陶氏超高压反渗透技术及其在浓盐水处理中的应用

Dow Water & Process Solutions
陶氏水处理及过程解决方案

Dow.com

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现有技术
- 投资成本高
- 运行成本高

市场需要可以用得起的技术及产品

Dow™ UHP RO
陶氏超高压反渗透

陶氏超高压反渗透膜产品参数

- 最高操作压力120bar @ max 30˚C
- 8英寸膜元件有效过滤面积：27m^2
- 设计及运行通量：4-13L/m^2.h（视进水水质及预处理工艺）
- 进水流道34 mil
- 标准测试性能：产水量1m^3/h（6,400 gpd），稳定脱盐率: 99.7 %

标准测试条件：32,000 ppm NaCl, 800 psi (5.5 MPa), 77° F (25 ℃), pH 8, 8% recovery

产品名称	最大操作压力	组件直径 英寸	组件长度 英寸	有效面积 平方英尺	平方米
XUS180808	120bar (30℃)	7.9	40	285	27
XUS180804	120bar (30℃)	3.9	40	60	5.6
XUS180802	120bar (30℃)	2.4	40	18	1.7

产品参数表PDS

Product Data Sheet

DOW™ XUS180808 Reverse Osmosis Element

Ultra-High Pressure, High-Rejection, Reverse Osmosis Elements for Industrial Water Purification

Description

The DOW™ XUS180808 Reverse Osmosis Element is an ultra-high pressure element offering an industry wide unique combination of features:

- Up to 120 bar (1,740 psi), ultra-high feed pressure capability due to special element and membrane design
- Increasing the overall efficiency of Zero-Liquid-Discharge (ZLD) by achieving highest solute concentrations thus reducing the size of downstream thermal treatment
- Excellent for recovery of salts in process streams
- Robust DOW FILMTEC™ reverse osmosis (RO) membrane sheet;
- 34 mil feed spacer to lessen the impact of fouling on the pressure drop across a vessel and to enhance cleaning effectiveness.

Product Type

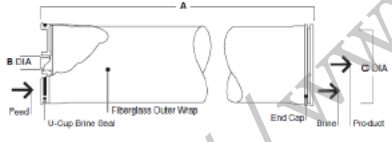
Spiral-wound element with polyamide thin-film composite membrane

Product Specifications

DOW™ Specialty Membrane Element	Active Area (ft²)	Active Area (m²)	Feed Spacer Thickness (mil)	Permeate Flow Rate (GPD)	Permeate Flow Rate (m³/d)	Typical Stabilized Salt Rejection (%)	Minimum Salt Rejection (%)
XUS180808	285	27	34	6,400	24.2	99.7	99.5

1. Permeate flow and salt (NaCl) rejection based on the following standard test conditions: 32,000 ppm NaCl, 800 psi (55 bar), 77°F (25°C), pH 8, 8% recovery.
2. Flow rates for individual elements may vary but will be no more than ± 15%.
3. Sales specifications may vary as design revisions take place.
4. Active area guaranteed ± 3%. Active area as stated by Dow Water & Process Solutions is not comparable to nominal membrane area often stated by some manufacturers. Measurement method described in Form No. 609-00434.

Element Dimensions



DOW™ Specialty Membrane Element	A (in.)	A (mm)	B (in.)	B (mm)	C (in.)	C (mm)
XUS180808	40.0	1,016	1.125 ID	29 ID	7.9	201

1. Refer to Dow Water & Process Solutions Design Guidelines for multiple-element applications. 1 inch = 25.4 mm
2. Element to fit nominal 8-inch (203-mm) I.D. pressure vessel.

Operating and Cleaning Limits*

Maximum Operating Temperature [a, d]	113°F (45°C)
Maximum Operating Pressure at 30°C[d]	1,740 psig (120 bar)
Maximum Element Pressure Drop	15 psig (1.0bar)
pH Range, Continuous Operation [a]	2 – 11
pH Range, Short-Term Cleaning (30 min.) [b]	1 – 13
Maximum Feed Silt Density Index (SDI)	SDI 5
Free Chlorine Tolerance [c]	< 0.1 ppm

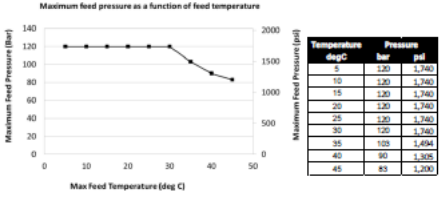
* Results may vary depending on specific operating conditions.

[a] Maximum temperature for continuous operation above pH 10 is 95°F (35°C).

[b] Refer to guidelines in specification sheet 609-23010 for more information.

[c] Under certain conditions, the presence of free chlorine and other oxidizing agents will cause premature membrane failure. Since oxidation damage is not covered under warranty, Dow Water & Process Solutions recommends removing residual free chlorine by pretreatment prior to membrane exposure. Please refer to technical bulletin 609-23010 for more information.

[d] Relation between maximum allowed feed pressure and maximum feed temperature:



Temperature degC	Pressure bar	Pressure psi
5	120	1,740
10	120	1,740
15	120	1,740
20	120	1,740
25	120	1,740
30	120	1,740
35	103	1,494
40	90	1,305
45	83	1,200

Additional Important Information

Before use or storage, review these additional resources for important information:

- Usage Guidelines for DOW FILMTEC™ 8" Elements (technical bulletin 609-50176)
- System Operation: Initial Start-Up (technical bulletin 609-02077)
- Handling, Preservation and Storage (technical bulletin 609-02103)

Regulatory Note

These membranes may be subject to drinking water application restrictions in some countries; please check the application status before use and sale.

