is comparatively difficult to clean out. The sulphate scaling shall be cleaned as early as possible, otherwise the performance of RO system will be unlikely restored after cleaning in case the scaling has been formed for more than one week. Therefore, high level pretreatment is required for the water source featured by high sulphate content. Special attention shall be paid to monitoring the system, and the system shall be cleaned properly soon after there is any sulphate scaling.

The sulphate scaling can be cleaned out by using the following formula:

Major Contaminants	Cleaning Solution Recommended	Remarks
Sulphate Scaling	0.1% Sodium Hydroxide; 1.0% EDTA tetrasodium	NaOH、EDTA tetrasodium，pH=12， Maximum temperature at 30℃

Cleaning shall be implemented as per the aforesaid steps.

2. Symptom of Colloidal Fouling and Its Cleaning

The colloids in RO feedwater may include sludge, inorganic colloid, colloidal silica and a number of organic substances, etc., which can be removed generally by using flocculation filtration, activated carbon adsorption, etc.

Symptom of Inorganic Colloidal Fouling:

In a RO system, the symptom of inorganic colloidal fouling first appears in the first stage, where the permeate flow decreases gradually, the pressure difference becomes higher gradually, and the conductivity of product water rises slightly. The most frequently seen symptoms of colloidal fouling are the gradual variation of permeate flow and pressure difference.

The inorganic colloidal fouling can be cleaned out by using the following formula:

Major Contaminants	Cleaning Solution Recommended	Remarks
Inorganic Colloid	0.1% sodium hydroxide ＋ 0.025% SDBS (sodium dodecyl benzene sulfonate)	NaOH ＋ Na-DDBS，pH=12, With maximum temperature at 30℃
	Cleaning Solution Recommended	Remarks

Cleaning shall be implemented as per the aforesaid steps.

3. Symptom of Fouling by Organic Substances and Their Cleaning

The RO system with surface water, wastewater or seawater, etc. as water source is possibly subject to the risk of fouling by organic substances, and the compositions of said organic substances mainly include humus, organic acid, etc.

The most frequently seen symptoms of fouling by organic substances are the drastic drop of permeate flow while the rejection rate remains substantially unchanged. In case of fouling by organic substances, the following formula can be used for cleaning:

Major Contaminants	Cleaning Solution Recommended	Remarks
Organic Substance	0.1% sodium hydroxide ＋ 0.025% SDBS (sodium dodecyl benzene sulfonate) 0.2% hydrochloric acid	First use NaOH and Na-DDBS solution for cleaning, with pH = 12 and maximum temperature at 30℃, then clean it by using HCl solution, with pH = 2 and maximum temperature at 45℃.
	Cleaning Solution Recommended	Remarks

Cleaning shall be implemented as per the aforesaid steps.

4. Symptoms of Fouling by Microbes and its Cleaning

Microbe fouling usually comes into being during the downtime of RO system or in the RO system with surface water, recycled water (Grade-III wastewater) or seawater as the feedwater source, and is concurrent with fouling by organic substances. The biological fouling shall be cleaned out immediately at the beginning, otherwise it will become the biological film which is very difficult to clean and the membrane element has to be replaced.

It is recommended that the HOR (high oxidation resistant) membrane elements be selected for those RO systems apt to microbial fouling, where such germicides as NaCLO can be dosed online into the feedwater of membrane elements to build a germ-free system thus preventing the occurrence of microbial fouling.

Symptoms of Microbial Fouling

The fouling occurs in all stages of the system, and pressure difference in the first stage and the second stage increases rapidly while the permeate flow decreases and the conductivity of product water remains unchanged substantially. The most common symptom is the increase of pressure difference.

The microbial fouling can be cleaned out by using the following formula:

Major Contaminant	Recommended Cleaning Solution	Remarks
Microbe	0.1%（NaOH）＋0.025%（Na-DDBS）	Preferred. Use NaOH and Na-DDBS solution for cleaning, with pH = 12 and maximum temperature at 30℃.
	0.1%（NaOH）	Preferred. Use NaOH solution for cleaning, with pH = 12 and maximum temperature at 30℃.
	2.0%（STPP）+0.025%（Na-DDBS）	Acceptable. Use $Na_5P_3O_{10}$ and Na-DDBS solution for cleaning, with pH = 10 and maximum temperature at 30℃.

Cleaning shall be implemented in accordance with the aforesaid steps.

For the RO system with microbial fouling, the chemical cleaning shall be followed by disinfection of the system, and the pretreatment shall be improved in order to prevent the reoccurrence of microbial fouling.

5. Fouling of Metallic Compound

Fouling of metallic fouling involves mainly in metallic oxide or metallic hydroxide, etc, especially the ferrous fouling. The factors causing such fouling include mainly the defect of pretreatment and the rust of pipings, with the symptoms of decrease in both permeate flow and rejection rate and increase of pressure difference among membrane elements. The following formula can be used for cleaning:

Major Contaminants	Cleaning Solution Recommended	Remarks
Metallic Oxide	1.0% sodium pyrosulfite	$Na_2S_2O_5$, pH=5, with maximum temperature at 30℃
	2.0% citric acid	$C_6H_8O_7$, pH>2, with maximum temperature at 45℃

Cleaning shall be implemented according to the aforesaid steps.

6. Calculation of Volume of Cleaning Solution

The total volume of cleaning solution includes the volume of pressure vessel, cleaning pipe, high-pressure pipe and filter plus 20% overmeasure. The calculation of cleaning solution volume includes two manners, i.e. rough estimation and precise calculation.

Rough estimation of cleaning solution volume: Depending on the model of membrane elements and the degree of fouling.

For common fouling, each 4040-sized membrane element shall be furnished with 10 litres of cleaning solution, and each 8-inch membrane element shall be furnished with 40 liters of cleaning solution.

In case of serious fouling, each 4040-sized membrane element shall be furnished with 18 liters of cleaning solution, and each 8-inch element shall be furnished with 55 liters of cleaning solution.

Examples of precise calculation: Refer to Table 2 and Table 3 for rough estimate of volume of pressure vessel and cleaning pipe.

Table 2: Volume Fraction of Regular Pipe

Pipe Diameter (in)	Volume Fraction
2	0.16 Gallon / Foot 2.0 Liter / Meter
3	0.37Gallon / Foot 4.6 Liter / Meter
4	0.65 Gallon / Foot 8.1 Liter / Meter

Table 3: Volumetric Capacity of Pressure Vessel

Volumetric Capacity of Pressure Vessel	
Membrane Element Sizes	Volumetric Capacity of Each Element, in Gallon (Liter)
2540	0.8（3）
4040	2（8）
8040	8（32）

Taking 36 pieces of 8040-sized elements as example, following is the calculation:

The RO system is in a 4:2 array, with each pressure vessel containing 6 pieces of 8080 elements, and shall be cleaned stage by stage.

The cleaning pipe with 3 inches nominal diameter and 15 meters length amounts to a volumetric capacity of 69 liters (15x4.6), the safety filter can hold 60 liters of water, and the volumetric capacity of pressure vessel in the first stage is 768 liters (4x6x32=768), and thus the total volume of cleaning solution is 897 liters (69+60+768=897), i.e. 1076 liters (897+897x20%=1076) of cleaning solution shall be prepared for cleaning the first stage. Similarly, 615 liters of cleaning solution shall be prepared for cleaning the second stage.

Table 4: Total Volume of Cleaning Solution Required

Estimate of Total Volume of Cleaning Solution		
	Volume (Liter)	
	1st Stage	2nd Stage
Pressure Vessel	4×6×32=768	2×6×32=384
Cleaning Pipe	15×4.6=69	15×4.6=69
Safety Filter	60	60
20% Overmeasure	180	102
Total Volume	1076	615

Notes:

1. When in chemical cleaning, be sure to prevent the chemical medicaments from injuring the operating personnel. Especially certain chemical medicaments with strong corrosivity are used (fluorochemical possibly used for cleaning the silica fouling, for example), it is strongly recommended that the cleaning shall be implemented under the guidance of professionals.

2. The exampled calculation of cleaning solution volume is only for reference.

Chapter VI–Troubleshooting of RO System

There are mainly two kinds of breakdown in the RO system:

(1) The permeate flow and rejection rate become abnormal since the initial running (adjustment) of RO system.

(2) The RO runs normally during the initial period, and the permeate flow and rejection rate decrease after a period of running. Following are the analysis of these two kinds of breakdown.

6–1 Troubleshooting of RO System During the Initial Running (Adjustment) Period

At the initial adjustment of RO system, you can compare the actual performance of system with the results figured out using the VONTRON ROdesign software (with fouling coefficient = 1) so as to determine whether the initial performance of system is normal.

6–1.1 Low Permeate Flow and High Pressure

This situation may be brought about by the following causes:

(1) Deviation in Readings of Instrument and Meter

The pressure gauge or flowmeter not calibrated prior to use may bring about inaccurate readings. The pressure gauge is mounted at the position far away from the ends of pressure vessel, and its reading contains the pressure loss within pipings. If said reading is used as the pressure of feedwater, it will be caused that the feedwater pressure is inadequate and the permeate flow is relatively low.

(2) Temperature

The feedwater temperature is lower than the initially designed value. In each temperature drop of feedwater by 3℃, the permeate flow can decrease by approximately 10%.

(3) Feedwater Conductivity (or TDS)

The feedwater conductivity (or TDS) is much higher than designed value. For NaCl solution, if the TDS increases by 1000ppm, then the osmotic pressure increases by around 11.4psi (0.8bar), which means that the permeate flow will decrease under same pressure of feedwater.

(4) Pressure at Product Water Side

Under same feedwater pressure, since pressure suppression is set at the product water side or the product water pipe is relatively small while the destination is far away and is at a high position, an obstacle is formed, resulting in the drop of net pressure and decrease of permeate flow.

(5) Pressure Difference

Under regular circumstance, for the RO system with each housing containing 6 pieces of 8040-sized elements, the pressure difference between two stages is 3~4 bar. The improper design of piping which may cause considerable pressure loss or the incomplete closing of concentrate discharging valve in the second stage may result in the decrease of loss, thus causing the decrease of permeate flow.

(6) Flux Attenuation of Membrane Element

- The wet-type membrane element not preserved properly or not protected properly after being installed in the system can become dry, resulting in the drastic attenuation or even complete losing of permeate flow and thus causing the lower water yield of the system.

- Before the membrane elements are installed in the system, the feedwater hasn't been confirmed to be acceptable, and the feedwater used for soaking and flushing the membrane elements may contain cation, neutral or amphoteric surfactant or other chemicals incompatible with membrane, thus causing the attenuation of flux of membrane element and then resulting in the low permeate flow of system.

6–1.2 Low Rejection Rate and High Conductivity of Product Water

(1) Deviation in Readings of Instrument and Meter

The conductivity meter (or TDS meter) not calibrated before use has a considerable deviation of readings, thus figuring out a lower rejection rate.

(2) Leakage in the sealing of membrane element connector or the adapter connecting the end plate of pressure vessel.

During the installation of membrane elements, the O-ring of connector may be twisted or fall off, and the high salinity water then enters the product water.

Diagnosis: First measure the conductivity of product water from each pressure vessel. If a certain pressure vessel contains the product water with relatively high conductivity, use the "Probe Method" to determine the exact position of salt leakage. If the salt leakage happens at the connection position, this problem can be corrected by reinstalling the membrane element, or the membrane element must be replaced if the leakage happens at the membrane element.

(3) pH value of Feedwater

The advisable pH value of RO membrane ranges between 6~8. Excessively lower or higher pH value may have influence on the rejection rate.

(4) The feedwater is of ground water, with relatively high content of hydrogen carbonate (HCO_3^-).

