Hunan Ovay Technology Co.,Ltd.

2024 Edition

RO&NF Membrane Elements

Technical Manual

Company Profile

Hunan Ovay Technology Co., Ltd. is located in Zhuzhou City, Hunan Province, with a registered capital of 128.88 million yuan. It is committed to the research, development, production, sales and service of membrane materials and membrane elements such as reverse osmosis, nanofiltration and ultrafiltration. It has the core technology and large-scale production capacity of membrane manufacturing, and is a provider of system design and application services with strong technical support. The Company has a team of doctors, masters and overseas returnees, with 44 patents, including 23 invention patents and 21 utility model patents.

OVAY Technology is a national high-tech enterprise, a national special and sophisticated “Little Giant” enterprise, with “Hunan Enterprise Technology Center”, and as the support unit, it has established several scientific research and innovation platforms such as “Hunan Engineering Research Center for Membrane Separation Technology” and “Hunan Engineering Technology Research Center of Liquid Separation Membrane Material”. It has two industrial parks in Zhuzhou, and currently has an annual production capacity of 21 million square meters of composite reverse osmosis membrane and nanofiltration membrane. After years of technology accumulation, more than 50 kinds of reverse osmosis membrane products independently developed by the Company have been widely recognized in the industry, and the product performance has reached the international advanced level. OVAY Technology has passed ISO9001 Quality Management System Certification, ISO14001 Environmental Management System Certification and ISO45001 Occupational Health and Safety Management System Certification; Its reverse osmosis membrane products have passed WQA, NSF-58 and NSF-61 certification in the United States, and are exported to Europe, Russia, India, Vietnam, Indonesia and other countries and regions, and have a complete sales network and stable sales network in the world. At the same time, hollow fiber ultrafiltration membrane and MBR products jointly developed by OVAY Technology and well-known domestic universities have been widely used in reverse osmosis pretreatment, municipal sewage treatment and other fields.

OVAY Technology has completed the whole process of independent development and research from the membrane material formula process, membrane element/component structure process, and membrane preparation core equipment. The product quality and technical level are among the advanced in the industry, and it is widely used in drinking water, pure water or ultra-pure water preparation, seawater and brackish water desalination, reclaimed water reuse, industrial wastewater advanced treatment and recycling, municipal sewage treatment and upgrading and transformation, and special separation industries.

“Ingenuity forging quality, reliable brand building”. Based on the principle of technology-oriented and quality strengthening, OVAY Technology pursues the eternal corporate vision of “using technology to provide a safe, environmentally friendly and healthy life for mankind". With a strong sense of social responsibility, we will focus on environmental protection, strive to innovate, continue to provide stable and high-quality products and services, and give back your trust and love.

Contents

Chapter I The Introduction of OVAY Reverse Osmosis Membrane and Nanofiltration Membrane ... - 1 -

[1.1] Main Membrane Product Series ... - 1 -
[1.2] Company's Naming Rules for Membrane Elements ... - 3 -
[1.3] Solute Removal Rate of OVAY Reverse Osmosis Membrane ... - 5 -
[1.4] OVAY Reverse Osmosis Membrane and Nanofiltration Membrane Product Performance and Selection ... - 6 -
1.4.1 Performance of Household Reverse Osmosis Membrane Elements ... - 6 -
1.4.2 Performance of Domestic Nanofiltration Membrane Elements ... - 6 -
1.4.3 Performance of Industrial Reverse Osmosis Membrane Elements ... - 7 -
1.4.4 Performance of Industrial Nanofiltration Membrane Elements ... - 9 -
1.4.5 Guidelines for selection of common reverse osmosis membranes ... - 10 -

Chapter II Characteristics and Performance of Reverse Osmosis Membrane and Nanofiltration Membrane Products ... - 11 -

[2.1] OVAY Household Reverse Osmosis Membrane Element ... - 11 -
[2.2] OVAY Household Nanofiltration Membrane Element ... - 16 -
[2.3] OVAY Extra-low Pressure Series Membrane Elements ... - 19 -
[2.4] OVAY Ultra-low Pressure series membrane elements ... - 21 -
[2.5] OVAY Low Pressure Series Membrane Elements ... - 25 -
[2.6] OVAY Fouling-resistant Series Membrane Elements ... - 28 -
[2.7] OVAY Antioxidant Series Membrane Elements ... - 31 -
[2.8] OVAY Sea Water Desalination Series Membrane Elements ... - 33 -
[2.9] OVAY Water Treatment Series Industrial Nanofiltration Membrane Element ... - 35 -
[2.10] OVAY Material Separation Series Industrial Nanofiltration Membrane Element ... - 37 -
[2.11] OVAY Magnesium-Lithium Separation Series Industrial Nanofiltration Membrane Element - 40 -

Chapter III Hydrochemistry and Pretreatment ... - 41 -

[3.1] Hydrochemistry ... - 42 -
3.1.1 Raw Water Type ... - 42 -
3.1.2 Raw Water Quality Analysis ... - 43 -
[3.2] Prevention of Scaling ... - 45 -
[3.3] Prevention of Colloidal Contamination ... - 49 -
[3.4] Prevention of Membrane Biological Fouling ... - 52 -
[3.5] Biological Pollution Control ... - 53 -
[3.6] Organic Pollution Control ... - 53 -
[3.7] Prevent the Degradation of Membrane Itself ... - 53 -

Chapter IV The Guide to the Use of OVAY Reverse Osmosis System Design Software ... - 54 -

[4.1] Installation Requirements of OVAY Reverse Osmosis Software ... - 54 -
[4.2] The Use of the Software ... - 54 -

[4.3] Test - 65 -

Chapter V Installation and Operation - 66 -

[5.1] Membrane Element Installation - 66 -
5.1.1 Preparation before Installation - 66 -
5.1.2 Installation of Elements - 66 -
5.1.3 Remove Elements - 67 -
[5.2] Operation of System First Running - 68 -
5.2.1 Equipment Preparation - 68 -
5.2.2 Start Inspection - 68 -
5.2.3 First Start Step - 68 -
5.2.4 Initial and Stable Performance of Membrane Elements - 70 -
[5.3] Daily Start and Stop of the System - 71 -
[5.4] Stop Management of System - 71 -
5.4.1 Short-term Stop (less than 48 hours) - 71 -
5.4.2 Long-term Stop (more than 48 hours) - 71 -
[5.5] Operation Record - 72 -
5.5.1 Pretreatment Operation Parameter Record - 72 -
5.5.2 System Dosing Parameter Record - 72 -
5.5.3 Membrane System Operation Parameter Record - 73 -
5.5.4 Maintenance and Chemical Cleaning Records - 74 -

Chapter VI Diagnosis and Elimination of System Faults - 76 -

[6.1] Low Water Yield - 76 -
[6.2] Desalination Rate Decreased - 80 -
[6.3] Pressure Drop Increases - 82 -
[6.4] Summary of Symptom Diagnosis and Troubleshooting of Faults - 83 -

Chapter VII Cleaning and Disinfection - 84 -

[7.1] Overview of Membrane System Cleaning - 84 -
7.1.1 Brief Introduction of Membrane Fouling - 84 -
7.1.2 Cleaning Conditions - 84 -
7.1.3 Calculation of Cleaning Liquid Volume - 84 -
7.1.4 Cleaning Considerations - 85 -
[7.2] Cleaning Steps of Membrane System - 85 -
[7.3] Predicting Fouling of Membrane System and Selection of Cleaning Agents - 87 -
7.3.1 Inorganic Salt Scaling Pollution and Cleaning - 87 -
7.3.2 Contamination and Cleaning of Metal Compounds - 87 -
7.3.3 Colloid Contamination and Cleaning - 88 -
7.3.4 Organic Contamination and Cleaning - 88 -
7.3.5 Microbial Contamination and Cleaning - 89 -
[7.4] Disinfection of Membrane System - 90 -

Chapter VIII Appendix - 91 -

[8.1] Service Process - 91 -

8.1.1 Pre-sales Services - 91 -
8.1.2 Services in Sale - 91 -
8.1.3 After-sales Service - 91 -
[8.2] Quality Assurance Agreement - 92 -
[8.3] Brief Introduction of Qualification - 94 -
8.3.1 ISO9001 Quality Management System Certification - 94 -
8.3.2 ISO14001 Environmental Management System Certification - 95 -
8.3.3 ISO45001 Occupational Health and Safety Management Systems Certification - 96 -
8.3.4 NSF Certification - 97 -
8.3.5 American WQA Water Quality Association Certification - 98 -
8.3.6 Wading Approval Document of the Ministry of Health - 99 -
[8.4] Company Honor - 100 -

Chapter I The Introduction of OVAY Reverse Osmosis Membrane and Nanofiltration Membrane

[1.1] Main Membrane Product Series

The membrane elements of OVAY brand are spiral wound structure. It consists of a central water collecting pipe, a multi-page membrane bag and a grid-shaped inlet water runner cloth between the film bags. Each membrane bag consists of two membrane attached to each other on the back of the membrane, an output water runner cloth sandwiched between the back surfaces and a grid-shaped inlet water runner placed on the front surface of the membrane; Three sides of the membrane bag are sealed with adhesive, and the fourth side is opened on the perforated water production collection pipe. Compared with other components such as tube, plate and hollow fiber, it has the advantages of uniform water flow distribution, high pollution resistance, low replacement cost, simple external pipeline, easy cleaning and convenient maintenance.

There are different models of OVAY membrane elements, and each model is suitable for different applications and use environments:

1. Household Membrane Elements

- It is mainly used in various household pure water machines and small equipment such as pure water devices used in hospitals and laboratories.
- It is suitable for desalination of water below TDS 500ppm, with the characteristics of high desalination rate and low operation pressure.

2. X Series of Extra-low Pressure Composite Reverse Osmosis Membrane Elements

- It can achieve the same high water flux and high desalination rate under the operation pressure of 1/2 of the conventional operation pressure of low-pressure composite membrane.
- Reduce the investment cost of related pumps, pipelines, containers and other equipment and the operation cost of reverse osmosis system, to improve economic benefits.

3. U Series of Ultra-low Pressure Composite Reverse Osmosis Membrane Elements

- It can achieve the same high water flux and high desalination rate as conventional low pressure membrane under lower operation pressure, to greatly reduce operating cost.
- It can effectively save the cost of pumps, pipelines and pressure vessels, and is suitable for small and medium-sized drinking water systems.

4. L Series of Low Pressure Composite Reverse Osmosis Membrane Elements

- It is mainly used for desalting brackish water, with the characteristics of low pressure operation, high water yield and good desalting performance, and also the high performance of removing TOC, SiO_2 and chlorine-containing pesticides.
- It's widely used in the manufacture of pure water and ultra-pure water, but also used in food concentration

and heavy metal recovery industries.

5. FR Series of Fouling-resistant Composite Reverse Osmosis Membrane Elements

- It's mainly used for wastewater reuse and the inlet water is a high pollution source of surface water, which is designed for poor water quality conditions
- It has strong anti-scaling and resistance to organic and microbial contamination, reduces chemical cleaning frequency and operation cost to prolong service life.

6. CR Series of Antioxidant Composite Reverse Osmosis Membrane Elements

- It is mainly used in the water source with wastewater reuse and high microbial contamination of surface water, and the water source with oxidizing substances in the inlet water.
- The oxidation resistance of the membrane element is enhanced and the service life is prolonged.

7. SW Series of Desalination Composite Reverse Osmosis Membrane Elements

- Seawater desalination membrane has the characteristics of high desalination rate and stable performance, which is used to desalinate seawater into industrial water and drinking water.
- At the same time, it is suitable for desalination of brackish water with total salt content exceeding 10,000 ppm.

8. Nanofiltration Membrane Element NF Series

- It is mainly used for purification of drinking water and industrial water, purification of wastewater, concentration of valuable components in process fluid and so on.
- It can remove 98% of divalent ions, and is suitable for softening water, pretreatment of seawater desalination and municipal water plants.

[1.2] Company's Naming Rules for Membrane Elements

1. Nomenclature of Household Membrane Elements

OV-ULP 18 12 - 50

- **50**: Water yield expressed in GPD
  - 50 (50GPD)
  - 75 (75GPD)
  - 100 (100GPD)
- **12**: Length of membrane element in inches
- **18**: Diameter of membrane element in inches (value x0.1)
  - 1812: 1.8 inches in diameter and 12 inches in length
  - 2012: 2.0 inches in diameter and 12 inches in length
  - 2812: 2.8 inches in diameter and 12 inches in length
  - 3012: 3.0 inches in diameter and 12 inches in length
  - 3013: 3.0 inches in diameter and 13 inches in length
- **OV-ULP**: Indicates the membrane type
  - OV-ULP: Ordinary Ultra-low Pressure Household Reverse Osmosis Membrane
  - OV-NF: Nanofiltration Membrane for Drinking Water

2. Naming Convention of Reverse Osmosis Membrane Elements for Industrial Use

OV–U – 80 40 400 - (HR)

Membrane element characteristics
HR: High desalting membrane element
HF: High flux membrane element

Effective membrane area
440 440 square feet
440 400 square feet
380 380 square feet
365 365 square feet
330 330 square feet

Length of membrane element in inches

Diameter of membrane element in inches (value x0.1)
2514: 2.5 inches in diameter and 14 inches in length
2521: 2.5 inches in diameter and 21 inches in length
2540: 2.5 inches in diameter and 40 inches in length
4021: 4 inches in diameter and 21 inches in length
4040: 4 inches in diameter and 40 inches in length
8040: 8 inches in diameter and 40 inches in length

Membrane element series
OV-X: Extra-low Pressure Series
OV-U: Ultra-Low Pressure Series
OV-L: Low Pressure Series
OV-FR: Fouling-resistant Series
OV-CR: Antioxidant Series
OV-SW: Seawater Desalination Series
OV-NF10: High Separation Nanofiltration Series
OV-NF30: High Flux Nanofiltration Series
OV-NF60: High Interception Nanofiltration Series
OV-NF90: High Removal Nanofiltration Series

[1.3] Solute Removal Rate of OVAY Reverse Osmosis Membrane

Solute Removal Rate of OVAY L Series and FR Series Membrane Elements

Serial Number	Solute	Molecular weight	Removal rate (%)
1	Sodium fluoride NaF	42	99
2	Sodium cyanide NaCN	49	97
3	Sodium Chloride NaCl	58	99
4	Silicon dioxide SiO_2	60	98
5	Sodium bicarbonate $NaHCO_3$	84	99
6	Sodium nitrate $NaNO_3$	85	97
7	Magnesium chloride $MgCl_2$	95	99
8	Calcium chloride $CaCl_2$	111	99
9	Magnesium sulfate $MgSO_4$	120	99
10	Nickel sulfate $NiSO_4$	155	99
11	Copper sulfate $CuSO_4$	160	99
12	Formaldehyde	30	35
13	Methanol	32	25
14	Ethanol	46	70
15	Isopropyl alcohol	60	90
16	Urea	60	70
17	Lactic acid (pH 2)	90	94
18	Lactic acid (pH 5)	90	99
19	Glucose	180	98
20	Sucrose	342	99
21	Chlorine-containing insecticide	-	99
22	COD	-	97

[1.4] OVAY Reverse Osmosis Membrane and Nanofiltration Membrane Product Performance and Selection

1.4.1 Performance of Household Reverse Osmosis Membrane Elements

Membrane element category	Membrane element model	Stable desalination rate (%)	Average water yield GPD (m^3/d)	Test conditions		
				Test pressure psi (MPa)	Test solution concentration (ppm)	Recovery rate (%)
Reverse osmosis membrane elements for ordinary household use	OV-ULP 1812-50	97.5	50 (0.19)	60 (0.41)	500	50
	OV-ULP 1812-75	97.5	75 (0.28)			
	OV-ULP 2012-100	97.5	100 (0.38)			
	OV-ULP 3012-300	97.0	300 (1.14)	100 (0.69)	500	60
	OV-ULP 3012-400	95.0	400 (1.52)			
	OV-ULP 3012-600	93.0	600 (2.28)			
	OV-ULP 3013-400	95.0	400 (1.52)			
	OV-ULP 3013-600	93.0	600 (2.28)			
	OV-ULP 3213-800	93.0	800 (3.04)			

Test solution: It is prepared with GB34914-2021 "Water Efficiency Limit Value and Water Efficiency Grade of Reverse Osmosis Water Purifier"

1.4.2 Performance of Domestic Nanofiltration Membrane Elements

Membrane element category	Membrane element model	Stable desalination rate (%)	Average water yield GPD (m^3/d)	Test conditions		
				Test pressure psi (MPa)	Test solution concentration (ppm)	Recovery rate (%)
Household nanofiltration membrane element	OV-NF-1812	30±10	100 (0.38)	60 (0.41)	250 NaCl	50
		96.0			500 $MgSO_4$	
	OV-NF-2012	30±10	150 (0.57)	60 (0.41)	250 NaCl	
		96.0			500 $MgSO_4$	
	OV-NF-3012	30±10	400 (1.52)	60 (0.41)	250 NaCl	
		96.0			500 $MgSO_4$	
	OV-NF-3013	30±10	400 (1.52)	60 (0.41)	250 NaCl	
		96.0			500 $MgSO_4$	

1.4.3 Performance of Industrial Reverse Osmosis Membrane Elements

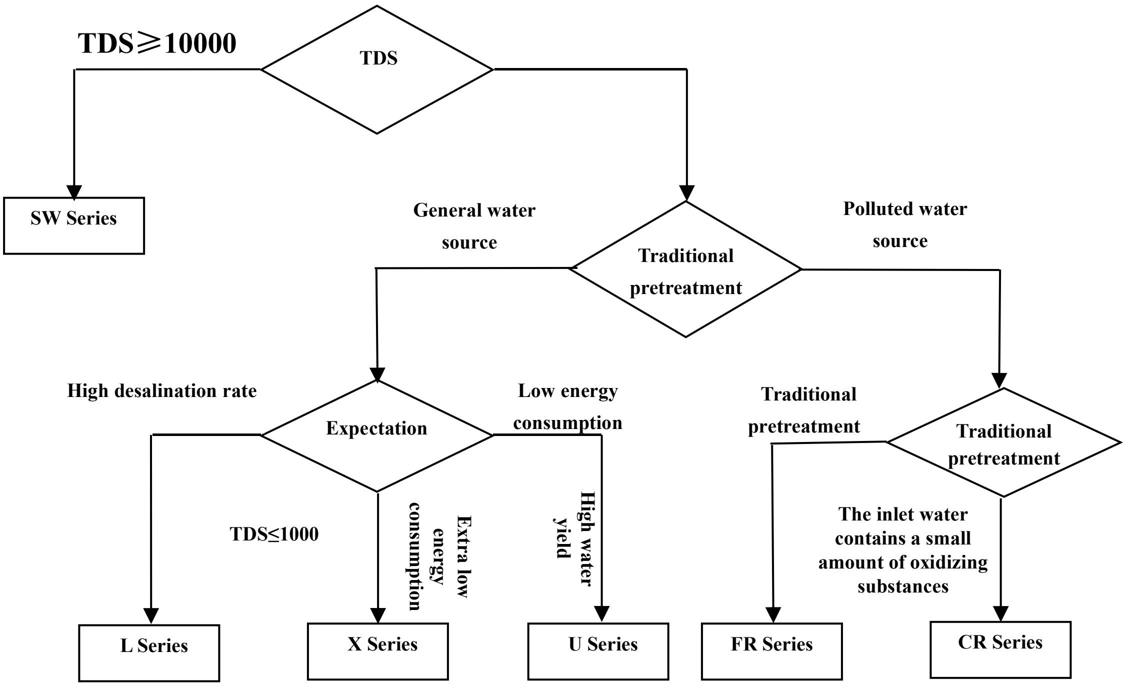
Membrane element category	Membrane element model	Stable desalination rate (%)	Average water yield GPD	Test conditions		
				Test pressure psi (MPa)	Test solution concentration NaCl(ppm)	Recovery rate (%)
Extra-low pressure reverse osmosis membrane element	OV-X-4040	99.2	2600 (9.8)	100 (0.69)	500	15
	OV-X-8040 400	99.2	12000 (45.4)			
	OV-X-8040 440	99.2	13200 (49.9)			
Ultra-low pressure reverse osmosis membrane element	OV-U-4040-HF	99.0	2600 (9.8)	150 (1.03)	1500	15
	OV-U-4040	99.5	1900 (7.2)			
	OV-U-4040-HR	99.7	2200 (8.3)			
	OV-U-8040-HF	99.0	11200 (42.3)			
	OV-U-8040	99.5	9600 (36.3)			
	OV-U-8040-HR	99.7	10500 (39.7)			
	OV-U-8040 440	99.7	12000 (45.4)			
Low pressure reverse osmosis membrane element	OV-L-4040	99.7	2400 (9.1)	225 (1.55)	2000	15
	OV-L-8040 365	99.7	9600 (36.3)			
	OV-L-8040 400	99.7	10500 (39.7)			
	OV-L-8040 440	99.7	12650 (48.0)			
Fouling-resistant membrane element	OV-FR-4040	99.7	2200 (8.3)	225 (1.55)	2000	15
	OV-FR-8040 365	99.7	9600 (36.3)			
	OV-FR-8040 400	99.7	10500 (39.7)			

<table>
<tr><td rowspan="2">Antioxidant membrane element</td><td>OV-CR-8040</td><td>99.5</td><td>9000 (34.0)</td><td rowspan="2">225 (1.55)</td><td rowspan="2">2000</td><td rowspan="2">15</td></tr>
<tr><td>OV-CR-4040</td><td>99.5</td><td>2200 (8.3)</td></tr>
<tr><td rowspan="9">Seawater desalination membrane element</td><td>OV-SW-4040-LE</td><td>99.8</td><td>1900 (7.2)</td><td rowspan="9">800 (5.5)</td><td rowspan="9">32000</td><td rowspan="9">8</td></tr>
<tr><td>OV-SW-4040-HR</td><td>99.8</td><td>1600 (6.1)</td></tr>
<tr><td>OV-SW-8040-LE 400</td><td>99.8</td><td>9000 (34.0)</td></tr>
<tr><td>OV-SW-8040-HR 400</td><td>99.8</td><td>7500 (28.4)</td></tr>
<tr><td>OV-SW-8040-LE 440</td><td>99.8</td><td>9900 (37.4)</td></tr>
<tr><td>OV-SW-8040-HR 440</td><td>99.8</td><td>8200 (31.0)</td></tr>
<tr><td>OV-SW-8040 FR</td><td>99.8</td><td>7500 (28.4)</td></tr>
<tr><td>OV-SW-8040-XLE 400</td><td>99.7</td><td>9500 (36.0)</td></tr>
<tr><td>OV-SW-8040-XHR 400</td><td>99.85</td><td>7000 (26.5)</td></tr>
</table>

1.4.4 Performance of Industrial Nanofiltration Membrane Elements

<table>
<tr><th rowspan="2">Membrane element category</th><th rowspan="2">Membrane element model</th><th rowspan="2">Stable desalination rate (%)</th><th rowspan="2">Average water yield
GPD (m³/d)</th><th colspan="2">Test conditions</th></tr>
<tr><th>Test pressure</th><th>Test fluid</th></tr>
<tr><td rowspan="8">Series of industrial nanofiltration for water treatment</td><td>OV-NF10-8040</td><td>≥90.0</td><td>15000 (56.8)</td><td rowspan="8">70 psi
(0.48MPa)</td><td rowspan="8">2000 ppm
MgSO₄</td></tr>
<tr><td>OV-NF10-4040</td><td>≥90.0</td><td>3000 (11.3)</td></tr>
<tr><td>OV-NF30-8040</td><td>≥97.0</td><td>12000 (45.5)</td></tr>
<tr><td>OV-NF30-4040</td><td>≥97.0</td><td>2400 (9.1)</td></tr>
<tr><td>OV-NF60-8040</td><td>≥98.5</td><td>10000 (37.9)</td></tr>
<tr><td>OV-NF60-4040</td><td>≥98.5</td><td>2000 (7.5)</td></tr>
<tr><td>OV-NF90-8040</td><td>≥99.0</td><td>9000 (34.1)</td></tr>
<tr><td>OV-NF90-4040</td><td>≥99.0</td><td>1800 (6.8)</td></tr>
<tr><td rowspan="8">Material separation series industrial nanofiltration</td><td>OV-NF30-8040S34</td><td>≥98.0</td><td>10000 (37.9)</td><td rowspan="8">100 psi
(0.69MPa)</td><td rowspan="8">2000 ppm
MgSO₄</td></tr>
<tr><td>OV-NF30-4040S34</td><td>≥98.0</td><td>2000 (7.5)</td></tr>
<tr><td>OV-NF30-8040S46</td><td>≥98.0</td><td>8000 (30.3)</td></tr>
<tr><td>OV-NF30-4040S46</td><td>≥98.0</td><td>1600 (6.1)</td></tr>
<tr><td>OV-NF60-8040S34</td><td>≥99.0</td><td>9000 (34.1)</td></tr>
<tr><td>OV-NF60-4040S34</td><td>≥99.0</td><td>1800 (6.8)</td></tr>
<tr><td>OV-NF60-8040S46</td><td>≥99.0</td><td>7000 (26.5)</td></tr>
<tr><td>OV-NF60-4040S46</td><td>≥99.0</td><td>1400 (5.3)</td></tr>
<tr><td rowspan="6">Magnesium-lithium separation series industrial nanofiltration</td><td>OV-SLNF1-8040 400</td><td>≥90.0</td><td>10000 (37.9)</td><td rowspan="6">100 psi
(0.69MPa)</td><td rowspan="6">2000 ppm
MgCl₂</td></tr>
<tr><td>OV-SLNF1-4040 90</td><td>≥90.0</td><td>2000 (7.5)</td></tr>
<tr><td>OV-SLNF2-8040 400</td><td>≥96.0</td><td>9000 (34.1)</td></tr>
<tr><td>OV-SLNF2-4040 90</td><td>≥96.0</td><td>1800 (6.8)</td></tr>
<tr><td>OV-SLNF3-8040 400</td><td>≥98.0</td><td>8000 (30.3)</td></tr>
<tr><td>OV-SLNF3-4040 90</td><td>≥98.0</td><td>1600 (6.1)</td></tr>
</table>

1.4.5 Guidelines for selection of common reverse osmosis membranes



Chapter II Characteristics and Performance of Reverse Osmosis Membrane and Nanofiltration Membrane Products

[2.1] OVAY Household Reverse Osmosis Membrane Element

1. Product Performance Characteristics

Household reverse osmosis membrane elements are suitable for desalination of the water sources below TDS 500ppm, with the characteristics of high desalination rate and low operation pressure, and are widely used in various household water purifiers, hospital and laboratory water purifiers and other small equipment.