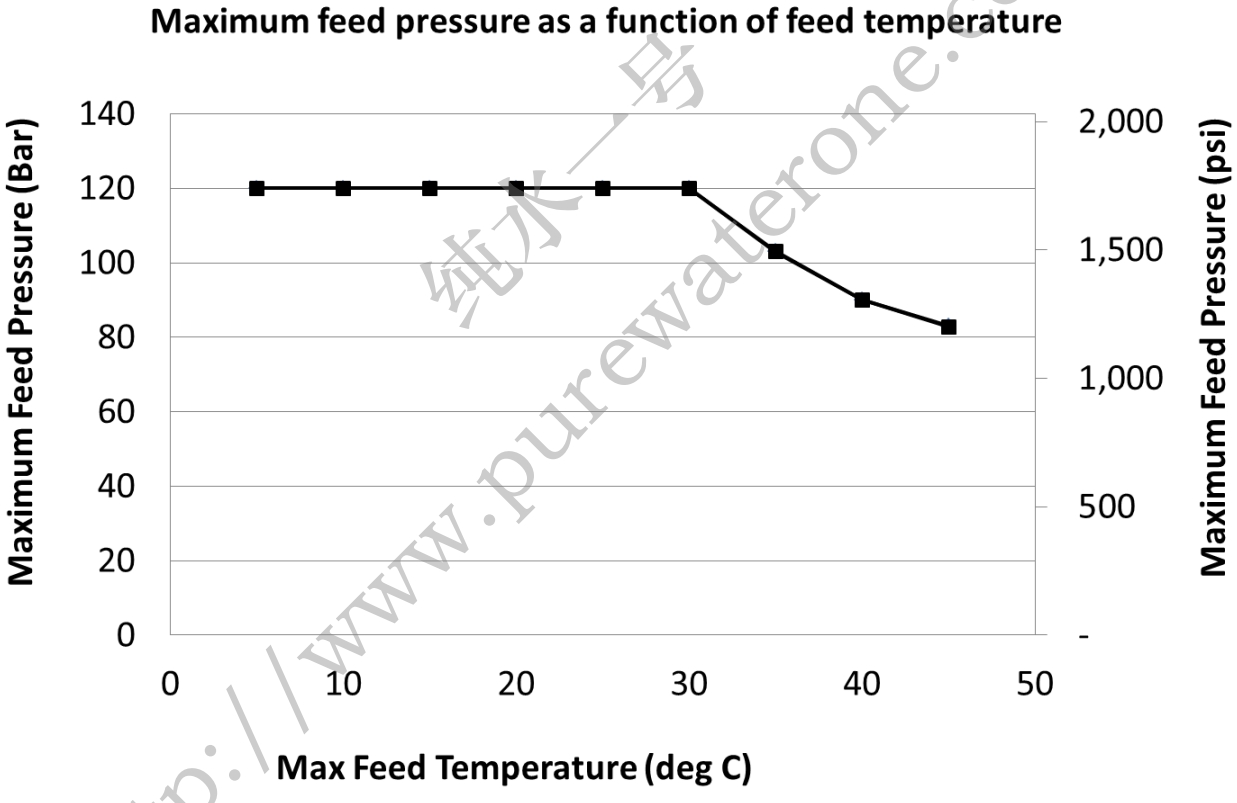
Product Stewardship

Dow has a fundamental concern for all who make, distribute, and use its products, and for the environment in which we live. This concern is the basis for our product stewardship philosophy by which we assess the safety, health, and environmental information on our products and then take appropriate steps to protect employee and public health and our environment. The success of our product stewardship program rests with each and every individual involved with Dow products—from the initial concept and research, to manufacture, use, sale, disposal, and recycle of each product.

Customer Notice

Dow strongly encourages its customers to review both their manufacturing processes and their applications of Dow products from the standpoint of human health and environmental quality to ensure that Dow products are not used in ways for which they are not intended or tested. Dow personnel are available to answer your questions and to provide reasonable technical support.

最大操作压力Vs 进水温度的关系

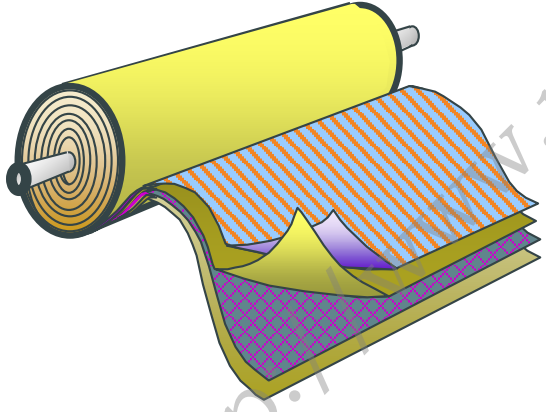


陶氏超高压反渗透膜耐高压性能测试

- 在极端条件下，对膜组件进行了耐高压性能测试：
  - ✓ 测试产品：8英寸组件 – XUS180808
  - ✓ 测试压力：80%的时间下，压力维持在120bar
  - ✓ 测试温度: 25˚C to 52˚C（大大超过30 ˚C ）
  - ✓ 测试液： 32,000 mg/L to 105,000 mg/L NaCl溶液
  - ✓ 测试持续时间：7天
- 测试结果
  - ✓ 在120bar，105,000 mg/L NaCl浓度下，稳定的渗透液流量：230L/h
- 组件完整性复测（海水膜标准测试条件）
  - ✓ 极端试验后脱盐率：99.75%，产水量：0.19 m^3/h（ 1,227 gpd ）
  - ✓ 标准脱盐率：99.70%，产水量：1 m^3/h（ 6,400 gpd ）

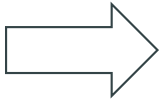
陶氏超高压反渗透膜特点

- 成熟的卷式膜技术；
- 经过优化的组件构造，确保忍受超高运行压力；
- 结实耐用的耐高压反渗透膜片；
- ROSA软件配合设计模拟。



陶氏超高压反渗透膜的优势

- 经过优化成熟可靠的卷式反渗透膜技术
  - ✓ 耐高压
  - ✓ 抗污染
- 大幅降低浓盐水处理、零排放系统的成本
  - ✓ 低投资成本
  - ✓ 低运行成本
- 运行维护更方便
  - ✓ 结构简单、系统简洁
  - ✓ 用户卷式膜系统运行经验