The ground water has high alkalinity and high content of hydrogen carbonate (HCO_3^-), and if the hydrogen carbonate (HCO_3^-) is removed, the balance of ($CO_2 + H_2O$ à $HCO_3^- + H^+$) moves rightward, resulting in the decrease of pH value of product water and the rise of conductivity.

(5) Oxidation of Membrane Element

If the water after pretreatment is not inspected before the membrane elements are mounted into the system, the feedwater to membrane system contains excessive residual chlorine or other oxidant and thus results in the oxidation of membrane and the decreased rejection rate of membrane element. In addition, the cation, neutral or amphoteric surfactant may also result in the decrease of rejection rate of membrane element.

6–2 Troubleshooting of Failures of RO System Occurring after Regular Running

Such failures usually exhibit at least one of the following situations:

◆ The permeate flow decreases after standardization, and it is usually necessary to increase the operating pressure for the purpose of maintaining the rated permeate flow.

◆ The rejection rate decreases after standardization, and the conductivity of product water rises in the RO system.

◆ The pressure drop increases, and with the flow rate of feedwater remaining unchanged, the pressure difference between feedwater and concentrated water increases.

In case any of the above failures occurs with RO system, following steps shall be taken to analyze and dispose of it:

(1) Preliminarily determine the type of contaminations (fouling, scaling or microbial contamination, etc.) based upon the symptom and position of failure as well as the data and records of system routine running. In case there is no record of system routine running, it is necessary to analyze the water quality of raw water and concentrated water and to check the controlling indexes of pretreated water for the purpose of analyzing the possible cause of failure.

(2) Further determine the cause of failure by means of visual inspection, weighing and on-site dissection, etc.

- Visual inspection: Open the feedwater endplate of the first stage and the product water endplate of the second stage of the pressure vessel, and check the cross section of membrane and the internal wall of pressure vessel. If the internal wall feels velvety and smells odorous, microbial fouling has been formed. In case the internal wall feels relatively rough, it means there is scaling.

- Weighing: Measure the weight of the first membrane element in the first stage and the last membrane element of the second stage. If the first membrane element in the first stage has a relatively heavy weight, it means that there may be contamination by suspending or colloidal substances. If the last membrane element in the second stage has a relatively high weight, it means that there probably exists contamination caused by scaling.

- On-site Dissection of the Membrane Element: Observe the contaminants on the membrane surface, and add acid or alkali on the membrane surface and then observe what will happen.

(3) If the cause of problem cannot be determined from the above two steps, you can take out a membrane element from the system and conduct overall analysis, upon which the cause of failure can be basically determined. Overall analysis includes visual inspection, weighing, performance test, dissection, analysis of contaminants on membrane sheet, pressurized dying, chemical treatment, etc.

(4) The cause of failure can be basically determined after the above analysis, and the cleaning programs and corrective measures can be properly formulated in accordance with “Guide to Cleaning of RO System”.

The following paragraphs deal in detail with the major causes of the three failures mentioned above, the method to identify such failures and the preventive measures:

Decrease in Permeate Flow after Regular Running

In case the permeate flow of RO system decreases after standardization, the cause of failure can be sought according to the following situations:

1. If the decrease of permeate flow occurs in the first stage of RO system, it means there is deposition of granular contaminants.

2. If the decrease of permeate flow occurs in the last stage of RO system, it means that there exists contamination of scaling.

3. If the decrease occurs in all stages of the RO system, it means there exists fouling.

Determine the cause of failure based upon the symptom and exact position of failure, take corrective measures accordingly, and clean the system in line with Guide to Cleaning of RO System.

In addition, the decrease in permeate flow of RO system is always accompanied by such situations as the decrease or increase of rejection rate, etc.

(1) Decrease in both Permeate Flow and Rejection Rate after Standardization

The decrease in both permeate flow and rejection rate after standardization is the system failure most frequently seen, and is possibly caused by the following:

① Colloidal Fouling

The causes of colloidal fouling:

1. Insufficient amount of flocculant is dosed in the pretreatment process, the jar test hasn't been carried out for determining the optimum dosage, and on-line flocculation hasn't achieved a satisfactory result.

2. The multi-media filtration and activated carbon filtration have been overloaded, and the designed velocity of filtration flow is a little higher than necessary, and the system is not backwashed and flushed in time. The designed pore diameter of microfiltration or ultrafiltration membrane is a little larger than necessary.

3. The SDI and turbidity values are not monitored during regular routine operation and management owing to that sufficient importance has not been attached.

In order to identify the colloidal fouling, it is necessary to:

1. Measure the SDI of raw water

2. Analyze the retained substances on the surface of membrane for SDI test.

3. Inspect and analyze the sediments on the end surface of the first membrane element in the first stage.

② Fouling by Metallic Oxides

The fouling by metallic oxides mainly occurs in the first stage, usually caused by the following reasons:

1. The feedwater contains such ions as iron, manganese and aluminum, etc.

2. The feedwater contains H2S and air enters the system, thus generating the sulphide salt.

3. The fouling is formed by the erosive products from the pipe, pressure vessel, etc.

Following are the methods for identifying the metallic oxides:

1. Observe the contaminants retained inside the safety filter, and also observe the end surface of the first membrane element and the internal wall of pressure vessel.

2. Take out the first membrane element, and dissect it to analyze the composition of metallic ions on the membrane surface.

③ Scaling

Scaling is formed by the slightly or hardly soluble salts depositing on the membrane surface, and generally takes place in the brackish water system that operates under high hardness and alkalinity of raw water and requires high recovery rate. It occurs especially in the last stage of RO system, and gradually spreads toward the preceding stages. Scaling may possibly occurs in those raw water containing calcium, bicarbonate radical or sulfate radical within several hours of running, which can block the RO system. Other scaling may be formed slowly. Following situations can cause the fouling:

1. The quality of raw water has not been analyzed, and insufficient amount of antiscalant has been dosed or the antiscalant has inferior effect.

2. The raw water contains high hardness and the recovery rate is excessively high, therefore the precipitation and separation cannot be inhibited by simply dosing the antiscalant.

The method to identify whether scaling occurs:

1. Check the concentrate side of system to make sure whether scaling is formed, which may cause the roughness feeling of internal wall and end plate of pressure vessel.

2. Take out a membrane element from the system and measure its weight. The membrane element with serious scaling generally has a heavy weight.

3. Analyze the quality data of raw water.

(2) Decrease in Permeate Flow and Increase in Rejection Rate after Standardization

This failure is possibly caused by the following reasons:

① Densification of Membrane

If the membrane is densified, it will usually come into being that the permeate flow decreases and the rejection rate increases. The densification of membrane will likely occur in the following situations:

1. The pressure of feedwater is excessively high pressure and exceeds the permitted limit.

2. The feedwater is at a relatively high temperature and there is serious phenomenon of water hammer, in which case the instantaneous pressure exceeds the permitted limit.

The method to identify the densification of membrane: Take out a membrane element and dissect it. Take out a piece of membrane for analysis of its microstructure.

② Contamination by Organic Substances

The organic substances contained in the feedwater can be adsorbed to the surface of membrane element and result in loss of permeate flow, which occurs generally at the first stage. The reasons causing organic contamination are basically similar to the ones causing the colloidal contamination.

Following are the methods for identifying the contamination caused by organic substances:

1. Analyze the retained substances on the filtering element of safety filter.

2. Inspect the flocculant for pretreatment, especially the cation polymer.

3. Analyze the oil and organic contaminants in feedwater.

4. Inspect the detergent and the surfactant.

Decrease in Rejection Rate after Normal Running

(1)Permeate flow remains regular and rejection rate decreases after standardization.

The causes of this failure include:

① Leakage in O-ring

If the O-ring is damaged by lubrication with certain incompatible chemicals or by mechanical stress (movement of membrane element caused by the effect of water hammer, for example), leakage will occur in the O-ring. If the O-ring is not installed or is improperly installed, leakage may also occur.

The method for preventing the leakage of O-ring: Use the prepared glycerin as the lubricant; Insert a pad during installation to prevent the membrane element from shifting to and fro.

② Telescoping Phenomenon

The telescoping phenomenon is caused by the excessively large pressure difference between feed water and concentrated water. Comparatively serious telescoping phenomenon can cause mechanical damage to the membrane element.

The method to prevent the telescoping phenomenon: Reinforce the recording and analyzing of running data. When the pressure difference is 15% higher than the original value, effective corrective measures shall be taken and chemical cleaning shall be done immediately. Particularly, be sure that the pressure difference shall not exceed the permitted limit.

③ Membrane Surface Damage

Membrane surface damage is mostly caused by the combined effect of sharp granules in water, the crystals and the water hammer.

Methods for Preventing the Membrane Surface Damage:

1. Replace the cartridge of safety filter in time, and prevent the sharp and hard granules or activated carbon granules contained in the water from entering the membrane element.

2. Evacuate the air from membrane system before starting the high-pressure pump, or additionally install an electrical slow-open gate or start up the high-pressure pump with variable frequency in order to prevent the water hammer.

3. / When cleaning the scaled membrane element, the initial flow rate shall be as small as possible to avoid the damage caused by the impact of excessively large flow rate.

④ Back Pressure

Whenever the pressure of product water is 0.3 bar higher than that of feedwater or rejected water, inter-layer peeling may occur in the compound membrane, thus damaging the membrane element.

(2) Rejection rate drops and permeate flow rises after standardization.

The causes of this failure include:

① Membrane Oxidation

When the membrane contacts the oxidative substances in the water, the oxidation can damage the membrane and result in irreversible chemical damage, in which case all membrane elements must be replaced.

The membrane can be oxidated possibly by the following reasons:

1. The residual chlorine or other oxidative substances contained in the feedwater of membrane system exceed the provided standard; or

2. The system is not cleaned and sterilized in strict accordance with relevant requirements or procedures, and the cleaning time or temperature exceeds the limits thus causing the oxidation of membrane.

Pressurized dying test can be performed to determine whether the membrane has been oxidated.

② Leakage

If the O-ring is seriously damaged or the central pipe is broken, the feedwater and rejected water will seep into the product water, and the problem will become more serious especially when the system works under relatively high pressure.

Pressure drop increases after regular running, and it causes the decrease in permeate flow or rejection rate.

Pressure drop refers to the pressure difference between feedwater and rejected water. The upper limit of pressure drop is 3.5bar for each pressure vessel containing a number of membrane elements, or 1bar for each membrane element held in FRP casing. Excessive pressure drop will cause the telescoping phenomenon to occur in the membrane element and the FRP casing to be broken, thus resulting in the mechanical damage of membrane element. If the flow rate of feedwater remains constant, the increase of pressure drop is caused generally by the contaminants or scaling substances contained in the flowing passage of feedwater mesh. Once the flowing passage of feedwater is blocked, the permeate flow will decrease as a result.

Following are the reasons frequently seen that causes the increase of pressure drop.

① Microbial Fouling

Microbial contamination can usually cause obvious increase of pressure drop in all stages of RO system. Microbial contamination occurs mostly in those systems using surface water or reused wastewater as raw water.

Solutions to Microbial Contamination

1. Dose germicide in feedwater. Be sure to prevent the oxidative germicide from entering the membrane element so as to prevent the oxidation of membrane element.

2. Change to use the oxidation-resistant membrane element and dose germicide in the whole system (including RO system)

② Scaling Contamination

Since the scaling that fouls the feedwater flow passage can usually cause the increase of pressure drop in the membrane elements of the last stage, it must be ensured that suitable measures be taken to control the scaling, that proper chemicals be used for cleaning the membrane element and that the recovery rate be kept at reasonable level.