2. Membrane Element Specification and Performance

Membrane element model	Stable desalination rate (%)		Average water yield GPD (m^3/d)	Effective membrane area $ft^2(m^2)$
	Water use efficiency solution condition	NaCl solution conditions		
OV-ULP 1812-50	97.5	98.5	50 (0.19)	3.6 (0.33)
OV-ULP 1812-75	97.5	98.5	75 (0.28)	5.0 (0.46)
OV-ULP 2012-100	97.5	98.5	100 (0.38)	6.0 (0.56)
OV-ULP 3012-300	97.0	98.5	300 (1.14)	13.2 (1.23)
OV-ULP 3012-400	95.0	98.5	400 (1.52)	17.0 (1.58)
OV-ULP 3012-600	93.0	97.0	600 (2.28)	22.1 (2.05)
OV-ULP 3013-400	95.0	98.5	400 (1.52)	17.0 (1.58)
OV-ULP 3013-600	93.0	97.0	600 (2.28)	22.1 (2.05)
OV-ULP 3213-800	93.0	97.0	800 (3.04)	27.7 (2.57)

Note: For more household reverse osmosis membrane element models, please refer to OVAY official website or consult marketing personnel

3. Test conditions

Test pressure ………………… 60 psi (1812-50, 1812-75, 2012-100)

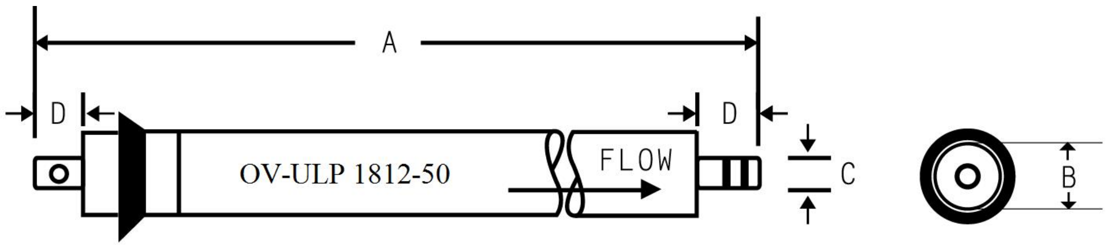
		100 psi (3012-300, 3012-400, 3013-400, 3013-600, 3013-800)
Test solution temperature	…………………	25℃
Test solution concentration	…………………	500ppm NaCl or water use efficiency standard (GB34914-2021) experimental water
PH value of test solution	…………………	7.5
Recovery rate of single membrane element	…………………	50%-60%

4. Limit Service Conditions

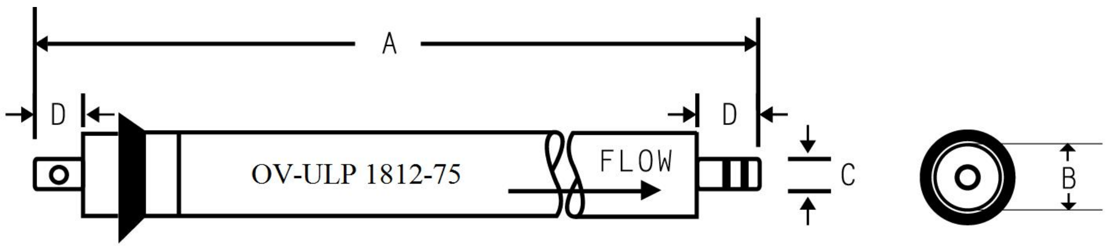
Maximum operation pressure	……………………...........	300 psi(2.07 MPa)
Maximum inlet temperature	……………………...........	45℃
Maximum inlet SDI_{15}	……………………...........	5
Free Chlorine Concentration in Inlet	……………………...........	＜0.1 ppm
PH range of inlet during continuous operation	……………………...........	3-10
PH range of inlet during chemical cleaning	……………………...........	2-12
Maximum pressure drop of single membrane element	……………………...........	10 psi

5. Dimensions of Membrane Elements

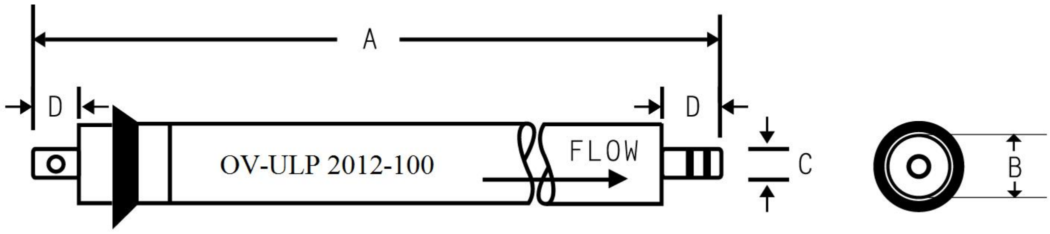
All units shown in the diagram are in millimeters (inches)



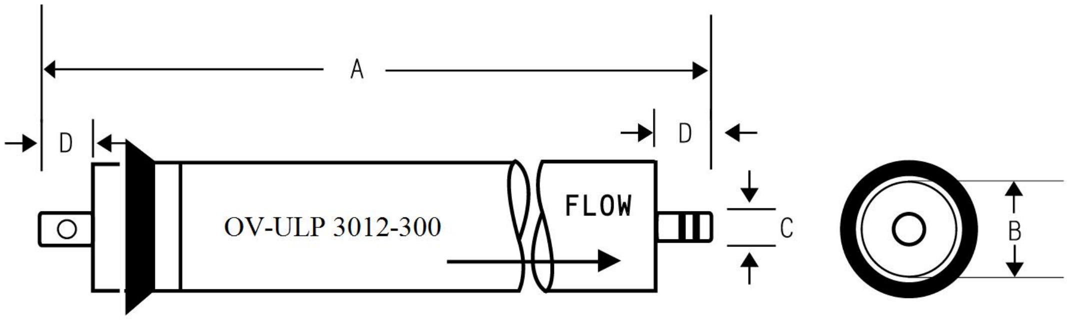
A=298mm(11.7 ") B=44mm(1.73 ") C=17.0mm(0.67 ") D=38.0mm(1.50")



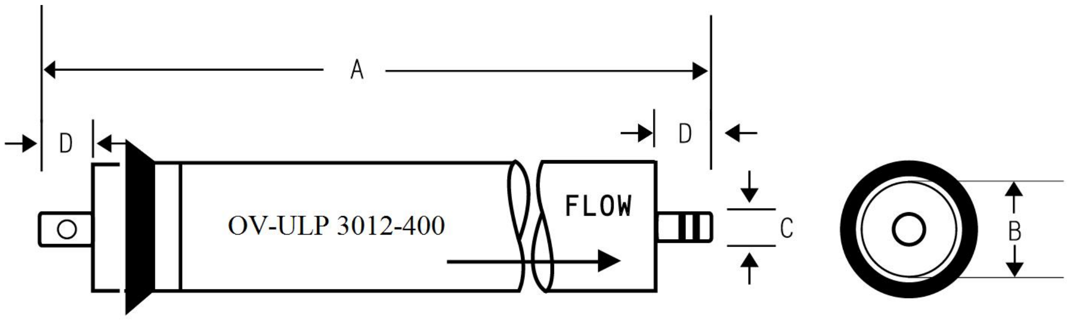
A=298mm(11.7 ") B=44mm(1.73 ") C=17.0mm(0.67 ") D=21.0mm(0.83 ")



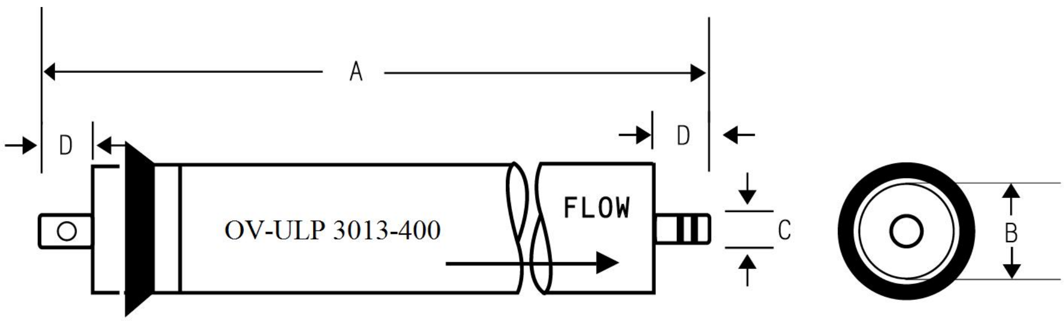
A=298mm(11.7 ") B=47.2mm(1.86 ") C=17.0mm(0.67 ") D=21.0mm(0.83 ")



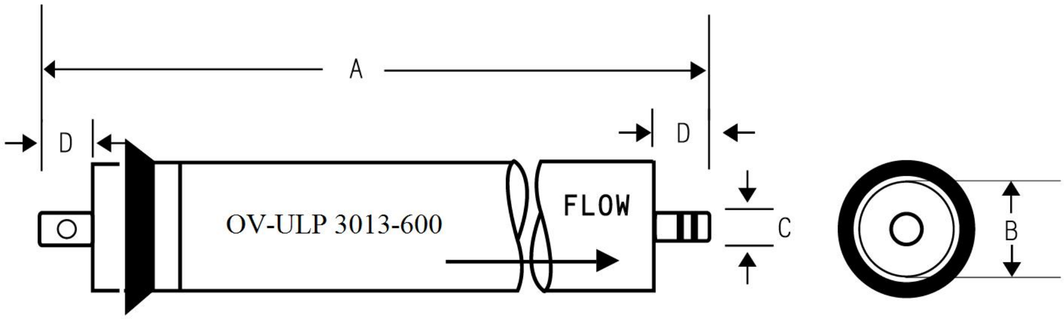
A=298mm(11.1 ") B=71 mm(2.8") C=17.0mm(0.67 ") D=21.0mm(0.83 ")



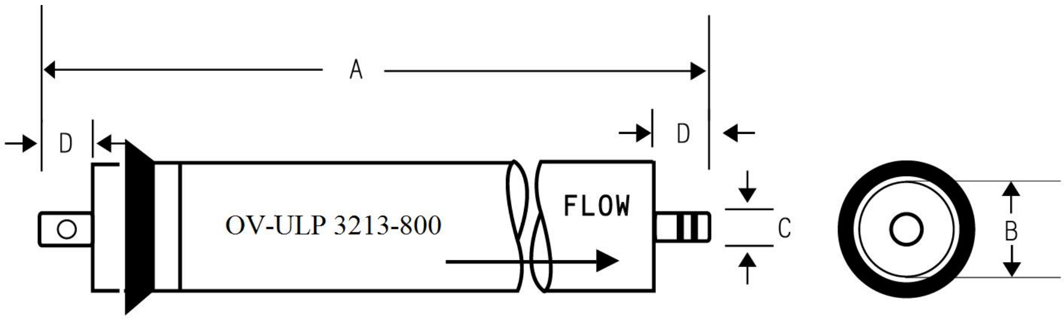
A=298mm(11.1 ") B=73mm(2.9") C=17.0mm(0.67 ") D=21.0mm(0.83 ")



A=333mm(13.1 ") B=67.8mm(2.67 ") C=17.0mm(0.66 ") D=21.0mm(0.82 ")



A=333mm(13.1 ") B=67.8mm(2.67 ") C=17.0mm(0.66 ") D=21.0mm(0.82 ")



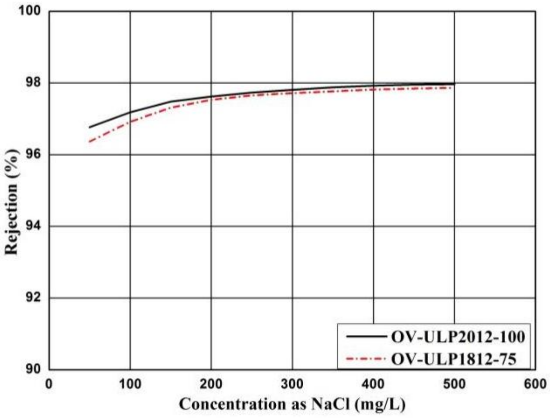
A=333mm(13.1 ") B=76.5mm(3.11 ") C=17.0mm(0.66 ") D=21.0mm(0.82 ")

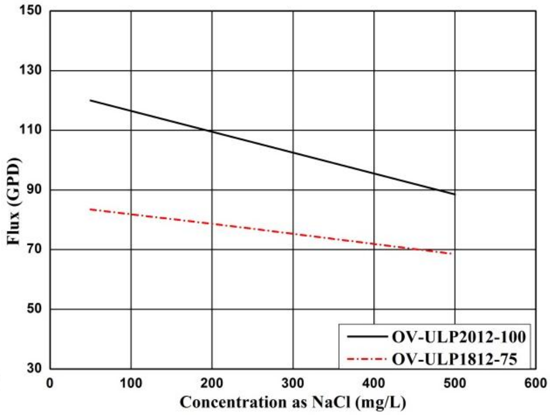
Note: The dimensions of membrane elements shown in the above figure are not marked with tolerances

6. Important Information

- The water yield listed in the table is the average value, and the error of water yield of single membrane element is within 20%.
- The water produced in the first hour when the membrane element is used for the first time shall be discharged.
- When the membrane element leaves the factory, the dry membrane element has no protective solution, and once the element is wet, it should always be wet.
- Wet membrane elements are tested with water before leaving the factory, stored in 1.5% sodium bisulfite solution (10% propylene glycol antifreeze should be added in winter), and then vacuum packed.
- Users must strictly follow the operation limits and rules set in this manual, otherwise Hunan Ovay Technology Co., Ltd. will not bear all the consequences arising therefrom.
- Users are strictly forbidden to use any chemicals that have an impact on membrane elements during storage and operation. If such chemicals are used in violation, Hunan Ovay Technology Co., Ltd. will not bear all the consequences arising therefrom.
- Due to technological progress and product upgrade, product technical data may be updated at any time.

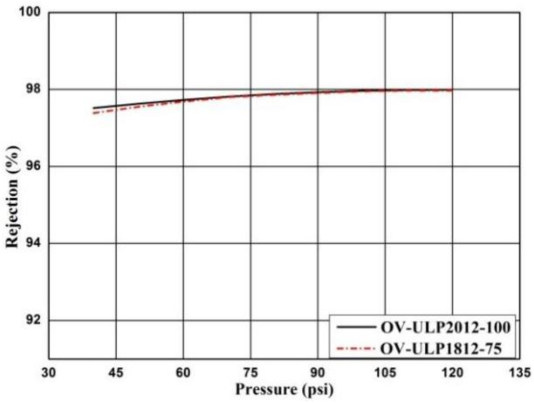
Desalination rate and water production performance under different raw water concentrations

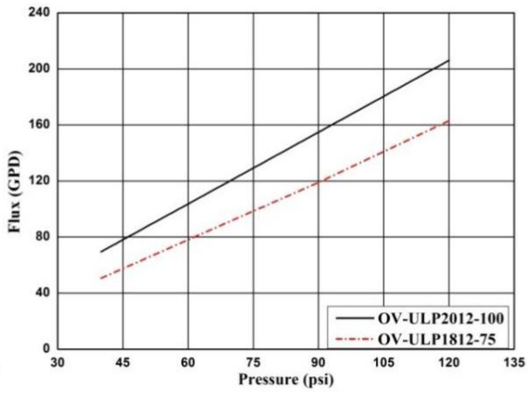




Test conditions: 25℃, 60psi, pH=7, the recovery rate is about 50%

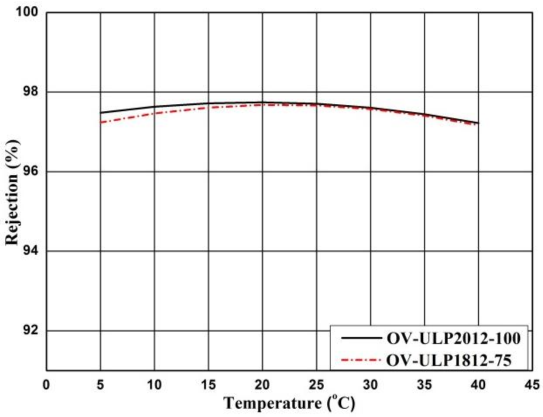
Desalination rate and water production performance under different inlet water pressures

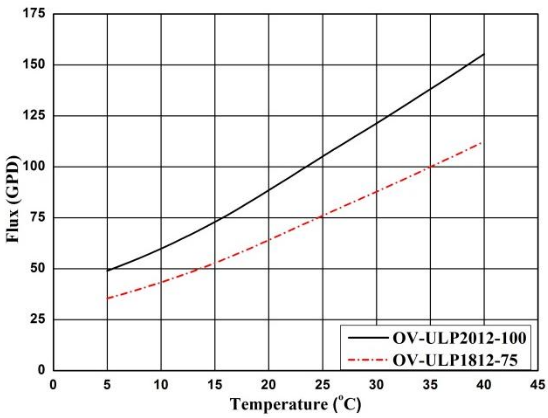




Test conditions: 25℃, 500ppm NaCl, pH=7, the recovery rate is about 50%

Desalination rate and water production performance at different temperatures





Test conditions: 60psi, 500ppm NaCl, pH=7, the recovery rate is about 50%

[2.2] OVAY Household Nanofiltration Membrane Element

1. Product Performance and Characteristics

Household nanofiltration membrane elements are suitable for desalting the water sources below TDS 500 ppm, and have high removal rate for organisms, microorganisms and most divalent and above metal ions in water, and monovalent ions beneficial to human body can be partially retained, which can be widely used in various household water purifiers, mineralizing direct drinking machines and other small equipment.

2. Membrane Element Specification and Performance

Membrane element model	Stable desalination rate (%)	Average water yield GPD (m^3/d)	Type of test fluid	Effective membrane area ft^2 (m^2)
OV-NF-1812	30±10	100 (0.38)	NaCl	5.0 (0.46)
	96.0		$MgSO_4$	
OV-NF-2012	30±10	150 (0.57)	NaCl	6.0 (0.56)
	96.0		$MgSO_4$	
OV-NF-3012	30±10	400 (1.52)	NaCl	17.0 (1.58)
	96.0		$MgSO_4$	
OV-NF-3013	30±10	400 (1.52)	NaCl	17.0 (1.58)
	96.0		$MgSO_4$	

3. Test conditions

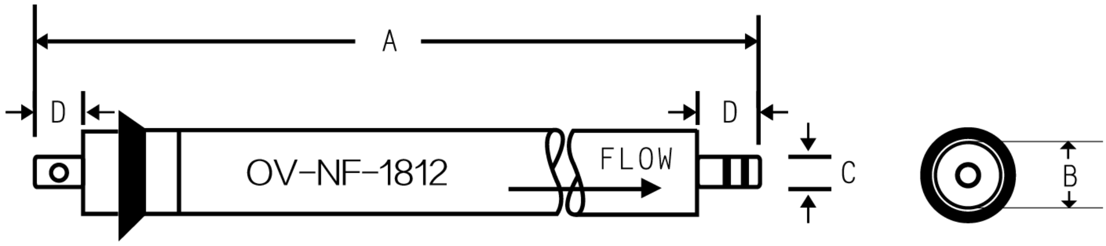
Test pressure .... 60 psi
Test solution temperature .... 25℃
Test solution concentration (NaCl) .... 250 ppm
Test solution concentration ($MgSO_4$) .... 500 ppm
PH value of test solution 7.5
Recovery rate of single membrane element 50%

4. Limit Service Conditions

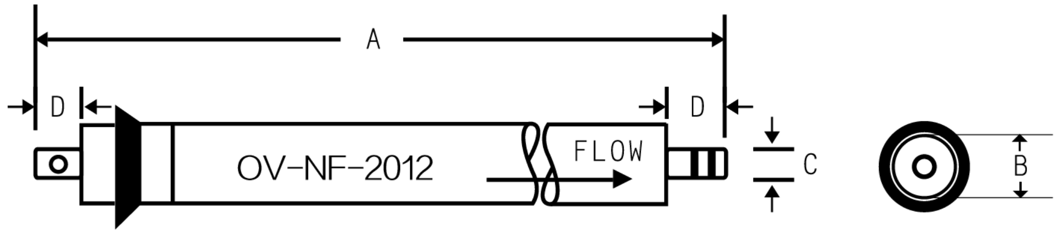
Maximum operation pressure .... 300 psi(2.07 MPa)
Maximum inlet temperature .... 45℃
Maximum inlet SDI_{15} 5
Maximum inlet water hardness .... 400 ppm (in $CaCO_3$)
Free Chlorine Concentration in Inlet .... ＜0.1ppm
PH range of inlet during continuous operation 3-10
PH range of inlet during chemical cleaning 2-12
Maximum pressure drop of single membrane element .... 10 psi (0.07 MPa)

5. Dimensions of Membrane Elements

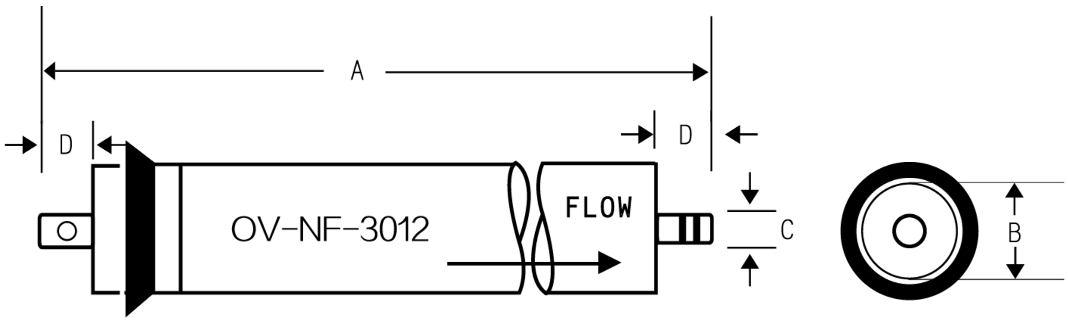
All units shown in the diagram are in millimeters (inches)



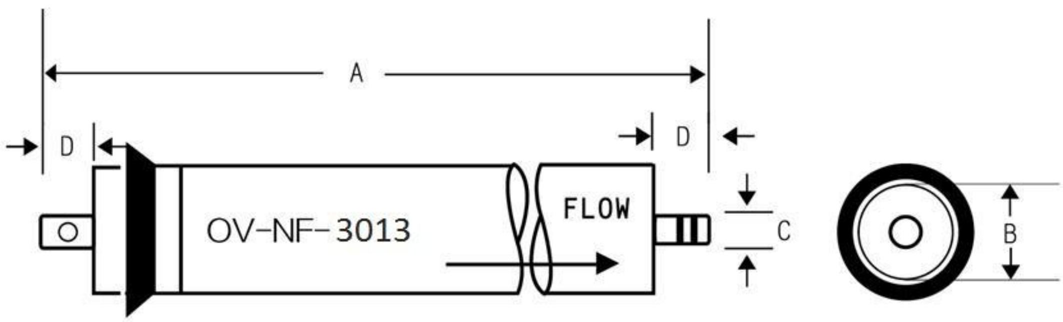
A=298mm(11.7 ")   B=44mm(1.73 ")   C=17.0mm(0.67 ")   D=21.0mm(0.83 ")



A=298mm(11.7 ")   B=47.2mm(1.86 ")   C=17.0mm(0.67 ")   D=21.0mm(0.83 ")



A=298mm(11.1 ")   B=71 mm(2.8")   C=17.0mm(0.67 ")   D=21.0mm(0.83 ")



A=333mm(13.1 ")   B=67.8mm(2.67 ")   C=17.0mm(0.66 ")   D=21.0mm(0.82 ")

Note: The dimensions of membrane elements shown in the above figure are not marked with tolerances

6. Important Information

- The water yield listed in the table is the average value, and the error of water yield of single membrane element is within 20%.
- The water produced in the first hour when the membrane element is used for the first time shall be discharged.
- When the membrane element leaves the factory, the dry membrane element has no protective solution, and once the element is wet, it should always be wet.
- Wet membrane elements are tested with water before leaving the factory, stored in 1.5% sodium bisulfite solution (10% propylene glycol antifreeze should be added in winter), and then vacuum packed.
- Users must strictly follow the operation limits and rules set in this manual, otherwise Hunan Ovay Technology Co., Ltd. will not bear all the consequences arising therefrom.
- Users are strictly forbidden to use any chemicals that have an impact on membrane elements during storage and operation. If such chemicals are used in violation, Hunan Ovay Technology Co., Ltd. will not bear all the consequences arising therefrom.
- Due to technological progress and product upgrade, product technical data may be updated at any time.

[2.3] OVAY Extra Low Pressure Series Membrane Elements

1. Product Performance and Characteristics

The new generation of OVAY Technology Extra-low Pressure (X) series optimizes the membrane making process of membranes, which has higher water flux and desalination rate compared with the previous generation, and has better pollution resistance. The membrane element is suitable for desalination and advanced treatment of raw water with low salt content, such as surface water, groundwater and tap water with salt content less than 1000 ppm, and can achieve high water yield under extremely low operation pressure or small membrane area. It can be widely used in the second stage of wastewater recycling, purification of drinking water of various scales, boiler make-up water and other fields, and is also an ideal choice in the field of municipal water supply treatment with surface water and well water as water sources.

2. Membrane Element Specification and Performance

Membrane element model	Stable desalination rate (%)	Minimum desalination rate (%)	Average water yield GPD (m^3/d)	Effective membrane area ft^2(m^2)
OV-X-4040	99.2	99.0	2600 (9.8)	90 (8.4)
OV-X-8040 400	99.2	99.0	12000 (45.4)	400 (37.2)
OV-X-8040 440	99.2	99.0	13200 (49.9)	440 (40.9)

3. Test conditions

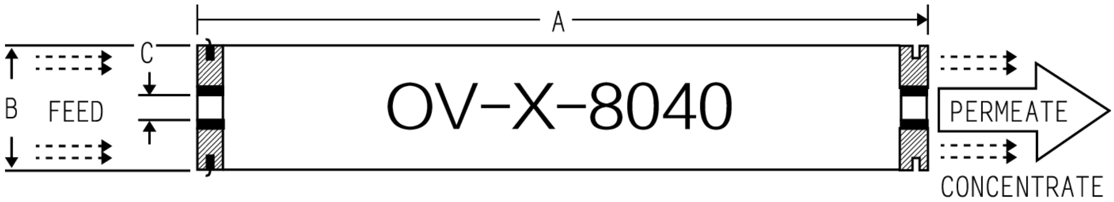
Test pressure …………………………………… 100 psi (0.69 MPa)
Test solution temperature …………………………………… 25℃
Test solution concentration (NaCl) …………………………………… 500 ppm
PH value of test solution …………………………………… 7.5
Recovery rate of single membrane element …………………………………… 15%

4. Limit Service Conditions

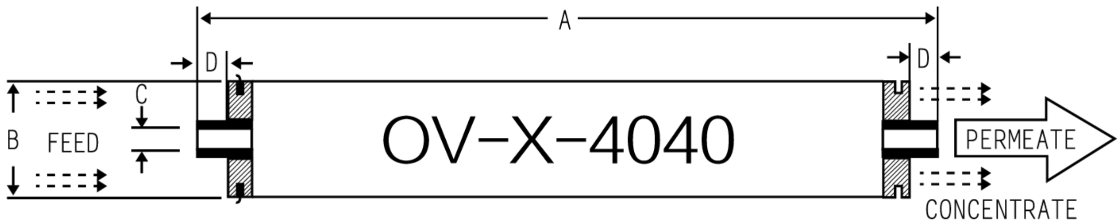
Maximum operation pressure …………………………………… 600 psi(4.14 MPa)
Maximum inlet flow …………………………………… 75 gpm (17m^3/h) (8040)
16 gpm (3.6m^3/h) (4040)
Maximum inlet temperature …………………………………… 45℃
Maximum inlet SDI_{15} …………………………………… 5
Free Chlorine Concentration in Inlet …………………………………… ＜0.1 ppm
PH range of inlet during continuous operation …………………………………… 3-10
PH range of inlet during chemical cleaning …………………………………… 2-12
Maximum pressure drop of single membrane element …………………………………… 15 psi (0.1 MPa)

5. Dimensions of Membrane Elements

All units shown in the diagram are in millimeters (inches)



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



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

Note: The dimensions of membrane elements shown in the above figure are not marked with tolerances

6. Important Information

- The water yield listed in the table is the average value, and the error of water yield of single membrane element is within 20%.
- The water produced in the first hour when the membrane element is used for the first time shall be discharged.
- When the membrane element leaves the factory, the dry membrane element has no protective solution, and once the element is wet, it should always be wet.
- The feed pressure should be gradually increased within a time range of 30-60 seconds, otherwise irreversible damage to membrane elements may be caused.
- Avoid back pressure on the water producing side at all times.
- Wet membrane elements are tested with water before leaving the factory, stored in 1.5% sodium bisulfite solution (10% propylene glycol antifreeze should be added in winter), and then vacuum packed.
- The system is shut down for a long time. In order to prevent microbial growth, it is recommended to immerse the membrane element in 1.5% (weight ratio) sodium bisulfite (food grade) protective solution and change the protective solution regularly.
- Users must strictly follow the operation limits and rules set in this manual, otherwise Hunan Ovay Technology Co., Ltd. will not bear all the consequences arising therefrom.
- Users are strictly forbidden to use any chemicals that have an impact on membrane elements during storage

and operation. If such chemicals are used in violation, Hunan Ovay Technology Co., Ltd. will not bear all the consequences arising therefrom.

- Due to technological progress and product upgrade, product technical data may be updated at any time.

[2.4] OVAY Ultra-low Pressure series membrane elements

1. Product Performance and Characteristics

Ultra-low pressure (U) series is an aromatic polyamide composite membrane element developed by OVAY Technology for desalting raw water with low salt concentration. It can achieve higher water flux and desalination rate under lower operation pressure, and can be widely used in pure water preparation, reclaimed water reuse, food processing and other fields.

2. Membrane Element Specification and Performance

Membrane element model	Stable desalination rate (%)	Minimum desalination rate (%)	Average water yield GPD (m^3/d)	Effective membrane area $ft^2(m^2)$
OV-U-4040-HR	99.7	99.4	2200 (8.3)	100 (9.3)
OV-U-8040-HF	99.2	98.8	12000 (45.4)	400 (37.2)
OV-U-8040	99.5	99.3	9600 (36.3)	365 (33.9)
OV-U-8040-HR	99.7	99.4	10500 (39.7)	400 (37.2)
OV-U-8040 440	99.7	99.4	12000 (45.4)	440 (40.9)

3. Test conditions

Test pressure	…………………………………	150 psi (1.03 MPa)
Test solution temperature	…………………………………	25℃
Test solution concentration (NaCl)	…………………………………	1500 ppm
PH value of test solution	…………………………………	7.5
Recovery rate of single membrane element	…………………………………	15%

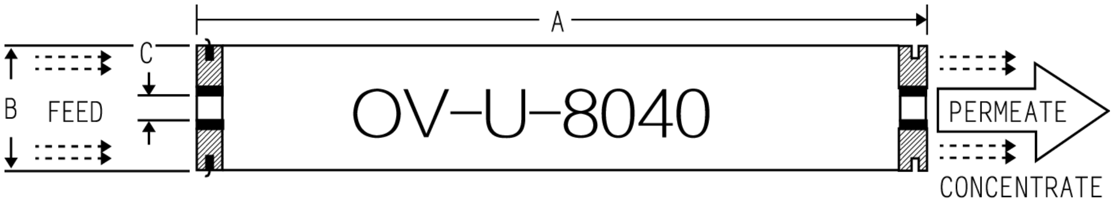
4. Limit Service Conditions

Maximum operation pressure	…………………………………	600 psi(4.14 MPa)
Maximum inlet flow	…………………………………	75 gpm(17 m^3/h) (8040) 16 gpm (3.6 m^3/h) (4040)
Maximum inlet temperature	…………………………………	45℃
Maximum inlet SDI_{15}	…………………………………	5
Free Chlorine Concentration in Inlet	…………………………………	＜0.1 ppm
PH range of inlet during continuous operation	…………………………………	3-10
PH range of inlet during chemical cleaning	…………………………………	2-12
Maximum pressure drop of single	…………………………………	15 psi (0.1 MPa)

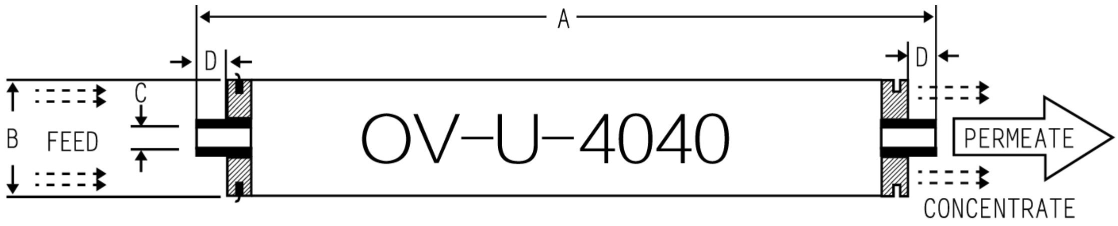
membrane element

5. Dimensions of Membrane Elements

All units shown in the diagram are in millimeters (inches)



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



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

Note: The dimensions of membrane elements shown in the above figure are not marked with tolerances

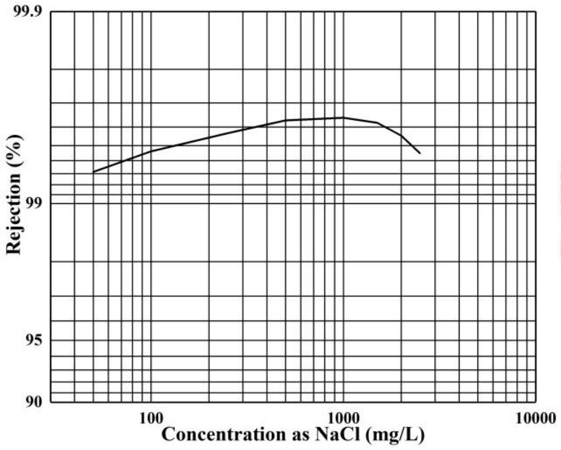
6. Important Information

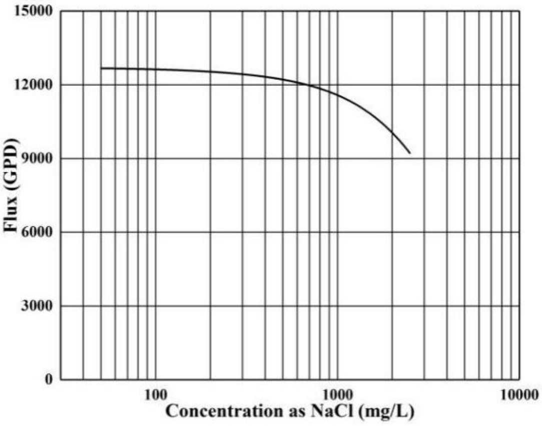
- The water yield listed in the table is the average value, and the error of water yield of single membrane element is within 20%.
- The water produced in the first hour when the membrane element is used for the first time shall be discharged.
- When the membrane element leaves the factory, the dry membrane element has no protective solution, and once the element is wet, it should always be wet.
- The feed pressure should be gradually increased within a time range of 30-60 seconds, otherwise irreversible damage to membrane elements may be caused.
- Avoid back pressure on the water producing side at all times.
- Wet membrane elements are tested with water before leaving the factory, stored in 1.5% sodium bisulfite solution (10% propylene glycol antifreeze should be added in winter), and then vacuum packed.
- The system is shut down for a long time. In order to prevent microbial growth, it is recommended to immerse the membrane element in 1.5% (weight ratio) sodium bisulfite (food grade) protective solution and change the protective solution regularly.
- Users must strictly follow the operation limits and rules set in this manual, otherwise Hunan Ovay Technology Co., Ltd. will not bear all the consequences arising therefrom.
- Users are strictly forbidden to use any chemicals that have an impact on membrane elements during storage

and operation. If such chemicals are used in violation, Hunan Ovay Technology Co., Ltd. will not bear all the consequences arising therefrom.