客户
用得
起的
可靠
技术

陶氏超高压膜的主要应用

- 陶氏超高压反渗透主要用于浓盐废水的处理，包括：

火力发电行业
- 脱硫废水
- 循环冷却水排污水

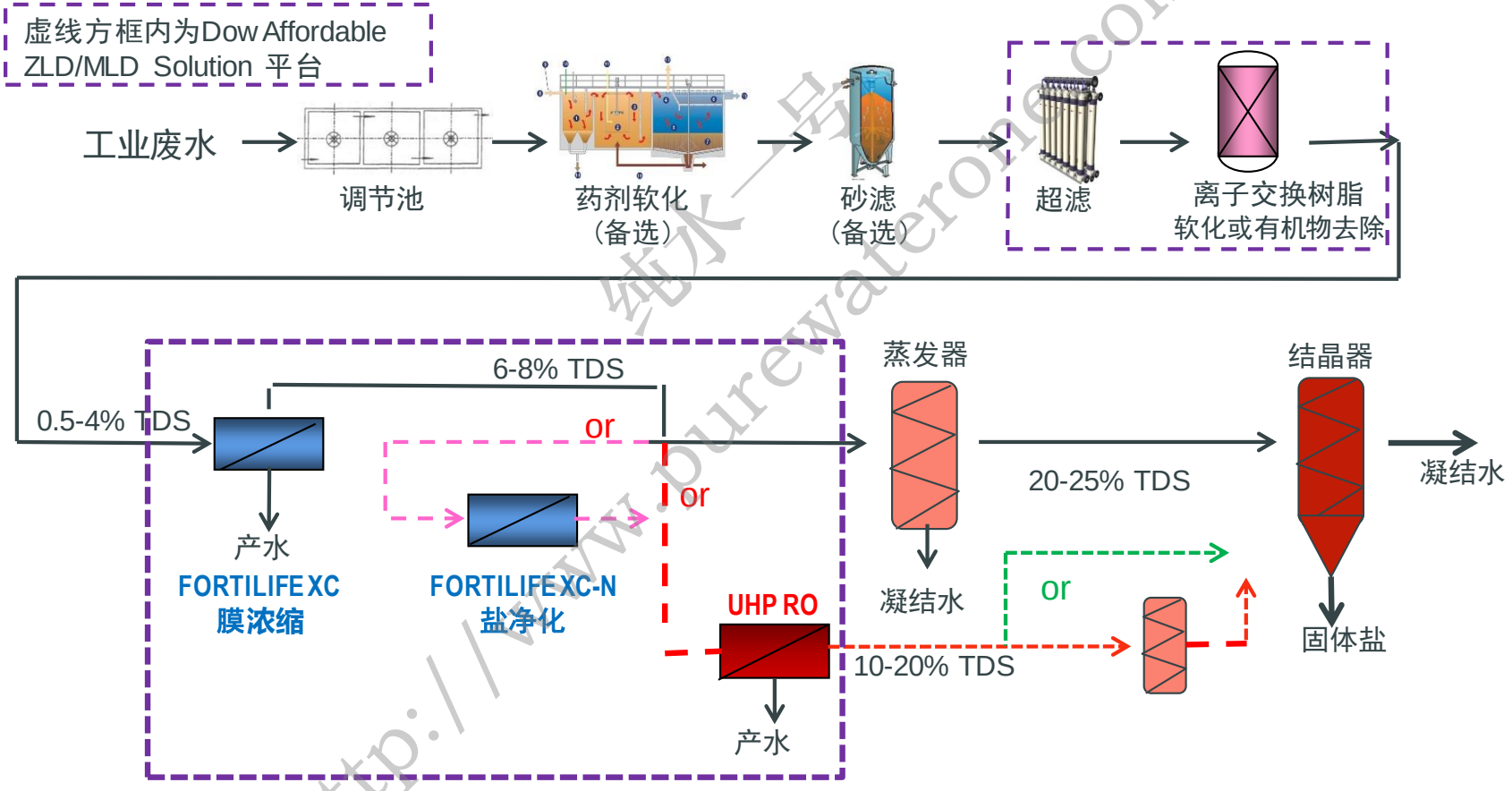
冶金及湿法冶金
- 采矿尾水
- 矿山废水
- 湿法冶金废水

化工及石化行业
- 煤化工废水
- 化工废水
- 炼化废水

油气开采行业
- 油田采出水
- 煤层气废水

- 陶氏超高压反渗透也可以用于含盐液体、特殊液体的浓缩等。

陶氏超高压反渗透用于浓盐水处理的典型工艺流程



超高压反渗透膜系统设计

1	估计系统规模	根据设计通量 4 -13 L/m^2/h（原水水质、含盐量及盐的种类有关）和设计产水规模确定
2	初步设计	DWPS根据客户提供原水水质分析报告，利用ROSA软件进行初步设计计算。
3	中试实验	如果需要，可采用真实的原水进行高压膜中试，并配备合理的预处理，来确定最优通量、化学清洗周期及清洗方式等。
4	优化设计	基于中试结果，DWPS与客户一起对设计工艺进行优化

工业化应用

- 从今年初正式推出超高压反渗透，经过半年的商务推广，目前已有三个工业化项目
  - 湖北某新能源材料零排放项目一期：70支
  - 山东某化工集团化工废水零排放项目：48支
  - 湖北某新能源材料零排放二期：140支
- 以上项目会陆续在三、四季度调试运行，后续我们会分享系统的运行情况的信息。