Summary of Failure Symptoms, Causes and Corrective Measures of RO System

Symptoms			Possible Causes	Corrective Measures
Flux	Salt Passage	Pressure Difference		
↓●	↑	↑	Scaling Contamination	Chemical cleaning; controlling the scaling
↓●	↑	↑	Colloidal Contamination	Chemical cleaning; improving the pretreatment
↓	→	↑●	Biological contamination	Chemical cleaning, disinfection; improving the pretreatment
↓●	→	→	Organic Contamination	Chemical cleaning; improving the pretreatment
↓●	↓	→	Densification	Replace or add new membrane element
↑	↑●	→	Oxidative Destruction	Replace membrane element and dose reductant; Replace with oxidation resistant element
↑	↑●	→	Leakage of damaged membrane sheet; O-ring leakage	Replace the element Improve the filtration effect of safety filter Replace the O-ring Replace the element.

↑ Rise ↓Fall →Unchanged ● Major Symptom

6–3 Forms of System Design or In–use Details of VONTRON Membrane Elements

Table 1–Summary Description of System

Registration No.:		Date of Recording:
User Information	User Name	Contact
	E-mail:	Tel / Fax
	Project Site:	End User (optional)
	Address (optional)	Post Code
Data of Water Source	Features of Water Source: □ RO-filtered □ Underground / Deep Well □ Surface Water □ Tap Water □ Seawater □ Municipal (living) sewage □ Industrial Wastewater	
	Water Temperature: Minimum ___ ℃; Maximum_℃; Average__℃; Designed___℃	
Basic Information of System	Chemicals dosed: □ Reductant □ Flocculant □ Germicide □ Coagulant aid □ Acidizing agent □ Antiscalant □ Others	
	Current Pretreatment: □ Multimedia + Activated carbon □ MF/UF □ SDI_{15} Value ____	
	Designed Conductivity of Product Water: Conductivity of Product Water of System:	System Rejection Rate:
	Designed Water Yield (m^3/h): System Water Yield (m^3/h):	System Recovery Rate:
	Process Flow of RO System	
	Applications of System: □ water for medical and pharmaceutical purposes □Refined water for medical purpose □ Electrical power industry □ Preparation of purified water □Water for living and drinking purposes □ Chemical industry □ Water for boiler (high pressure, medium pressure, low pressure); □ Electronic industry □ Metallurgical industry □ Treatment of Recycled Wastewater □ Water for other industries	
	Way of System Running: □ 24 hours continuously □ 8 hours continuously □ 24 hours intermittently □ 8 hours intermittently	
	Post-treatment equipment and process flow	

Table 2: Detailed Data of System Pretreatment

Mechanical Filter (Quartz Sand Filter)					
Material: □Stainless steel □ Regular steel-lined rubber □ FRP					
Mode of Control: □ By hand □ Auto-control valve □ Power-driven valve					
Filter Sizes (mm)			Detail of Fillings: Type, thickness and granular dia, etc.		
Diameter	Height	Thickness of Fillings			
Rinsing Frequency and Intensity					
Rinsing Frequency	Flushing Duration	Backwash Duration			

Activated Carbon Filter					
Material: □Stainless steel □ Regular steel-lined rubber □ FRP					
Mode of Control: □ By hand □ Auto-control valve □ Power-driven valve					
Filter Sizes (mm)			Detail of Fillings: Type, thickness and granular dia, etc.		
Diameter	Height	Thickness of Fillings	Type of Activated Carbon	Filling mass	Density of Activated Carbon
Rinsing Frequency and Intensity			Remarks:		
Rinsing Frequency	Flushing Duration	Backwash Duration			

Reductant Dosed				
Dosed? □ Yes □ No		Concentration dosed	Way of Dosing	Time of Contacting
Composition of Reductant				

Softener					
Material: □Stainless steel □ Regular steel-lined rubber □ FRP					
Mode of Control: □ By hand □ Auto-control valve □ Power-driven valve					
Filter Size (mm)			Information of Resin		
Dia.	Height	Filling Thickness	Brandname of Resin	Type of Resin	Filling Weight

Table 3: Data of Raw Water Quality of RO System

Project Name ___________ Sampling Time ___________ Sampling Place ___________

Type of Raw Water ___________ Time of Analysis ___________ Prepared by: ___________

pH		Turbidity (NTU)		Water Temp(℃)	
SDI		Conductivity (µS/cm)		ORP (mV)	

Composition of Ions	ppm	meq/L	Composition of Ions	ppm	meq/L
Ca^{2+}			Cl^-		
Mg^{2+}			SO_4^{2-}		
Na^+			CO_3^{2-}		
Ba^{2+}			HCO_3^-		
K^+			PO_4^{3-}		
Fe^{2+}			F^-		
Fe^{3+}			NO_3^-		
Al^{3+}			SiO_2		
Total Cations			Total Anions		

Total Solids (ppm)		BOD(ppm)	
Total Hardness $CaCO_3$ (ppm)		COD(ppm)	
Total Alkalinity (mL)		Number of bacteria, per liter	
Phenolphthalein alkalinity (mL)		Residual chlorine concentration (ppm)	

PART TWO: SERVICE INSTRUCTIONS

Chapter VII–Quality Assurance of VONTRON Membrane Elements

7–1 Three–year Warranty for RO Membrane Elements

VONTRON RO membrane elements shall be used according to the specifications and procedures set forth by Vontron Technology Co., Ltd. (hereinafter referred to "Vontron"), and only on this condition will Vontron ensure the quality of RO membrane elements manufactured and sold by itself, and offer a three-year period of limited quality guarantee, with the terms specified as follows:

Guarantee on Producing Technologies and Materials

Vontron ensures that the RO membrane elements produced and sold by itself are integral and intact in respect of producing technologies and materials. Vontron's obligation under this limited warranty covers a period of 12 month from the date received by the buyer, and is limited to the gratis repair or, at Vontron's discretion, replacement of any element which, when examined by Vontron, appears to be originally defective under this provision of limited warranty.

Guarantee on Performance

The new membrane products have the initial performance specified in the brochure of said product. Vontron warrants the performance of its elements for three years from the date when the RO system is put into operation or 6 months after the goods is shipped (whichever occurs first), during which period Vontron warrants as follows:

① Performance of Membrane Element within Three-year Period of Limited Warranty

(1) The average salt permeability doesn't exceed 2 times of the value specified in the sample book of products when the membrane elements are used or measured on the testing condition specified in the General Technical Specifications of Vontron.

(2) The average permeate flow is not less than 70% of the initial permeate flow when the membrane elements are used or measured on the testing condition specified in the sample book of products provided by Vontron.

② Initial Performance

Vontron guarantees the initial minimum permeate flow and rejection rate as specified in the technical specifications. These parameters are obtained under standard testing conditions set forth by Vontron. If these membrane elements fail to reach the minimum initial values as specified, Vontron will, after confirming the performance failure, repair the membrane elements or refund to customer the expenses for purchasing those defective membrane elements, in which case Vontron itself will bear the freight charges.

③ In case the buyer fails to satisfy any of the following requirements, Vontron will bear no liability for performing the three-year quality warranty mentioned above:

(1) Feedwater turbidity shall not exceed 1.0NTU; SDI15 shall not exceed 5; feedwater temperature shall not be higher than 45℃.

(2) Feedwater shall not contain any harmful substance that may cause physical and chemical damage to the membrane element.

(3) Before being installed or put into operation, the membrane element shall be stored in original packing box and preserved at the temperature not higher than 45℃ for dry-type membranes and at the temperature within 0~45℃ for wet-type membranes.

(4) The pH value of feedwater shall be within the range of 3~10 during regular running. When the system is cleaned, the pH value of feedwater shall be within 2~12.

(5) The feedwater shall not contain such oxidizing substances as chlorine, potassium permanganate and hypochlorous acid radical, etc. (Notes: This article is not applicable to HOR series which shall work with the feedwater suitable for it)

(6) The maximum operating pressure for membrane element is as follows (except otherwise specified in the product instructions):

Membrane Series	Max Operating Pressure
XLP Series	600 psi
ULP Series	600 psi
LP Series	600 psi
SW Series	1000 psi
FR Series	600 psi
HOR Series	600 psi

(7) In no case should the backpressure exerted on the membrane element be greater than 5 psi; besides, the membrane element should be avoided from the impact of water hammer when the system is in operation.

(8) If, under standard operating conditions, the performance of system decreases by 10% or if the contamination or scaling of membrane elements occurs, the membrane elements should be cleaned immediately in accordance with specified procedures.

(9) The system composition and design parameters of system, such as the array of membrane modules, configuration of instruments and meters and the recovery rate, etc., shall be

surely in conformity with the proper engineering design.

⑽ The seller shall be responsible for providing the user with proper manuals of system operation and maintenance, and conduct relevant training for the operating and managerial personnel so as to ensure that the user has the capability of cleaning the system, and other capabilities such as recovering the performances and diagnosing the failures of system.

⑾ The user must frequently and systematically record the standardized performance data of the whole system and its subsystems, ensure that these data are true, complete and continuous, and then keep these data on file for future reference. When any claim is lodged against Vontron according to the terms of quality assurance, these data will be the evidence for Vontron to perform its guarantee for the quality.

The Conditions for Composing an RO System

① The integral and effective pretreatment, the array of elements, the setup of instruments and meters, the design standards of equipment and the components shall be all in conformity with the guide to RO membrane design and the relevant technical standards of Vontron, and Vontron shall have the right to examine the design to confirm whether it is in conformity with the design guidance and relevant technical standards.

② The RO system shall be equipped with proper devices that can prevent the formation of microbial contamination and other kinds of contamination, and shall have applicable protective measures

Conditions of Raw Water

① The feedwater of RO system must ensure that the membrane surface will not suffer the adhesion by any of the colloidal matter, microorganism or other deposit

② The RO membrane should be free from the damage of those harmful chemicals, such as surfactant, organic solvent, grease, high-molecular polymer, etc.

③ The raw water should be free from any strong oxidative substance, such as ozone, chlorine or potassium permanganate, etc.

④ The feedwater temperature shall be lower than 45℃.

⑤ The SDI15 of raw water entering the RO system shall surely be less than 5 all the time, and the maximum turbidity of feedwater shall be less than 1.0NTU, while the turbidity of feedwater in continuous operation shall be controlled within 0.3~0.5NTU, and the SDI shall be preferably less than 3.

⑥ No colloidal sulfur shall be contained in raw water.

Operating Conditions

① Determine the most suitable recovery rate for the RO system in running time based upon the degree of separation-out of hardly solved substances.

② The RO system shall be surely free from fouling and scaling formed by calcium, magnesium, barium, strontium, and silicon, etc. during the running time.

③ The RO system shall be equipped with special-purpose device to prevent RO elements from being affected by the water hammer from when the high-pressure pump is started up and is in running.

④ The RO system shall use the chemicals as recommended by Vontron or as permitted for use. In case you are going to use those chemicals not recommended by Vontron, please obtain the consent from Vontron first.

Cleaning Conditions

Please refer to "Guide to Cleaning of VONTRON Membrane Elements"

Points for Attention during the Use of RO Elements

① Any specific application must be limited within the extreme operating conditions. We strongly recommend you to refer to the latest edition of technology manual and design guide prepared by Vontron Technology Co., Ltd., or consult experts proficient in membrane technology. In case the customer fails to follow the operating conditions as specified in this manual, Vontron technology Co., Ltd. will assume no liability for all results

② All membrane elements have been strictly tested before leaving the factory. The wet-type elements have been treated with the preservative solution made of RO-filtered water and 1.0% sodium hydrogen sulfite (an antifreeze solution of 10% propanediol is required in winter) for storage purpose, then sealed with plastic bag in vacuum, and further packed in carton boxes. In order to prevent the breeding of microbes during short-time storage, transportation and system standby, we recommend you to soak the membrane elements with protective solution (prepared with RO-filtered water) containing 1.0% sodium hydrogen sulfite (foodstuff purpose).

③ The RO-filtered water produced in the first hour of running shall be discarded.

④ During storage time and run time, it is strictly prohibited to dose any chemical medicament that may be harmful to membrane elements. In case of any violation in using this kind of chemical medicament, Vontron Technology Co., Ltd. assumes no liability for any outcome incurred herefrom.