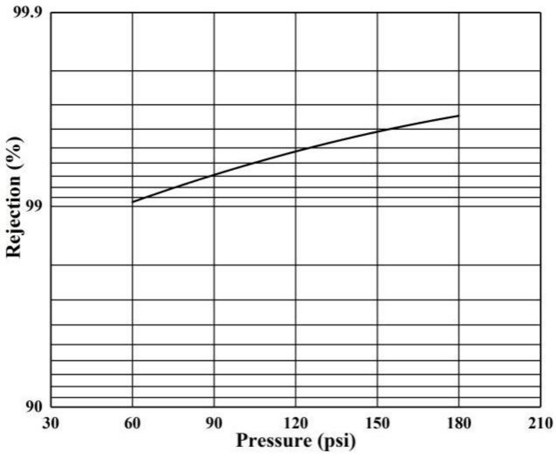
- Due to technological progress and product upgrade, product technical data may be updated at any time.

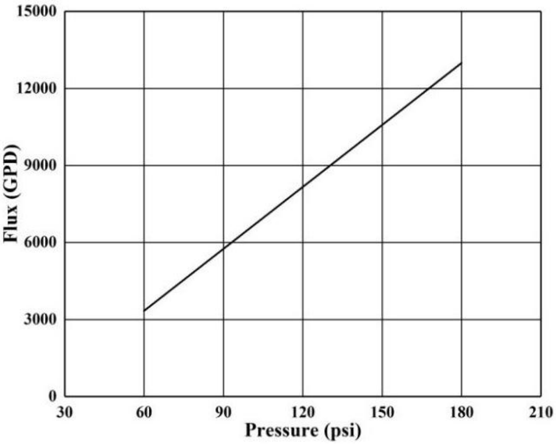
Desalination rate and water production performance of OV-U-8040-HR under different raw water concentrations (25℃, 225psi, pH=7, recovery rate 15%)



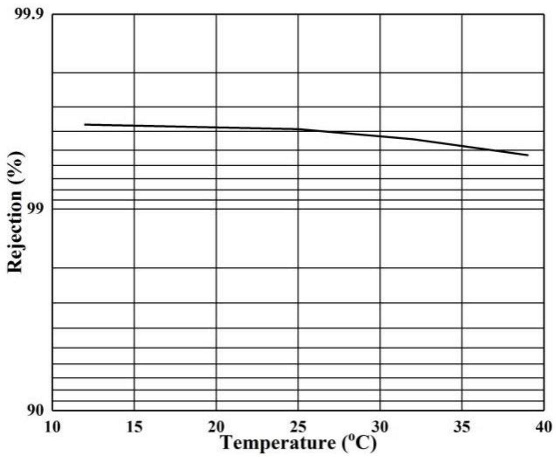


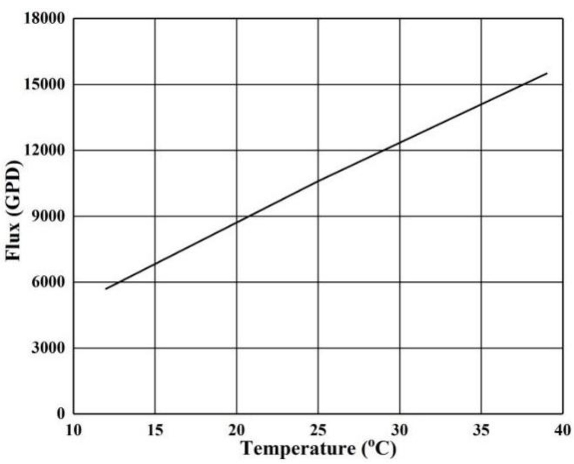
Desalination rate and water production performance of OV-U-8040-HR under different inlet water pressures (25℃, 2000ppm NaCl, pH=7, recovery rate 15%)





Desalination rate and water production performance of OV-U-8040-HR at different temperatures (225psi, 2000ppm NaCl, pH=7, recovery rate 15%)





[2.5] OVAY Low Pressure Series Membrane Elements

1. Product Performance and Characteristics

Low pressure (L) series is an aromatic polyamide composite membrane element developed by OVAY Technology for desalting medium and low concentration brackish water. It has the characteristics of high desalination rate and large flux, and can be widely used in municipal water supply, surface water reuse, coal chemical industry, thermal plant boiler make-up water, food industry water, textile printing and dyeing, electroplating industry and other fields.

2. Membrane Element Specification and Performance

Membrane element model	Stable desalination rate (%)	Minimum desalination rate (%)	Average water yield GPD (m^3/d)	Effective membrane area ft^2(m^2)
OV-L-4040	99.7	99.5	2400 (9.1)	90 (8.4)
OV-L-8040 365	99.7	99.5	9600 (36.3)	365 (33.9)
OV-L-8040 400	99.7	99.5	10500 (39.7)	400 (37.2)
OV-L-8040 440	99.7	99.5	12650 (48.0)	440 (40.9)

3. Test conditions

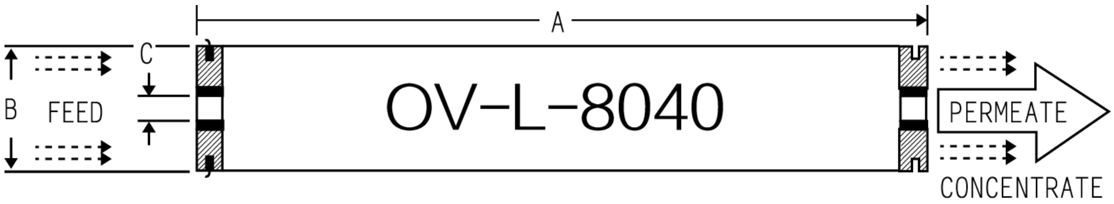
Test pressure	……………………………………..	225 psi (1.55 MPa)
Test solution temperature	……………………………………..	25℃
Test solution concentration (NaCl)	……………………………………..	2000 ppm
PH value of test solution	……………………………………..	7.5
Recovery rate of single membrane element	……………………………………..	15%

4. Limit Service Conditions

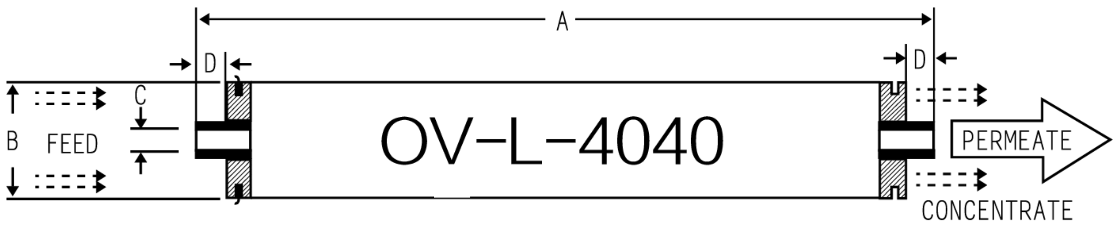
Maximum operation pressure	……………………………………..	600 psi (4.14 MPa)
Maximum inlet flow	……………………………………..	75 gpm(17 m^3/h) (8040) 16 gpm (3.6 m^3/h) (4040)
Maximum inlet temperature	……………………………………..	45℃
Maximum inlet SDI_{15}	……………………………………..	5
Free Chlorine Concentration in Inlet	……………………………………..	＜0.1ppm
PH range of inlet during continuous operation	……………………………………..	2-11
PH range of inlet during chemical cleaning	……………………………………..	1-13
Maximum pressure drop of single membrane element	……………………………………..	15 psi (0.1 MPa)

5. Dimensions of Membrane Elements

All units shown in the diagram are in millimeters (inches)



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



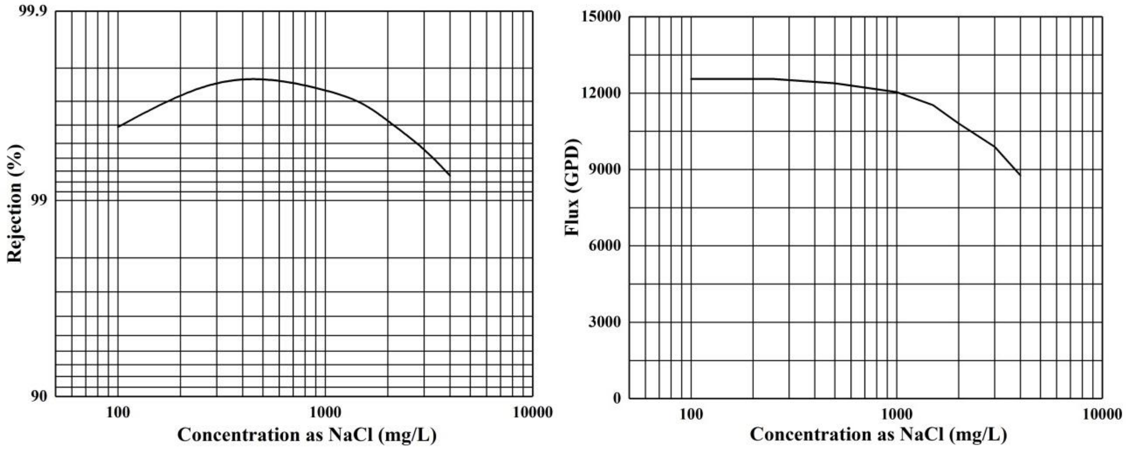
A=1016.0 mm (40") B=99.7 mm (3.9") C=19.1 mm (0.75") D=26.7 mm (1.05")

Note: The dimensions of membrane elements shown in the above figure are not marked with tolerances

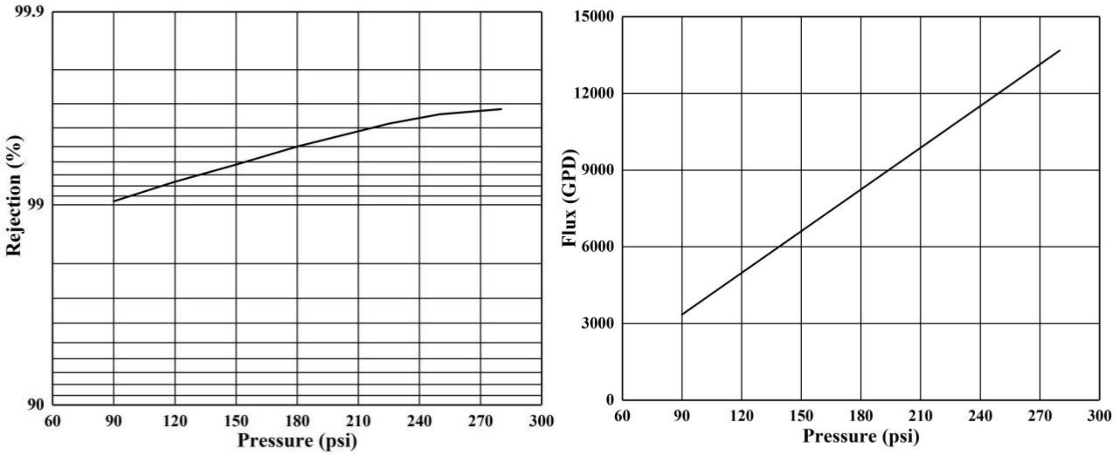
6. Important Information

- The water yield listed in the table is the average value, and the error of water yield of single membrane element is within 20%.
- The water produced in the first hour when the membrane element is used for the first time shall be discharged.
- When the membrane element leaves the factory, the dry membrane element has no protective solution, and once the element is wet, it should always be wet.
- The feed pressure should be gradually increased within a time range of 30-60 seconds, otherwise irreversible damage to membrane elements may be caused.
- Avoid back pressure on the water producing side at all times.
- Wet membrane elements are tested with water before leaving the factory, stored in 1.5% sodium bisulfite solution (10% propylene glycol antifreeze should be added in winter), and then vacuum packed.
- The system is shut down for a long time. In order to prevent microbial growth, it is recommended to immerse the membrane element in 1.5% (weight ratio) sodium bisulfite (food grade) protective solution and change the protective solution regularly.
- Users must strictly follow the operation limits and rules set in this manual, otherwise Hunan Ovay Technology Co., Ltd. will not bear all the consequences arising therefrom.
- Users are strictly forbidden to use any chemicals that have an impact on membrane elements during storage and operation. If such chemicals are used in violation, Hunan Ovay Technology Co., Ltd. will not bear all the consequences arising therefrom.
- Due to technological progress and product upgrade, product technical data may be updated at any time.

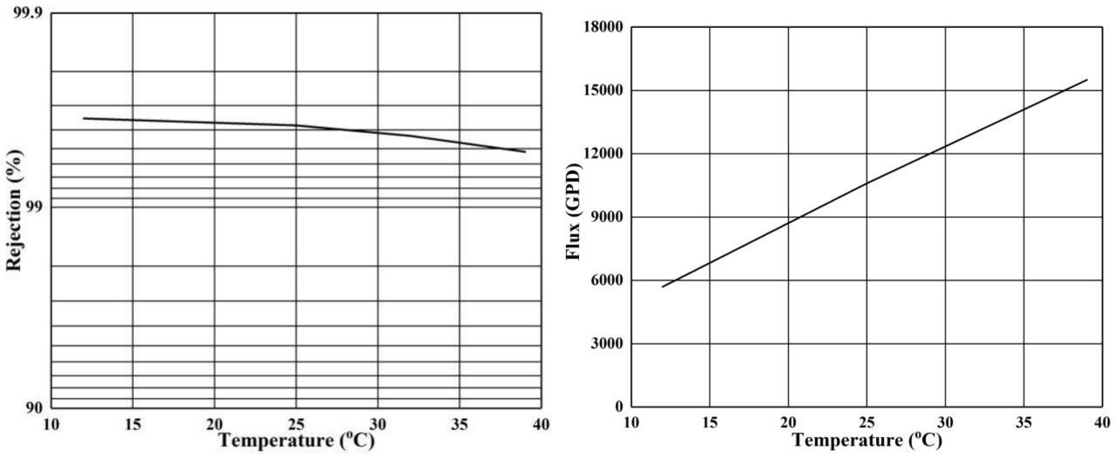
Desalination rate and water production performance of OV-L-8040 400 under different raw water concentrations (25℃, 225psi, pH=7, recovery rate 15%)



Desalination rate and water production performance of OV-L-8040 400 under different inlet pressures (25℃, 2000ppm NaCl, pH=7, recovery rate 15%)



Desalination rate and water production performance of OV-L-8040 400 at different temperatures (225psi, 2000ppm NaCl, pH=7, recovery rate 15%)



[2.6] OVAY Fouling-resistant Series Membrane Elements

1. Product Performance and Characteristics

The fouling-resistant (FR) series membrane elements of OVAY Technology adopt special technology to treat the membrane surface, which changes the charge and smoothness of the membrane surface, increases the hydrophilia of the membrane surface, effectively reduces the fouling of colloid, organism and other fouling, and greatly improves the cleaning and recovery performance of the membrane. At the same time, the 34mil wide inlet water runner design is adopted, which further strengthens the fouling-resistant ability and better washability of membrane elements.

The fouling-resistant (FR) series membrane elements of OVAY Technology have the characteristics of high desalination rate and large flux, which are suitable for desalination of the surface water with salt content below about 10000 ppm, such as groundwater, tap water, and municipal water. They can be widely used in various industrial water treatment such as industrial reclaimed water reuse, municipal water supply and surface water reuse, coal chemical industry, thermal plants boiler make-up water, etc., especially suitable for the treatment of industrial wastewater containing a small amount of organic pollutants and micro-polluted water sources.

2. Membrane Element Specification and Performance

Membrane element model	Stable desalination rate (%)	Minimum desalination rate (%)	Average water yield GPD (m^3/d)	Effective membrane area $ft^2(m^2)$
OV-FR-4040	99.7	99.5	2200 (8.3)	90 (8.4)
OV-FR-8040 365	99.7	99.5	9600 (36.3)	365 (33.9)
OV-FR-8040 400	99.7	99.5	10500 (39.7)	400 (37.2)

3. Test conditions

Test pressure	………………………………	225 psi (1.55 MPa)
Test solution temperature	………………………………	25℃
Test solution concentration(NaCl)	………………………………	2000 ppm
PH value of test solution	………………………………	7.5
Recovery rate of single membrane element	………………………………	15%

4. Limit Service Conditions

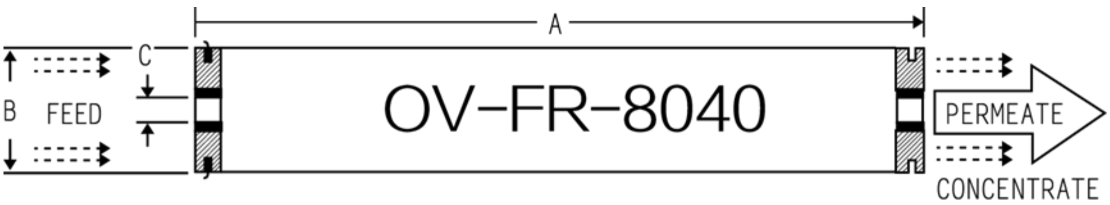
Maximum operation pressure	………………………………	600 psi(4.14 MPa)
Maximum inlet flow	………………………………	75 gpm(17 m^3/h) (8040) 16 gpm(3.6 m^3/h) (4040)
Maximum inlet temperature	………………………………	45℃
Maximum inlet SDI_{15}	………………………………	5
Free Chlorine Concentration in Inlet	………………………………	＜0.1 ppm
PH range of inlet during continuous operation	………………………………	2-11
PH range of inlet during chemical	………………………………	1-13

cleaning

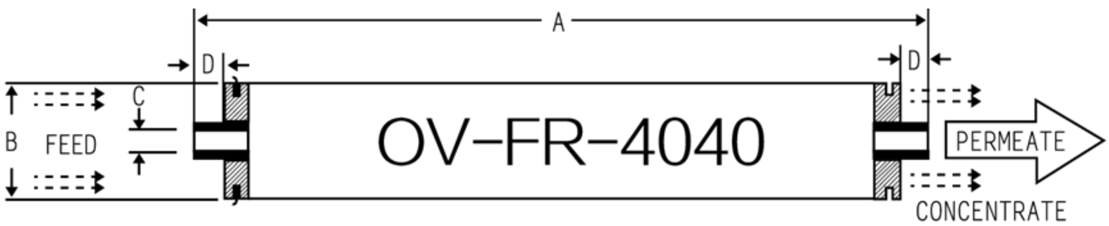
Maximum pressure drop of single membrane element ………………………………. 15 psi (0.1 MPa)

5. Dimensions of Membrane Elements

All units shown in the diagram are in millimeters (inches)



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



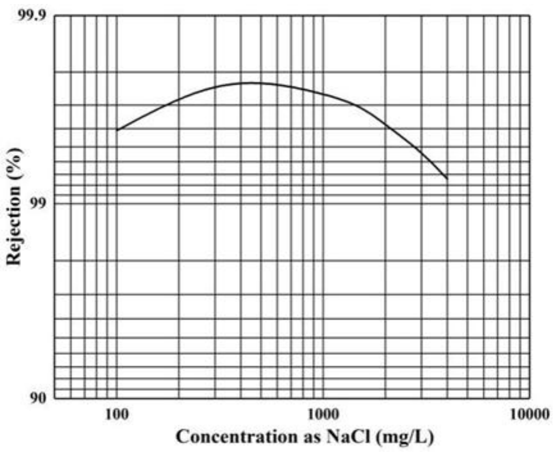
A=1016.0 mm (40") B=99.7 mm (3.9") C=19.1 mm (0.75") D=26.7 mm (1.05")

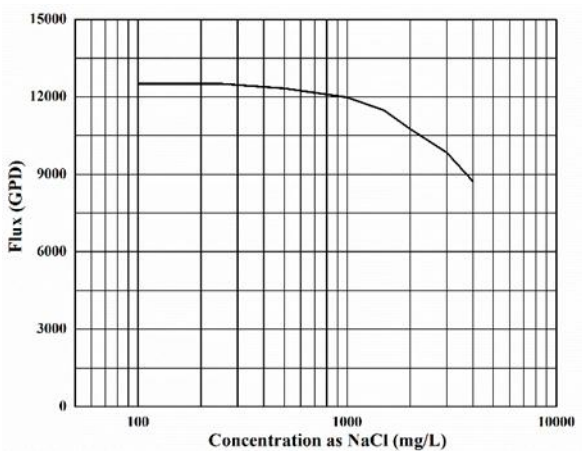
Note: All dimensions of membrane elements in the illustration are not marked with tolerances

6. Important Information

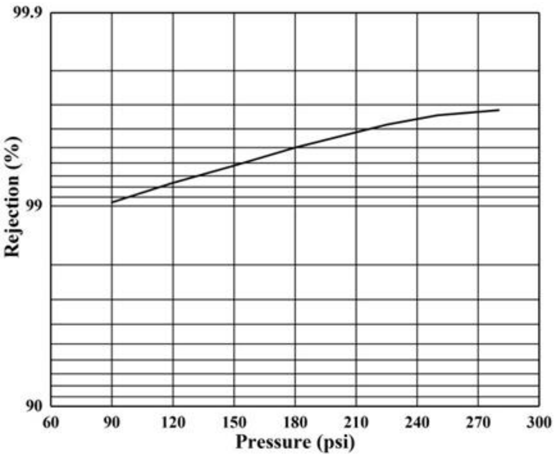
- The water yield listed in the table is the average value, and the error of water yield of single membrane element is within 20%.
- The water produced in the first hour when the membrane element is used for the first time shall be discharged.
- When the membrane element leaves the factory, the dry membrane element has no protective solution, and once the element is wet, it should always be wet.
- The feed pressure should be gradually increased within a time range of 30-60 seconds, otherwise irreversible damage to membrane elements may be caused.
- Avoid back pressure on the water producing side at all times.
- Wet membrane elements are tested with water before leaving the factory, stored in 1.5% sodium bisulfite solution (10% propylene glycol antifreeze should be added in winter), and then vacuum packed.
- The system is shut down for a long time. In order to prevent microbial growth, it is recommended to immerse the membrane element in 1.5% (weight ratio) sodium bisulfite (food grade) protective solution and change the protective solution regularly.
- Users must strictly follow the operation limits and rules set in this manual, otherwise Hunan Ovay Technology Co., Ltd. will not bear all the consequences arising therefrom.
- Users are strictly forbidden to use any chemicals that have an impact on membrane elements during storage and operation. If such chemicals are used in violation, Hunan Ovay Technology Co., Ltd. will not bear all the consequences arising therefrom.
- Due to technological progress and product upgrade, product technical data may be updated at any time.

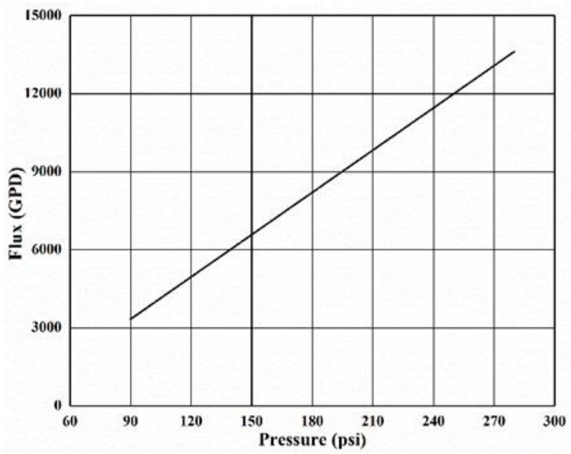
Desalination rate and water production performance of OV-FR-8040 400 under different raw water concentrations (25℃, 225psi, pH=7, recovery rate 15%)



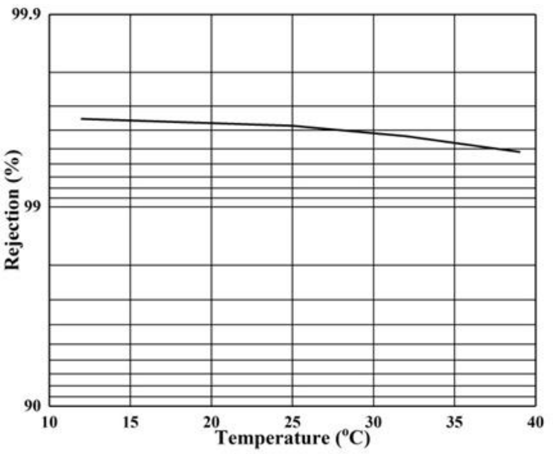


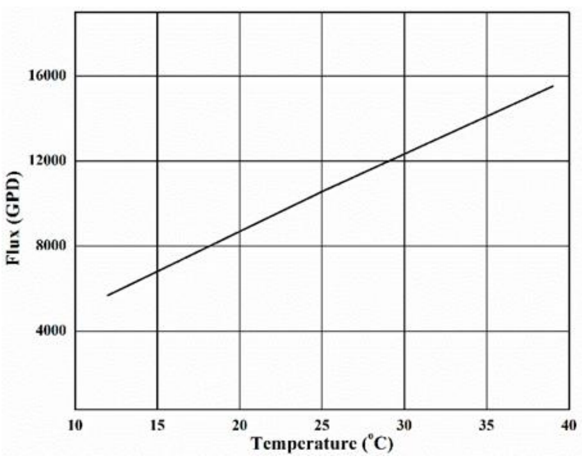
Desalination rate and water production performance of OV-FR-8040 400 under different inlet pressures (25℃, 2000ppm NaCl, pH=7, recovery rate 15%)





Desalination rate and water production performance of OV-FR-8040 400 at different temperatures (225psi, 2000ppm NaCl, pH=7, recovery rate 15%)





[2.7] OVAY Antioxidant Series Membrane Elements

1. Product Performance and Characteristics

Antioxidant (CR) series is developed by OVAY Technology for desalting brackish water containing micro-oxidizing substances. It has the characteristics of high desalting rate and large flux. It adopts special preparation technology to enhance the oxidation resistance of membrane elements and can bear the impact of a certain amount of oxidizing substances. It can be widely used in municipal water supply, reclaimed water reuse, surface water reuse, coal chemical industry, thermal plants boiler make-up water, food industry water, textile printing and dyeing, electroplating industry and other fields.