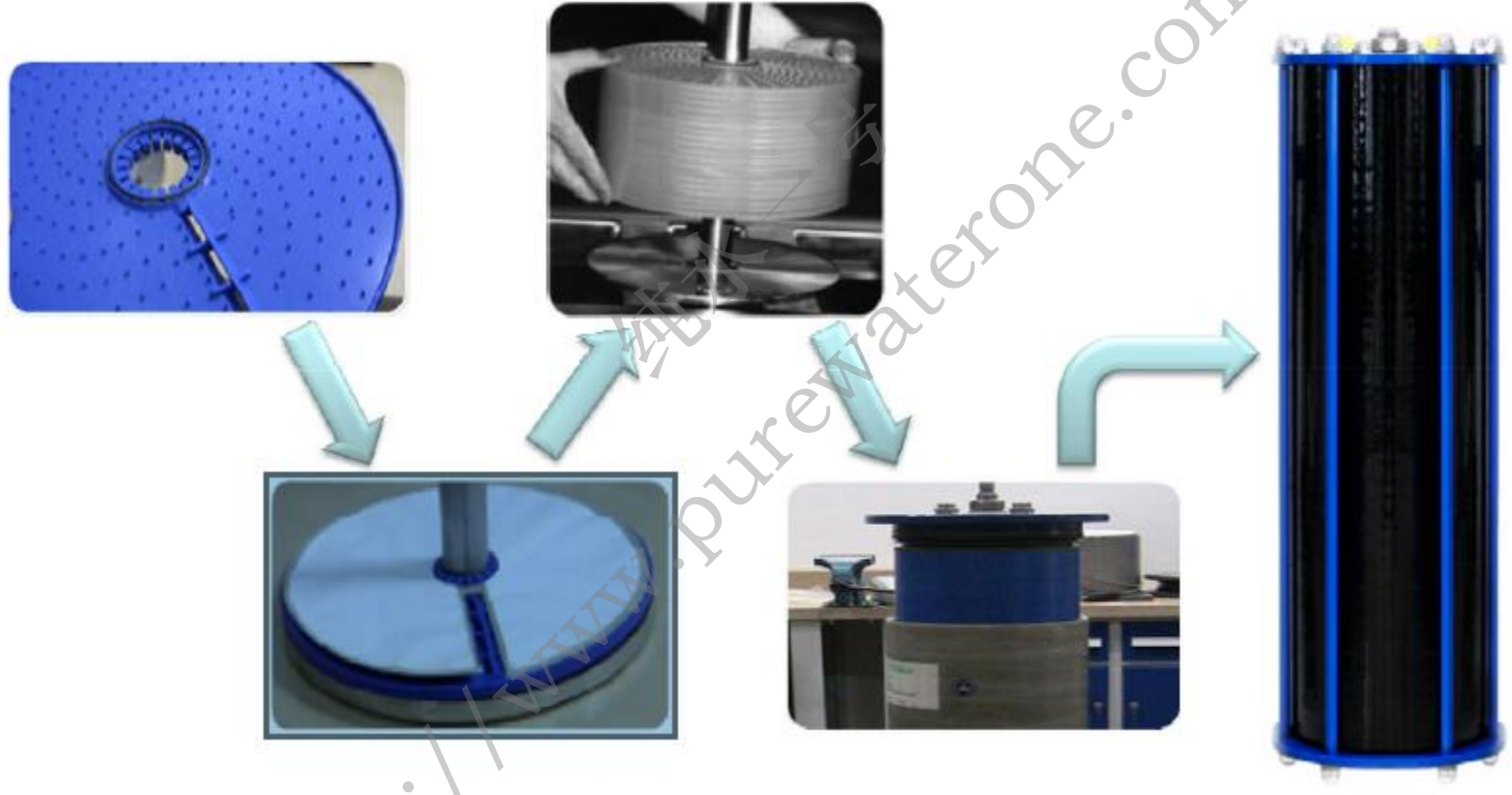
总结

- 陶氏超高压反渗透已经工业化，有8、4和2.5英寸的膜组件可供客户选择；
- 通过对成熟传统卷式膜工艺的改进，陶氏超高压反渗透的最大运行压力可达120bar，并通过极端压力和温度测试。
- 陶氏超高压反渗透可以大大降低浓盐水处理或零排放系统的投资和运行成本
- 陶氏将协助客户ROSA模拟，试验支持及设计优化等。
- 除了超高压反渗透外，陶氏还为客户提供预处理、预浓缩技术及产品。

期待与您合作!

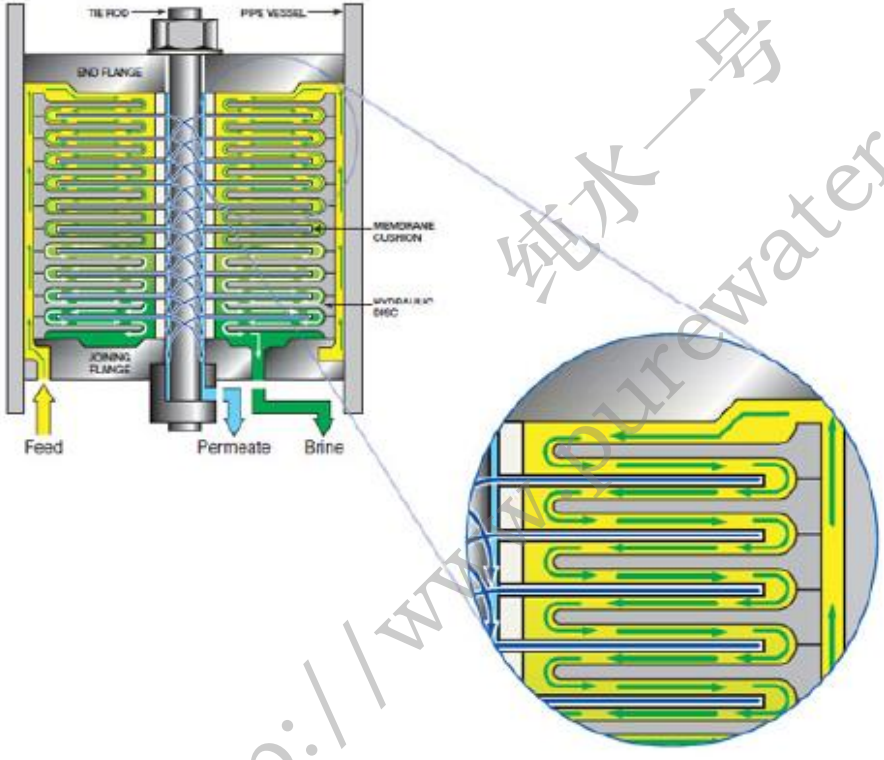
Backup slides

DTRO design



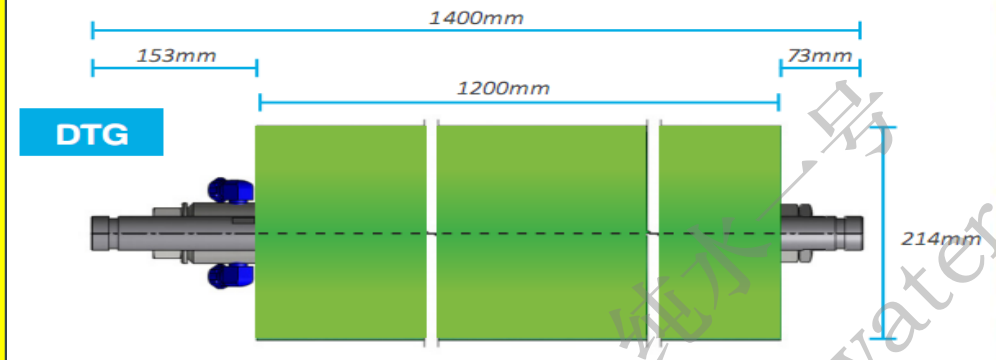
DTRO flow scheme cont'd

*This design is similar to that seen at the Nanjing Huanmei LFL end user site



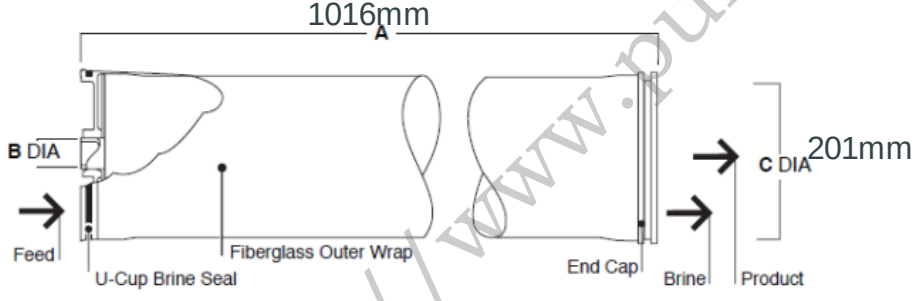
UHP RO Vs DTRO：运行维护

DTRO



有效过滤面积:9.4m²

UHPRO



有效过滤面积:26.5m²

- UHP RO有更高的过滤效率，同样规模使用的组件更少，需要配件、接头少，系统简洁，管理方便；
- DTRO组件设计复杂，单个组件9.4m²就有200个O型密封圈，实际使用中有很大的泄漏风险；
- DTRO虽然可以拆卸进行人工清洗，但有可能伤及膜片，同时劳动量大，反复拆卸组装，易泄漏。