7–2 Procedures for Repair and Replacement of Membrane Element

In case the customer definitely requests to implement the procedures on repair and replacement of membrane elements, the following procedures set forth by Vontron shall be implemented:

7–2.1 Procedure on Repair of Membrane Element

Before any membrane element is returned for repair, you must contact first the regional sales manager of Vontron and obtain the agreement from said manager.

The procedure on repair of membrane element includes two methods: On-the-spot inspection and testing of the membrane elements conducted by Vontron's technical personnel at the customer's site; or returning of the membrane element to the site of Vontron for inspection and testing.

① In case of on-the-spot inspection and testing:

(1) For the products within the quality guarantee term with the problems caused by the membrane materials and the producing technologies of Vontron, Vontron shall, upon completion of the inspection and testing, bear all the expenses for inspection and testing of the membrane elements, and the customer can obtain the membrane elements compensated by Vontron that are in conformity with the technical specifications, with the freight charges borne by Vontron.

(2) For the products within the quality guarantee term with the problems not caused by the membrane materials or the producing technologies of Vontron, the customer shall, upon completion of the inspection and testing, bear all the expenses for inspection and testing and for replacement of membrane elements, with the freight charges also borne by the customer.

(3) As for the products beyond the quality guarantee term, the customer shall, upon completion of the inspection and testing, bear all the expenses for inspection and testing and for replacement of membrane elements, with the freight charges also borne by the customer.

② In case of returning the membrane elements to the site of Vontron for inspection and testing:

(1) The customer shall fill in "Registration Form for Return, Repair and Replacement of Membrane Element(s)", and send it to the regional sales manager of Vontron by e-mail, fax or other ways. Upon confirmation, the regional sales manager shall notify the customer to return the membrane element.

(2) Besides sending back the membrane element, the customer shall also provide the following information:

■ Model and serial number of membrane element, and contract number.

■ Detailed description of failures of product

■ All data that can reflect the properties of membrane element(s) returned, such as rejection rate, temperature, pressure, salt concentration of feedwater, and permeate flow, etc.

7–2.2 Packing and Transportation

① Before transportation, the customer shall take necessary measures for protecting and storing the membrane elements of various types as stipulated in the terms set forth in the technical announcement of Vontron.

② The membrane element(s) shall be packed in sealed plastic bag and then placed in the carton box to avoid mechanical damage in the course of transportation, and shall be surely kept away from moisture and exposure to sunlight.

③ After obtaining the notice of return from Vontron, the customer shall send out the membrane element(s) as soon as possible in order to avoid the change in properties of membrane element(s) caused by excessively long time of storage.

7–2.3 Procedures for Inspection and Testing

① In case it is necessary to conduct destructive experiment on the returned membrane element(s) for the purpose of technical inspection, Vontron shall, upon having its regional sales manager of Vontron contacting the customer and obtaining authorization from the customer, carry out the destructive experiment.

② As for the membrane element(s) within the quality guarantee term, if the testing result proves that the problem of membrane element(s) is not caused by the membrane materials or the producing process, the customer shall exclusively bear all of the expenses for inspection and testing, and cannot get compensation from Vontron. Vontron will, according to the instructions of customer, dispose of the membrane element(s) or, at the customer's charges, send back the element(s) to the customer.

③ In case the testing result proves that there actually exists defect in the material or producing process of the membrane element(s), Vontron will bear the expenses for inspection and testing; besides, the customer can obtain the membrane element(s) compensated by Vontron that are in conformity with the technical specifications, with the freight charges borne by Vontron.

④ As for the membrane element(s) beyond the quality guarantee term, the customer shall bear all the expenses for inspection, testing and replacement of membrane element(s) as well as the freight charges.

7–2.4 Additional Provisions

① Vontron shall bear the transportation expenses for returning the membrane element(s) back to the company

② / In case Vontron doesn't receive the membrane element(s) within the specified time, it will notify the customer of ending the repair program. In general case, the specified time shall be within one month from the date when the customer receives the Registration Form for Repair and Replacement of Membrane Elements signed by the regional sales manager of Vontron.

③ The quality warranty shall be invalidated upon the occurrence of any of the following:

■ The membrane element bears no serial number of Vontron Technology Co. Ltd.

■ It is obviously visible that the membrane element(s) has suffered the contamination of inferior water quality in the course of service.

■ The mechanical damage is obviously visible, which is caused in the course of service.

■ The membrane element has been damaged due to improper storage or transportation.

■ The membrane element(s) has/have been arbitrarily transformed without the permission of Vontron Technology Co. Ltd.

Attachment 1–Registration Form for Repair and Replacement of Membrane Elements

VONTRON TECHNOLOGY CO., LTD. **Registration Form for Repair and Replacement of Membrane Elements**			
Name of Customer		Name of Seller	
Contact Person		Fax	
Telephone		E-mail	
Attached Information			
Model and S/N :			
Detailed Description of Failure (including the time of initial operation):			
Below is for Vontron Membrane Technology Co. Ltd. only			
Comments of Regional Sales Manager			

7–3 Quality Certification

Certification of ISO901:2000

Vontron Technology Co., Ltd. was certified to ISO9001:2000 Quality System on November 15, 2003, and passed the reexamination of certifying organization separately on March 2007 and March 2010.

CQC 副本

QUALITY MANAGEMENT SYSTEM CERTIFICATE

Certificate No.: 00110Q22290R2S/5200

We hereby certify that

Vontron Membrane Technology Co., Ltd.

#206 Room of Office Building, South Huiton Hi-tec Industrial district, Guiyang, Guizhou, P.R.China

by reason of its

Quality Management System

has been awarded this certificate for compliance with the standard

ISO9001: 2008

GB/T 19001-2008

The Quality Management System Applies in the following area:

Design, Development and Production for Reverse Osmosis Products

Certified since: Mar. 15, 2007 Valid from: Mar. 05, 2010 Valid until: Mar. 04, 2013

After a surveillance cycle, the certificate is valid only when used together with an Acceptance Notice of Surveillance Audit issued by CQC. Please access www.cqc.com.cn for checking validity of the certificate.

CNAS MANAGEMENT SYSTEM CNAS C001-Q IAF

Signed by: Wang Kejiao

IQNet

CHINA QUALITY CERTIFICATION CENTRE

CHINA QUALITY CERTIFICATION CENTRE

Section 9, No.188, Nansihuan(the South Fourth Ring Road) Xilu(West Road), Beijing 100070, China

http://www.cqc.com.cn

Q 0006382 2009年版

NSF/ANSI 58 Certification

Vontron's residential series of membrane elements were certified to NSF/ANSI 58.

NSF International

RECOGNIZES

Vontron Technology Co., Ltd.

China

AS COMPLYING WITH NSF/ANSI 58 AND ALL APPLICABLE REQUIREMENTS. PRODUCTS APPEARING IN THE NSF OFFICIAL LISTING ARE AUTHORIZED TO BEAR THE NSF MARK.

This certificate is the property of NSF International and must be returned upon request. For the most current and complete information please access NSF's website (www.nsf.org).

October 25, 2010
Certificate# 3D180 - 04

Thomas Bruursema, General Manager
Drinking Water Treatment Units

NSF

Inspection Report for Disease Control

The membrane product of Vontron Membrane Technology Co., Ltd. was certified by Chinese Center for Disease Control and Prevention on May 9, 2006 to conform to relevant hygiene requirements.

中国疾病预防控制中心环境与健康相关产品安全所

检 验 报 告

样品受理编号：2006KF0121 第　页/共　页

样品名称	汇通源泉（VONTRON）牌反渗透膜	检验类别	委托
样品规格或性状	ULP/白色反渗透膜	样品数量	4支
检验项目	理化指标共23项	生产日期或批号	2006.3
委托单位	汇通源泉环境科技有限公司	接样日期	2006年3月23日
委托单位地址	贵阳市新添寨南方高新科技工业园	检验完成日期	2006年4月28日
检验依据	《生活饮用水输配水设备及防护材料卫生安全评价规范》（2001）		

检验结果与评价：

根据《生活饮用水输配水设备及防护材料卫生安全评价规范》（2001），对汇通源泉环境科技有限公司送检的汇通源泉（VONTRON）牌反渗透膜样品进行卫生安全性检验，检验结果见附表。

检验方法采用《生活饮用水检验规范》（2001）；样品处理方法按照《生活饮用水输配水设备及防护材料卫生安全性评价规范》（2001）附录A进行；样品浸泡水采用附录A1.3.1节配制；浸泡时间24h±1h，浸泡温度25℃±5℃。

结果表明：色、浑浊度、臭和味、肉眼可见物、pH、溶解性总固体、耗氧量、砷、镉、铬（六价）、铝、铅、汞、三氯甲烷、挥发酚类、铁、锰、铜、锌、银、四氯化碳、硝酸盐氮和氟化物等指标均符合《生活饮用水输配水设备及防护材料卫生安全性评价规范》（2001）对水处理材料的卫生要求。

以下空白

法定代表人（或授权签字人）

最终审核日期 2006 年 5 月 9 日

中国疾病预防控制中心 环境与健康相关产品安全所 检验机构 检验报告专用章

Health Approval of Beijing

Vontron obtained the Health Approval issued by the Department of Health of Beijing on May 17, 2010.

京卫水字(2010)JS第1897号 2010 05 17

北京市生活饮用水
供水设备及用品卫生许可批件

批准文号： 京卫水字(2010)JS第1897号

产品名称： 汇通源泉牌ULP1812-50型卷式聚酰胺复合反渗透膜元件
ULP1812-75、ULP2012-100、ULP21-4040、ULP21-4021

产品类别： 输送水设备

申请单位： 北京时代沃顿科技有限公司

单位地址： 北京市昌平区昌平火车站西昌土路南6号

有效期限： 2010 年 05 月 17 日 至 2014 年 05月 17日

经审查，该产品符合《北京市生活饮用水卫生监督管理条例》的规定，现予以批准。

北京市卫生局

2010 年 05 月 17 日

京卫水字(2010)JS第1897号 2010 05 17

Chapter VIII–Specifications on Service of Membrane Elements

8–1 Control Procedure on Service

8–1.1 Subject Content and Application Range

● This Procedure is formulated according to Article 7.2 of ISO9001 (2000 version), regulating the content of product service, the requirements on service provided and the control procedure.

● This Procedure is applicable to the control of pre-sales, in-use and after-sale service provided by Vontron Technology Co., Ltd. before sales, the pre-sale, sale and after-sale services of reverse osmosis products of Beijing Vontron Technology Co., Ltd.

8–1.2 Function and Responsibility

● Manager of Marketing Department is responsible for organizing the formulation of Manual of Products, Technical Support and Service of reverse osmosis products upon the examination by management representative and approval by president.

● The purchasing supervisor is responsible for printing the Manual of Products, Technical Support and Service.

● The supervisor in charge of product research and technical support is responsible for formulating and revising the section of technical service of products in the Manual of Products, Technical Support and Service upon the examination by the Vice president of Technology and the chief engineering officer.