2. Membrane Element Specification and Performance

Membrane element model	Stable desalination rate (%)	Minimum desalination rate (%)	Average water yield GPD (m^3/d)	Effective membrane area ft^2(m^2)
OV-CR-4040	99.5	99.3	2200 (8.3)	90 (8.4)
OV-CR-8040	99.5	99.3	9000 (34.1)	365 (33.9)

3. Test conditions

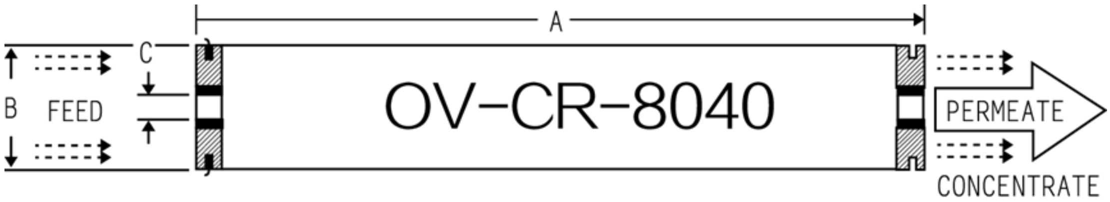
Test pressure	....	225 psi (1.55 MPa)
Test solution temperature	....	25℃
Test solution concentration (NaCl)	....	2000 ppm
PH value of test solution	....	7.5
Recovery rate of single membrane element	....	15%

4. Limit Service Conditions

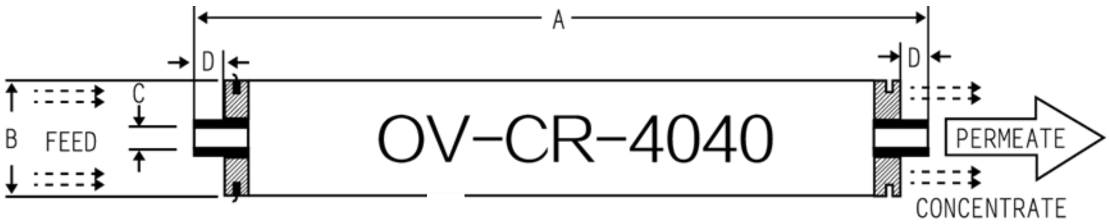
Maximum operation pressure	....	600 psi(4.14 MPa)
Maximum inlet flow	....	75 gpm(17 m^3/h) (8040) 16 gpm(3.6 m^3/h) (4040)
Maximum inlet temperature	....	45℃
Maximum inlet SDI_{15}	....	5
Free Chlorine Concentration in Inlet	....	＜0.5 ppm
PH range of inlet during continuous operation	....	2-11
PH range of inlet during chemical cleaning	....	1-13
Maximum pressure drop of single membrane element	....	15 psi (0.1 MPa)

5. Dimensions of Membrane Elements

All units shown in the diagram are in millimeters (inches)



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



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

Note: All dimensions of membrane elements in the illustration are not marked with tolerances

6. Important Information

- The water yield listed in the table is the average value, and the error of water yield of single membrane element is within 20%.
- The water produced in the first hour when the membrane element is used for the first time shall be discharged.
- When the membrane element leaves the factory, the dry membrane element has no protective solution, and once the element is wet, it should always be wet.
- The feed pressure should be gradually increased within a time range of 30-60 seconds, otherwise irreversible damage to membrane elements may be caused.
- Avoid back pressure on the water producing side at all times.
- Wet membrane elements are tested with water before leaving the factory, stored in 1.5% sodium bisulfite solution (10% propylene glycol antifreeze should be added in winter), and then vacuum packed.
- The system is shut down for a long time. In order to prevent microbial growth, it is recommended to immerse the membrane element in 1.5% (weight ratio) sodium bisulfite (food grade) protective solution and change the protective solution regularly.
- Users must strictly follow the operation limits and rules set in this manual, otherwise Hunan Ovay Technology Co., Ltd. will not bear all the consequences arising therefrom.
- Users are strictly forbidden to use any chemicals that have an impact on membrane elements during storage and operation. If such chemicals are used in violation, Hunan Ovay Technology Co., Ltd. will not bear all the consequences arising therefrom.
- Due to technological progress and product upgrade, product technical data may be updated at any time.

[2.8] OVAY Sea Water Desalination Series Membrane Elements

1. Product Performance and Characteristics

OVAY Technology Sea Water Desalination (SW) series membrane elements have the characteristics of low operation pressure and stable desalination performance, which are suitable for the treatment of seawater, subsea water and high-concentration brackish water, and can be used for various industrial water treatment such as seawater desalination, desalination of high-concentration brackish water, boiler make-up water of power plants, and can also be used for wastewater reuse, landfill leachate treatment and other application fields.

2. Membrane Element Specification and Performance

Membrane element model	Stable desalination rate (%)	Minimum desalination rate (%)	Average water yield GPD (m^3/d)	Effective membrane area ft^2(m^2)
OV-SW-4040-LE	99.8	99.6	1900 (7.2)	90 (8.4)
OV-SW-4040-HR	99.8	99.7	1600 (6.1)	90 (8.4)
OV-SW-8040-LE 400	99.8	99.6	9000 (34.0)	400 (37.2)
OV-SW-8040-HR 400	99.8	99.7	7500 (28.4)	400 (37.2)
OV-SW-8040-LE 440	99.8	99.6	9900 (37.4)	440 (40.9)
OV-SW-8040-HR 440	99.8	99.7	8200 (31.0)	440 (40.9)
OV-SW-8040-FR	99.8	99.6	7500 (28.4)	400 (37.2)
OV-SW-8040-XLE 400	99.7	99.6	9500 (36.0)	400 (37.2)
OV-SW-8040-XHR 400	99.85	99.75	7000 (26.5)	400 (37.2)

3. Test conditions

Test pressure	………………………………	800 psi (5.50 MPa)
Test solution temperature	………………………………	25℃
Test solution concentration (NaCl)	………………………………	32000 ppm
PH value of test solution	………………………………	7.5
Recovery rate of single membrane element	………………………………	8%

4. Limit Service Conditions

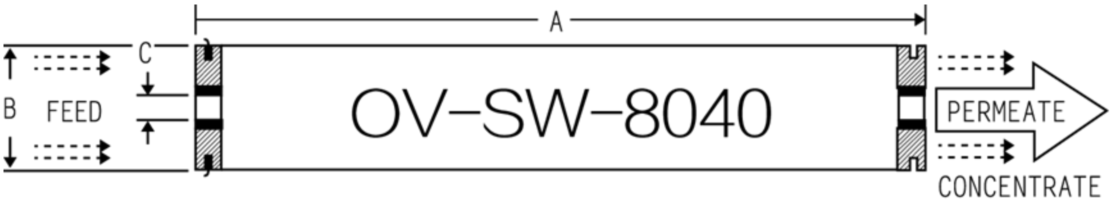
Maximum operation pressure	………………………………	1000 psi(6.9 MPa)
Maximum inlet flow	………………………………	75 gpm(17 m^3/h) (8040) 16 gpm(3.6 m^3/h) (4040)
Maximum inlet temperature	………………………………	45℃
Maximum inlet SDI_{15}	………………………………	5
Free Chlorine Concentration in Inlet	………………………………	＜0.1 ppm
PH range of inlet during continuous operation	………………………………	2-11
PH range of inlet during chemical	………………………………	1-13

cleaning

Maximum pressure drop of single membrane element ………………………………. 15 psi (0.1 MPa)

5. Dimensions of Membrane Elements

All units shown in the diagram are in millimeters (inches)



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

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

Note: The dimensions of membrane elements shown in the above figure are not marked with tolerances

6. Important Information

- The water yield listed in the table is the average value, and the error of water yield of single membrane element is within 20%.
- The water produced in the first hour when the membrane element is used for the first time shall be discharged.
- When the membrane element leaves the factory, the dry membrane element has no protective solution, and once the element is wet, it should always be wet.
- The feed pressure should be gradually increased within a time range of 30-60 seconds, otherwise irreversible damage to membrane elements may be caused.
- Avoid back pressure on the water producing side at all times.
- Wet membrane elements are tested with water before leaving the factory, stored in 1.5% sodium bisulfite solution (10% propylene glycol antifreeze should be added in winter), and then vacuum packed.
- The system is shut down for a long time. In order to prevent microbial growth, it is recommended to immerse the membrane element in 1.5% (weight ratio) sodium bisulfite (food grade) protective solution and change the protective solution regularly.
- Users must strictly follow the operation limits and rules set in this manual, otherwise Hunan Ovay Technology Co., Ltd. will not bear all the consequences arising therefrom.

- Users are strictly forbidden to use any chemicals that have an impact on membrane elements during storage and operation. If such chemicals are used in violation, Hunan Ovay Technology Co., Ltd. will not bear all the consequences arising therefrom.
- Due to technological progress and product upgrade, product technical data may be updated at any time.

[2.9] OVAY Water Treatment Series Industrial Nanofiltration Membrane Element

1. Product Performance and Characteristics

Water treatment series industrial nanofiltration (NF) is an aromatic polyamide composite membrane element developed by OVAY Technology for selective desalination, which has a high removal rate for divalent and above ions, organism, viruses, etc., and can partially retain monovalent ions such as sodium and potassium. Nanofiltration membrane has no chemical reaction, no heating, no destruction of biological activity in the separation process, with the advantages of low pressure and energy saving, which has been widely used in municipal water supply and water quality softening industries.

2. Membrane Element Specification and Performance

Membrane element model	Stable desalination rate (%)	Average water yield GPD (m^3/d)	Effective membrane area ft^2(m^2)
OV-NF10-8040	≥90.0	15000 (56.8)	400 (37.2)
OV-NF10-4040	≥90.0	3000 (11.3)	90 (8.4)
OV-NF30-8040	≥97.0	12000 (45.5)	400 (37.2)
OV-NF30-4040	≥97.0	2400 (9.1)	90 (8.4)
OV-NF60-8040	≥98.5	10000 (37.9)	400 (37.2)
OV-NF60-4040	≥98.5	2000 (7.5)	90 (8.4)
OV-NF90-8040	≥99.0	9000 (34.1)	400 (37.2)
OV-NF90-4040	≥99.0	1800 (6.8)	90 (8.4)

3. Test conditions

Test pressure	……………………………………...	70 psi (0.48MPa)
Test solution temperature	……………………………………...	25℃
Test solution concentration ($MgSO_4$)	……………………………………...	2000 ppm
PH value of test solution	……………………………………...	7.5
Recovery rate of single membrane element	……………………………………...	15%

4. Limit Service Conditions

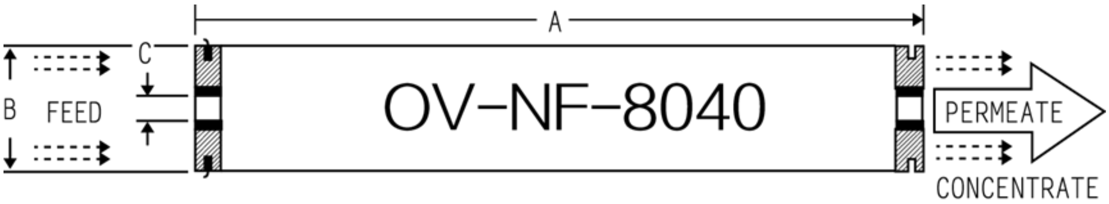
Maximum operation pressure	……………………………………..	600 psi(4.14 MPa)
Maximum inlet flow	……………………………………..	75 gpm(17 m^3/h) (8040) 16 gpm(3.6 m^3/h) (4040)
Maximum inlet temperature	……………………………………..	45℃
Maximum inlet SDI_{15}	……………………………………..	5
Free Chlorine Concentration in Inlet	……………………………………..	＜0.1 ppm

.

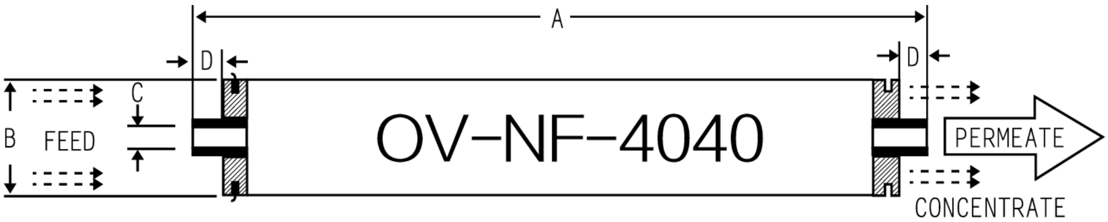
PH range of inlet during continuous operation	……………………………………..	3-10
PH range of inlet during chemical cleaning	……………………………………..	2-12
Maximum pressure drop of single membrane element	……………………………………..	15 psi (0.1 MPa)

5. Dimensions of Membrane Elements

All units shown in the diagram are in millimeters (inches)



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



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

Note: All dimensions of membrane elements in the illustration are not marked with tolerances

6. Important Information

- The water yield listed in the table is the average value, and the error of water yield of single membrane element is within 20%.
- The water produced in the first hour when the membrane element is used for the first time shall be discharged.
- When the membrane element leaves the factory, the dry membrane element has no protective solution, and once the element is wet, it should always be wet.
- The feed water pressure should be gradually increased in the time range of 30-60 seconds, otherwise irreversible damage to membrane elements may be caused. Avoid back pressure on the water producing side at all times.
- Wet membrane elements are tested with water before leaving the factory, stored in 1.5% sodium bisulfite solution (10% propylene glycol antifreeze should be added in winter), and then vacuum packed.
- The system is shut down for a long time. In order to prevent microbial growth, it is recommended to immerse

the membrane element in 1.5% (weight ratio) sodium bisulfite (food grade) protective solution and change the protective solution regularly.

- Users must strictly follow the operation limits and rules set in this manual, otherwise Hunan Ovay Technology Co., Ltd. will not bear all the consequences arising therefrom.
- Users are strictly forbidden to use any chemicals that have an impact on membrane elements during storage and operation. If such chemicals are used in violation, Hunan Ovay Technology Co., Ltd. will not bear all the consequences arising therefrom.
- Due to technological progress and product upgrade, product technical data may be updated at any time.

[2.10] OVAY Material Separation Series Industrial Nanofiltration Membrane Element

1. Product Performance and Characteristics

Material separation series industrial nanofiltration (NF) is an aromatic polyamide composite membrane element developed by OVAY Technology for selective desalination, which has a high removal rate for divalent and above ions, organism, viruses, etc., and can partially retain monovalent ions such as sodium and potassium. Nanofiltration membrane has no chemical reaction in the separation process, no heating, no destruction of biological activity, with the advantages of low pressure and energy saving. In the design process of the membrane element, a 34mil/46mil wide runner separated net which is easy to clean is used; In addition, the structural strength of the membrane element is improved, so that the membrane element can bear higher pressure difference. This series of products have been widely used in material separation, reclaimed water reuse, zero-discharge salt separation and landfill leachate industries.

2. Membrane Element Specification and Performance

Membrane element model	Stable desalination rate (%)	Average water yield GPD (m^3/d)	Effective membrane area $ft^2(m^2)$
OV-NF30-8040S34	≥98.0	10000 (37.9)	400 (37.2)
OV-NF30-4040S34	≥98.0	2000 (7.5)	90 (8.4)
OV-NF30-8040S46	≥98.0	8000 (30.3)	285 (26.5)
OV-NF30-4040S46	≥98.0	1600 (6.1)	70 (6.5)
OV-NF60-8040S34	≥99.0	9000 (34.1)	400 (37.2)
OV-NF60-4040S34	≥99.0	1800 (6.8)	90 (8.4)
OV-NF60-8040S46	≥99.0	7000 (26.5)	285 (26.5)
OV-NF60-4040S46	≥99.0	1400 (5.3)	70 (6.5)

3. Test conditions

Test pressure	……………………………………..	100 psi (0.69MPa)
Test solution temperature	……………………………………..	25℃
Test solution concentration ($MgSO_4$)	……………………………………..	2000 ppm
PH value of test solution	……………………………………..	7.5
Recovery rate of single membrane element	……………………………………..	15%

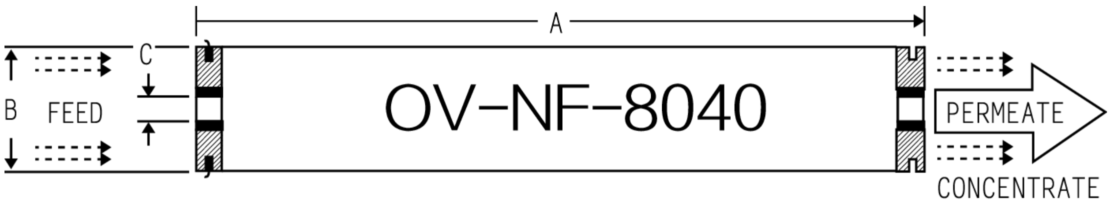
4. Limit Service Conditions

Maximum operation pressure	……………………………………..	600 psi(4.14 MPa)
Maximum inlet flow	……………………………………..	75 gpm(17 m^3/h) (8040); 16 gpm (3.6 m^3/h) (4040)
Maximum inlet temperature	……………………………………..	45℃
Maximum inlet SDI_{15}	……………………………………..	5
Free Chlorine Concentration in Inlet	……………………………………..	＜0.1 ppm
PH range of inlet during continuous operation	……………………………………..	3-10
PH range of inlet during chemical	……………………………………..	2-12

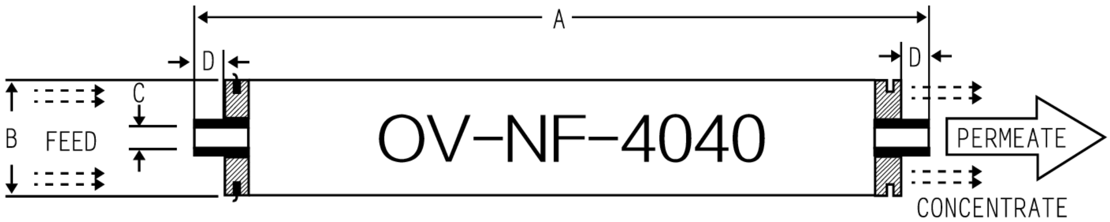
cleaning
Maximum pressure drop of single membrane element …………………………………….. 15 psi (0.1 MPa)

5. Dimensions of Membrane Elements

All units shown in the diagram are in millimeters (inches)



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



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

Note: All dimensions of membrane elements in the illustration are not marked with tolerances

6. Important Information

- The water yield listed in the table is the average value, and the error of water yield of single membrane element is within 20%.
- The water produced in the first hour when the membrane element is used for the first time shall be discharged.
- When the membrane element leaves the factory, the dry membrane element has no protective solution, and once the element is wet, it should always be wet.
- The feed pressure should be gradually increased within a time range of 30-60 seconds, otherwise irreversible damage to membrane elements may be caused.
- Avoid back pressure on the water producing side at all times.
- Wet membrane elements are tested with water before leaving the factory, stored in 1.5% sodium bisulfite solution (10% propylene glycol antifreeze should be added in winter), and then vacuum packed.
- The system is shut down for a long time. In order to prevent microbial growth, it is recommended to immerse the membrane element in 1.5% (weight ratio) sodium bisulfite (food grade) protective solution and change the protective solution regularly.
- Users must strictly follow the operation limits and rules set in this manual, otherwise Hunan Ovay Technology Co., Ltd. will not bear all the consequences arising therefrom.
- Users are strictly forbidden to use any chemicals that have an impact on membrane elements during storage and operation. If such chemicals are used in violation, Hunan Ovay Environmental Protection Technology Co., Ltd. will not bear all the consequences arising therefrom.
- Due to technological progress and product upgrade, product technical data may be updated at any time.

[2.11] OVAY Magnesium-Lithium Separation Series Industrial Nanofiltration Membrane Element

1. Product Performance and Characteristics

Magnesium-lithium separation series industrial nanofiltration (NF) is an aromatic polyamide composite membrane element developed by OVAY Technology for selective desalination. It has a high removal rate for divalent and above anions and cations, organism, viruses, etc., and can partially intercept monovalent ions such as sodium and chlorine. Nanofiltration membrane has no chemical reaction in the separation process, no heating, no destruction of biological activity, and has the advantages of low pressure and energy saving. By further optimizing the structural design of the membrane element, the structural strength of the membrane element is improved, so that the membrane element can bear higher pressure difference. This series of products have been widely used in magnesium and lithium separation, reclaimed water reuse and special separation industries.

2. Membrane Element Specification and Performance

Membrane element model	Stable desalination rate (%)	Average water yield GPD (m^3/d)	Effective membrane area ft^2(m^2)
OV-SLNF1-8040 400	≥90.0	10000 (37.9)	400 (37.2)
OV-SLNF1-4040 90	≥90.0	2000 (7.5)	90 (8.4)
OV-SLNF2-8040 400	≥96.0	9000 (34.1)	400 (37.2)
OV-SLNF2-4040 90	≥96.0	1800 (6.8)	90 (8.4)
OV-SLNF3-8040 400	≥98.0	8000 (30.3)	400 (37.2)
OV-SLNF3-4040 90	≥98.0	1600 (6.1)	90 (8.4)

3. Test conditions

Test pressure	……………………………………..	100 psi (0.69MPa)
Test solution temperature	……………………………………..	25℃
Test solution concentration ($MgCl_2$)	……………………………………..	2000 ppm
PH value of test solution	……………………………………..	7.5
Recovery rate of single membrane element	……………………………………..	15%

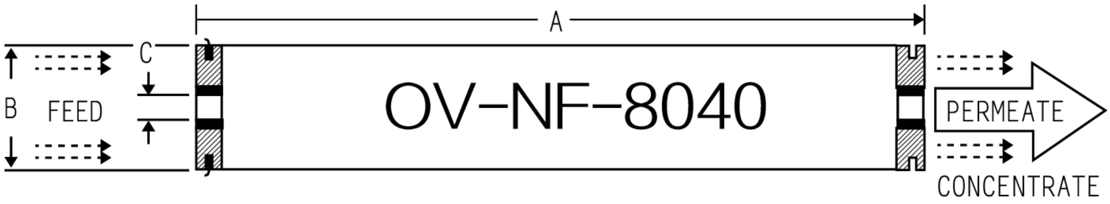
4. Limit Service Conditions

Maximum operation pressure	……………………………………..	600 psi(4.14 MPa)
Maximum inlet flow	……………………………………..	75 gpm(17 m^3/h) (8040) 16 gpm (3.6 m^3/h) (4040)
Maximum inlet temperature	……………………………………..	45℃
Maximum inlet SDI_{15}	……………………………………..	5
Free Chlorine Concentration in Inlet	……………………………………..	＜0.1 ppm
PH range of inlet during continuous operation	……………………………………..	3-10
PH range of inlet during chemical cleaning	……………………………………..	2-12
Maximum pressure drop of single	……………………………………..	15 psi (0.1 MPa)

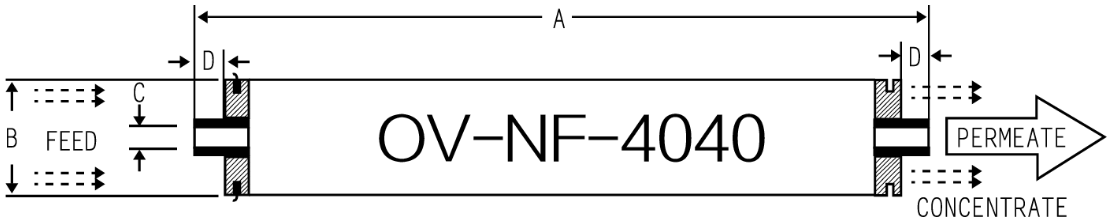
membrane element

5. Dimensions of Membrane Elements

All units shown in the diagram are in millimeters (inches)



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



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

Note: All dimensions of membrane elements in the illustration are not marked with tolerances

6. Important Information

- The water yield listed in the table is the average value, and the error of water yield of single membrane element is within 20%.
- The water produced in the first hour when the membrane element is used for the first time shall be discharged.
- When the membrane element leaves the factory, the dry membrane element has no protective solution, and once the element is wet, it should always be wet.
- The feed pressure should be gradually increased within a time range of 30-60 seconds, otherwise irreversible damage to membrane elements may be caused.
- Avoid back pressure on the water producing side at all times.
- Wet membrane elements are tested with water before leaving the factory, stored in 1.5% sodium bisulfite solution (10% propylene glycol antifreeze should be added in winter), and then vacuum packed.
- The system is shut down for a long time. In order to prevent microbial growth, it is recommended to immerse the membrane element in 1.5% (weight ratio) sodium bisulfite (food grade) protective solution and change the protective solution regularly.
- Users must strictly follow the operation limits and rules set in this manual, otherwise Hunan Ovay Technology Co., Ltd. will not bear all the consequences arising therefrom.
- Users are strictly forbidden to use any chemicals that have an impact on membrane elements during storage and operation. If such chemicals are used in violation, Hunan Ovay Environmental Protection Technology Co., Ltd. will not bear all the consequences arising therefrom.
- Due to technological progress and product upgrade, product technical data may be updated at any time.

Chapter III Hydrochemistry and Pretreatment

[3.1] Hydrochemistry

Because the functional layer of reverse osmosis and nanofiltration membrane is very thin, and fouling, scaling and membrane degradation are easy to occur in long-term operation, in order to improve the efficiency and service life of reverse osmosis and nanofiltration membrane system, the raw water must be effectively pretreated to minimize the possible damage factors to the functional layer of membrane. For different raw water quality conditions, selecting suitable pretreatment process and optimizing design parameters such as membrane element position arrangement and recovery rate can reduce fouling, scaling and membrane degradation, thus greatly improving system efficiency and realizing the optimization of system water yield, desalination rate, recovery rate and operation cost.

The selection and design of pretreatment scheme depends on water source, raw water composition and specific use conditions, which mainly depends on the source of raw water. Different water sources will adopt different pretreatment, for example, well water, surface water and municipal wastewater should be treated differently. Generally, the well water quality is stable and the possibility of pollution is low, so it only needs simple pretreatment, such as adding acid or scale inhibitor and 5 μm security filter. However, surface water flows on the ground all the year round, which is a kind of water source directly affected by seasons, and there is the possibility of high pollution from colloid and microorganism. Other pretreatments such as chlorine disinfection, flocculation/coagulation aid, clarification, multi-medium filtration, dechlorination, adding acid or scale inhibitor are needed. Industrial and municipal wastewater contains more complex organic and other inorganic components, some of which may seriously affect nanofiltration and reverse osmosis membranes, resulting in serious decline in water yield and irreversible membrane degradation. Once the selected inlet source is determined, a comprehensive and accurate raw water analysis must be carried out, which is the most critical basis for establishing a suitable pretreatment scheme and arranging design of nanofiltration and reverse osmosis systems.

3.1.1 Raw Water Type

In principle, for different types of water sources corresponding to different processes of pretreatment and different types of membrane elements, for small-scale engineering projects without water quality analysis or test conditions, the design can refer to the pretreatment of the projects that have been put into operation with the same type of water sources; However, for large-scale engineering projects, full water quality analysis must be carried out.

Raw water types of reverse osmosis system are divided in accordance with total dissolved solids content (TDS) and organism content:

- Seawater, TDS is generally about 35000 mg/L;
- Subsea water, TDS is generally between 5000 mg/L and 15000 mg/L;
- Brackish water, TDS is generally less than 5000 mg/L, which can be divided into surface water and groundwater in accordance with organism content;
- Tap water, TDS is generally less than 500 mg/L;
- RO produced water, TDS is generally less than 50 mg/L;

3.1.2 Raw Water Quality Analysis

The quality of raw water determines the selection of pretreatment process to a certain extent, and comprehensive water quality analysis data is an important guarantee for designing a reasonable pretreatment system and ensuring the long-term stable operation of reverse osmosis system. The water quality analysis report includes water quality types and main component indicators, and the required indicators include dissolved ions, silicon, colloids and organic matter (TOC), etc.

1. Water Temperature

The viscosity of water will decrease with the increase of temperature, and the change of water temperature will be quickly reflected in the water yield of membrane elements. In order to ensure stable water yield, the operation temperature of the system is very important. At the same time, if the temperature is too low, the solubility of silicate and sulfate will decrease, which will increase the scaling risk of the system and increase the operation cost. The increase of water temperature will lead to the decrease of desalination rate, which is mainly because the diffusion rate of salt through the membrane will be accelerated with the increase of water temperature.

2. Conductivity

Conductivity is an indicator to characterize the conductivity of ions in water, and its unit is μs/cm. The value of conductivity increases with the increase of ion concentration. However, the conductivity cannot accurately reflect the ion species, and even silicon ions have no effect on the change of conductivity.

3. Typical dissolved anions

Bicarbonate (HCO_{3}-), carbonate (CO_3^{2-}), hydroxide (OH^-), sulfate (SO_4^{2-}), chloride (Cl^-), fluorine (F^-), nitrate (NO_3^-), sulfur (S^{2-}), phosphate (PO_4^{3-})

4. Typical dissolved cations

Calcium ion (Ca^{2+}), magnesium ion (Mg^{2+}), sodium ion (Na^+), potassium ion (K^+), iron ion (Fe^{2+}, Fe^{3+}), manganese ion (Mn^{2+}), aluminum ion (Al^{3+}), barium ion (Ba^{2+}), strontium ion (Sr^{2+}), copper ion (Cu^{2+}) and zinc ion (Zn^{2+})

5. Organism

Organic compounds in water are usually characterized by BOD, COD, TOC and other indicators. Its main components include bacteria, pesticides, hormones, surfactants, etc. Different organisms have different effects on the membrane, and some specific organisms may accelerate the organic pollution of the system, resulting in short fouling time and increased cleaning frequency.

It is suggested to fill in the water quality analysis table of raw water in detail before design. The following is the list of water quality analysis items recommended by our Company.

Table 3.1 Raw Water Quality Analysis Table of Reverse Osmosis System

Raw water analysis unit		Date		Analyst	
Raw water source			Water source status		

Water sample temperature		PH value of water sample		Conductivity of water sample	
Turbidity (NTU)		SDI_{15} Value		ORP(mV)	
Ion composition	Content (ppm)	Ion composition	Content (ppm)	Ion composition	Content (ppm)
Calcium ion (Ca^{2+})		Ferrous ion (Fe^{2+})		Chloride ion (Cl^-)	
Magnesium ion (Mg^{2+})		Iron ion (Fe^{3+})		Sulfate radical (SO_4^{2-})	
Sodium ion (Na^+)		Aluminum ion (Al^{3+})		Carbonate (CO_3^{2-})	
Barium ion (Ba^{2+})		Nitrate (NO_3^-)		Bicarbonate (HCO_3^-)	
Strontium ion (Sr^{2+})		Silicon dioxide (SiO_2)		Phosphate (PO_4^{3-})	
Potassium ion (K^+)		Fluoride ion (F^-)		Other ions	
Hardness ($CaCO_3$ppm)			TDS Total dissolved solids (ppm)		
Total suspended solids (SS)			Total organic carbon TOC (ppm)		
Biological oxygen demand BOD (ppm)			Chemical oxygen demand COD (ppm)		
Total alkalinity (mmol/L)			Phenolphthalein alkalinity (mmol/L)		
Residual chlorine (ppm)			Number of bacteria (number/mL)		

The required indicators of reverse osmosis inlet water quality are shown in Table 3.2.