UHP RO Vs DTRO – 实际运行项目抗污染性能

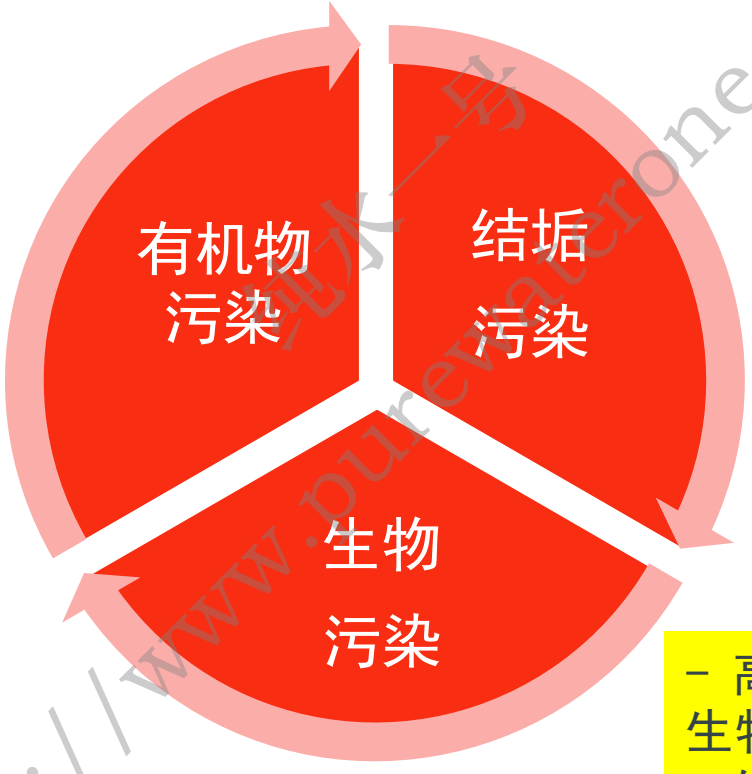
- 项目地点：南京垃圾填埋场渗滤液处理项目
- 项目有卷式SWRO系统和DTRO系统，预处理为管式超滤MBR

膜组件：SW30-400/34i
设计通量：10.5 LMH
单支产水：0.4 m^3/h
产水量：14 m^3/h
数量：36 支
化学清洗周期：**15-20d**

组件类型：DTRO
设计通量：10 LMH
单支产水：0.1 m^3/h
产水量：14 m^3/h
组件数量：144 支
化学清洗周期：**15-20d**
常发生组件泄漏问题

UHP RO Vs DTRO – 浓盐水处理应用抗污染性能分析

- 废水中的有机物性质；
- 采用膜片的性质及抗污染性能



- 废水中难溶物质的溶度积
- 阻垢剂的性能
- 软化预处理

- 高盐废水，微生物难生存；
- 生物污染不易发生

陶氏超高压反渗透UHP RO特点及与其它品牌比较

其它产品	DOW	
低脱盐率 苦咸水膜标准条件下 最低脱盐率98.0%	高脱盐率 海水膜标准条件下 最低脱盐率99.5%	出水水质更好，一般可直接回用，无需二次处理，效率高。
娇贵不耐压的 普通苦咸水膜片	皮实耐用的 抗高压FILMTEC SW30膜片	更耐“压密”效应，耐清洗，寿命长，众多DTRO品牌的选择
仅考虑原水流道，欠缺综合考虑的组件设计 31.9m^2/35mil	针对高压运行环境针对性的组件设计 27m^2/34mil	保证高压下的膜片的完整性，保证脱盐率，组件寿命更长

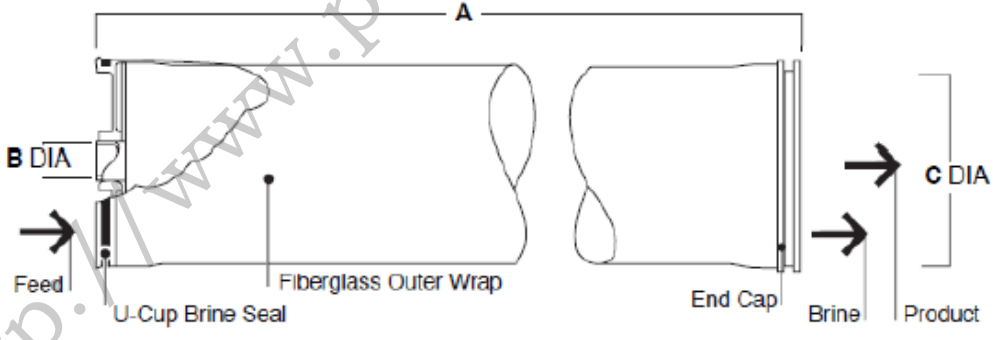
Product Data Sheet of Dow UHP RO

Product Specifications

DOW™ Specialty Membrane Element	Active Area (ft^2)	Active Area (m^2)	Feed Spacer Thickness (mil)	Permeate Flow Rate (GPD)	Permeate Flow Rate (m^3/d)	Typical Stabilized Salt Rejection (%)	Minimum Salt Rejection (%)
XUS180808	285	27	34	6,400	24.2	99.7	99.5

1. Permeate flow and salt (NaCl) rejection based on the following standard test conditions: 32,000 ppm NaCl, 800 psi (55 bar), 77°F (25°C), pH 8, 8% recovery.
2. Flow rates for individual elements may vary but will be no more than ± 15%.
3. Sales specifications may vary as design revisions take place.
4. Active area guaranteed ± 3%. Active area as stated by Dow Water & Process Solutions is not comparable to nominal membrane area often stated by some manufacturers. Measurement method described in Form No. 609-00434.

Element Dimensions



Product Data Sheet of Dow UHP RO

Operating and Cleaning Limits*

Maximum Operating Temperature [a, d]	113°F (45°C)
Maximum Operating Pressure at 30°C[d]	1,740 psig (120 bar)
Maximum Element Pressure Drop	15 psig (1.0bar)
pH Range, Continuous Operation [a]	2 – 11
pH Range, Short-Term Cleaning (30 min.) [b]	1 – 13
Maximum Feed Silt Density Index (SDI)	SDI 5
Free Chlorine Tolerance [c]	< 0.1 ppm

* Results may vary depending on specific operating conditions.