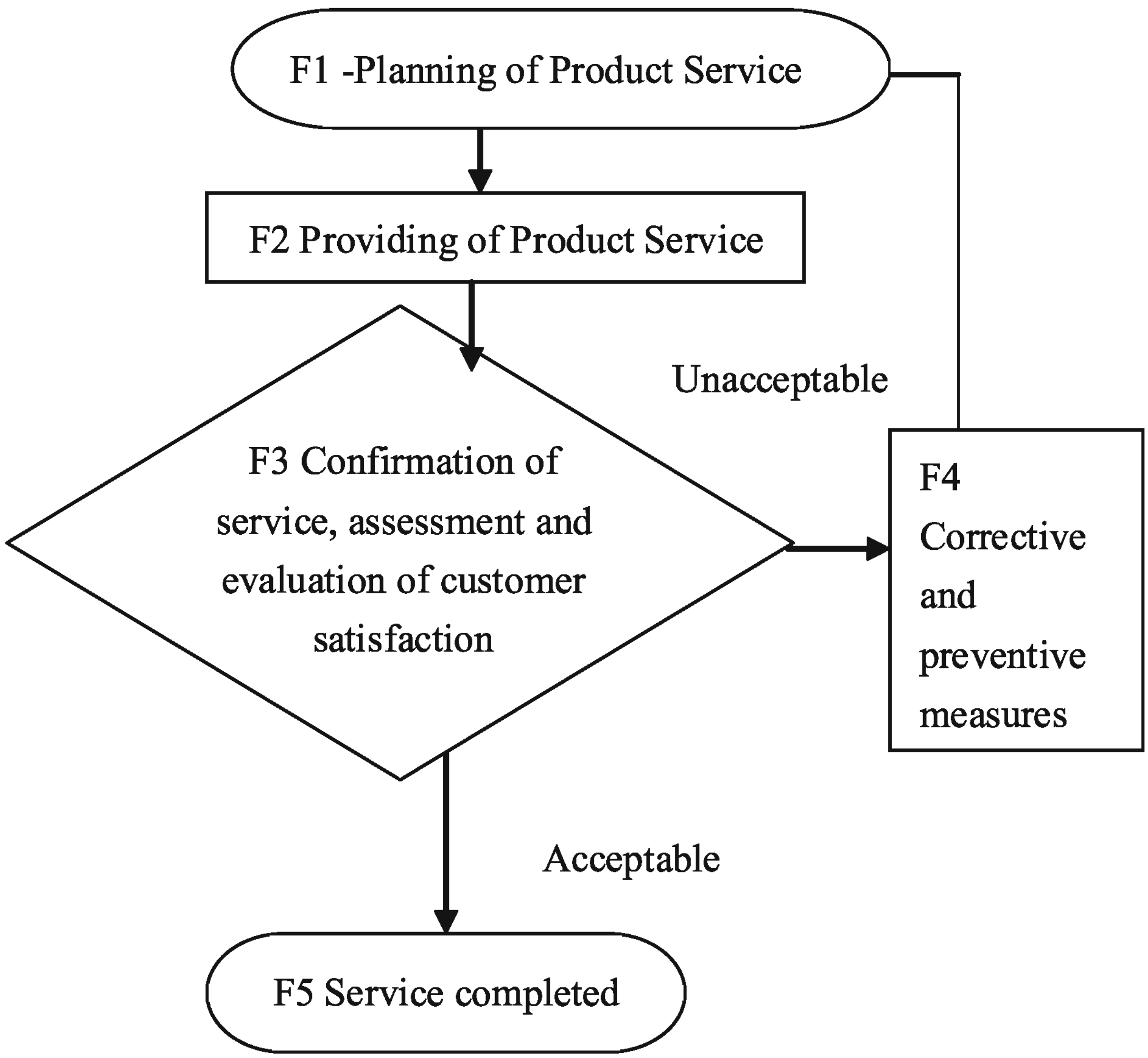
● The supervisor in charge of product research and technical support is responsible for organizing the formulation of General Technical Specifications of Products upon the examination by the vice president of technology and the chief engineering officer.

● The supervisor in charge of product promotion is responsible for formulating and revising the section of sales service in the Manual of Products, Technical Support and Service upon examination by the director of marketing center and approval by the vice president of marketing.

● The personnel in charge of product research and technical support are responsible for the technical support and service of products during the sales process, the confirmation of service and the assessment and evaluation of customer satisfaction degree.

- Each regional manager is responsible for the sales service, service confirmation and assessment and evaluation of customer satisfaction degree during the sales process of products.
- The quality assurance supervisor is responsible for the overall evaluation of customer satisfaction with service offered during the sales process of products and the formulation and follow-up verification of relevant corrective and preventive measures.

8–1.3 Control Diagram



8–1.4 Control Procedure

F1 Planning of service	1. The manager of marketing department is responsible for organizing timely the supervisor of product application and technical support and the supervisor of product promotion to formulate and revise the Manual of Product, Technical Support and Service according to the product and application characteristics and the customers' service needs specified in the General Technical Specifications of Products and the Report on Market Research and Analysis of Product. Said Manual shall be forwarded to the director of Purchase & Procurement Department for printing upon examination by the management representative and approval by the president. ① The section of "technical service for products" in the Manual of Product, Technical Support and Service shall be formulated and revised by the supervisor of product research and technical support, examined by the vice president of technology and approved by the chief engineering officer. ② The section of "service of product sales" in the Manual of Product, Technical Support and Service shall be formulated and revised by the supervisor of product promotion, examined by the manager of marketing department and approved by the vice president of marketing. ③ The Manual of Product, Technical Support and Service mainly includes the following content: a. General Technical Specifications of Products (including: main technical indexes of products and inspection and testing methods, regulations of packaging and transportation, duration and conditions of storage, etc.); b. Guide for Product Selection and Application (including: classification table of conventional products and individualized products supplied by the company, main technical indexes of products and their application range and characteristics, guide for product application and customer confirmation table for the applied technology condition of industrial membrane module, etc.); c. Guide for Product Service (including: control procedure for service, content and manner of products' pre-sales service, content and manner of in-sale service, and content and manner of products' after-sales service, etc.); d. Guide for the Assessment and Evaluation of Customer Satisfaction Degree (including: Assessment and Evaluation Table of Pre-sales Service Satisfaction degree, Assessment and Evaluation Table of In-sale service Satisfaction degree, Assessment and Evaluation Table of After-sales Service Satisfaction degree, and Application Form of Customer Complaints for Product Quality).	"Report on Market Research and Analysis of Product" "General Technical Specifications of Products" "Manual of Product, Technical Support and Service"

F2 Providing of product service	2. The manager of marketing department, based upon the Evaluation Report of Customer Satisfaction degree of the previous year and the Business Plan of next year, is responsible for formulating the Service Plan of next year according to the Regulations on Management of Overall Budget, which shall be implemented after being examined by the vice president of marketing, reviewed by the management team and approved by the president. ① The annual service plan mainly includes the following items: Service content, frequency, responsible department, time and resource arrangement, etc. a. Pre-sales service plan (including: Plan of promotion meeting on new products, new technologies and new fields, promotion plan of products and technologies in terms of professional fields, professional journals or media, etc.) b. In-sale service plan (including: training plan on knowledge and skills for application and inspection of products, plan of offering or participation in design scheme for the reverse osmosis system, etc.) c. After-sales service plan (including: "Three Guarantees" service within the guarantee period during the use of products, acceptance of complaints for product quality, acceptance for the customer service request and customer care service, etc.) ② The manager of Marketing Department organizes the supervisor in charge of product research and technical support and the supervisor of product promotion to duly boost the pre-sale service according to the requirement of time point for the service plan or the contract order; the supervisor in charge of product research and technical support is responsible for organizing the promotion of product technology and the formulation of relevant promotion manuscripts (if necessary, ask the relevant design and inspection personnel, the vice president of technology or the chief engineering officer to participate in), and the supervisor of product promotion is responsible for organizing and implementing the pre-sales service activities. ③As for the in-sale service, the manager of Marketing Department organizes the supervisor in charge of product research and technical support and the supervisor of product promotion to duly provide the on-site training on product application and inspection knowledge and skills according to the contract order request, or participate in the design and the on-site application guidance for the customer's reverse osmosis system scheme, help the customer establish and implement the application, inspection and maintenance standard and operation instruction of products (if necessary, ask the relevant design and inspection personnel or vice president of technology or chief engineering officer to participate in); ④ As for the after-sale service, the regional manager shall submit the "After-sales Service Request Form" or the "Acceptance Form of Complaints for Product Quality" through the CRM system, wherein: as for the complaints for "Three Guarantees" product quality within the scope of Three Years' Quality Guarantee for Reverse Osmosis Elements, the regional manager shall fill in the "Acceptance Form of Complaints for Product Quality" and then directly submit it to the quality assurance supervisor for handling with the complaints according to the Control Procedure for Customer Complaints; as for the product quality problems that are beyond the applicability of "Three Guarantees", the complaints shall be submitted to the deputy marketing director for approval by the regional manager according to the product presentation plan or relevant provisions and then shall be implemented. Regarding the request for after-sales technical service, the regional manager shall fill in the "Request Form for After-sales Service" and then submit it to the chief engineering officer for the latter to appoint relevant personnel to offer corresponding services in time. Regarding the request for after-sales service, the regional manager shall fill in the "Request Form for After-sales Service" and then submit it to the vice president of marketing to arrange relevant personnel to provide corresponding services in time. The vice president of marketing shall organize the business supervisor, the promoting supervisor and the regional manager to duly implement the customer care service according to the Service Plan (mainly including paying a visit and expressing thanks to the customer).	Regulations on Management of Overall Budget Evaluation Report of Customer Satisfaction degree Business Plan Request Form for After-sales Service Three Years' Quality Guarantee for Reverse Osmosis Elements Control Procedure for Customer Complaints

F3 Confirmation of service, assessment and evaluation of customer satisfaction	3. The product service personnel must fill in the corresponding "Assessment and Evaluation Table of Service Satisfaction degree" in time, which shall be signed and verified by the customer and then be fed back in time to the company's quality assurance supervisor for filing. ① As for the pre-sales service, the manager of Marketing Department shall organize the customer to fill in the Assessment and Evaluation Table of Pre-sales Service Satisfaction Degree on the site, which shall be signed and verified by the customer. ②As for the in-sale service, the supervisor of product research and technical support shall fill in the Assessment and Evaluation Table of Sale Service Satisfaction Degree after the completion of service, which shall be submitted to the customer for signing and verification. ③ When the field service is required as an after-sales service, the service provider shall fill in the "Assessment and Evaluation Table of After-sales Service Satisfaction Degree", which shall be submitted to the customer for signing and verification; when the field service is not provided, the relevant regional manager fills in the "Assessment and Evaluation Table of After-sales Service Satisfaction Degree", which shall be verified by the customer by telephone (signed and verified by regional manager). ④ The quality assurance supervisor shall be responsible for classifying and analyzing the acceptance status of customer complaints for product quality, following up and verifying the corrective and preventive measures according to the requirements of "Control Procedure for Customer Complaints", and shall submit a specific report to the monthly regular working meeting. ⑤The quality assurance supervisor shall be responsible for carrying out statistical analysis on the situations of the provision of product service and the assessment and evaluation of customer satisfaction degree, putting forward the corrective and preventive measures and following up and verifying them, and shall submit a specific report to the monthly regular working meeting. ⑥The quality assurance supervisor shall be responsible for classifying and analyzing the situations regarding the provision of product service and the assessment and evaluation of customer satisfaction degree for one year before middle November of each year, and then submitting to the management examination meeting and the year-end working seminar for examination and discussion.	Assessment and Evaluation Table of Pre-sale Service Satisfaction Degree Assessment and Evaluation Table of Sale Service Satisfaction Degree Assessment and Evaluation Table of After-sales Service Satisfaction Degree Control Procedure for Customer Complaints

8–2 Requirements on the Content and Procedure of Pre–sales Service

Content of pre-sales service: specific promotion of new products, new technologies and new fields, promotion of products and technologies in terms of professional fields, professional journals or media, etc.

Providing of pre-sale service: The manager of Marketing Department organizes the supervisor in charge of product research and technical support and the supervisor of product promotion to duly boost the pre-sale service according to the requirement of time point for the service plan or the contract order; the supervisor in charge of product research and technical support is responsible for organizing the promotion of product technology and the formulation of relevant promotion manuscripts (if necessary, ask the relevant design and inspection personnel, the vice president of technology or the chief engineering officer to participate in), and the supervisor of product promotion is responsible for organizing and implementing the pre-sales service activities.