Table 3.2 Water Quality Indicators of Reverse Osmosis Membrane Inlet Water

Projects		Water inlet requirement
1	Turbidity (°)	＜1
2	Silt density index SDI_{15} value	＜5
3	pH Value	3-10
4	Water Temperature (℃)	4-45
5	Hardness (Ca, Mg) (mg/L)	Consider together with alkalinity
6	Alkalinity (HCO_3^-)(mg/L)	Consider together with hardness
7	BOD (mg/L)	＜10
8	COD_{Mn} (mg/L)	＜15
9	TOC (mg/L)	＜3
10	Free Chlorine (mg/L)	＜0.1
11	Iron (total)(mg/L)	＜0.05
12	Manganese (mg/L)	＜0.1
13	Cationic, amphoteric, neutral surfactant (mg/L)	Failure to be detected
14	Detergent, oil, H_2S, etc.(mg/L)	Failure to be detected
15	Sediment salt, etc.(mg/L)	Concentrated water does not precipitate
16	LSI	pH-pH_s is negative

[3.2] Prevention of Scaling

In the membrane element, insoluble salts are continuously concentrated. When the concentration exceeds its solubility limit, scaling will occur on the membrane surface of reverse osmosis or nanofiltration membrane. The higher the recovery rate of the system is, the greater the risk of scaling is. At present, it is a common practice to set up reverse osmosis concentrated water recovery system to improve the recovery rate due to the shortage of water sources or the consideration of environmental impact. In this case, it is particularly important to take carefully designed and considered scaling control measures, and prevent micro-soluble salts from exceeding their solubility and causing precipitation and scaling. In RO/NF system, the common insoluble salts are $CaSO_4$, $CaCO_3$ and SiO_2, and other compounds that may produce scaling are CaF_2, $BaSO_4$, $SrSO_4$ and $Ca_3(PO_4)_2$.

Scaling on the surface of reverse osmosis membrane occurs when the concentration of insoluble salt in concentrated water reaches saturation value. The scaling probability of insoluble salts is in the following order: $CaCO_3 > CaSO_4 > SiO_2 > SrCO_3 > BaSO_4 > SrSO_4 > CaF_2 > CaSiO_3 > MgSiO_3 > Ca_3(PO_4)_2 > Fe(OH)_2$.

The following table lists the solubility product data of insoluble inorganic salts.

Table 3.3 Solubility Product Constants of Insoluble Inorganic Salts (291-298K)

Name	Molecular formula	Ksp	pKsp	Name	Molecular formula	Ksp	pKsp
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 sulfate	$BaSO_4$	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 sulfate	$CaSO_4$	9.1×10^{-6}	5.04	Zinc sulfide	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
Cupric hydroxide	$Cu(OH)_2$	5.6×10^{-20}	19.25	Ferrous hydroxide	$Fe(OH)_2$	1.6×10^{-14}	13.80
Copper sulfide	CuS	8.5×10^{-45}	44.07	Ferrous sulfide	FeS	6.3×10^{-18}	17.20
Copper chloride	$CuCl_2$	1.2×10^{-6}	5.92	Ferric hydroxide	$Fe(OH)_3$	1.1×10^{-36}	35.96
Magnesium carbonate	$MgCO_3$	3.5×10^{-8}	7.46	Iron phosphate	$FePO_4$	1.3×10^{-22}	21.89
Magnesium fluoride	MgF_2	6.4×10^{-9}	8.19	Lead sulfate	$PbSO_4$	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 sulfate	$SrSO_4$	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

In order to prevent inorganic salt scaling on the membrane surface, the following measures shall be adopted:

1. Add acid

The chemical equilibrium formula of the reaction between calcium carbonate and acid is as follows:

$$CaCO_3 + H^+ \quad \longleftrightarrow \quad Ca^{2+} + HCO_3^-$$

After adding acid to water, H+increased, chemical dynamic equilibrium shifted to the right, and $CaCO_3$ changed more into $Ca(HCO_3)_2$. The acid should use high-quality acid above food grade. Sulfuric acid and hydrochloric acid are commonly used, and hydrochloric acid is best added to the water with the scaling possibility of $CaSO_4$, $SrSO_4$ and $BaSO_4$. In order to avoid $CaCO_3$ scaling, the pH value of concentrated water should be lower than the full pH value (pHs), and this relationship is expressed by Langlier index (LSI)(SDSI index is usually used for seawater).

$$LSI = pH - pH_S \ (TDS < 10000 \ mg/L)$$

Where: pH--the actual pH value in the aqueous solution

pHs--pH value of saturated calcium carbonate in aqueous solution

Usually, when LSI > 0, it is considered that the system will have scaling tendency, otherwise, it will not. Because the pH value of concentrated water is higher than that of water at other positions in a normal system, the pH value of concentrated water side is generally considered first.

When the content of TDS in water is more than 10,000 mg/L, Davis Index (SDSI) is needed to predict it.

$$SDSI = pH - pCa - pAlk - K$$

Where: pCa--negative logarithm of calcium ion molarity

pAlk--negative logarithm of alkalinity molarity

K--Constants Depending on Temperature and Ionic Strength

2. Adding Scale Inhibitor

The scale inhibitor is adsorbed around the nucleus to prevent the insoluble salt from contacting with the nucleus and slow down the formation of insoluble salt. In this way, crystals are prevented from growing up and forming suspended solids from concentrated water. In addition, there are many scale inhibitors with dispersity. The scale inhibitors with anionic negative charge wrap suspended salt particles and organism, and the wrapped particles repel each other to prevent condensation into larger particles and precipitation. The efficiency of many scale inhibitors in preventing carbonate scale, sulfate scale and calcium sulfate scale is described below.

Sodium hexametaphosphate (SHMP) is widely used as the scale inhibitor medicine because of its low price, but care must be taken not to let SHMP hydrolyze in the medicine chest. Fresh solution should be prepared every 3 days. Hydrolysis not only reduces the scale inhibition effect, but also may have the danger of calcium phosphate formation. The concentration of SHMP in concentrated water should be about 20 mg/L, so the calculation method of the concentration in inlet water is as follows: 20 mg/L×(1-recovery rate).

The hydrolysis of **organophosphate** is weak, but the price is more expensive than that of SHMP. Its scale inhibition and dispersion effects are similar to those of SHMP.

Polyacrylic acid (PAA) has a good effect on scale inhibition and dispersion. The molecular weight of PAA is generally between 2,000 and 5000. PAA with high molecular weight ranges from 6,000 to 25,000, and its dispersion performance is very good, but its scale inhibition ability is not very good. Generally speaking, the efficacy of PAA is better than that of SHMP. However, when there are cations in concentrated water, especially high valence cations such as aluminum ions and iron ions, precipitation may occur.

Mixed scale inhibitors are usually the mixture of high molecular weight and low molecular weight PAA, or the mixture of low molecular weight PAA or organophosphate. Its dispersion and scale inhibition performance are excellent.

There are many scale inhibitor manufacturers in the world. Please contact each scale inhibitor supplier for consultation on the chemical characteristics and compatibility with RO membrane. Generally, the concentration of scale inhibitor on the concentrated water side is allowed to be as high as 50ppm. Reverse osmosis product water shall be used to dissolve the scale inhibitor, because calcium ions that may exist in the raw water will react with the scale inhibitor. We should be alert to the growth of microorganisms in the scale inhibitor solution tank, and pay attention to the fact that there should be no excessive cationic polymers in the water when adding anionic scale inhibitor.

3. Ion Exchange

The removal rate of Ca^{2+}, Ba^{2+} and Sr^{2+} by some highly efficient ion exchange resins is more than 99.5%, which can eliminate the danger of various carbonate and sulfate scale.

Strong acidic cationic softener Softeners can be used to remove Ca^{2+}, Mg^{2+}, Ba^{2+}, Sr^{2+}, and Fe^{2+} in small and medium-sized reverse osmosis systems, thus effectively preventing scaling. The resin is regenerated with saturated salt water after the exchange saturation. The disadvantage of this process is that it increases the consumption of salt and the cost, and the environmental protection shall be considered in the discharge of the flushing water after regeneration. As an option, the latest countercurrent regeneration technology can minimize salt consumption.

Weak acidic cationic softener Weak acidic cationic resin can only remove that related to bicarbonate such as Ca^{2+}, Ba^{2+} and Sr^{2+}, and release H+, so that resins with pH as low as 4.2 can no longer exchange. Therefore, it is only partially softened, which is more suitable for raw water with high bicarbonate content.

4. Lime Softening

The chemical reaction of lime [$Ca(OH)_2$] with calcium bicarbonate and magnesium bicarbonate to remove hardness is as follows:

$$Ca(HCO_3)_2 + Ca(OH)_2 \rightarrow 2CaCO_3\downarrow + 2H_2O$$

$$Mg(HCO_3)_2 + 2Ca(OH)_2 \rightarrow Mg(OH)_2 + 2CaCO_3\downarrow + 2H_2O$$

Non-carbonate hardness can be removed by adding sodium carbonate (soda), and the reaction formula is as follows:

$$CaCl_2 + Na_2CO_3 \rightarrow 2NaCl + CaCO_3\downarrow$$

Lime and soda softening can also remove part of silicon. If the mixture of lime and magnesia is used, silicon can be reduced to 1mg/l. Similarly, lime softening can also reduce organism such as barium-strontium sulfate and humic acid, and its effluent water should adjust pH value. Generally, this method is only used for brackish water systems with a scale greater than $200m^3/h$ (1.2 million gallons/day).

5. Protective Quick Flushing

Some small reverse osmosis systems do not have scale inhibitor dosing devices and use protective rapid flushing to protect reverse osmosis membranes. These small systems often operate at a low recovery rate of 25%, and the membrane is changed for 1-2 years. The simplest quick flushing method is to open a large concentrated water valve and lower the working pressure. Rapid flushing for several times in a short time is more effective than long interval and low frequency flushing. For example, flush every 30 minutes for 30 seconds. On the basis of regular flushing, the membrane can also be cleaned regularly with chemicals.

6. Adjust System Recovery, PH and Temperature

The insoluble salt in concentrated water can be successfully controlled below the saturation value and prevented from precipitating by properly reducing the recovery rate, increasing the inlet water temperature and adjusting the pH value. In order to use the above measures more quantitatively, the saturation value of insoluble salt in concentrated water needs to be calculated in accordance with the following formula in terms of the actual situation. Only when preventing silicon scaling, the above three methods may be used at the same time. Because the low recovery rate increases the energy consumption, increasing pH increases the scaling risk of $CaCO_3$. For small systems, low recovery rate combined with protective rapid flushing is the traditional method to control scaling.

[3.3] Prevention of Colloidal Contamination

Colloid refers to particles with particle size ranging from 1 nanometer to 1 micron, which is difficult to settle naturally. Colloidal fouling can seriously affect the performance of reverse osmosis and nanofiltration elements, such as greatly reducing water yield and sometimes reducing desalination rate of the system. The initial symptom of colloidal and particle fouling is the increase of system pressure difference.

The best technique for judging the contamination degree of inlet water colloid fouling in reverse osmosis and nanofiltration is to measure the inlet sedimeutation index (SDI value), sometimes also called contamination index (FI value). It is an important indicator that should be measured before designing RO/NF pretreatment system, and it also needs to be detected regularly during the daily operation of RO.

The methods to control colloid fouling mainly include:

1. Media filtration

Media filters remove particles, suspended solids, and colloids based on the fact that particles, suspended solids, and colloids adhere to the surface of the filter media as water flows through the bed of the filter media. The quality of filtered effluent depends on the size of impurities and filter media, surface charge and shape, raw water composition and operation conditions, etc. If the design and operation are reasonable, $SDI_{15} \leq 5$ can usually be reached after being treated by media filter.

The most commonly used filter media in water treatment system are quartz sand and anthracite. The effective diameter of quartz sand particles in fine sand filter is 0.35~0.5 mm; and that of the particles in anthracite filter is 0.7~0.8 mm. When double media filter filled with anthracite on quartz sand is used, it allows impurities such as suspended solids to enter the filter layer, resulting in more effective deep filtration and prolonging cleaning interval. The minimum designed total bed depth of the filter medium is 0.8 m. In the dual-medium filter, quartz sand with a height of 0.5 m and anthracite with a height of 0.4 m are usually filled.

There are two types of filters, gravity filtration and pressure filtration. Because the pressure filter cylinder can withstand pressure, and can use higher filter bed, finer filter media particle size and higher filtration speed, the designed filtration flow rate is usually less than 10~20m/h, and the backwashing flow rate is 40~50m/h. For the raw water with high pollution tendency (such as surface water, polluted well water or wastewater), the filtration flow rate must be less than 10m/h (generally 5m/h) or a secondary media filter must be used. For the water body with less colloid (groundwater), a higher filtration rate can be selected.

2. Oxidation-Filtration

Typically, some well water with the salt content in the brackish range is in a reduced state, typically characterized by divalent iron and manganese, and sometimes hydrogen sulfide and ammonia. If this kind of water source is treated by chlorination, or when the oxygen content in the water exceeds 5mg/L, Fe^{2+} will be converted into Fe^{3+}, forming insoluble colloidal hydroxide particles. The oxidation reaction of iron and manganese is as follows:

$$4Fe(HCO_3)_2 + O_2 + 2H_2O \rightarrow 4Fe(OH)_3 + 8CO_2$$

$$4Mn(HCO_3)_2 + O_2 + 2H_2O \rightarrow 4Mn(OH)_3 + 8CO_2$$

Because iron oxidation occurs at extra-low pH value, iron pollution occurs more than manganese pollution. Even if SDI is less than 5 and iron content in RO inlet water is less than 0.1 mg/L, iron pollution will still occur.

The inlet water with low alkalinity has higher iron ion content, because the solubility of $FeCO_3$ will limit the concentration of Fe^{2+}.

One way to treat such water sources is to prevent contact with air and any oxidants such as chlorine throughout the RO process. Low pH value is beneficial to delay the oxidation of Fe^{2+}. When pH < 6 and oxygen content < 0.5mg/L, the maximum allowable concentration of Fe^{2+} is 4mg/L. Another method is to use air, Cl_2 or $KMnO_4$ to oxidize iron and manganese to remove the formed oxides through a media filter. However, it should be noted that colloidal sulfur formed by hydrogen sulfide oxidation may be difficult to be removed by the filter. Adding oxidant to the media filter to oxidize Fe^{2+} through electron transfer can complete oxidation and filtration at the same time.

Glauconite is such a granular filter media. When its oxidation ability is exhausted, it can be regenerated by oxidation of $KMnO_4$. After regeneration, the residual $KMnO_4$ must be completely washed away to prevent oxidative damage to the membrane. When the content of Fe^{2+} in raw water is less than 2mg/L, this treatment method can be adopted. For example, when the content of Fe^{2+} in raw water is higher, $KMnO_4$ can be continuously added before the filter is inlet of water. However, in this case, measures must be taken, such as installing activated carbon filter to ensure that no potassium permanganate enters the membrane element.

Birm filtration can also be effectively used to remove Fe^{2+} from RO/NF inlet water. Birm is a filter medium coated with manganese dioxide on aluminum silicate substrate, which catalyzes the reaction between dissolved oxygen and ferric oxide, so that soluble ferric oxide and manganese form precipitates, and these precipitates can be flushed out of the filter by backwashing through the filter. Because of the increase of pH, LSI value may be changed, and it is necessary to prevent $CaCO_3$ precipitation in filter and RO/NF system.

3. Flocculation-Coagulation Aid

Flocculation is to neutralize the surface charge of colloidal particles by adding flocculant, which makes it easier for colloidal particles to aggregate. When the content of suspended solids and SDI in raw water is high, the traditional treatment process of coagulation-coagulation aid is best adopted. The hydroxide flocs produced grow and precipitate in a specially designed reaction space, and are discharged in the form of silt. The supernatant enters a multi-media filter for further treatment.

4. Microfiltration or Ultrafiltration

Microfiltration (MF) or ultrafiltration (UF) membranes can remove all suspended solids. Ultrafiltration can also remove some organisms in accordance with the molecular weight of organism and the molecular weight cut off by the membrane. If the design and operation are properly managed, SDI can be less than 1. At this time, the pollution problem is transferred from RO/NF membrane to MF or UF membrane, and solved by MF or UF system. However, after using MF or UF as pretreatment, the pollution is only reduced. RO/NF still needs to consider many factors, such as membrane element selection, arrangement and operation economy. If MF and UF membrane materials can resist chlorine, such as polysulfone membrane or ceramic membrane, chloroform shall also be added to cleaning water to prevent biological pollution.

5. Filter Element Filtration

Reverse osmosis and nanofiltration systems shall be equipped with a filter element type security filter with a minimum pore diameter of less than 10μm, which protects the membrane and high-pressure pump from possible damage of suspended particles. When the concentration of silicon in concentrated water exceeds the theoretical solubility, it is suggested that the pore diameter of filter element shall be 1μm to reduce the interaction between silicon and iron and aluminum colloids. Filter elements must be selected in accordance with the manufacturer’s recommended filtration flow rate and replaced before the pressure drop exceeds the allowable limit, but preferably not for more than three months.

6. Design and Operation Schemes

Preventing colloid and particle contamination is not only related to appropriate pretreatment technology, but also involves reasonable system design and operation. In order to reduce the burden of pretreatment and improve the inlet water quality, water sources with better water quality shall be used as much as possible. Water intake from surface water and seawater treatment systems is extremely important. Contamination of raw water by effluent discharge will cause serious operational problems for the RO/NF plant, as the existing systems are not designed for effluent sources, preferably from deep wells close to coasts and rivers, and if surface open water intake is necessary, as far away from the embankment as possible and requires the intake to be several metres below the surface. The newly-built well will release suspended solids in the first few days of use, so it is necessary to pay attention to proper cleaning first. Iron oxide pollution is also a common problem, and non-corrosive materials must be selected for manufacturing systems.

[3.4] Prevention of Membrane Biological Fouling

All raw water contains microorganisms: bacteria, algae, fungi, viruses and other higher organisms. The general size of bacteria is 1~3 μm. The difference between bacteria and inanimate particles is that they have reproductive ability and form biological membrane under suitable living conditions. When the thickness of biological membrane exceeds a certain limit, biological pollution will be formed.

Biological fouling of membrane elements will seriously affect the performance of reverse osmosis system, resulting in the rapid increase of pressure difference between inlet water and concentrated water, resulting in "telescoping" and mechanical damage of membrane elements and the decline of membrane water yield. Sometimes biological fouling even occurs at the water yield side of membrane elements, resulting in product water pollution.

1. Culture Method

The concentration of bacteria in water is an important factor affecting biological pollution. Total bacterial count (TBC) is a quantitative expression of the total number of existing microorganisms in water samples. In accordance with the method specified in ASTM F60, the total bacterial count is determined by filtering a certain amount of water samples by membrane filtration. The biological tissues accumulated on the surface of filter media are cultured in certain nutrients to form colonies, which can be observed and counted through a low magnifier. The main advantage of this method is that it can be carried out without expensive instruments and equipment, but the determination results cannot be obtained until 7 days later, and the counted colonies are only about 1~10% of the actual living microorganisms. However, culture technology is still an effective method to indicate the possibility and trend of microbial contamination. It can be used to observe the situation of inlet water, concentrated water and produced water. If the total number of bacteria in concentrated water increases, it indicates that biological membrane fouling occurs in membrane elements.

2. Direct Bacterial Count

Direct counting technology is to filter water samples first, and then count the microorganisms accumulated on the filter media directly under a microscope. In order for microorganisms to be visible, they must be colored with safranine and then counted under a transparent fluorescence microscope.

In this way, the exact number of total microorganisms can be obtained immediately, and the types of microorganisms can be distinguished from the sedimentary particles. However, it is impossible to distinguish the life and death of cells and tissues. At this time, INT technology shall be used, and the place where INT staining decreases is caused by enrichment of living cells, so that living cells can be distinguished from dead cells by using phase difference and differential interference contrast microscope. Because it is faster and more accurate than culture method, direct bacterial counting method shall be preferred.

3. Biological Membrane Detection

Microbial content in raw water, inlet water of membrane device and concentrated water is an important indicator to evaluate potential biological pollution. However, other factors such as the concentration and type of nutrients and operation parameters also determine the development trend of biological membrane. During the actual system operation, it is also effective to carefully check the filter element of the security filter and the inner surface of the water inlet and concentrated water pipes regularly. When slime and peculiar smell appear, it indicates microbial contamination.

[3.5] Biological Pollution Control

1. Chlorine Sterilization

Chlorine has long been used as a disinfectant to treat municipal and industrial water and wastewater because it can quickly inactivate many pathogenic microorganisms. The efficiency of chlorine depends on the concentration of chlorine, contact time and pH value of water. It is commonly used to sterilize drinking water, and the residual chlorine concentration is generally 0.5 ppm. In the industrial water treatment process, the residual chlorine concentration in water is maintained at 0.5~1.0 ppm.

Usually, chlorine disinfection is needed in the reverse osmosis pretreatment part to prevent microbial pollution, and the reaction time is maintained for 20~30 minutes, so that the residual chlorine concentration in the whole pretreatment pipeline can be maintained at 0.5~1.0 ppm. However, before entering the membrane element, it must be thoroughly dechlorinated to prevent the membrane from being destroyed by chlorine oxidation.

2. Ozone

Ozone is more oxidizing than chlorine, but it can be decomposed quickly. Therefore, it is necessary to maintain a certain level to kill microorganisms. At the same time, the ozone resistance of the equipment used shall be considered. Stainless steel is usually selected. In order to protect membrane elements, ozone must be carefully removed.

3. Ultraviolet Irradiation

Ultraviolet light of 254 nm has been proved to have bactericidal effect. It has been applied in small water plants. It does not need to add chemicals to water, and the equipment maintenance requirements are low. Only regular cleaning or replacement of mercury vapor lamps is needed. However, the application of ultraviolet irradiation is very limited, and it is only suitable for cleaner water sources, because colloids and organic matter will affect the penetration of light radiation.

[3.6] Organic Pollution Control

The adsorption of organism on the membrane surface will cause the loss of membrane flux, and irreversible flux loss will occur in especially serious cases. When the organic matter with high molecular weight is hydrophobic or positively charged, this adsorption process is easier to carry out; The main organism in natural water is humic acid, which is usually 0.5-20mg/L in terms of TOC content. When TOC exceeds 3mg/L, special consideration shall be given to removing the organicsm in pretreatment. Humic acid substances can be removed by flocculation process containing hydroxyl-flocculant, ultrafiltration or activated carbon adsorption. When the content of oil (hydrocarbon or silicon-based) and fat in inlet water into RO/NF exceeds 0.1mg/L, flocculation or activated carbon filtration must be adopted. These organisms will be adsorbed to the membrane surface at any time, however, if the resulting flux value drops by no more than 15%, they can be washed away by alkalic cleaning agent.

[3.7] Prevent the Degradation of Membrane Itself

In addition to preventing some substances in the inlet water of RO/NF system from fouling the membrane, it is also necessary to consider the chemical stability of the membrane material itself to these substances. Once the micro-structure or molecular structure of the membrane is changed due to physical or chemical attack, the performance of the membrane will decline irreversibly. In general, all oxidants are harmful to polyamide composite membranes, so they must be completely removed in the pretreatment process.

Chapter IV The Guide to the Use of OVAY Reverse Osmosis System Design Software

This section introduces some typical reverse osmosis water treatment projects treated by OVAY to illustrate the method of reverse osmosis design using OVAY reverse osmosis design software (latest version V1.0).

[4.1] Installation Requirements of OVAY Reverse Osmosis Software

1. Operation System

This software is suitable for WINDOWS 98 or above operation systems.

2. Installation Method

Before the installation, all other application software shall be closed, double-click SETUP to install the software, click “Confirm Acceptance” in all processes, and follow the path of “Next” to complete the installation.

[4.2] The Use of the Software

1. Double-click the “OVAY Reverse Osmosis System Simulation Software Icon” on the desktop to start OVAY RO design software, as shown in the following Figure (4.1).

(Figure 4.1)

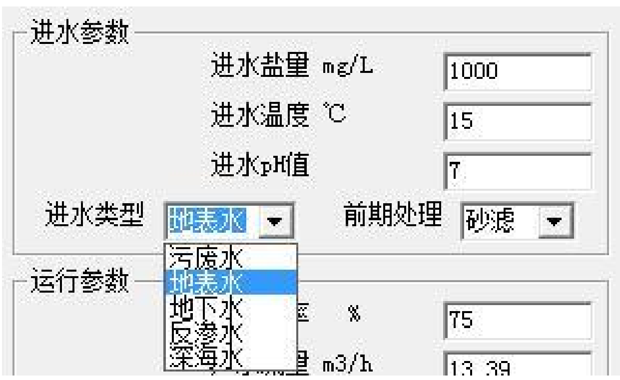
2. On the startup interface, click System Simulation to enter the main interface, as shown in the following Figure (4.2).

(Figure 4.2)

3. Input of system basic parameters

On the main interface, the design projects, design units and designers in the project overview can be custom written.

In the part of inlet water parameters, salt content, inlet water temperature and inlet water PH value can be set, and at the same time, inlet water types can be selected, which can be divided into sewage, surface water, groundwater, reverse osmosis water and deep sea water in accordance with the difference of water quality. As shown in Figure (4.3) below, the pretreatment can also be sand filtration or ultrafiltration.



(Figure 4.3)

4. System Design

The operation simulation of membrane system is always aimed at specific inlet water quality conditions, so the operation simulation software always needs to input specific inlet water quality parameters. As shown in Figure (4.4), the basic parameter input interface has project overview, inlet water parameters, operation parameters, pollution parameters, operation method, membrane segment structure, membrane segment parameters and element parameters.

(Figure 4.4)

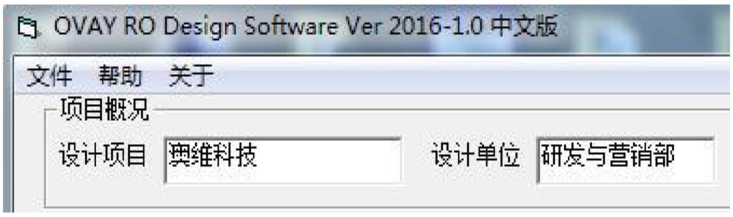
- The project overview column includes the parameter items such as design projects, design units, designers and time.
- The inlet water parameters column includes inlet water salinity, inlet water temperature, inlet water type and other parameters.
- The operation parameters column includes water yield flow rate, system recovery rate, membrane average flux and other parameters.
- The column of pollution parameters includes simulated operation period, annual growth rate of permeable salt, annual decline rate of permeable water and other parameters.
- The operation method includes inter-segment pressurization, permeate back pressure, fresh water reflux, concentrate recirculation and other parameters.
- The parameters of membrane segment include the variety of membrane elements, the number of membrane shells in each segment, the number of membrane shell elements and other parameter items.
- Element parameters include working pressure, permeable salt rate and membrane pressure decline of each membrane segment, membrane shell and each element.

In the above parameters, the number of membrane segments determines the number of membrane segments displayed in the column of membrane segment parameters and element parameters; The number of membrane shells per segment and the number of elements per shell in the column of membrane segment parameters determine the number of membrane shells and elements displayed in the column of element parameters; The flow rate of water yield in the column of operation parameters and the variety of membrane elements, the number of membrane shells in each section and the number of membrane elements in each shell in the column of membrane segments parameters determine the membrane average flux in the column of system parameters. Each parameter item in the Operation Method option column is an option. If it is not selected, it will not be set accordingly.

There are also three command keys in the basic parameter input interface: (return to simulation), (file save) and (software exit). Click the (Return to Simulation) command key, and the software will exit the basic parameter input interface and return to the initial interface of the software. Click the (file save) command key to save the results of system simulation calculation, and pop up the output interface of the save window to save the simulation calculation results, as shown in the following Figure (4.5).

(Figure 4.5)

This V1.0 software sets the pre-segment pressure drop and post-segment pressure drop of each membrane segment, but the default numbers of these additional parameters are all zero, as shown in Figure (4.6). The basic parameter input interface is equipped with three pull-down menus: (file), (help) and (about). (File) pull-down menu provides add, open, save, and print functions for the files formed by inputting parameters into each interface, so as to facilitate repeated analysis and research on specific parameter systems. The (Help) pull-down menu will give instructions for using the simulation software and related e-books. The (about) pull-down menu provides the version description of the software.



(Figure 4.6)

5. System Operation Method Setting

The operation method option column in the basic parameter input interface covers the special operation method options of four types of systems: inter-segment pressurization, permeate back pressure, fresh water reflux and concentrate recirculation, as shown in Figure (4.7). In accordance with the number of membrane segments in the system, the inter-segment pressurization option can set an inter-segment pressurization pump between the front and rear segments to improve the feed pressure in the rear segment; Fresh water back pressure option can set fresh water back pressure valve in the front membrane segment to increase the fresh water back pressure in this segment; Fresh water reflux option can set fresh water reflux at the end of the last membrane segment of the system; The concentrate recirculation option can set the concentrate recirculation at the end of the last membrane segment of the system.

(Figure 4.7)

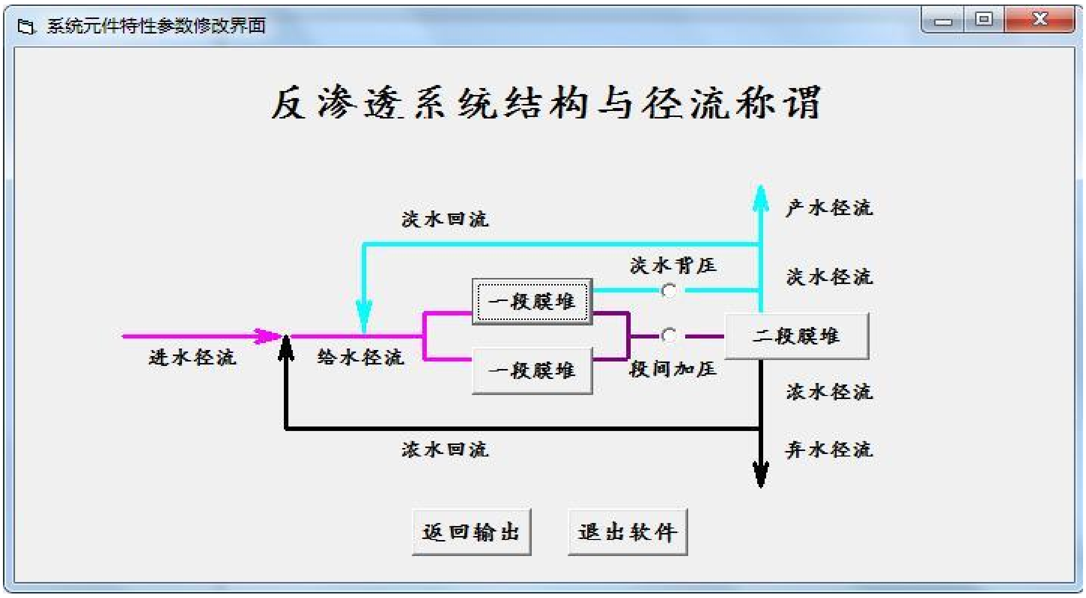
6. Run the Simulation Report

After completing all the input operation in the basic parameter input interface, click (simulation calculation) to carry out simulation calculation of system operation. After the simulation calculation is finished, the operation parameter output interface as shown in Figure (4.8) will pop up to display the system operation parameter report. The interface mainly composes of six columns, such as system operation parameters, element operation parameters, system operation parameter curve, modification of parameter identification, operation method option and operation parameter alarm.