[a] Maximum temperature for continuous operation above pH 10 is 95°F (35°C).

[b] Refer to guidelines in specification sheet 609-23010 for more information.

[c] Under certain conditions, the presence of free chlorine and other oxidizing agents will cause premature membrane failure. Since oxidation damage is not covered under warranty, Dow Water & Process Solutions recommends removing residual free chlorine by pretreatment prior to membrane exposure. Please refer to technical bulletin 609-22010 for more information.

[d] Relation between maximum allowed feed pressure and maximum feed temperature:

X Industrial RO Product Data Sheet

GE Power & Water
Water & Process Technologies

Fact Sheet

Industrial RO Series

Industrial High Pressure Brackish Water RO Elements

The S-Series proprietary thin-film reverse osmosis membrane is used in the Industrial RO3 elements. It is characterized by high sodium chloride rejection and a smooth, fouling-resistant membrane surface.

The A-Series proprietary thin-film reverse osmosis membrane is used in the Industrial RO5 and RO6 elements. It is characterized by high sodium chloride rejection and a high permeability.

Industrial RO Brackish Water Elements are used for concentration of wastewater streams with a high osmotic pressure or a high level of solids. They can also be used to concentrate diluted acids.

These elements feature a 35mil or 50mil spacer in a high pressure compatible element assembly.

Table 1: Element Specification

Membrane	S-Series, Thin-film membrane (TFM*) A-Series, Thin-film membrane (TFM*)

Model	Average permeate flow gpd (m3/day)[1,2]	Average NaCl rejection[1,2]	Minimum NaCl rejection[1,2]
INDUSTRIAL RO3 4040F3S	1,900 (7.2)	99.0%	98.5%
INDUSTRIAL RO3 4040F5S	1,450 (5.5)	99.0%	98.5%
INDUSTRIAL RO3 8040F3S	7,800 (29.5)	99.0%	98.5%
INDUSTRIAL RO3 8040F5S	6,500 (24.6)	99.0%	98.5%
INDUSTRIAL RO5 4040F3S	1,950 (7.4)	99.5%	99.0%
INDUSTRIAL RO5 8040F3S	9,100 (34.4)	99.5%	99.0%
INDUSTRIAL RO5 8040F5S	7,400 (28.0)	99.5%	99.0%
INDUSTRIAL RO6 4040F3S	3,250 (12.3)	99.0%	98.0%
INDUSTRIAL RO6 8040F3S	15,400 (58.3)	99.0%	98.0%

[1] Average salt rejection after 24h operation. Individual flow rate may vary ±15%.
[2] Testing conditions: 2,000ppm NaCl solution at 425psi (2,930kPa) operating pressure for RO3 at 225psi (1,550kPa) for RO5 and RO6, 77°F, pH 6.5 and 15% recovery.

Model	Spacer mil (mm)	Active area ft² (m²)	Outer wrap	Part number
INDUSTRIAL RO3 4040F3S	35 (0.89)	77 (7.1)	Fiberglass	3050577
INDUSTRIAL RO3 4040F5S	50 (1.27)	61 (5.7)	Fiberglass	3069999
INDUSTRIAL RO3 8040F3S	35 (0.89)	333 (30.9)	Fiberglass	1207651
INDUSTRIAL RO3 8040F5S	50 (1.27)	269 (25.0)	Fiberglass	1207652
INDUSTRIAL RO5 4040F3S	35 (0.89)	77 (7.1)	Fiberglass	3050576
INDUSTRIAL RO5 8040F3S	35 (0.89)	333 (30.9)	Fiberglass	3144696
INDUSTRIAL RO5 8040F5S	50 (1.27)	269 (25.0)	Fiberglass	3097294
INDUSTRIAL RO6 4040F3S	35 (0.89)	77 (7.1)	Fiberglass	3144698
INDUSTRIAL RO6 8040F3S	35 (0.89)	333 (30.9)	Fiberglass	3144697

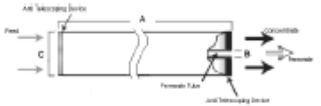


Figure 1a: Element Dimensions Diagram (Female) – 8040

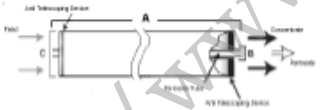


Figure 1b: Element Dimensions Diagram (Male) – 4040

Find a contact near you by visiting www.gewater.com and clicking on "Contact Us".
* Trademark of General Electric Company; may be registered in one or more countries.

Table 2: Dimensions and Weight

Model*	Dimensions, inches (cm) A	B†	C‡	Boxed Weight lbs (kg)
4040F	40.0 (101.6)	0.75 (1.90)	3.9 (9.9)	9 (4.1)
8040F	40.0 (101.6)	1.125 (2.86)	7.9 (20.1)	29 (13.21)

* These elements are dried then bagged before shipping.
† Internal diameter unless specified OD (outside diameter).
‡ The element diameter (dimension C) is designed for optimum performance in GE pressure vessels. Other pressure vessel dimension and tolerance may result in excessive bypass and loss of capacity.

Table 3: Operating and CIP Parameters

Typical Operating Flux	5 - 20 GFD (8 – 34 LMH)
Maximum Operating Pressure	1,200psi (8,276kPa) @ T≤77°F (25°C) 600psi (4,000kPa) @ T>77°F (25°C)
Maximum Temperature	Continuous operation: 122°F (50°C) Clean-in-Place (CIP): 122°F (50°C)
pH Range	Optimum rejection: 6.5-7.0, Continuous operation: 2.0-10.0, Clean-in-Place (CIP): 1.0-11.5
Maximum Pressure Drop	Over an element: 15psi (103kPa) Per housing: 60psi (414kPa)
Chlorine Tolerance	500+ ppm hours, dechlorination recommended
Feedwater	NTU < 1 SDI < 5

GE Water Industrial RO

Table 1: Element Specification

Membrane	S-Series, Thin-film membrane (TFM*) A-Series, Thin-film membrane (TFM*)