Looking forward to your support and assistance: we will invite you to participate in Vontron's promotion or introduction activities of new technologies and new products in all professional fields, and you can also learn about the information about the company's new technologies and new products by visiting our company's website or reading professional journals; the company's Marketing Department will duly organize you to fill in, confirm and feed back the Assessment and Evaluation Table of Pre-sales Service Satisfaction Degree.

8–3 Requirements on the Content and Procedure of In–sale Service

Content of sale service: training of knowledge and skills in product application and inspection, providing of design scheme of reverse osmosis system or participation in design, etc.

Providing of In-sale service: The manager of Marketing Department organizes the supervisor in charge of product research and technical support and the supervisor of product promotion to duly provide the on-site training of knowledge and skills in product application and inspection according to the requirement of contract or order, or participate in the design of customer's reverse osmosis system and offer guidance to the on-site application thereof, help the customer establish and implement the application, inspection and maintenance standards and operation instructions of products (if necessary, ask the relevant design and inspection personnel or vice president of technology or chief engineering officer to participate in);

Looking forward to your support and assistance: In order to ensure that you can better select, use and maintain the products supplied by our company, you are required to clearly specify the content and requirement of all services in the contract for purchase and marketing of products or service contract. We will provide you with the timely training on product application and inspection knowledge and skills, the design scheme or advice of reverse osmosis system and instruct the installation and debugging of reserve osmosis products, etc., and help you establish an operation monitoring system for the reserve osmosis system. After the completion of service, we will duly organize you to fill in, confirm and feed back the Assessment and Evaluation Table of In-sale service Satisfaction.

8–4 Requirements for the Content and Providing of After–sales Service

Content of after-sale service: "Three Guarantees" service within the guarantee period during the use of products, acceptance of complaints for product quality, acceptance for the customer service request and customer care service, etc.

Providing of after-sales service: The regional manager shall submit the "After-sales Service Request Form" or the "Acceptance Form of Complaints for Product Quality" through the CRM system, wherein: as for the complaints for "Three Guarantees" product quality within the scope of Three Years' Quality Guarantee for Reverse Osmosis Elements, the regional manager shall fill in the "Acceptance Form of Complaints for Product Quality" and then directly submit it to the quality assurance supervisor for handling with the complaints according to the Control Procedure for Customer Complaints; as for the product quality problems that are beyond the applicability of "Three Guarantees", the complaints shall be submitted to the deputy marketing director for approval by the regional manager according to the product presentation plan or relevant provisions and then shall be implemented. Regarding the request for after-sales technical service, the regional manager shall fill in the "Request Form for After-sales Service" and then submit it to the chief engineering officer for the latter to appoint relevant personnel to offer corresponding services in time. Regarding the request for after-sales service, the regional manager shall fill in the "Request Form for After-sales Service" and then submit it to the vice president of marketing to arrange relevant personnel to provide corresponding services in time. The vice president of marketing shall organize the business supervisor, the promoting supervisor and the regional manager to duly implement the customer care service according to the Service Plan (mainly including paying a visit and expressing thanks to the customer).

Looking forward to your support and assistance: In case there is any problem relating to our company's reverse osmosis products and their relevant operating indexes during the delivery, acceptance and application process of products, you are simply required to directly fill in the "Acceptance Form of Complaints for Tangible Product Quality" and feed it back to the sales engineer in the corresponding region, and you will obtain the confirmation of problem within a shortest period. Then we will give you an analysis report of quality problems and put forward the improvement opinions and suggestions. After the completion of service, we will duly organize you to fill in, confirm and feed back the Assessment and Evaluation Table of After-sales Service Satisfaction Degree. You can also confirm your feedback comments by telephone or by your signature.

Chapter IX–Guide for Assessment and Evaluation of Customer Satisfaction Degree

Adhering to the principle of “Focusing on the Customer”, in order to fully learn about the customer demands and boost the improvement of product quality inside the company and the service level outside the company, Vontron Technology Co., Ltd. will periodically carry out assessment and evaluation on customer satisfaction degree according to the relevant provisions of the internal business process.

9–1 Mode of Assessment and Evaluation

(1) Vontron shall implement the assessment and evaluation work of customer satisfaction degree in pre-sales, in-use and after-sales stages.

(2) The assessment and evaluation of customer satisfaction degree is carried out in a way of questionnaires. The regional sales managers of Vontron shall dispatch the questionnaires on Customer Satisfaction Degree to the customers, collect said questionnaires from customers after being filled in, and submit same to the relevant departments Vontron for them to make relevant statistics and analysis.

9–2 Scope of Assessment and Evaluation

(1) The products involved in the assessment and evaluation of customer satisfaction degree include the entire series of Vontron’s membrane elements.

(2) The persons involved in the assessment and evaluation of customer satisfaction degree include all users who purchase and use the membrane elements of Vontron Company.

9–3 Content of Assessment and Evaluation

The assessment and evaluation of customer satisfaction degree mainly centers on the customers’ concern about the product quality and service quality. The specific assessment and evaluation items are shown as follows:

(1) Satisfaction on Tangible Product Quality

a. Performance stability

b. Rejection rate

c. Permeate

d. Appearance and safeguard of products

e. Service life

(2) Customer's Satisfaction Degree with Sales and Technical Service

a. Professional accomplishment of service personnel

b. Cost-efficiency ratio of products

c. Timely delivery of products

d. Timely disposal of products

e. Effectiveness of technical service

9–4 Improvement

The statistical analysis results of assessment and evaluation of customer satisfaction degree will be regarded as the basis for Vontron Company to carry out quality planning and quality improvement. Vontron will constantly optimize the company's business process, and provide customers with the products with more consistent performance and the more value-added services to the customers as per customer's demands.

Questionnaire of Customer Satisfaction Degree with Pre-sale Services

Dear customers: Thank you for using our company's products. In order to improve product quality and customer service level of our company, please fill in this form. In order to provide better product and service for you, Vontron needs your support. For convenience, please tick √ in the box and fill in words in the blanks you think are appropriate.	
Company name:	Address:
Contact person:	Telephone number:
Fax number:	**e-mail:**
1. Your understanding of the reverse osmosis membrane products of Vontron company □ Very familiar □ Familiar □Know a little □having heard of □Know nothing	
2. By what means do you know Vontron Company and its products? □All kinds of exhibitions □Media & advertising □Introduction given by the salesman □Introduction from the peers	
3. Your positioning on Vontron's image □Mature manufacturing company of reverse osmosis membrane element □A new comer in this field □ low known company □Know nothing about it	
4. Your attitude toward the publicity and promotion methods of Vontron □Very satisfactory □Satisfactory □ Average □Unsatisfactory □Very unsatisfactory The reason you tick "unsatisfactory" or "very unsatisfactory":	
5. The main factors you take into consideration when you choose reverse osmosis membrane elements □ Quality □Service □Price □Brand influence □Others	
6. The reverse osmosis technology you are most interested in is □ Fouling-resistant technology □ Oxidation-resistant technology □Low-pressure high-permeate product □Reverse osmosis membrane element with enhanced performance	
7. The product type you mainly choose □ Ultra (extremely) low pressure element □Brackish water element □ Fouling-resistant element □Non-standard reverse osmosis membrane element	
8. Are you willing to use native-brand reverse osmosis membrane element: □ Yes □ No The reason you tick "No":	
9. Other suggestions from you:	

Questionnaire of Customer Satisfaction Degree with In-sale service

Dear customers:
Thank you for using our company's product. In order to improve product quality and customer service level of our company, please fill in this form. In order to provide better product and service for you, Vontron needs your support. For convenient, please tick √ in the box and fill in words in the blanks you think are appropriate.

Company name:	Address:
Contact person:	Telephone number:
Fax number:	**e-mail:**

1. The reverse osmosis system failures you usually encounter with are :

2. If facing the above problems, you will: □ Solve them by your own technical force
□ Ask the manufacturer or dealer to solve them
□ Replace the product □ Return the product

3. The services you hope to get from our company: □ On-site trouble shooting
□ Cleaning the membrane element
□ Providing pretreatment process
□ Operation and maintenance of system Others:

5. Your evaluation on the current technical services provided by Vontron:

6. Your evaluation on the current sales service provided by Vontron:

7. Other suggestions from you:

Questionnaire of Customer Satisfaction Degree with after-sales Service

Dear customers:
Thank you for using our company's product. In order to improve product quality and customer service level of our company, please fill in this form. In order to provide better product and service for you, Vontron needs your support. For convenient, please tick √ in the box and fill in words in the blanks you think are appropriate.

Customer information	Company name:		Address:
	Contact person:		Telephone number:
	Fax number:		**e-mail:**
	The main product models you are using:		
Satisfaction Degree with Product and Service	Satisfaction with tangible product quality	1. Fouling-resistant performance: □ Very satisfactory □ Satisfactory □ Average □ Unsatisfactory □ Very unsatisfactory	
		2. Consistency of performance index □ Very satisfactory □ Satisfactory □ Average □ Unsatisfactory □ Very unsatisfactory	
		3. Appearance and size of product □ Very satisfactory □ Satisfactory □ Average □ Unsatisfactory □ Very unsatisfactory	
		4. Permeate flow: □ Very satisfactory □ Satisfactory □ Average □ Unsatisfactory □ Very unsatisfactory	
		5. Rejection Rate □ Very satisfactory □ Satisfactory □ Average □ Unsatisfactory □ Very unsatisfactory	
		6. Packaging and protection of the product □ Very satisfied □ Satisfied □ So so □ Unsatisfied □ Very unsatisfied	
		7. Service life of the product □ Very satisfactory □ Satisfactory □ Average □ Unsatisfactory □ Very unsatisfactory	
		8. Your overall evaluation on the quality of Vontron's Products □ Very satisfactory □ Satisfactory □Average □ Unsatisfactory □ Very unsatisfactory	
		9. What item of product quality do you most hope Vontron to focus on:	

Satisfaction degree with Sales and Technical Service		10. Cost-efficiency performance of the product □ Very satisfactory □ Satisfactory □ Average □ Unsatisfactory □ Very unsatisfactory
		11. Product price □ Very satisfactory □ Satisfactory □ Average □ Unsatisfactory □ Very unsatisfactory
		12. Timeliness of delivery □ Very satisfactory □ Satisfactory □ Average □ Unsatisfactory □ Very unsatisfactory
		13. Professional level of the technicians □ Very satisfactory □ Satisfactory □ Average □ Unsatisfactory □ Very unsatisfactory
		14. Effectiveness of the technical services □Very satisfactory □Satisfactory □Average □ Unsatisfactory □Very unsatisfactory
		15. Professional skills of the sales personnel □ Very satisfactory □ Satisfactory □ Average □ Unsatisfactory □ Very unsatisfactory
		16. Do you receive any visit from Vontron's sales personnel: □ Frequently □ Many times □ Averagely □ Seldom □ Never
		17. Timeliness of responding to complaints □ Very satisfactory □ Satisfactory □ Average □ Unsatisfactory □ Very unsatisfactory
Others	18. Are you willing to buy Vontron's products next time □ Very willing □ Willing □ averagely □ Unwilling □ Extremely unwilling The reasons you tick "unwilling" or "extremely unwilling" are:	
	19. Are you willing to introduce our company's products to others □ Very willing □ Willing □ averagely □ Unwilling □ Extremely unwilling The reasons you tick "unwilling" or "extremely unwilling" are:	
Suggestions from the customer	20. Your other suggestions on Vontron's products and services:	

Customer Complaints on Tangible Product Quality

Document No.: Use No.:

<table>
<tr><td>Sources of information</td><td>□End customers; □ Distributors; □ Engineering unit</td></tr>
<tr><td rowspan="2">Customer information</td><td>Corporate name (File No.): Recipient's address:</td></tr>
<tr><td>Post code: Contact person: Phone:</td></tr>
<tr><td>Way of submission</td><td>□Telephone: □ Fax: □ E-mail: □CRM:</td></tr>
<tr><td>Submitter</td><td>Name: Position:
TEL: FAX: E-MAIL:</td></tr>
<tr><td>Category of products and services</td><td>Service categories: □ technical service □Sales service Others:
Models and quantity of products involved:</td></tr>
<tr><td>Reasons for Service Applied for</td><td></td></tr>
<tr><td colspan="2">Service requirement: please provide the following services before the date _____

□send personnel to provide services on site □provide solutions in a remote way

Signature of the business manager/Date:</td></tr>
<tr><td colspan="2">Confirmation on Acceptance of Service Request:
We agree to send ____________________________(personnel names) to provide the following services before the date_________
□Send personnel to provide services on site □Provide solutions in a remote way

Signature of Chief Engineering Officer (or Vice President of Marketing) / Date:</td></tr>
<tr><td colspan="2">Confirmation on Offering of Service:</td></tr>
<tr><td colspan="2">Corrective and Preventive Measures:

Formulated by the quality assurance supervisor/ Date:

Verified by the supervisor of the implementing department/ Date:

Approved by the management representative/ Date:</td></tr>
<tr><td colspan="2">Verification and feedback on the corrective and preventive measures:

Signature of quality supervisor/ Date:

Signature of management representative / Date:</td></tr>
</table>

Appendix 1: Technical References

The Application of Reverse Osmosis in ILIJAN Power Plant's Water Treatment System in PHILIPPINES

Zhong Weilei, Liu Feng, Liu Xia, Guo Yongjie, Kang Yan

(VONTRON TECHNOLOGY CO., LTD, Beijing 100044, CHINA)

Abstract: RO technology applying in LIJIAN Power Plant's water treatment system in PHILIPPINES is introduced in this paper. The performances of VONTRON's membranes are also introduced in this paper.

Key words: Power Plant; Seawater Desalination; RO system; VONTRON membranes.

1 Some information about ILIJAN Power Plant

Invested by KEPCO (Korea Electric Power Corporation) and established in June 2006, ILIJAN Power Plant is the largest one in the Philippines and has ever obtained the reputation of the world's annual best power plant as appraised by Power Magazine of the United States.

2 Water Treatment Process of ILIJAN Power Plant

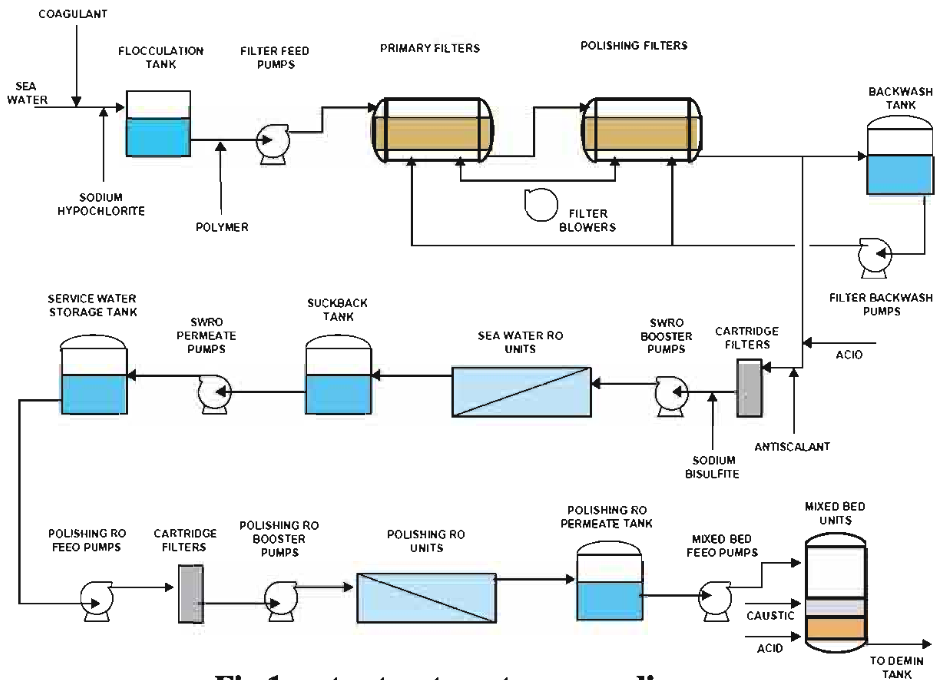


Fig.1 water treatment process diagram

3 RO Water Treatment Systems

The product water of RO system is mainly purposed for boiler water replenishment in the power plant. The seawater from the waters near BATANGAS city, a coastal city of the Philippines, is used as the raw water, with salinity (TDS) at 25000~45000 mg/L. The data collection finished by August 2009. The seawater is treated in 3 stages. The first stage is for seawater desalination system, using 342 elements of SW22-8040 in 3 trains of (19:0)×6 array; The second stage is low-pressure desalination system, using 144 elements of LP22-8040 in 3 trains of (5:3)×6 array; The third stage is mixed-bed treatment system.

Seawater Desalination System

Low–pressure Filtration System

4 Introduction of Seawater Desalination System

4.1 Specification of SW RO membrane element

Tab.1 Specifications and Main Properties of SW22-8040

Model.	Average Salt Rejection Rate %	Average Permeate flow GPD(m^3/d)	Active Membrane Area ft^2(m^2)
SW22-8040	99.7	6000（22.7）	380（35.2）

Testing Conditions:
Testing Pressure.. 800psi (8.5Mpa)
Temperature of Testing Solution............................ 25℃
Concentration of Testing Solution (NaCl).............. 32800 mg/L
pH Value of Testing Solution................................ 7.5
Recovery Rate of Single Element.......................... 8%
Concentration of free chlorine in feed water.............. <0.1mg/L

4.2 RO system recovery and flow (inlet and permeate)

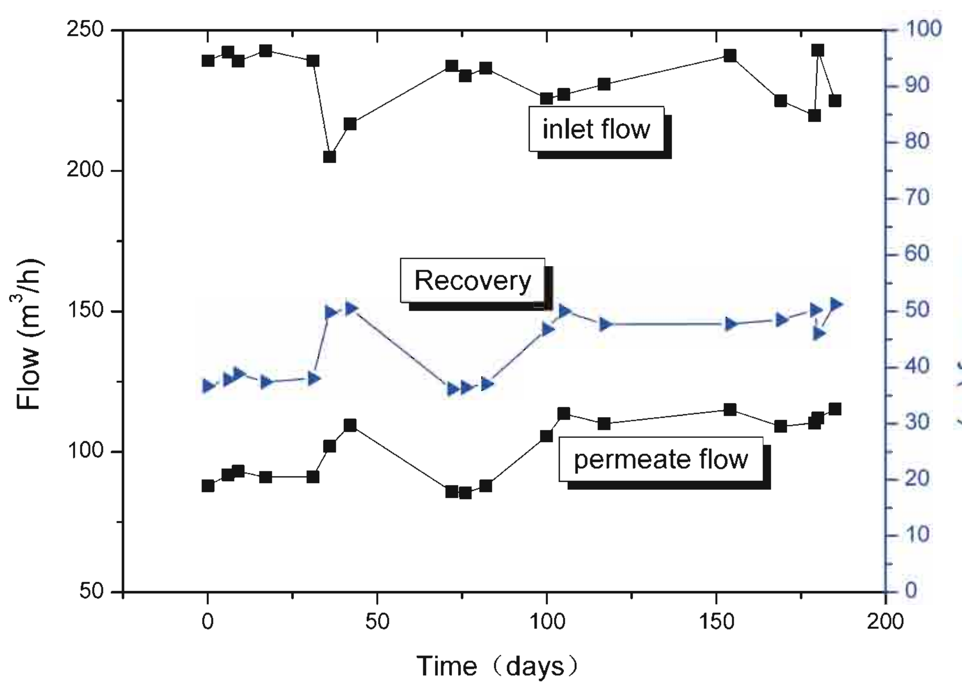


Fig.2 Changing curves of RO system's recovery according to RO system's flow of inlet and permeate water

After the replacement, It can be seen from the chart that the permeate flow were not stabilization all the time, that was because the water quantity of power plant need changed; and the system recovery were between 40% and 50%.

4.3 RO system salt rejection and conductivity (inlet and permeate)

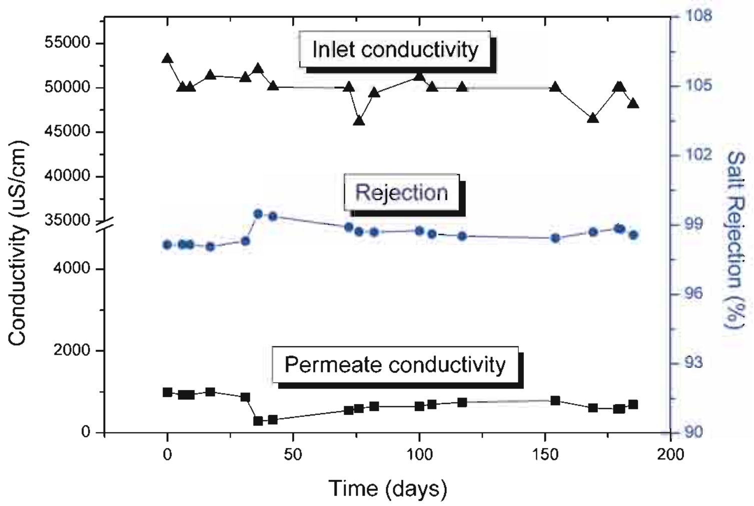


Fig.3 Changing curves of RO system's salt rejection according to RO system's conductivities of inlet and permeate water

It can be seen from the running of RO seawater desalination system that the conductivity of product water was relatively high in the beginning period, and became lower rapidly after a period of running and then became consistent. The conductivity was even held around 300μS/cm within a certain period of operation, showing the excellent performance of membranes.

4.4 Permeate flow and inlet pressure、temperature

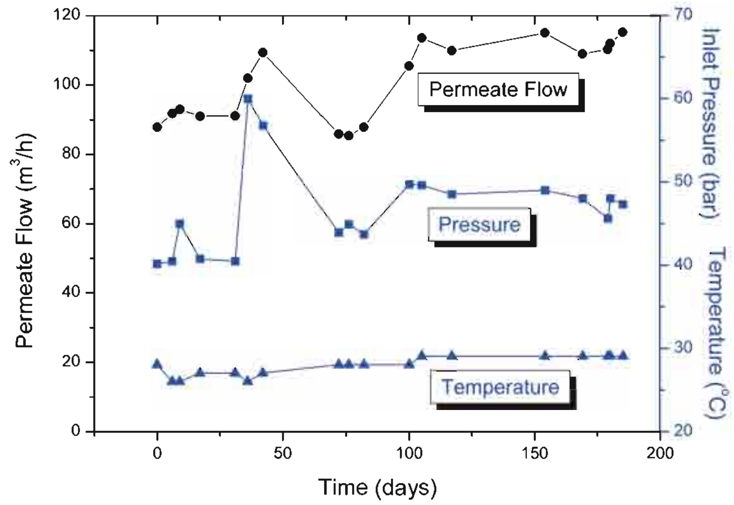


Fig.4 Changing curves of RO system's permeate flow and inlet pressure、temperature

It can be seen from the chart that the permeate flow and inlet pressure changed in direct proportion, the average inlet pressure was about 50bar, and the average permeate flow was about 60m3/h; and the inlet temperature were stable relatively, around 28℃.