(Figure 4.8)

The system operation parameters column shows the system operation parameters such as system working pressure, system recovery rate, fresh water flow rate, fresh water concentration, concentrated water flow rate, concentrated water concentration, permeable salt rate and system power consumption.

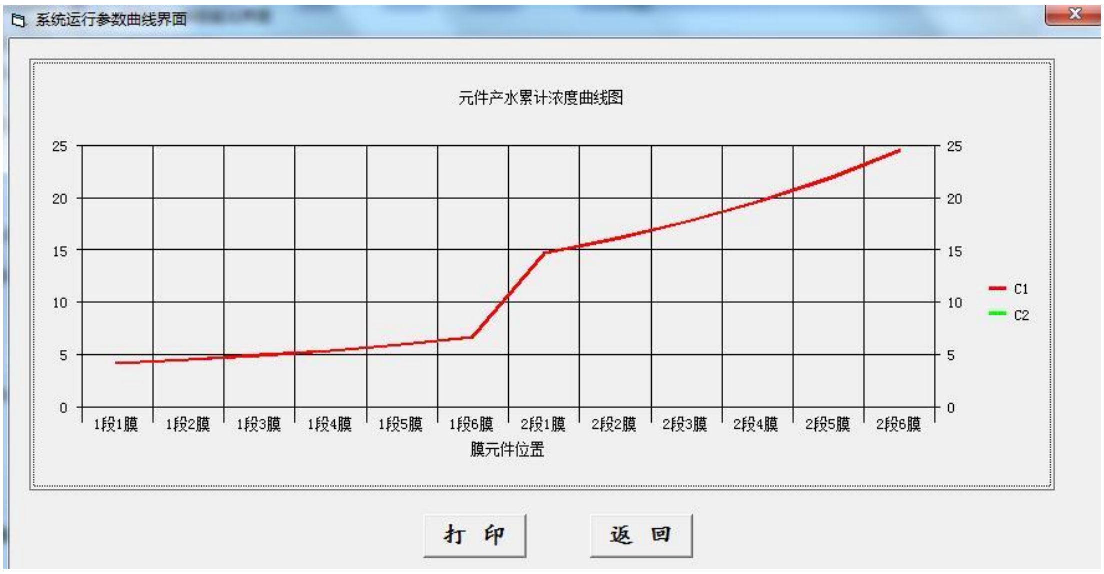
The element operating parameters column shows the operation parameters of each membrane segment, each membrane shell and each membrane element of the system such as feed pressure, feed water flow, concentrated water flow rate, water yield flow rate, feed water salinity, concentrated water salinity, fresh water salinity, recovery rate and concentration polarization; The operation parameters such as average water yield flux, average fresh water concentration, terminal concentrated water pressure and membrane pressure drop of each membrane shell and each membrane segment are also displayed. The system structure is shown in Figure (4.9).



(Figure 4.9)

In the system operation parameter curve column, there are (feed pressure)(feed water flow)(produced water flow)(concentrated water flow)(produced water concentration)(feed water concentration)(element recovery rate)(concentrated water concentration)(concentration polarization) and other curve drawing buttons. Click the relevant button to pop up the interface of the change curve of corresponding parameters along the system flow. As shown in Figure (4.10) for example.

There is also a (file) pull-down menu in the operation parameter output interface, which provides the functions of creating, opening, saving and printing files formed by system simulation calculation result data, so as to facilitate repeated analysis and research on simulation calculation of specific systems.

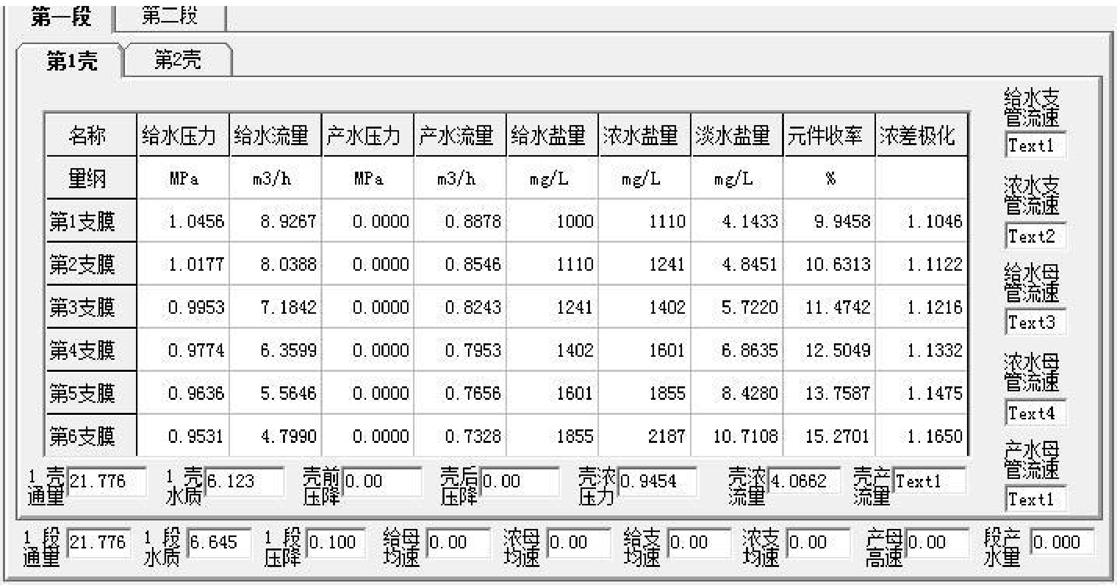


(Figure 4.10)

7. Modification of Element Characteristics

Click the option key (element characteristics) in the basic parameter input interface, and the parameter modification window interface will pop up. In the element characteristics interface, the relationship structure among each segment, shell and element in the system membrane stack will be displayed.

The simulation software has given corresponding default numbers to the original parameters in the element characteristic interface. When modifying the permeance coefficient of a segment, a shell or an element in the element characteristic interface, click on the parameter item to pop up a form similar to that shown in Figure (4.11), and modify relevant parameters in the form. Click the command keys (confirm modification), (restore parameters) and (exit modification) in the element characteristic interface to execute corresponding operations and return to the basic parameter input interface, cancel data modification and restore interface parameters, cancel data modification and exit the element characteristic interface, etc.



名称	给水压力	给水流里	产水压力	产水流里	给水盐里	浓水盐里	淡水盐里	元件收率	浓差极化
里纲	MPa	m3/h	MPa	m3/h	mg/L	mg/L	mg/L	%	
第1支膜	1.0456	8.9267	0.0000	0.8878	1000	1110	4.1433	9.9458	1.1046
第2支膜	1.0177	8.0388	0.0000	0.8546	1110	1241	4.8451	10.6313	1.1122
第3支膜	0.9953	7.1842	0.0000	0.8243	1241	1402	5.7220	11.4742	1.1216
第4支膜	0.9774	6.3599	0.0000	0.7953	1402	1601	6.8635	12.5049	1.1332
第5支膜	0.9636	5.5646	0.0000	0.7656	1601	1855	8.4280	13.7587	1.1475
第6支膜	0.9531	4.7990	0.0000	0.7328	1855	2187	10.7108	15.2701	1.1650

(Figure 4.11)

Appendix: Sample of Operation Simulation Report of Reverse Osmosis System

Operation Simulation Report of Reverse Osmosis System

============Design Basic Parameters============

Overview of work	Project Name:	OVAY Technology	Design unit:	OVAY Technology	Designer:	Liu Yuanli		
Inlet water parameter	Salt content of inlet water:	1000 ppm	Inlet water temperature:	15 °C	Type of inlet water:	Surface water	Process type:	Sand filter
System requirements	Water production flow:	13.39 m^3/h	System yield:	75 %				
Operation condition	Membrane average flux:	20.00 L/m^2h	Operation period:	0 a	Permeable salt gaining rate:	10 %	Permeability decay rate:	12 %
System structure	Number of system segments:	2	Total number of containers:	3	Total number of elements:	18		
Component variety	1 segment:	OV-L-8040-400	2 segment:	OV-L-8040-400	3 segment:	OV-L-8040-400		
Number of containers	1 segment:	2	2 segment:	1	3 segment:	0		
Number of elements	1 segment:	6	2 segment:	6	3 segment:	0		

============Special Operation Method========

1-2 inter-segment pressurization:	0.00 MPa		
Fresh water back pressure in segment 1:	0.00 MPa	Fresh reflux flow:	0.00 m^3/h
Concentrate recirculation flow:	0.00 m^3/h		

============Standard Element Parameter============

============System Parameter Distribution============

Work pressure	1.045 MPa	Water production flow	13.38 m^3/h	Discarded water flow	4.463 m^3/h	System yield	74.99 %
Concentrated	0.855 Mpa	Produced	11.53 mg/L	Concentrated	3965. mg/L	Systematic	98.84 %

water pressure		water concentration		discard concentration		desalination		
Inlet water flow	17.85 m^3/h	Fresh water flow	13.38 m^3/h	Concentrated water flow	4.463 m^3/h			
Acidity of inlet water	7.000	Acidity of produced water	6.567	Acidity of concentrated water	7.501			
One-segment pressure feeding	1.046 Mpa	Two-segment pressure feeding	0.945 Mpa	Three-segment pressure feeding	0.856 Mpa			
One-segment water supply	17.85 mg/L	Two-segment water supply	8.13 mg/L	Three-segment water supply	4.46 mg/L			
One-segment water production	0.00 m^3/h	Two-segment water production	0.00 m^3/h	Three-segment water production	0.00 m^3/h			
Fresh water reflux concentration	24.50 mg/L	Concentrate recirculation concentration	3965 mg/L					
Feed parent speed	0.000 m/s	Concentrated parent speed	0.000 m/s	Production parent speed	0.000 m/s			
Operation Parameter Warning:	Shell feed water flow:	Within boundary	Shell concentrated water flow:	Within boundary	System flux:	Within boundary	Concentration polarization:	Within boundary

First Segment	Segment average flux	21.7 Lmh	Water quality of segment production	6.64 mg/L	Segment pressure drop	100.2 kPa	Component variety	OV-L-8040-400
First shell	Pressure drop in front of shell	0.00 kPa	Pressure drop behind shell	0.00 kPa	Shell average flux	21.7 Lmh	Water quality of shell production	6.64 mgL
	Shell water supply	8.93 m^3/h	Shell water yield	4.86 m^3/h	Concentrated water of shell	4.07 m^3/h	Shell cross-flow ratio	1.337
First shell	The First Branch Membrane	The Second Branch Membrane	The Third Branch Membrane	The Fourth Branch Membrane	The Fifth Branch Membrane	The Sixth Branch Membrane	Dimension	

Inlet water pressure	1.045	1.017	0.995	0.977	0.963	0.953	MPa
Feed water flow	8.926	8.038	7.184	6.359	5.564	4.798	m^3h
Concentrated	8.038	7.184	6.359	5.564	4.798	4.066	m^3h

water flow							
Water production flow	0.887	0.854	0.824	0.795	0.765	0.732	m^{3}h
Salt content of feed water	1000.	1109.	1241.	1401.	1600.	1855.	ppm
Salt content of concentrated water	1109.	1241.	1401.	1600.	1855.	2187.	ppm
Salt content of produced water	4.143	4.845	5.722	6.863	8.427	10.71	ppm
Element yield	9.945	10.63	11.47	12.50	13.75	15.27	%
Concentration polarization	1.104	1.112	1.121	1.133	1.147	1.164	

Second shell	Pressure drop in front of shell	0.00 kPa	Pressure drop behind shell	0.00 kPa	Shell average flux	21.7 Lmh	Water quality of shell production	6.64 mgL
	Shell water supply	8.93 m^3/h	Shell water yield	4.86 m^3/h	Concentrated water of shell	4.07 m^3/h	Shell cross-flow ratio	1.337

Second shell	The First Branch Membrane	The Second Branch Membrane	The Third Branch Membrane	The Fourth Branch Membrane	The Fifth Branch Membrane	The Sixth Branch Membrane	Dimension
Inlet water pressure	1.045	1.017	0.995	0.977	0.963	0.953	MPa
Feed water flow	8.926	8.038	7.184	6.359	5.564	4.798	m^{3}h
Concentrated water flow	8.038	7.184	6.359	5.564	4.798	4.066	m^{3}h
Water production flow	0.887	0.854	0.824	0.795	0.765	0.732	m^{3}h
Salt content of feed water	1000.	1109.	1241.	1401.	1600.	1855.	ppm
Salt content of concentrated water	1109.	1241.	1401.	1600.	1855.	2187.	ppm
Salt content of produced water	4.143	4.845	5.722	6.863	8.427	10.71	ppm
Element yield	9.945	10.63	11.47	12.50	13.75	15.27	%
Concentration polarization	1.104	1.112	1.121	1.133	1.147	1.164	

Second Segment	Segment average flux	16.4 Lmh	Water quality of segment production	24.5 mg/L	Segment pressure drop	89.43 kPa	Component variety	OV-L-8040-400

Second shell	Pressure drop in front of shell	0.00 kPa	Pressure drop behind shell	0.00 kPa	Shell average flux	16.4 Lmh	Water quality of shell production	24.5 mgL
	Shell water supply	8.13 m^3/h	Shell water yield	3.67 m^3/h	Concentrated water of shell	4.46 m^3/h	Shell cross-flow ratio	1.717

First shell	The First Branch Membrane	The Second Branch Membrane	The Third Branch Membrane	The Fourth Branch Membrane	The Fifth Branch Membrane	The Sixth Branch Membrane	Dimension
Inlet water pressure	0.945	0.922	0.903	0.887	0.874	0.864	MPa
Feed water flow	8.132	7.429	6.763	6.133	5.539	4.981	m^3h
Concentrated water flow	7.429	6.763	6.133	5.539	4.981	4.463	m^3h
Water production flow	0.703	0.666	0.630	0.594	0.557	0.518	m^3h
Salt content of feed water	2187.	2393.	2626.	2894.	3202.	3556.	ppm
Salt content of concentrated water	2393.	2626.	2894.	3202.	3556.	3965.	ppm
Salt content of produced water	14.67	17.56	21.21	25.94	32.22	40.78	ppm
Element yield	8.645	8.964	9.315	9.686	10.05	10.40	%
Concentration polarization	1.090	1.093	1.097	1.101	1.105	1.109	

============Calculation Report End============

[4.3] Test

The system performance of a water treatment system with a clear source and composition can be accurately predicted by computer design software, but in some cases, it is recommended to obtain a suitable system design through experiments, including:

- Unable to understand the inlet water quality and special quality requirements of produced water;
- Unable to understand the fluctuation of inlet water quality;
- Extremely high system recovery rate (> 80%);
- Special or new application areas, such as new processes or wastewater treatment;
- Large system: more than 500m^3/h (3.5mgd).

Chapter V Installation and Operation

[5.1] Membrane Element Installation

5.1.1 Preparation before Installation

1. Check whether the toolbox for disassembling and assembling endplates, glycerin for lubrication, waterproof shoes, gloves and other protective equipment are fully prepared.
2. Check the water inlet pipeline of the membrane system upstream to ensure that there is no silt, oil, metal debris, etc., and confirm that the upstream pipeline, pressure vessel, and high-pressure pipeline have been flushed clean.
3. Check whether the pretreatment of produced water meets the requirements of reverse osmosis/nanofiltration inlet water quality, such as SDI, turbidity, residual chlorine, temperature, pH, ORP, etc. Before installing membrane elements, flush the system with pre-treated qualified water for 30 minutes and check the pipeline for leaks.
4. Flush the opened pressure container with clean water to remove dust and sediment. If conditions permit, 50% glycerine aqueous solution can be used to wet the inner wall of the pressure container to facilitate the installation of membrane elements.

5.1.2 Installation of Elements

1. Carefully remove the membrane element from the packing container and check whether the position and direction of the concentrated water seal ring on the element are correct. Apply a small amount of glycerol to the inner walls of the central pipes at both ends of the first branch membrane element for lubrication.
2. Push the end of the membrane element without salt water seal ring parallel from the water inlet end of the pressure container until the element is exposed about 15cm outside the water inlet end of the pressure container. Apply a small amount of glycerin to the concentrated water seal ring and the “O” ring at both ends of the membrane element connector. The first membrane element is secured to prevent it from being pushed into the pressure container and a segment of the connector is inserted into the center tube of the first membrane element.
3. Carefully remove the second branch membrane element from the packing container, also check whether the position and direction of the concentrated water seal ring on the element are correct, apply a small amount of glycerin in the central pipes at both ends, carefully hold the element and let the connector on the first branch element be inserted into the central production pipe of the element. To prevent the connector from being damaged by the natural fall of the second branch membrane element outside the pressure container, push the element into the pressure container in parallel until the second branch element is exposed about 15cm outside, apply a small amount of glycerin on the concentrated water seal ring and the “O” ring of the connector, and insert one end of the connector into the central pipe of the second branch membrane element.
4. Repeat step 3 until all membrane elements are loaded into the pressure container, noting that the last membrane element does not need to be inserted into the connector. Transfer to the concentrated water end, and install a connector on the water production center pipe of the first branch membrane element.
5. Refer to the pressure container manufacturer’s schematic diagram, install a thrust ring at the concentrated

water end of the pressure container. If no the installation of the thrust ring, the membrane element will be seriously damaged.

6. Install the endplate of the concentrated water end of the pressure container first in accordance with the following steps.

- Carefully check the “O” ring on the element adapter (transition joint between element and endplate, commonly known as grenade), insert the element adapter into the concentrated water endplate, carefully position the concentrated water endplate of the pressure container for the connection with external pipeline, and push the concentrated water end plate assembly into the pressure container in parallel with the element connector.
- Rotate and adjust the concentrated water endplate assembly so as to align it with the external connection pipe.
- Install the endplate snap ring with reference to the schematic diagram provided by the pressure container manufacturer.

7. Push the membrane element from the water inlet end to the water outlet end until the first installed membrane element is firmly in contact with the concentrated water end plate.
8. Install the inlet endplate similar to Step 6. Before installing the inlet endplate, it is recommended to adjust the gap between the membrane element and the end plate with a tab. Installation of the tab prevents the components from shifting in the axial direction and the impact between the components when the system is started and shut down.
9. Repeat the above steps and install the membrane element with the pressure container.
10. After installation of membrane elements for all pressure containers, install all external water inlet, concentrated water and production water lines.

5.1.3 Remove Elements

When the membrane element is to be removed from the system pressure container, it shall be performed by two persons as follows:

1. Remove the external nozzles at both ends of the pressure vessel, remove the endplates and sealing assemblies at both ends of the pressure container, number all the removed parts and put them in order.
2. Push out the membrane elements from the water inlet end of the pressure container in turn. Only one membrane element is allowed to be pushed out at a time. When the membrane element is pushed out of the pressure container more than 1/3 of the length of the element, another person should hold the membrane element so that the membrane element can be pushed out of the pressure container in parallel as far as possible to prevent the connector and membrane element from being damaged or injured due to the natural falling of the membrane element.

[5.2] Operation of System First Running

5.2.1 Equipment Preparation

The first test run of the system shall be carried out immediately after installing the membrane elements. Before the test run, the following equipment shall be prepared:

1. SDI tester;
2. Thermometer;
3. pH meter;
4. Conductivity meter;
5. Protective glasses;
6. Weighing balance;
7. Water sample sampling bottle;
8. Analytical instruments, mainly including test instruments for measuring the following water quality index: total hardness, calcium ions, total alkalinity, chloride, sulfate, iron ions, silicon dioxide, free chlorine (active chlorine), TOC, redox potential ORP and chromaticity.

5.2.2 Start Inspection

Check items before startup:

1. All pipelines and equipment shall conform to the design pressure.
2. All pipelines and equipment can meet the pH range (2-12) specified in the design.
3. All equipment including pipelines, containers, meters and water pumps shall be made of corrosion-resistant materials, and flowmeters and gauges shall be calibrated.
4. A clean new security filter element is installed immediately on the upstream of the high-pressure pump.
5. Before connecting the pressure container, the water inlet pipeline and high-pressure pipeline have been cleaned and flushed.
6. The concentration of the medicament in the dosing tank is adjusted correctly. The chemical dosing point is located correctly, proper check valve and anti-siphon valve are installed on the dosing pipeline, and proper mixing measures are taken in the dosing inlet pipeline.
7. Check whether the automatic control electrical elements used in reverse osmosis system are working properly.
8. The pretreated effluent complies with the inlet water indicators of reverse osmosis system, including $SDI_{15} < 5$, turbidity < 1 NTU, residual chlorine < 0.1ppm, temperature < 45℃, pH=3-10, and no other oxidants (ORP < 200).

5.2.3 First Start Step

1. Complete all inspection items before the system starts up.

2. Check all valves to ensure that they are in the correct position, and the system water inlet valve, produced water valve and concentrated water valve are fully opened.
3. Use pretreated qualified produced water to drive away the air in membrane elements and pressure containers at low pressure and low flow rate. The flushing pressure is 30-60 psi. The flushing flow rate of each 4-inch pressure vessel is 0.8-3.0 m^3/h, and that of each 8-inch pressure vessel is 2.5-12.0 m^3/h. All produced water and concentrated water during flushing shall be discharged. No scale inhibitor should be added to the pretreated part during flushing.
4. During flushing operation, check whether there are leakage points at all valve and pipeline joints, especially pay attention to check whether there are leakage points in high-pressure parts, and if there are leakage points, tighten or repair them.
5. For the first flushing of membrane elements, it is recommended to continuously flush at low pressure for more than 4-6 hours or flush for 1-2 hours first, and then flush for about 1 hour after soaking overnight.
6. In order to prevent the impact of water hammer on membrane elements, for small reverse osmosis systems without electric slow door opening, the pressure container shall be filled with pretreated water before starting the high-pressure pump; However, large reverse osmosis systems mostly use electric slow door opening or frequency conversion start.
7. Start the high pressure pump. Slowly open the inlet water control valve of high-pressure pump outlet, and slowly close the concentrated water control valve to increase the pressure until the system recovery rate and water yield reach the design value; Wherein the time of increasing pressure process is not less than 30-60 seconds, and the time of increasing inlet water flow is not less than 20-30 seconds; Check whether the operation pressure of the system and the pressure drop of the membrane element exceed the limit value.
8. After the high-pressure pump is started, check whether the dosage of all chemicals is accurate, such as acid, scale inhibitor and sodium metabisulfite (sodium bisulfite), and determine the pH value of inlet water.
9. Measure pH value, conductivity, calcium hardness and alkalinity of concentrated water, calculate Langlier saturation index (LSI) or Steve-David stability index (S&DSI) of concentrated water, and judge whether there is $CaCO_3$ scaling in the system under this operation condition.
10. Detect the conductivity value of water produced by each pressure container, analyze whether there are corresponding pressure containers that meet the expected performance, and judge whether there are leakage or other faults of membrane elements and “O” rings of pressure containers.
11. Let the system run continuously for 1 hour and record all operation parameters. After 24-48 hours of continuous operation of the system, all operation data, including inlet water pressure, pressure difference, temperature, inlet water flow rate and conductivity, concentrated water flow rate and conductivity, produced water flow rate and conductivity and system recovery rate, are collected and sorted out, which are used as the reference for comparing the operation parameters of the system in the future.
12. Compare the design parameters with the actual performance parameters of the system, check whether the equipment runs normally and judge whether it meets the design requirements.
13. In the first week after putting into operation, the system performance shall be tested regularly, and the operation parameters shall be carefully recorded to ensure that the system is within the appropriate

performance range at the initial stage of operation.

5.2.4 Initial and Stable Performance of Membrane Elements

Reverse osmosis and nanofiltration systems need a certain time from the initial performance to the steady state of performance. Usually, wet membrane elements will basically achieve stable performance after continuous operation for 12 hours, while dry membrane elements need continuous operation for 2 days or longer to achieve stable performance.

[5.3] Daily Start and Stop of the System

Once the membrane system is put into operation, every start-up and stop after that will involve sudden changes in system pressure and flow rate, which will more or less produce mechanical stress on membrane elements. Therefore, the number of starts and stops of system equipment shall be reduced as much as possible, and the normal start-up and stop process should be as smooth as possible. The routine startup method is the same as the initial running procedure, which requires slow increase of pressure and flow rate.

Shutdown method of membrane system: First, open the produced water discharge valve, open the bypass control valve of high-pressure pump to reduce the inlet water flow of the system, and at the same time slowly open the concentrated water control valve to reduce the pressure to about 30-40 psi, and close the corresponding dosing device. A higher flow rate is beneficial to improve the flushing effect, but it shall not exceed the maximum inflow rate of a single membrane element, and the pressure difference between the two ends of the pressure container should not exceed the limit value. Maintain this low pressure flushing for about 10-20 minutes.

The start and stop of the system can be automatically controlled by PLC (Programmable Controller), but it is necessary to check whether the running state of the corresponding electrical equipment is normal regularly.

[5.4] Stop Management of System

5.4.1 Short-term Stop (less than 48 hours)

Management of short-term shutdown (less than 48 hours) shut down the system according to normal shutdown steps, flush the whole system at low pressure during shutdown, and flush it again every 24 hours to prevent microbial growth.

5.4.2 Long-term Stop (more than 48 hours)

When the system needs to be shut down for a long time (more than 48 hours), shut down the system in accordance with the normal shutdown steps, and then take the following procedures to save the system:

1. Flush the system with RO qualified produced water to completely expel the air in the system. After the pressure container and related pipelines are filled with water, close the valve to ensure that the pressure container is filled with product water produced by reverse osmosis.

2. When the temperature is higher than 20℃, the system shall be flushed repeatedly every day, and when the temperature is lower than 20℃, it shall be flushed repeatedly every two days.

3. When it is impossible to flush the system every day or every two days, the system must be preserved with protective fluid. 1~1.5% (wt) sodium bisulfite protective solution is prepared with RO qualified produced water. The membrane elements are flushed circularly by chemical cleaning system to expel the air in the pressure container, and the membrane elements are completely immersed in the protective solution to prevent the membrane elements from drying. All water inlet valves, concentrated water valves and produced water valves are closed to prevent air from entering and invalidating the protective solution.

4. Check the pH value of the protective solution every week, and replace the protective solution in time when the pH is lower than 3.

5. During the system shutdown, the temperature is kept between 5℃ and 45℃. Low temperature is beneficial to the preservation of membrane elements, but it is also necessary to prevent the system and its related

pipelines from freezing.

[5.5] Operation Record

From the debugging of the system to the normal operation of the system, all the data related to the system must be collected, recorded and filed to analyze the operation status of the membrane system. Operation data record is also one of the effective tools to find and troubleshoot system faults, and one of the basis for applying for warranty under warranty clauses. Therefore, it is necessary to make records of system pretreatment operation parameters, system dosing parameters, membrane system operation parameters, maintenance and chemical cleaning records.

5.5.1 Pretreatment Operation Parameter Record

The quality of system pretreatment will directly affect the performance of the subsequent reverse osmosis/nanofiltration system, and the service life of the filter element and membrane element of the security filter also depends on whether the system pretreatment is reasonable or not. Therefore, the operation characteristics of pretreatment equipment must be recorded regularly. Due to the different pretreatment processes of different systems, a unified table cannot be established. Conventional pretreatment systems need to record the following items:

The inlet water pressure, temperature, total residual chlorine concentration and pH are recorded. Record the pressure drop of all filters; Record the consumption of medicament; Record any abnormal operation.

5.5.2 System Dosing Parameter Record

Reverse osmosis/nanofiltration system to add the type of medicament depending on the specific system, users can do a good job of dosing parameters records in accordance with the actual situation of the system with reference to the following table for table making.

Table 5.1 Dosage Record of Reverse Osmosis/Nanofiltration System

Time	Date												
	Time												
Flocculant	Liquid level of medicine chest												
	Supplemental amount												
	Concentration												
	Dosage L/h												
Add acid	Liquid level of medicine chest												
	Supplemental amount												
	Concentration												
	Dosage L/h												
Reducing agent	Liquid level of medicine chest												

	Supplemental amount												
	Concentration												
	Dosage L/h												
Scale inhibitor	Liquid level of medicine chest												
	Supplemental amount												
	Concentration												
	Dosage L/h												
Alkali addition	Liquid level of medicine chest												
	Supplemental amount												
	Concentration												
	Dosage L/h												
Remarks													

5.5.3 Membrane System Operation Parameter Record

Reverse osmosis/nanofiltration membrane unit is the core unit of the system, and its operation status directly affects the produced water quality. Therefore, it is very important to record the operation parameters of membrane system. For most systems, we can refer to the following table for data recording.