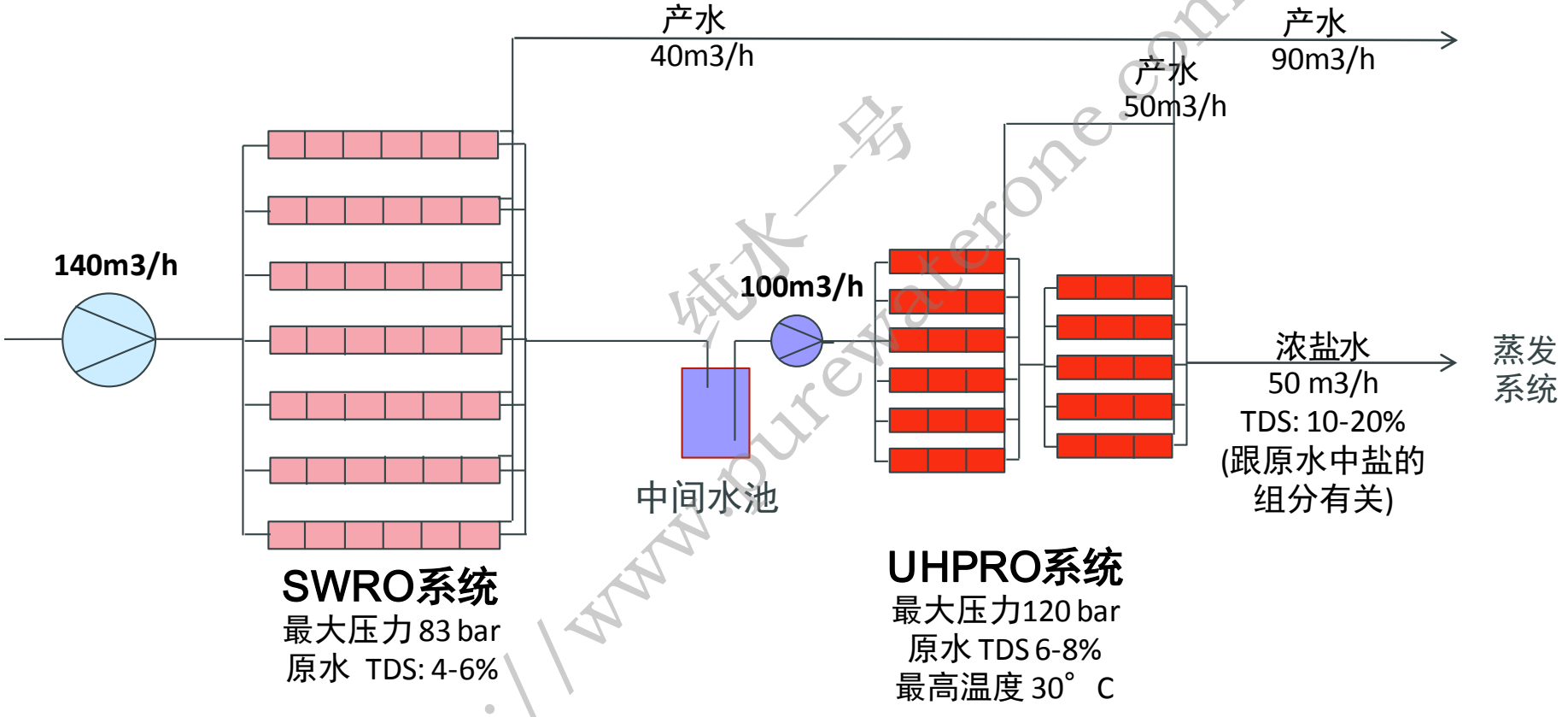
Model	Average permeate flow gpd (m3/day) [1,2]	Average NaCl rejection [1,2]	Minimum NaCl rejection [1,2]
INDUSTRIAL RO3 4040F35	1,900 (7.2)	99.0%	98.5%
INDUSTRIAL RO3 4040F50	1,450 (5.5)	99.0%	98.5%
INDUSTRIAL RO3 8040F35	7,800 (29.5)	99.0%	98.5%
INDUSTRIAL RO3 8040F50	6,500 (24.6)	99.0%	98.5%
INDUSTRIAL RO5 4040F35	1,950 (7.4)	99.5%	99.0%
INDUSTRIAL RO5 8040F35	9,100 (34.4)	99.5%	99.0%
INDUSTRIAL RO5 8040F50	7,400 (28.0)	99.5%	99.0%
INDUSTRIAL RO6 4040F35	3,250 (12.3)	99.0%	98.0%
INDUSTRIAL RO6 8040F35	15,400 (58.3)	99.0%	98.0%

[1] Average salt rejection after 24h operation. Individual flow rate may vary ±25%.
[2] Testing conditions: 2,000ppm NaCl solution at 425psi (2,930kPa) operating pressure for RO3 vs 225psi (1,550kPa) for RO5 and RO6, 77°F, pH 6.5 and 15% recovery.

Table 3: Operating and CIP Parameters

Typical Operating Flux	5 - 20 GFD (8 – 34 LMH)
Maximum Operating Pressure	1,200psi (8,276kPa) if T<77°F (25°C) 580psi (4,000kPa) if T>77°F (25°C)
Maximum Temperature	Continuous operation: 122°F (50°C) Clean-In-Place (CIP): 122°F (50°C)
pH Range	Optimum rejection: 5.5-7.0, Continuous operation: 2.0-10.0, Clean-In-Place (CIP): 1.0-11.5
Maximum Pressure Drop	Over an element: 15psi (103kPa) Per housing: 60psi (414kPa)
Chlorine Tolerance	500+ ppm hours, dechlorination recommended
Feedwater	NTU < 1 SDI < 5