5 Introduction of Low–pressure Desalination System

5.1 Specification of LP RO membrane element

Tab.2 Specifications and Main Properties of LP22-8040

Model.	Average Salt Rejection Rate %	Average Permeate flow GPD(m^3/d)	Active Membrane Area ft^2(m^2)
LP22-8040	99.5	10500（39.7）	400（37.0）

Testing Conditions:

Testing Pressure... 225psi (1.55Mpa)
Temperature of Testing Solution.......................... 25℃
Concentration of Testing Solution (NaCl)................. 2000 mg/L
pH Value of Testing Solution................................ 7.5
Recovery Rate of Single Element.......................... 15%
Concentration of free chlorine in feed water.............. <0.1mg/L

5.2 RO system recovery and flow (inlet and permeate)

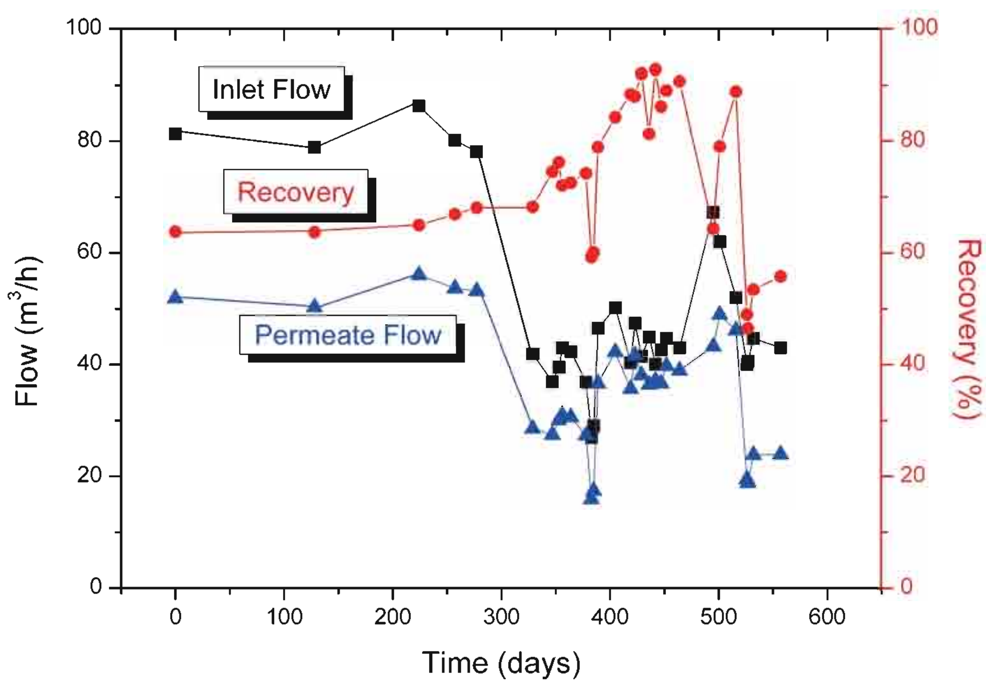


Fig.5 Changing curves of RO system's recovery according to RO system's flow of inlet and permeate water

After the replacement, It can be seen from the chart that the permeate flow were not stabilization all the time, after 260 days, the permeate flow decreased, that was because the water quantity of power plant need changed; the system's recovery changed all the time, and the system's average recovery was about 70%.

www.famcocorp.com
E-mail: info@famcocorp.com
@famco_group
Tel:۰۲۱- ۴۸۰۰۰۰۴۹
Fax:۰۲۱ - ۴۴۹۹۴۶۴۲
تهران، کیلومتر ۲۱ بزرگراه لشگری (جاده مخصوص کرج)
روبروی پالایشگاه نفت پارس، پلاک ۱۲

5.3 RO system salt rejection and conductivity (Inlet and permeate)

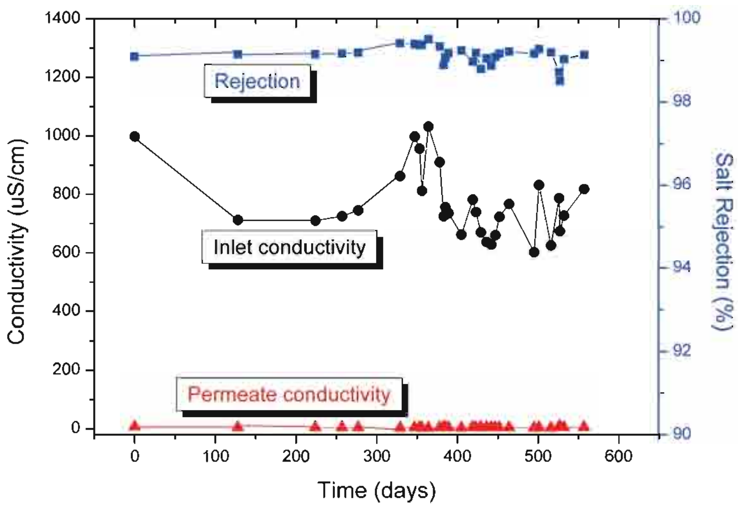


Fig.6 Changing curves of RO system's salt rejection according to RO system's conductivities of inlet and permeate water

It can be seen from the running of RO system that the permeate conductivities were very good and stability, below 15 μS/cm, though the inlet water's conductivities always changed; and the system's salt rejection was very high, above 98%, and always stably.

5.4 Permeate flow、temperature、inlet pressure

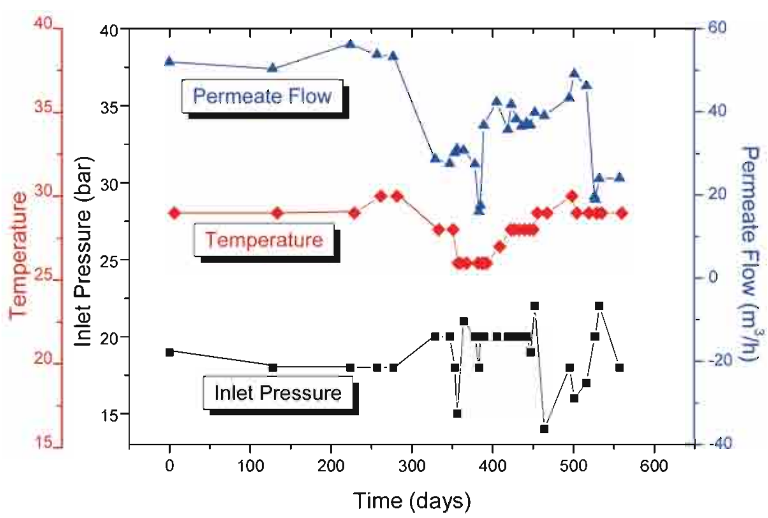


Fig.7 Changing curves of RO system's permeate flow and inlet pressure、temperature

It can be seen from the chart that the permeate flow and inlet pressure changed in direct proportion, the average inlet pressure was about 18bar, and the average permeate flow was about 40m3/h; and the inlet temperature were stable relatively, changed between 25℃ and 30℃.

6 Cost analyses

In this desalination system, the cost of per cubic meter of pure water (in RMB) consists of the following: investment cost is about RMB 1.20; electricity cost is about RMB 2.00; Cost for replacement of RO membrane element is now RMB 0.30 (VONTRON), comparing to RMB 0.36 (FILMTEC) before replacement; maintenance cost is RMB 0.15; costs for chemical and other consumables is RMB 0.30; costs for labor and management is RMB 0.15. The total cost is RMB 4.10 per cubic meter of pure water (VONTRON), achieving a cost decrease of RMB 0.80 comparing to RMB 4.90 of FILMTEC.

7 Conclusions

1）The water treatment system of ILIJAN has been in normal operation since 2002, thus testifying that RO technology is applicable to seawater desalination and water treatment for boiler water replenishment. This project also set up a reference application of RO technology in water treatment in power plant.

2) Since the membrane elements previously installed in the primary filtration system (seawater desalination) were replaced by VONTRON's SW22-8040, the system has been in regular operation with system rejection remaining in around 99%.

3) Since the membrane elements previously installed in the secondary filtration system (low-pressure filtration) were replaced by VONTRON's LP22-8040, the system has been in regular operation for 2 years, with system rejection remaining in around 99%.

Appendix 2: Temperature Correction Factors for Permeate Flow

Temp (℃)	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
5	2.160	2.151	2.142	2.134	2.125	2.117	2.108	2.100	2.091	2.083
6	2.075	2.066	2.058	2.050	2.042	2.034	2.025	2.017	2.009	2.001
7	1.993	1.986	1.978	1.970	1.962	1.954	1.946	1.939	1.931	1.923
8	1.916	1.908	1.901	1.893	1.886	1.878	1.871	1.863	1.856	1.849
9	1.841	1.834	1.827	1.820	1.813	1.805	1.798	1.791	1.784	1.777
10	1.770	1.763	1.756	1.750	1.743	1.736	1.729	1.722	1.716	1.709
11	1.702	1.696	1.689	1.682	1.676	1.669	1.663	1.656	1.650	1.643
12	1.637	1.631	1.624	1.618	1.612	1.605	1.599	1.593	1.587	1.581
13	1.575	1.568	1.562	1.556	1.55	1.544	1.538	1.532	1.527	1.521
14	1.515	1.509	1.503	1.497	1.492	1.486	1.480	1.474	1.469	1.463
15	1.457	1.452	1.446	1.441	1.435	1.430	1.424	1.419	1.413	1.408
16	1.403	1.397	1.392	1.387	1.381	1.376	1.371	1.366	1.360	1.355
17	1.350	1.345	1.340	1.335	1.330	1.325	1.320	1.315	1.310	1.305
18	1.300	1.295	1.290	1.285	1.280	1.275	1.270	1.266	1.261	1.256
19	1.251	1.247	1.242	1.237	1.232	1.228	1.223	1.219	1.214	1.209
20	1.205	1.200	1.196	1.191	1.187	1.182	1.178	1.174	1.169	1.165
21	1.16	1.156	1.152	1.147	1.143	1.139	1.135	1.130	1.126	1.122
22	1.118	1.114	1.110	1.105	1.101	1.097	1.093	1.089	1.085	1.081
23	1.077	1.073	1.069	1.065	1.061	1.057	1.053	1.049	1.045	1.042
24	1.038	1.034	1.030	1.026	1.022	1.019	1.015	1.011	1.007	1.004
25	1.000	0.997	0.995	0.992	0.989	0.987	0.984	0.982	0.979	0.976
26	0.974	0.971	0.969	0.966	0.963	0.961	0.958	0.956	0.953	0.951
27	0.948	0.946	0.943	0.941	0.938	0.936	0.933	0.931	0.928	0.926
28	0.924	0.921	0.919	0.916	0.914	0.912	0.909	0.907	0.904	0.902
29	0.900	0.897	0.895	0.893	0.89	0.888	0.886	0.883	0.881	0.879
30	0.877	0.874	0.872	0.870	0.868	0.865	0.863	0.861	0.859	0.856
31	0.854	0.852	0.850	0.848	0.845	0.843	0.841	0.839	0.837	0.835
32	0.832	0.830	0.828	0.826	0.824	0.822	0.820	0.818	0.816	0.813
33	0.811	0.809	0.807	0.805	0.803	0.801	0.799	0.797	0.795	0.793
34	0.791	0.789	0.787	0.785	0.783	0.781	0.779	0.777	0.775	0.773
35	0.771	0.769	0.767	0.765	0.763	0.761	0.760	0.758	0.756	0.754
36	0.752	0.750	0.748	0.746	0.744	0.743	0.741	0.739	0.737	0.735
37	0.733	0.731	0.730	0.728	0.726	0.724	0.722	0.721	0.719	0.717
38	0.715	0.713	0.712	0.710	0.708	0.706	0.705	0.703	0.701	0.699
39	0.698	0.696	0.694	0.693	0.691	0.689	0.687	0.686	0.684	0.682
40	0.681	0.679	0.677	0.676	0.674	0.672	0.671	0.669	0.667	0.666

[Corrected Permeate Flow] = [Permeate Flow Measured] ×[Temperature Correction Factor corresponding to feedwater temperature]