Table 5.2 Reverse Osmosis/Nanofiltration System Operation Record

Time	Date											
	Time											
Pressure (psi)	First segment inlet water											
	Second segment inlet water											
	Produced water											
	Concentrated water											
Pressure difference (psi)	Security filter											
	First segment											
	Second segment											
Flow (m^3/h)	Inlet water											
	Produced water											
	Concentrated water											
Recovery rate (%)	Recovery rate											
Conductivity (us/cm)	Inlet water											
	First segment water production											

	Second segment water production											
	Total water production											
	Concentrated water											
pH Value	Inlet water											
	Produced water											
Temperature (°C)	Inlet water											
	Produced water											
Standardization	Water yield											
	Desalination rate											
	Operation pressure											
Remarks												

5.5.4 Maintenance and Chemical Cleaning Records

During the use of the system, it is necessary to record the routine maintenance of the system, the mechanical failure and replacement, the replacement or addition of all equipment and devices, and the cleaning operation of the membrane system (please refer to Chapter VII for chemical cleaning methods and steps of the membrane system). Chemical cleaning can be recorded in detail with reference to the following table.

Table 5.3 Record of Chemical Cleaning

Time	Composition and concentration of cleaning fluid	Cleaning fluid volume	PH value of cleaning fluid	Temperature of cleaning fluid	Cleaning start time	Cleaning end time	Remarks

Chapter VI Diagnosis and Elimination of System Faults

Water yield and desalination rate are two important indicators for system design and operation, and the abnormal fluctuation of these two performances is a common fault in reverse osmosis and nanofiltration systems. In addition, the pressure drop after the operation of the system is also worthy of attention. When the pressure drop suddenly increases greatly, it is necessary to consider whether the effluent of the front security filter meets the inlet requirements of reverse osmosis and whether there is abnormality in the pretreatment link. If the water yield, desalination rate and pressure drop change only slowly, this indicates that the system has normal fouling and can be treated by regular and proper cleaning. Therefore, it is very necessary to record the system operation data regularly and carry out standardized treatment. Through the analysis of the recorded data, we can find out the potential problems in the system operation as soon as possible, so as to take timely and effective corrective measures and prevent the system from having irreparable major accidents.

The steps of system fault diagnosis and troubleshooting can be divided into the following steps:

1. Instrument check: Calibrate pressure gauge, flowmeter, conductivity meter, thermometer, pH meter, etc.
2. Fault diagnosis: Check the equipment running status records, standardize and analyze the running data, and then determine the causes of performance changes and fault points.
3. Troubleshooting: In accordance with the fault diagnosis results, take appropriate treatment measures for the system.

The following is the analysis and introduction of several typical fault symptoms and corresponding corrective measures.

[6.1] Low Water Yield

After determining that all instruments have been calibrated, if the standardized water yield of the system is low, the reasons can be found in accordance with the following three situations:

1. When the water yield in the first segment of the membrane system decreases, there will be deposition of particulate pollutants;
2. When the water yield in the last segment of the membrane system decreases, there will be scaling pollution;
3. If the water yield of all segments of the membrane system decreases, there will be fouling;

In addition, the decrease of water yield in reverse osmosis system is usually accompanied by the decrease, increase or constant of desalination rate, and the cause of failure can be determined in accordance with different symptom combinations.

1. The desalination rate decreases with the decrease of water yield

Decrease in water yield and desalination rate is the most common system failure, and its possible causes are:

(1) Colloidal fouling

Causes of colloidal fouling:

1) The dosage of flocculant in pretreatment is insufficient, and the beaker test is not carried out to

determine the best dosage, so the on-line flocculation effect is not good;

2) Multi-media and activated carbon filtration load is too large, the design of filtration flow rate is too large, and reverse washing and washing are not carried out in time; The pore diameter of micro-or ultra-filtration membrane is too large.

3) SDI and turbidity values are not monitored in daily operation and management, with insufficient attention.

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

1) Determining SDI value of raw water;

2) Analyzing the retention on the surface of the SDI test membrane;

3) Analyzing the retention on the filter element of the security filter;

4) Check and analyze the sediment on the end face of the first branch membrane element of the first segment.

Corrective measures: chemical cleaning; The pretreatment is improved.

(2) Metal oxide fouling

Metal oxide fouling mainly occurs in the first segment, and the common failure causes are:

1) The inlet water contains iron or aluminum plasma

2) The inlet water contains H2S and air enters to produce sulfide salt;

3) Corrosion products are produced in pipeline, pressure container or parts upstream of membrane body;

Measures of distinguishing metal oxide fouling;

1) Analyze the iron and aluminum in the raw water, observe the contaminants intercepted in the security filter, the end face of the first branch membrane element and the inner wall of the pressure vessel;

2) Taking out the first membrane element, dissecting and analyzing the metal ion composition on the membrane surface.

Corrective measures: chemical cleaning; Replace the corroded pipeline system; Improve pretreatment.

(3) Scaling

Scaling refers to the sediments on the surface of membrane as slightly soluble salt or insoluble salts, and occurs in brackish water system with great hardness, high alkalinity and recovery rate, and often occurs in the last segment of RO system, and then gradually diffuses forward. The raw water containing calcium, bicarbonate or sulfate may form scaling to block the membrane system within several hours, while scaling containing barium and fluorine generally forms slowly.

The causes of scaling may be:

1) The water quality of raw water is not analyzed, and the dosage of scale inhibitor is small or the effect is poor;

2) The hardness of raw water is high and the recovery rate is too high, so the precipitation can not be inhibited only by adding scale inhibitor.

Method of distinguishing scaling or not:

1) Analyzing raw water quality data;

2) Check whether there is scaling on the concentrated water side of the system, and the inner wall and end plate of the pressure container feel rough;

3) Taking out the last membrane element and weighing, and the membrane element with serious scaling is generally heavier;

4) Dissect the last membrane element. When the membrane element is seriously scaled, the membrane surface usually becomes hard and brittle. The crystal structure of the sediment on the membrane surface can be observed under a microscope, and the type of scaling can be determined by chemical analysis or XRD analysis.

Corrective measures: choose appropriate chemicals for cleaning; Improve pretreatment to inhibit scaling.

2. The water yield decreases and the desalination rate increases

The possible reasons for the decrease of water yield and the increase of desalination rate of membrane system are as follows:

(1) Compaction

When the membrane is compacted, it usually shows a decrease in water yield and an increase in desalination rate. Compaction of the membrane is easy to occur under the following circumstances:

1) The inlet water pressure is too high and exceeds the allowable limit value;

2) The inlet water temperature is too high and exceeds the allowable limit value;

3) When there is air in the system, the high-pressure pump is started, which leads to serious water hammer, and the instantaneous pressure exceeds the allowable limit value.

The method of distinguishing membrane compaction is to dissect the membrane elements and analyze the micro-structure of the membrane.

Corrective action: Replace membrane elements.

(2) Organic Pollution

The organism in inlet water adsorbs on the surface of membrane elements, resulting in flux loss, which usually occurs in the first stage. The causes of organic pollution are basically the same as those of colloidal pollution.

Methods for distinguishing organic pollution:

1) Analyze the retention on the filter element of the security filter and SDI filter membrane;

2) Check the pretreated flocculant, especially cationic polyelectrolyte;

3) Analyzing the oil and organic pollutants in inlet water;

4) Check cleaning agents and surfactants.

Corrective measures: chemical cleaning; Improve pretreatment.

3. The water yield decreases and the desalination rate is normal

Possible reasons for the decrease of water yield and normal desalination rate are as follows:

(1) Pollution by microorganisms and natural organism

When operating with the same inlet water pressure and recovery rate, the water yield decreases and the desalination rate is normal, especially in the front segment of the system, which indicates that microbial contamination may occur in the membrane elements. Methods for distinguishing microbial contamination:

1) When running at the same inlet water pressure, the recovery rate of the system decreases;

2) Check the pressure difference between the two ends of the pressure container. When a large number of microbial contamination occurs, the system pressure difference will increase significantly;

3) Detect microbial content in water sample of inlet water, produced water and concentrated water;

4) Observe membrane elements and pressure containers. After microbial contamination, it will feel greasy and often have unpleasant smell.

Corrections:

1) Cleaning the whole system and disinfecting it;

2) Replace or improve the pretreatment.

(2) Irreversible drying of membrane elements

Therefore, once the membrane element is soaked, it shall always be wet.

Corrective action: Replace membrane elements.

[6.2] Desalination Rate Decreased

1. The desalination rate decreases and the water yield is normal

The causes of this symptom are:

(1) Leakage of "O" ring

When the "O" ring is damaged by some corrosive chemicals or damaged by mechanical stress (such as the movement of membrane elements caused by water hammer), the "O" ring will leak, and sometimes the "O" ring will not be installed, and the "O" ring will be installed incorrectly.

Methods to prevent leakage of "O" ring: correctly install "O" ring; When lubricating, use the formulated lubricant "glycerin"; Install gaskets to prevent membrane elements from moving back and forth.

(2) Telescoping phenomenon

The reason of telescoping phenomenon is that the pressure difference between inlet water and concentrated water is too large; Serious telescoping phenomenon will cause mechanical damage to membrane elements, so it is necessary to replace the membrane elements of water-producing telescoping.

Methods to prevent telescoping: strengthen the recording and analysis of operation data. When the pressure difference exceeds 15% of the initial value, effective corrective measures and chemical cleaning shall be taken in time, especially paying attention to the fact that the pressure difference will not exceed the allowable maximum value.

(3) Surface damage

The damage of membrane surface is mostly caused by the joint action of the components at the front end of the system which are damaged by crystals in raw water, sharp suspended solids and other mechanical forces.

Measures to prevent membrane surface damage:

1) Replace the filter element of the security filter in time to prevent sharp and hard particles or activated carbon particles in water from entering the membrane element;
2) Before starting the high-pressure pump, expel the membrane system first, or install an electric slow door opening, or start the high-pressure pump with variable frequency starting to prevent water hammer;
3) When cleaning scaled membrane elements, the initial flow rate shall be as small as possible to prevent damage caused by excessive flow rate flushing.

(4) Back pressure

At any time, when the water production pressure is higher than the inlet water or concentrated water pressure by 0.3bar, the composite membrane may be peeled off between composite layers, thus damaging the membrane elements.

2. The desalination rate decreases and the water yield increases

The causes of this symptom are:

(1) Oxidation

When the membrane comes into contact with oxidizing substances in water, the membrane is oxidized and destroyed, which is irreversible chemical damage. Once this happens, all membrane elements can only be replaced.

Possible reasons for membrane oxidation: residual chlorine or other oxidizing substances in the inlet water of membrane system exceed the standard; During cleaning and disinfection, the requirements of cleaning and disinfection are not strictly followed, and the membrane is oxidized due to excessive cleaning time or temperature.

Whether the membrane element is oxidized or not can be determined by pressure dyeing test.

(2) Leakage

Serious damage of ‘O’ ring or rupture of central pipe will lead to inlet water or concentrated water seeping into produced water, especially when operation pressure is high, the more serious the problem is.

[6.3] Pressure Drop Increases

The pressure difference between inlet water and concentrated water is called pressure drop; The upper limit of pressure drop of each pressure container with multiple membrane elements is 3.5 bar, and that of a single membrane element with fiberglass shell is 1 bar. Excessive pressure drop will lead to telescope phenomenon of membrane elements and rupture of fiberglass shell of membrane elements, thus causing mechanical damage of membrane elements. When the inlet flow rate is constant, the increase of pressure drop is often due to the presence of pollutants or scaling in the inlet grid channel of the component. Once the inlet runner is blocked, it is often accompanied by the decrease of water yield.

The following are common causes of increased pressure drop:

1. Microbial contamination

Microbial contamination often causes a significant increase in pressure drop in all sections of RO system. Microbial contamination often occurs in the system where the water source is surface water and wastewater reuse.

Methods to solve microbial contamination:

(1) Add fungicides to inlet water, and pay attention to prevent oxidizing fungicides from entering the membrane elements to avoid oxidation of the membrane elements;

(2) Replace with antioxidant membrane elements, and add fungicides to the whole system (including reverse osmosis membrane system).

2. Scaling pollution

Scaling and fouling in the inlet water runner often leads to an increase in the pressure drop of the last membrane element, so it is necessary to ensure that appropriate measures are taken to control scaling, appropriate chemicals are used to clean the membrane element, and appropriate recovery rate is controlled.

[6.4] Summary of Symptom Diagnosis and Troubleshooting of Faults

The following table summarizes the symptoms, causes and corrective measures of common system failures.

Table 6.1 Symptoms, causes and corrective measures of common faults in membrane system

Malfunction symptom			Possible causes	Corrections
Water yield	Desalination rate	Pressure difference		
↑	⇓	→	Oxidative damage	Replacing membrane elements and adding reducing agent; Replace antioxidant membrane element
↑	⇓	→	Membrane damage leakage	Replacing membrane elements; Improve the filtering effect of security filter
↑	⇓	→	Leakage of “O” ring	Replace “O” ring
↑	⇓	→	Leakage of production pipe	Replace membrane element
⇓	↓	↑	Scaling pollution	Chemical cleaning to control scaling
⇓	↓	↑	Colloidal contamination	Chemical cleaning, improved pretreatment
↓	→	⇑	Biological pollution	Chemical cleaning, disinfection and improved pretreatment
⇓	→	→	Organic Pollution	Chemical cleaning, improved pretreatment
⇓	↑	→	Compaction	Replace or add membrane elements

↑ increase ↓ decrease → constant ⇑ ⇓ Main Symptoms

Chapter VII Cleaning and Disinfection

[7.1] Overview of Membrane System Cleaning

7.1.1 Brief Introduction of Membrane Fouling

Suspended solids, colloids, microorganisms, organism and some insoluble salts in the inlet water gradually concentrate and precipitate during the operation of the system, and attach to the membrane surface, thus polluting the membrane elements. The most common pollutants are silicon precipitates, metal (iron, manganese, copper, etc.) oxide precipitates, calcium carbonate scaling, microorganisms (algae, mould, fungi, etc.), natural and synthetic organic compounds, calcium sulfate, barium sulfate precipitates, inorganic or organic precipitates mixtures, etc. In general, the pollution in the process of system operation is gradually developing, and there are many factors affecting the pollution rate, such as inlet water quality and system recovery rate. Reasonable system pretreatment process can remove most pollutants, reduce membrane pollution and prolong the service life of the system. However, pretreatment cannot completely remove the pollutants in water, and the membrane elements will be polluted after the system runs for a certain time, which will lead to the degradation of the system performance.

7.1.2 Cleaning Conditions

The water yield and desalination rate mentioned in our manual refer to the standardized water yield and desalination rate, because the measured water yield and desalination rate of membrane element system are different under different conditions such as temperature, pressure, pH and inlet water salt concentration. Generally, the new system takes the performance value after 2-3 days of continuous operation as the initial value, and the recorded data in the future is compared with the initial value (please confirm that the data have been converted into standardized data before comparison). If any of the following conditions occurs, the membrane element system shall be chemically cleaned in time:

1. Under standardized conditions, the pressure difference between inlet water and concentrated water in a certain section of the system is 15% higher than the initial pressure difference.
2. Under standardized conditions, the water yield of the system is reduced by more than 15% compared with the initial value.
3. Under standardized conditions, the permeable salt rate of the system is increased by more than 10% compared with the initial value.

If the system achieves one of the above three conditions under standardized conditions, it is recommended that the user immediately clean the system in accordance with the method introduced in the cleaning steps, so as to avoid the fact that the chemical cleaning effect is very small with the aggravation of pollution, thus causing the performance of membrane elements to be irrecoverable and affecting the final produced water quality. Under normal circumstances, the system performance can be restored to the greatest extent by proper cleaning.

7.1.3 Calculation of Cleaning Liquid Volume

When preparing cleaning fluid, the total volume of cleaning fluid needs to be calculated in accordance with the volume of pressure container, high pressure pipeline, filter and cleaning pipeline. In accordance with the membrane element model and pollution degree, the cleaning fluid volume can be roughly estimated:

For general pollution: 9 liters of cleaning fluid shall be prepared for each 4040 membrane element; Each

8040 membrane element needs to be prepared with 40 liters of cleaning fluid. For serious pollution: 16 liters of cleaning fluid should be prepared for each 4040 membrane element; 60 liters of cleaning fluid should be prepared for each 8040 membrane element.

7.1.4 Cleaning Considerations

1. When preparing cleaning fluid, high-quality water without oxidants such as residual chlorine shall be used for preparation (qualified RO produced water is recommended for preparation), and chemicals shall be well dissolved and mixed before cleaning.
2. Pay attention to prevent the harm of chemical agents to operators during chemical cleaning, especially when using some corrosive chemical agents (such as fluorine-containing agents may be used when cleaning silicon pollution). It is recommended to clean under the guidance of professionals.
3. Pay attention to monitoring the temperature of cleaning fluid during cleaning. When the pH value is 2-10, the temperature shall not exceed 45°C; When the pH value is 1-11, the temperature shall not exceed 35°C; When the pH value is 1-12, the temperature shall not exceed 30°C.

[7.2] Cleaning Steps of Membrane System

The cleaning process of the membrane system can be carried out as follows:

1. Shut down the flushing system

When the system meets the cleaning conditions described above, first stop the machine and switch to the manual operation mode, and flush the system with qualified RO produced water to replace the residual water in the membrane system.

2. Prepare cleaning fluid

Predict the pollution type of the system in accordance with the recorded data, prepare the cleaning fluid in terms of the cleaning fluid corresponding to the pollutants in the manual (it is recommended to prepare with qualified product water), weigh the chemicals accurately, and mix the cleaning fluid well with the mixing loop of the cleaning water tank.

3. Low pressure circulation of cleaning fluid

First, open the concentrated water discharge valve of the system, and input the cleaning fluid at the lowest possible pressure (30~40psi). When the cleaning fluid completely replaces the water in the membrane elements and pipelines, return the cleaning fluid to the cleaning water tank (in order to prevent the water in the system from entering the cleaning fluid to dilute the cleaning fluid and affect the cleaning effect). Let the cleaning fluid circulate in the pipeline for about 10 minutes, and ensure that the temperature of the cleaning fluid is constant. Observe and detect the turbidity and pH value of the return flow. If the return flow becomes obviously turbid or the pH value changes more than 0.5, it is necessary to add a proper amount of cleaning agent or reprepare the cleaning fluid to repeat the above operation.

The flow rate of cleaning fluid is set in accordance with the size of membrane elements installed in the system. The recommended flow rate of 2.5-inch membrane elements is 4gpm (about 0.9m^3/h), the recommended flow rate of 4-inch membrane elements is 9gpm (about 2.1m^3/h), and the recommended flow rate of 8-inch membrane elements is 40gpm (about 9.1m^3/h).

4. Soak

Stop the cleaning pump, close the pipeline valve connecting the system, prevent the cleaning fluid from flowing out of the pressure container, and soak for about 1 hour. For some pollutants that are difficult to clean, it is necessary to prolong the soaking time or even soak overnight. In order to maintain the temperature of the soaking process, an extra-low flow rate can be used for circulation (about 10% of the normal cleaning flow rate).

5. High flow cycle

The cleaning fluid flow rate is increased to twice the normal cleaning flow rate for cleaning, and the pollutants washed down by the cleaning fluid can be washed away by circulating for 30-60 minutes. At this time, the pressure shall not be too high, so that the system has no obvious water production pressure. At the same time, pay attention to the pressure difference between membrane elements and pressure vessels shall not exceed the limit value.

6. Flush

First flush the system with product water for about 5 minutes, then flush the system with pretreated qualified produced water for 30 minutes. To prevent precipitation, the minimum flushing temperature is 20℃ to ensure that the cleaning fluid is completely washed out and no residue in the system. Start the system operation, check the cleaning effect, drain the produced water first and do not enter the product water tank, and then inlet the produced water into the product water tank after all performance indexes of the produced water meet the standards and are stable.

[7.3] Predicting Fouling of Membrane System and Selection of Cleaning Agents

The daily operation record of the system is an important basis for judging whether the system is polluted or not and taking reasonable cleaning methods after pollution. Therefore, we must pay attention to the recording and analysis of operation data parameters. The symptoms of several major pollution situations and the selection of corresponding cleaning fluids are summarized as follows:

7.3.1 Inorganic Salt Scaling Pollution and Cleaning

The most common inorganic salt scaling pollution in membrane system is calcium carbonate and calcium sulfate scaling. Calcium carbonate scale is a kind of mineral scaling. When the scale inhibitor adding system fails, calcium carbonate scale may be sendiment. Because calcium carbonate reacts with acid easily, this kind of scale can be removed by acid washing, and it can generally return to its initial performance after cleaning. Calcium sulfate scale is much harder than calcium carbonate mineral scaling and difficult to remove, so sulfate scaling shall be found as soon as possible to prevent membrane surface sediment from damaging the film. If sulfate scaling is discovered late, the possibility of clear recovery of membrane system performance is extremely low.

The main symptoms of inorganic salt fouling pollution are as follows: the conductance of the second segment of the membrane system is abnormal (conductance increases), the water yield is greatly reduced, the pressure is gradually increasing, and the pressure difference of the second segment is also gradually increasing. The most obvious symptom is a sharp drop in water production. The main reason for this kind of scaling is usually the high recovery rate of the system or the insufficient addition of scale inhibitor.

After inorganic salt scaling pollution occurs, cleaning fluid can be prepared in accordance with the following method:

Table 7.1 Formula of Inorganic Salt Scaling Cleaning Fluid

Major pollutants	Recommended cleaning solution	Remarks
Carbonate scale	0.2%(wt) hydrochloric acid (HCl)	The optimum temperature is less than 38℃, pH value is 1~2
	2.0%(wt) citric acid ($C_6H_8O_7$), or 1.0%(wt) sodium metabisulfite ($Na_2S_2O_4$), or 0.5%(wt) orthophosphoric acid (H_3PO_4)	Optional, citric acid, temperature < 45℃; Sodium metabisulfite or orthophosphoric acid, temperature < 30℃
Sulfate scale	0.1%(wt) Sodium Hydroxide (NaOH) +1.0%(wt)Na_4-EDTA	pH=12, Temperature ＜30℃

7.3.2 Contamination and Cleaning of Metal Compounds

Metal compound pollution is mainly metal oxides, metal hydroxides and so on. Typical metal compound pollution sources are iron, zinc, manganese, copper, aluminum and so on. Such fouling may be caused by corrosion products of device pipelines and containers, or by iron or aluminum coagulant-aids used in pretreatment systems. Iron pollution is the main pollution of metal compounds. It mainly happens in the first segment of the system.

The main symptoms of membrane fouling are: water yield and desalination rate decrease, and pressure difference of membrane elements increases.

When metal compound pollution occurs, it can be cleaned in accordance with the following formula:

Table 7.2 Cleaning formula for scaling of metal compounds

Major pollutants	Recommended cleaning solution	Remarks
Metal compound	1.0% Sodium Metabisulfite ($Na_2S_2O_5$)	Optimum, pH=5, temperature < 30℃
	2.0% citric acid ($C_6H_8O_7$), or 0.5%(wt) orthophosphoric acid (H_3PO_4)	Optional, citric acid, temperature < 45℃; Orthophosphoric acid, temperature < 30℃

7.3.3 Colloid Contamination and Cleaning

Colloids are the particles of inorganism or mixture of organism and inorganism suspended in water, which will not precipitate due to their own gravity. Colloids usually contain one or more of the following components: iron, aluminum, silicon, sulfur or organism. Colloids in reverse osmosis inlet water include sludge, inorganic colloid, colloidal silicon and some organism, which can be removed by flocculation filtration and activated carbon adsorption in pretreatment, and colloid pollution mainly occurs in the first segment of the system.

The main symptoms of colloid fouling in membrane system are as follows: water yield decreases, pressure difference gradually increases, and water conductance is normal or slightly increased. The main symptoms of colloid fouling are the changes of water yield and pressure difference.

When inorganic colloid pollution occurs, cleaning fluid can be prepared in accordance with the following methods for cleaning:

Table 7.3 Formula of inorganic colloid contaminated cleaning fluid

Major pollutants	Recommended cleaning solution	Remarks
Inorganic colloid	0.1%(wt) Sodium Hydroxide (NaOH)+0.025%(wt) Sodium Dodecyl Sulfonate (Na-SDS)	pH=12, Temperature ＜30℃

7.3.4 Organic Contamination and Cleaning

There is a high risk of organic pollution in reverse osmosis system with surface water, wastewater or seawater as water source, which mainly composes of humus and organic acids. It is usually caused by the decomposition of nutrients in water. The chemical mechanism of organic fouling is very complex. The adsorption of undissolved organism on the membrane surface may cause rapid fouling of membrane elements. Once the adsorption occurs, the gel or block fouling process will begin.

The main symptoms of organic pollution in membrane system are: water yield decreases greatly, and desalination rate remains basically unchanged. Open the contaminated membrane shell, observe the inner wall of the membrane shell and the contaminated membrane elements, and feel greasy when touched by hand. Organic pollution often occurs together with microbial pollution.

When organic pollution occurs, cleaning fluid can be prepared in accordance with the following methods for cleaning:

Table 7.4 Formula of cleaning fluid for organic pollution

Major pollutants	Recommended cleaning solution	Remarks
Organism	0.1%(wt) sodium hydroxide (NaOH)+0.025%(wt) sodium dodecyl sulfate (Na-SDS), 0.2%(wt) hydrochloric acid (HCl)	The first step is cleaning with NaOH and Na-SDS solution, pH=12, temperature < 30°C; The second step is cleaning with HCl solution, pH value is 1~2, and temperature is less than 30°C.

7.3.5 Microbial Contamination and Cleaning

Microbial contamination usually occurs during the shutdown of reverse osmosis system and in reverse osmosis system with surface water, reclaimed water (tertiary wastewater) and seawater as inlet water sources. When microbial contamination occurs, it is usually accompanied by organic pollution. Such contaminants are difficult to remove, especially when the feed passage is completely blocked, which makes it difficult for clean inlet water to fully and evenly enter the membrane element. Biological pollution shall be cleaned in time at the initial stage. Once the biological membrane is formed, it is very difficult to clean, so only the membrane elements shall be replaced.

The main symptoms of microbial contamination in membrane system are as follows: the pressure difference between the first and second segments increases rapidly, the water yield decreases, and the conductance of water yield remains basically unchanged; The main symptom is increased pressure difference.

When contaminated by biological microorganisms, they can be cleaned in accordance with the following formula:

Major pollutants	Recommended cleaning solution	Remarks
Microorganisms	0.1%(wt) Sodium Hydroxide (NaOH)+0.025%(wt) Sodium Dodecyl Sulfonate (Na-SDS)	Optimum, pH=12, temperature < 30°C
	0.1%(wt) Sodium Hydroxide (NaOH) +1.0%(wt)Na_4-EDTA	Optional, pH=12, temperature < 30°C
	2.0%(wt) sodium tripolyphosphate (STPP)+0.025%(wt) sodium dodecyl sulfate (Na-SDS)	Optional, pH=10, temperature < 30°C

[7.4] Disinfection of Membrane System

The reverse osmosis membrane system with microbial contamination needs systematic disinfection treatment after chemical cleaning. The optional disinfection methods of reverse osmosis membrane system are as follows:

1. Disinfect with DBNPA

BNPA (2, 2-dibromo-3-nitrilo-propionamide) is a highly effective and non-oxidizing bactericide, which is widely used in sterilization of membrane systems. In summer when biological activities are vigorous, the frequency of disinfection of membrane system is higher, about 3~5 days/time; In winter when biological activities are not vigorous, the frequency of disinfection can be slightly lower, usually 6~8 days/time; The best disinfection frequency of the system shall be determined in accordance with the actual operation of the system.

When disinfecting with DBNPA, the dosage depends on the severity of microbial contamination in the system. When there is biological membrane fouling in the system, it is recommended to add 30ppm of active ingredients for continuous treatment for more than 3 hours, and clean with alkaline cleaning fluid; For the water sources with low biological activity, the method of short-term dosing can be adopted, and 10~30ppm active ingredients can be added every 5 days for treatment for 30 minutes to 3 hours.

2. Disinfect with Hydrogen Peroxide

The membrane system can also be sterilized and disinfected with hydrogen peroxide solution. Because hydrogen peroxide has strong oxidizability, long-term contact with membrane elements may reduce the desalination rate of membrane, so it can only be contacted for a short time, and it is ensured that iron and other transition metals are not present in membrane elements and systems before contact. It is recommended to use hydrogen peroxide solution with concentration less than 0.2% to soak or wash the membrane element below 25℃ for 2~12 hours.

3. Disinfect with Formaldehyde

When using formaldehyde disinfection, the membrane element must be continuously operated for at least 24 hours, otherwise the water yield of the membrane element will be attenuated. After 24 hours of initial operation, the membrane element or system can be rinsed or soaked for a short or long time with formaldehyde aqueous solution with concentration below 3%.

Chapter VIII Appendix

[8.1] Service Process

8.1.1 Pre-sales Services

- OVAY Technology Customer Service Hotline: 0731-22500038(For detailed consultation, please call OVAY Technology)
- Customer demand analysis (professionals select and analyze in accordance with the specific needs of customers)
- Suggestions of customer selection (in accordance with the specific needs of customers, make suggestions for customers on membrane element selection and provide the most suitable products)
- Sample trial production and long-term operation monitoring (in accordance with the requirements of customers, sample trial production and long-term operation monitoring of samples)
- Visit the production base (Welcome to visit the Liyu production workshop of our headquarters to further understand our production strength)

8.1.2 Services in Sale

- Business cooperation (based on the understanding of products and company strength, both parties establish friendly business cooperation)
- Order production and progress tracking (after the cooperation relationship is confirmed, order production is carried out in accordance with the contract requirements and customer demand, and production progress is tracked to ensure every production process)
- Logistics tracking (order production is completed, our Company arranges delivery, and informs customers of logistics order number, logistics tracking of product transportation)

8.1.3 After-sales Service

- Customer feedback and satisfaction survey (confirm the feedback after customers use the products, and conduct satisfaction survey on the sales service of our Company)
- Product application and after-sales service/warranty support (if customers are unfamiliar with product application, they can contact the account manager or the customer service of the headquarters, and OVAY Technology provides warranty support for products)

[8.2] Quality Assurance Agreement

OVAY Technology always adheres to the idea of "product quality promotes the sustainable development of the Company". Ensure the quality of reverse osmosis membrane elements produced and sold through integrated supply chain management, automated production and strict process control. In order to eliminate your purchase concerns, OVAY Technology products provide the following effective quality assurance:

1. Guarantee of Manufacturing Process and Materials

OVAY Technology guarantees that the reverse osmosis membrane elements produced and sold by OVAY Technology have no defects in manufacturing process and materials. Under the condition that the Buyer uses and maintains the membrane elements correctly in accordance with the technical documents provided by OVAY Technology, if there are quality problems in manufacturing process and materials, OVAY Technology shall undertake the guarantee obligation for 12 months from the date when the products arrive at the port designated by the Buyer, and repair or replace them free of charge when the inspection finds that there are defects.