浓盐水处理系统设计理念

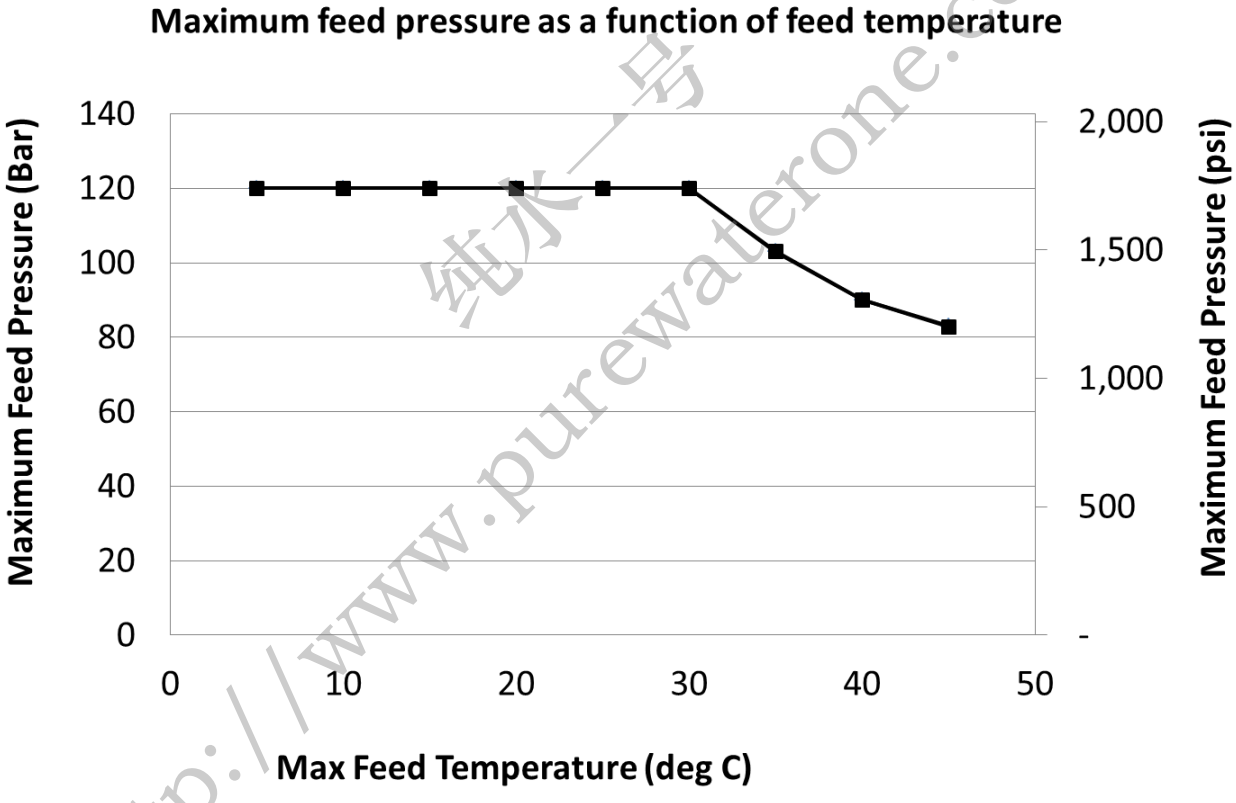


陶氏特种膜产品参数

	产品名称	直径 英寸	组件长度 英寸	有效膜面积 平方英尺 (m^2)	标准测试 流量GPD (m^3/d)	标准条件下 最小脱盐率%	操作极限
UHP RO	XUS180808	8	40	285 (27)	6,400 (24)	99.70[1)]	120 bar (at max 30C)
	XUS180804	4	40	60 (5.6)	1,350 (5.1)		
	XUS180802	2.5	40	18 (1.7)	400 (1.5)		
HT RO	XUS120308	8	38	235 (22)	5,250	99.70[1)]	80C (at max 30 bar)
	XUS120304	4	40	42 (3.9)	950		
NF 48 Mil	XUS290908	8	38	270 (25)	n.a.[2)]	n.a.	54.8bar (at max 50C)
	XUS290904	4	38	54 (5.0)	n.a.	n.a.	
HT NF	XUS290508	8	40	320 (30)	n.a.[2)]	n.a.	70C (at max 28 bar)
	XUS290504	4	40	70 (6.5)	n.a.	n.a.	

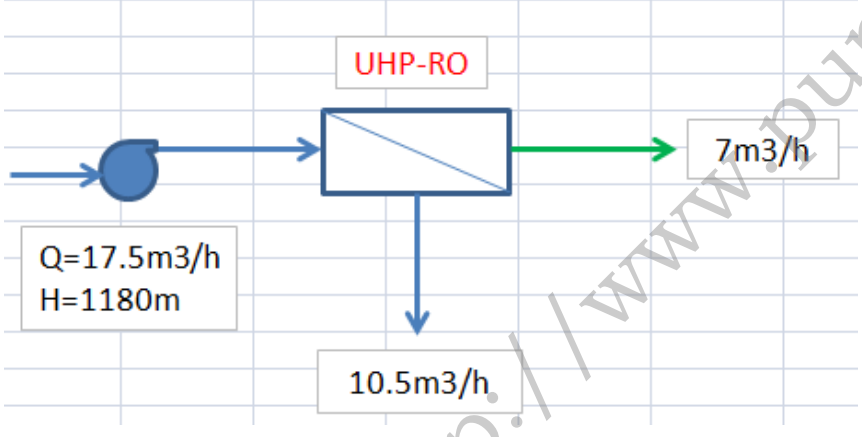
1) 32,000mg/l NaCl, 25C, 8% recovery, 800 psi
2) NF Process elements are wet tested but min flow or rejection is typically not required

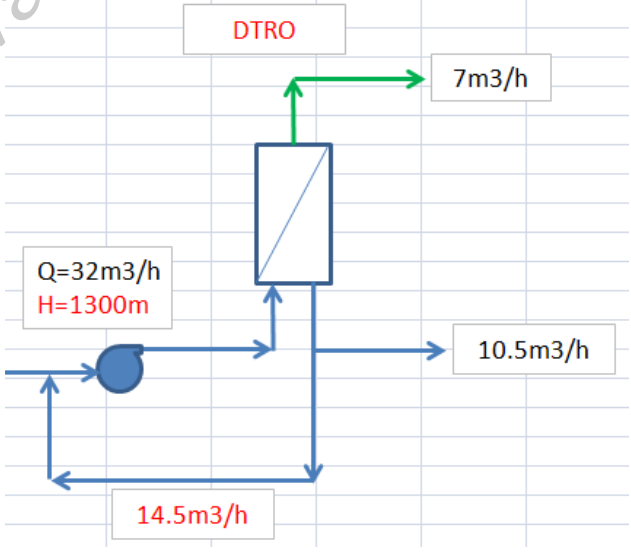
最大操作压力Vs 进水温度的关系



UHP RO Vs DTRO - 浓盐水处理应用经济性分析

- 以化工废水项目为例
  - ✓ 原水量17.5m³/h；
  - ✓ 原水TDS为88,000mg/L，其中硫酸根53,000mg/L，硝酸根2,400mg/L，氯离子4,300mg/L，钠离子27,500mg/L；
  - ✓ 系统回收率按40%考虑，即产水为7m³/h，得到浓水的TDS为146,370mg/L。





UHP RO Vs DTRO – 成本比较

- 系统配置

	DTRO	Dow UHP RO
膜组件数量	80 （通量9.3LMH）	30 （通量8.8LMH）
膜壳数量	组件自带	5支6芯装膜壳
高压泵规格	Q=32m³/h H=130bar N=160KW	Q=17.5m³/h H=118bar N=75KW
循环泵规格	不设循环泵 为保证流速浓水减压后回流至原水箱或保安过滤器前	无需浓水循环

- 投资成本， UHP RO系统比DTRO低60%以上。
- 运行成本，UHP RO系统比DTRO低30%以上。