2. Initial Performance Guarantee

Under the standard test conditions and the correct use and maintenance conditions of the product specified by OVAY Technology, OVAY Technology's new reverse osmosis membrane element has the minimum water yield and desalination rate specified in the product sample. If the product does not reach the specified minimum performance for the first time, OVAY Technology shall undertake the guarantee obligation for 12 months from the date when the product arrives at the port designated by the Buyer, and repair the membrane element or refund the purchase cost of the defective membrane element after confirming the initial performance defect. In this case, the freight will be paid by OVAY Technology.

3. Performance Guarantee

Under the test conditions specified by OVAY Technology product samples, OVAY Technology provides the following performance guarantees for the products:

1) Permeable salt rate does not exceed twice the minimum value specified in the "Product Technical Manual".

2) The water yield shall not be less than 70% of the average water yield specified in the "Product Technical Manual".

OVAY Technology provides a three-year product performance guarantee, and the three-year time is whichever comes first at any of the following time points:

1) From the date when the reverse osmosis system is put into operation;

2) Calculated six months after the date of shipment of membrane elements.

NOTE: In the event that Buyer fails to meet any of the following conditions, OVAY Technology will not fulfill the above-mentioned three-year limited warranty liability:

1) Feed water turbidity of membrane element ≤ 1.0 NTU, $SDI_{15} \leq 5$, feed water temperature ≤ 45°C;

2) The feed water of the membrane element does not contain oil, grease and harmful substances that may cause physical and chemical damage to the membrane element;

3) Before installation or use, the membrane elements shall be stored in the original vacuum packaging bag, the storage temperature of dry membrane elements should be ≤ 45°C, and the storage temperature of wet membrane elements should be 5~45°C;

4) In normal operation, the pH value of the feed water of the membrane element ranges from 3 to 10; During cleaning, the pH value of feed water of membrane elements ranges from 2 to 12;

5) The feed water of the membrane element does not contain oxidizing substances such as chlorine, potassium permanganate and hypochlorite;

6) Maximum operation pressures for membrane elements are shown in Table A below (unless otherwise specified in the product description):

Table A. Maximum Operation Pressure of Membrane Elements

Membrane element series	**Maximum operation pressure**
Household membrane element OV-ULP series	300psi(2.07Mpa)
OV-U Series of Ultra-low Pressure Composite Reverse Osmosis Membrane Elements	600psi(4.14Mpa)
OV-X Series of Extra-low Pressure Composite Reverse Osmosis Membrane Elements	300psi(2.07Mpa)
OV-L Series of Low Pressure Composite Reverse Osmosis Membrane Elements	600psi(4.14Mpa)
OV-SW Series of Desalination Composite Reverse Osmosis Membrane Elements	1000psi(6.9Mpa)
OV-FR Series of Fouling-resistant Composite Reverse Osmosis Membrane Elements	600psi(4.14Mpa)

- In any case, the back pressure on the membrane element shall not exceed 5psi, and the water hammer impact on the membrane element shall be avoided during system operation;
- Under standard conditions, when the system performance drops by 10%, or membrane fouling and membrane scaling occur, it shall be cleaned in time in accordance with the prescribed procedures;
- The system structure and design parameters such as membrane module arrangement, instrument configuration and recovery rate shall be consistent with reasonable engineering design;
- Seller is responsible for providing appropriate training to users to ensure that users have the ability of system cleaning and other system performance recovery and fault diagnosis;
- Users must regularly and systematically record the standardized performance data of the whole system and subsystems to ensure the authenticity, integrity and continuity of the data, and archive the data for future reference. This information will be the basis for OVAY Technology to fulfill its performance guarantee when claiming compensation in accordance with the warranty terms.

In a scientific and rigorous attitude, OVAY reverse osmosis membrane elements can ensure the quality of reverse osmosis membrane elements produced and sold by OVAY Technology Co., Ltd. only when they are used in accordance with the design and operation specifications proposed by Hunan Ovay Technology Co., Ltd..

[8.3] Brief Introduction of Qualification

8.3.1 ISO9001 Quality Management System Certification


CERTIFICATE

质量管理体系认证证书

证书编号：00221Q27552R2M

兹证明

湖南澳维科技股份有限公司

统一社会信用代码：91430200320660964Y
住所：湖南省株洲市天元区栗雨工业园火炬四道

与其他场所共同构成的单一管理体系符合
GB/T 19001-2016/ISO 9001:2015

覆盖的范围

膜材料、膜元件及膜组件的设计开发、生产和服务

覆盖的各场所及认证范围见附件

（本证书信息可在国家认证认可监督管理委员会官方网站 www.cnca.gov.cn 或方圆标志认证集团官方网站上查询。年度监督审核的《确认证书》用以证实本证书的持续有效性。）

生效日期：2021 年 11 月 22 日
有效期至：2024 年 11 月 30 日
换证日期：2022 年 03 月 23 日

CQM 是国际认证联盟的成员
IQNet
THE INTERNATIONAL CERTIFICATION NETWORK

中国认可
国际互认
管理体系
MANAGEMENT SYSTEM
CNAS C002-M

AA 0043376

方圆标志认证集团
CHINA QUALITY MARK CERTIFICATION GROUP
地址：北京市海淀区增光路33号（100048） Address:No.33,Zengguang Road,Haidian District,Beijing,P.R. China(100048)
http://www.cqm.com.cn

8.3.2 ISO14001 Environmental Management System Certification

CERTIFICATE

方圆认证 CQM CERTIFICATION

环境管理体系认证证书

证书编号：00220E33794R0M

兹证明

湖南澳维科技股份有限公司

统一社会信用代码：91430200320660964Y
住所：湖南省株洲市天元区栗雨工业园火炬四道

与其他场所共同构成的单一管理体系符合
GB/T 24001-2016/ISO 14001:2015

覆盖的范围

膜材料、膜元件及膜组件的设计开发、生产和服务及相关管理活动

覆盖的各场所及认证范围见附件

（本证书信息可在国家认证认可监督管理委员会官方网站 www.cnca.gov.cn 或方圆标志认证集团官方网站上查询。年度监督审核的《确认证书》用以证实本证书的持续有效性。）

生效日期：2020 年 11 月 25 日
有效期至：2023 年 11 月 24 日
换证日期：2022 年 03 月 23 日

CQM 是国际认证联盟的成员
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THE INTERNATIONAL CERTIFICATION NETWORK

中国认可
国际互认
管理体系
MANAGEMENT SYSTEM
CNAS C002-M

方圆标志认证集团有限公司

AA 0043379

方圆标志认证集团
CHINA QUALITY MARK CERTIFICATION GROUP
地址：北京市海淀区增光路33号（100048） Address:No.33,Zengguang Road,Haidian District,Beijing,P.R. China(100048)
http://www.cqm.com.cn

8.3.3 ISO45001 Occupational Health and Safety Management Systems Certification

方圆认证 CQM CERTIFICATION

CERTIFICATE

职业健康安全管理体系认证证书

证书编号：00220S23409R0M

兹证明

湖南澳维科技股份有限公司

统一社会信用代码：91430200320660964Y
住所：湖南省株洲市天元区栗雨工业园火炬四道

与其他场所共同构成的单一管理体系符合
GB/T 45001-2020/ISO 45001:2018

覆盖的范围

膜材料、膜元件及膜组件的设计开发、生产和服务及相关管理活动

覆盖的各场所及认证范围见附件

（本证书信息可在国家认证认可监督管理委员会官方网站 www.cnca.gov.cn 或方圆标志认证集团官方网站上查询。年度监督审核的《确认证书》用以证实本证书的持续有效性。）

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有效期至：2023 年 11 月 24 日
换证日期：2022 年 03 月 23 日

CQM 是国际认证联盟的成员
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中国认可
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管理体系
MANAGEMENT SYSTEM
CNAS C002-M

方圆标志认证集团有限公司

AA 0043382

方圆标志认证集团
CHINA QUALITY MARK CERTIFICATION GROUP
地址：北京市海淀区增光路33号（100048） Address:No.33,Zengguang Road,Haidian District,Beijing,P.R. China(100048)
http://www.cqm.com.cn

8.3.4 NSF Certification

NSF International

789 N. Dixboro Road, Ann Arbor, MI 48105 USA

RECOGNIZES

Hunan Ovay Technology Co., Ltd.

Facility: Zhuzhou, China

AS COMPLYING WITH NSF/ANSI 58, 61 AND ALL APPLICABLE REQUIREMENTS. PRODUCTS APPEARING IN THE NSF OFFICIAL LISTING ARE AUTHORIZED TO BEAR THE NSF MARK.

Certification Program Accredited by the American National Standards Institute

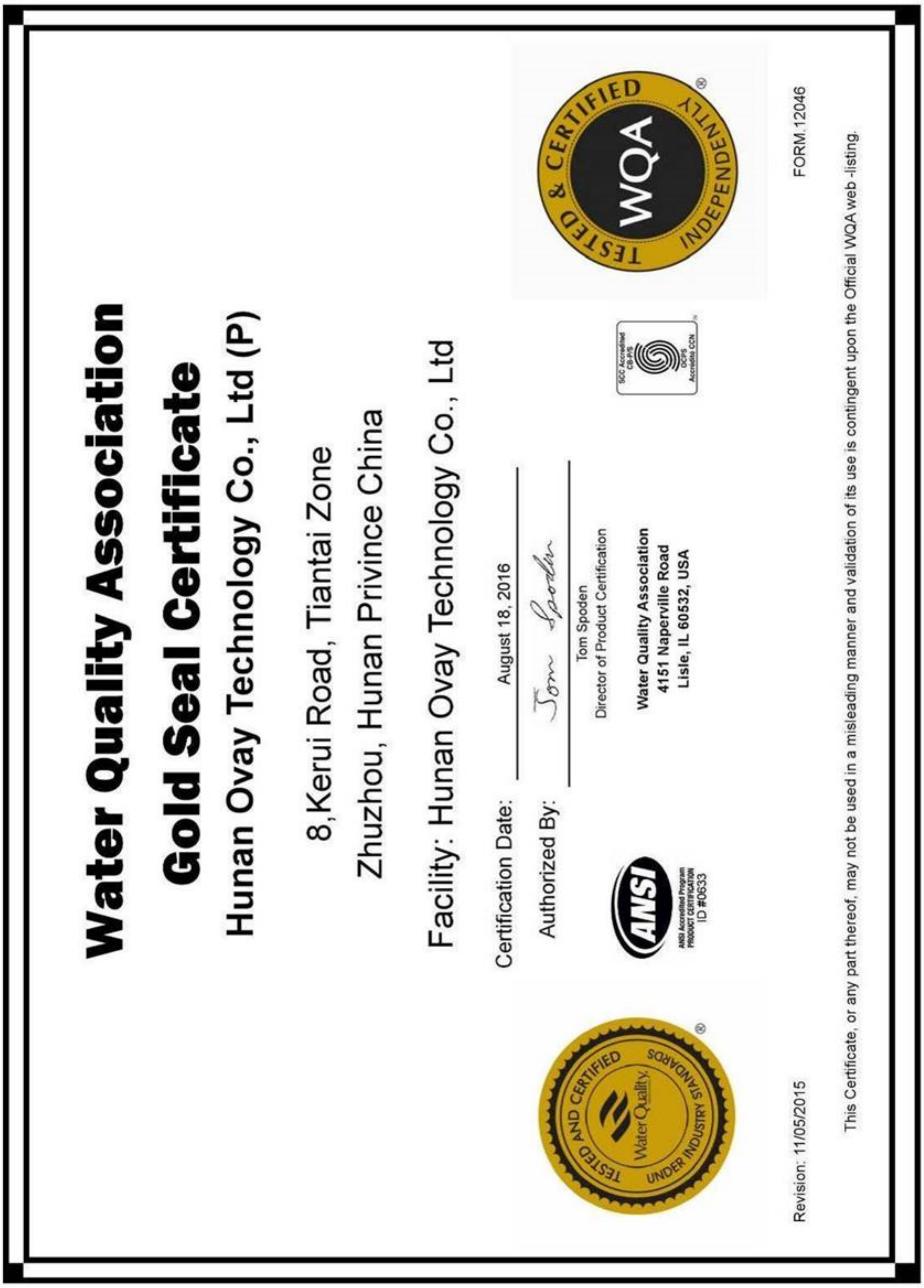
Certification Program Accredited by the Standards Council of Canada

This certificate is the property of NSF International and must be returned upon request. This certificate remains valid as long as this client has products in Listing for the referenced standards. For the most current and complete Listing information, please access NSF's website (www.nsf.org).

February 17, 2017
Certificate# C0270790 - 02

Tina Yerkes
General Manager, Water Systems

8.3.5 American WQA Water Quality Association Certification



Water Quality Association

Gold Seal Certificate

Hunan Ovay Technology Co., Ltd (P)

8,Kerui Road, Tiantai Zone

Zhuzhou, Hunan Privince China

Facility: Hunan Ovay Technology Co., Ltd

Certification Date: August 18, 2016

Authorized By: Tom Spoden

Tom Spoden
Director of Product Certification

Water Quality Association
4151 Naperville Road
Lisle, IL 60532, USA

Revision: 11/05/2015

FORM.12046

This Certificate, or any part thereof, may not be used in a misleading manner and validation of its use is contingent upon the Official WQA web -listing.

8.3.6 Wading Approval Document of the Ministry of Health

湖南省国产涉及饮用水卫生安全产品
卫生许可批件

共2页 第1页

产品名称	澳维牌反渗透膜元件
产品类别	水处理材料
产品规格或型号	OV-ULP 型、OV-U 型、OV-L 型、OV-X 型、、OV-FR 型、OV-CR 型、OV-SW 型
申请单位	湖南澳维科技股份有限公司
申请单位地址	湖南省株洲市天元区栗雨工业园火炬四道
实际生产企业	湖南澳维科技股份有限公司
实际生产企业地址	湖南省株洲市天元区栗雨工业园火炬四道
审批结论	经审核，该产品符合《生活饮用水卫生监督管理办法》的有关规定，现予批准。
批准文号	(湘)卫水字(2016)第 0027 号
批准日期	2022 年 03 月 25 日
批件有效期	截至 2024 年 04 月 16 日

共2页 第2页

产品技术信息

【产品说明】

1、产品类型：水处理材料

2、产品型号：OV-ULP 型、OV-U 型、OV-L 型、OV-X 型、OV-SW 型、OV-FR 型、OV-CR 型

3、技术参数

型号	OV-ULP 型									
规格	1810	1812	2012	2008	2009	2010	2812	3012	3013	3020
脱盐率(NaCl%)	≥96.0	≥96.0	≥96.5	≥96.0	≥96.0	≥96.0	≥97.0	≥97.0	≥97.0	≥97.0
最低产水量(m^3/d)	0.23	0.19	0.38	0.23	0.28	0.34	0.76	1.14	1.52	1.60
型号	OV-L 型		OV-FR 型		OV-CR 型		OV-U 型			
规格	4040	8040	4040	8040	4040	8040	2521	2540	4021	4040
脱盐率(NaCl%)	≥99.5	≥99.5	≥99.5	≥99.5	≥99.5	≥99.5	≥99.0	≥99.0	≥98.0	≥98.0
最低产水量(m^3/d)	9.1	36.3	8.3	36.3	8.3	36.3	1.1	2.8	3.2	7.2
型号	OV-U 型	OV-X 型		OV-SW 型						
规格	8040	4040	8040	2514	2521	2540	4021	4040	8040	
脱盐率(NaCl%)	≥98.0	≥98.0	≥98.0	≥99.2	≥99.2	≥99.2	≥99.2	≥99.5	≥99.7	
最低产水量(m^3/d)	39.7	7.6	38.0	0.5	0.9	2.3	3.0	6.1	22.7	

【主要成份或部件】

序号	材料名称	材质	用量
1	反渗透膜	聚酰胺复合膜	<47.5m^2
2	聚丙烯网	聚丙烯	<22.5m^2
3	流道布	聚对苯二甲酸乙二酯	<23.5m^2
4	中心管	丙烯腈－丁二烯－苯乙烯共聚物	1支
5	胶粘剂	聚氨酯	<0.85Kg

【使用范围】

生活饮用水过滤系统配套使用。

【注意事项】

1、运输、贮存过程中应固定牢靠，防雨防潮，不得重压，不得与有毒有害物品混运、混放。

2、正常使用前充分清洗，使用过程中定期清洗。

备注

1、本批件只对与所载明内容(包括名称、类别、规格、申请单位、企业、附件内容等)一致的产品有效，且必须在本批件注明的实际生产企业生产。

2、批准时仅对其所申报材料对应产品的卫生安全性进行了审核，未对其所宣传的功能和其他质量问题进行评价。

请于批件有效期届满 30 个工作日之前提出延续申请。

湖南省卫生健康委员会

2022 年 03 月 25 日(变更)

湖南省国产涉及饮用水卫生安全产品
卫生许可批件

共2页 第1页

产品名称	澳维牌纳滤膜元件
产品类别	水处理材料
产品规格或型号	OV-NF-1810、OV-NF-1812、OV-NF-2012、OV-NF-2812、OV-NF-3012、OV-NF-3013、OV-NF-3213；OV-NF10-8040、OV-NF10-4040、OV-NF10-2540、OV-NF10-4021、OV-NF10-2521；OV-NF30-8040、OV-NF30-4040、OV-NF30-2540、OV-NF30-4021、OV-NF30-2521；OV-NF60-8040、OV-NF60-4040、OV-NF60-2540、OV-NF60-4021、OV-NF60-2521；OV-NF90-8040、OV-NF90-4040、OV-NF90-2540、OV-NF90-4021、OV-NF90-2521
申请单位	湖南澳维科技股份有限公司
申请单位地址	湖南省株洲市天元区栗雨工业园火炬四道
实际生产企业	湖南澳维科技股份有限公司
实际生产企业地址	湖南省株洲市天元区栗雨工业园火炬四道
审批结论	经审核，该产品符合《生活饮用水卫生监督管理办法》的有关规定，现予批准。
批准文号	(湘)卫水字(2019)第 0090 号
批准日期	2022 年 03 月 25 日
批件有效期	截至 2023 年 12 月 18 日

共2页 第2页

产品技术信息

【产品说明】

1、产品类型：水处理材料

2、产品型号：OV-NF系列、OV-NF10系列、OV-NF30系列、OV-NF60系列、OV-NF90系列

3、技术参数

型号	OV-NF 系列						
规格	1810	1812	2012	2812	3012	3013	3213
截留率 $MgSO_4$%	≥96	≥96	≥96	≥96	≥96	≥96	≥96
截留率 NaCl%	30±10	30±10	30±10	30±10	30±10	30±10	30±10
最低产水流量 m^3/d	0.28	0.38	0.57	1.14	1.52	1.52	2.28

型号	OV-NF10 系列					OV-NF30 系列				
规格	8040	4040	2540	4021	2521	8040	4040	2540	4021	2521
截留率 $MgSO_4$%	≥90	≥90	≥90	≥90	≥90	≥96	≥96	≥96	≥96	≥96
截留率 NaCl%	10±10	10±10	10±10	10±10	10±10	30±10	30±10	30±10	30±10	30±10
最低产水流量 m^3/d	56.8	11.3	4.5	5.6	1.9	45.5	9.1	3.8	4.5	1.5
型号	OV-NF60 系列					OV-NF90 系列				
规格	8040	4040	2540	4021	2521	8040	4040	2540	4021	2521
截留率 $MgSO_4$%	≥97	≥97	≥97	≥97	≥97	≥98	≥98	≥98	≥98	≥98
截留率 NaCl%	60±10	60±10	60±10	60±10	60±10	90±10	90±10	90±10	90±10	90±10
最低产水流量 m^3/d	37.9	7.5	3.0	3.7	1.2	34.1	6.8	2.7	3.4	1.1

【主要成份或部件】

序号	材料名称	材质	用量
1	纳滤膜	聚酰胺复合膜	<47.5m^2
2	PP浓水网格	聚丙烯	<22.5m^2
3	导流布	聚对苯二甲酸乙二酯	<23.5m^2
4	中心管	丙烯腈－丁二烯－苯乙烯共聚物	1支
5	双组份聚氨酯密封胶	聚氨酯	<0.85Kg

【使用范围】

适用于生活饮用水处理系统配套使用。

【注意事项】

1、使用寿命 3-5 年；

2、本品的贮存温度为 0-45℃，运输过程中应固定牢靠，防雨防潮，不得重压，不得与有毒有害物品混运输；

3、纳滤膜元件成品使用前应充分冲洗，使用过程中定期清洗，停用应冲洗消毒，重新使用前充分清洗。

备注

1、本批件只对与所载明内容(包括名称、类别、规格、申请单位、企业、附件内容等)一致的产品有效，且必须在本批件注明的实际生产企业生产。

2、批准时仅对其所申报材料对应产品的卫生安全性进行了审核，未对其所宣传的功能和其他质量问题进行评价。

请于批件有效期届满 30 个工作日之前提出延续申请。

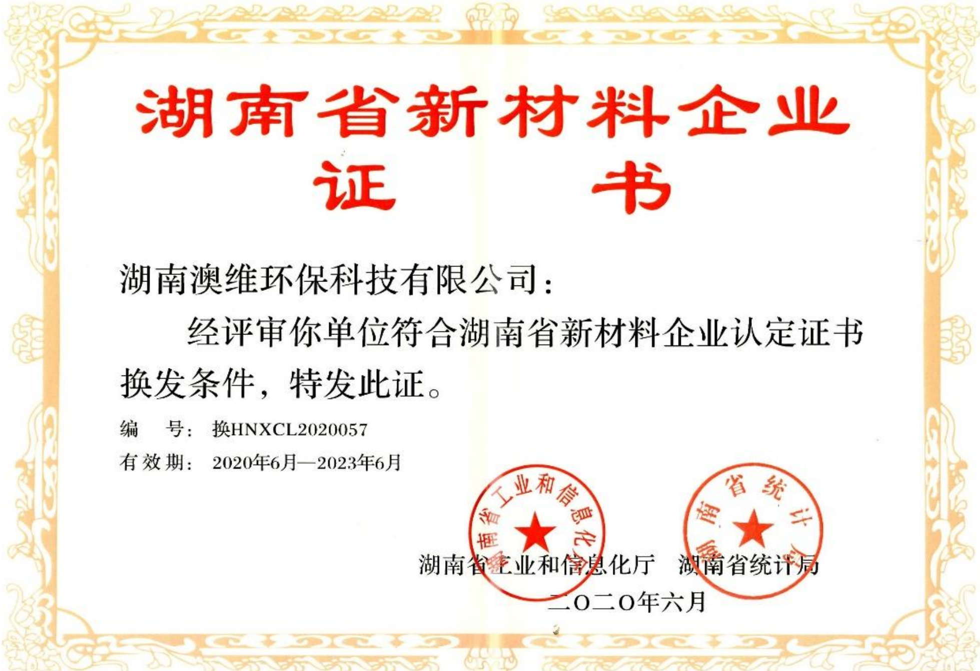
湖南省卫生健康委员会

2022 年 03 月 25 日(变更)

[8.4] Company Honor

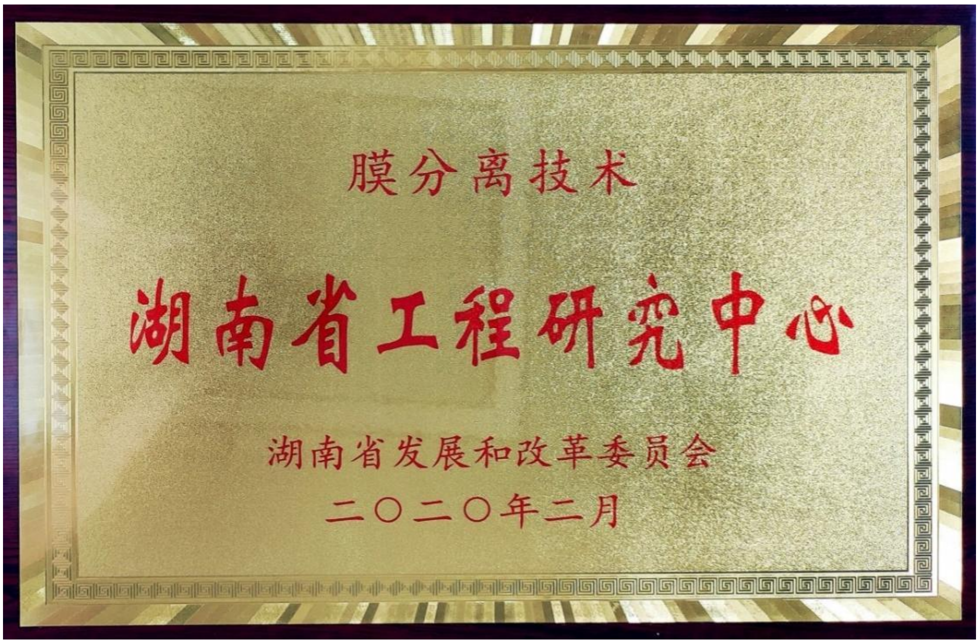
High-tech Enterprise

Hunan New Material Enterprise



Hunan Enterprise Technology Center

Hunan Engineering Research Center of Membrane Separation Technology



Hunan Engineering Technology Research Center of Liquid Separation Membrane

Special and Sophisticated “Little Giant” Enterprise

AAA Credit Certification of Membrane Industry Association of China

Science and Technology Award of Membrane Industry Association of China

Hunan Science and Technology Progress Award

湖南省科学技术进步奖

证 书

为表彰湖南省科学技术进步奖获得者，特颁发此证书。

获奖项目：新型反渗透复合膜材料研发

奖励等级：三等奖

获奖单位：湖南澳维环保科技有限公司
（第1完成单位）

湖南省人民政府

证书号：20194198-J3-102-D01

2020年04月

Hunan Patent Award

湖南专利奖

证书

为表彰湖南专利奖获得者，特颁发此证书。

获奖专利：一种大通量聚酰胺复合膜

专 利 号：ZL201410775101.6

奖励等级：三等奖

专利权人：湖南澳维环保科技有限公司

发 明 人：彭 博 路宏伟 胡群辉 喻 慧

贺 攀 王 进 刘 旦 王纯清

刘鹏君

湖南省专利奖奖励委员会

二〇二〇年四月

证书号:HNZL2019-J3-Q26

Schedule 1: System Design Parameters

Raw water source		RO Produced water	Groundwater	Surface water	Deep well brine	Surface seawater	Tertiary wastewater
Inlet water quality index	Maximum SDI (15 mins)	1	2	4	3	4	4
	Turbidity (NTU)	0.1	0.1	0.2	0.1	0.1	0.2
	TOC	1	3	5	3	3	10
	BOD	3	8	13	8	8	26
	COD	4	11	18	11	11	36
Average system flux: GFD		21	16	12	10	8	10
Flux attenuation:% (year)		5	7	7	7	7	15
Permeable salt rate increase:% (year)		5	10	10	10	10	10
Maximum inlet water flow GPM/m^3/h (4” Membrane shell)		16/3.6	16/3.6	16/3.6	16/3.6	16/3.6	16/3.6
Maximum inlet water flow GPM/m^3/h (8” Membrane shell)		75/17.0	75/17.0	75/17.0	75/17.0	75/17.0	75/17.0
Pressure loss: Psi (single container)		40	40	40	40	40	40
Pressure loss: Psi (single membrane element)		10	10	10	10	10	10
Water Temperature ℃		5-45	5-45	5-45	5-45	5-45	5-45

Schedule 2: Unit Conversion

Pressure:

	atm	mmHg	psi	kg/cm^2	MPa	bar
atm	1	760	14.696	1.0332	0.1013	1.0133
mmHg	1.316×10^{-3}	1	1.934×10^{-2}	1.360×10^{-3}	1.333×10^{-4}	1.333×10^{-3}
psi	6.805×10^{-2}	51.715	1	7.031×10^{-2}	6.895×10^{-3}	6.895×10^{-2}
kg/cm^2	0.9679	735.58	14.224	1	9.807×10^{-2}	0.9807
MPa	9.8692	7500.8	145.04	10.197	1	10.00
bar	0.9869	750.00	14.504	1.0197	0.1000	1

Flow:

	L/m^2h	GFD	cm^3/cm^2s	m^3/m^2d	L/m^2d
L/m^2h	1	0.59	2.780×10^{-5}	2.400×10^{-2}	24
GFD	1.70	1	4.720×10^{-4}	4.070×10^{-2}	40.730
cm^3/cm^2s	36000	21200	1	864	8.640×10^{5}
m^3/m^2d	41.667	24.550	1.157×10^{-3}	1	1×10^{3}
L/m^2d	4.167×10^{-2}	2.455×10^{-2}	1.157×10^{-6}	1×10^{-3}	1

Area:

	m^2	cm^2	in^2	ft^2
m^2	1	10000	1550	10.764
cm^2	1×10^{-4}	1	0.1550	1.0764×10^{-3}
in^2	6.4516×10^{-4}	6.4516	1	6.9444×10^{-3}
ft^2	9.2903×10^{-2}	929.03	144	1

Volume:

	m^3	l	in^3	ft^3	US gal
m^3	1	1000	61024	35.315	264.17
l	1×10^{-3}	1	61.024	3.5315×10^{-2}	0.2642
in^3	1.6387×10^{-5}	1.639×10^{-2}	1	5.7871×10^{-4}	4.3290×10^{-3}
ft^3	2.8317×10^{-2}	28.317	1728.0	1	7.4805
US gal	3.7854×10^{-3}	3.7854	231.00	0.1337	1

Schedule 3: Standardized Temperature Correction Coefficient Table of Water Yield

Temperature ℃	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	1.550	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	1.160	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	0.890	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

Actual water yield at a certain temperature=standard water yield at 25℃ ÷ correction coefficient at this temperature