nanostone water

Combining the Power of Ceramic & Polymeric Membranes

Membrane Modules for Landfill Leachate, Coal-To-Chemical (CTX) & Flue Gas Desulfurization (FGD)

About our company

Polymeric Membrane, Element and Module Production
Carlsbad, California

Nanostone Water is a membrane solutions company with a broad and unique portfolio of ceramic and polymeric membranes serving industrial process fluid and water treatment applications. Headquartered in Eden Prairie, Minnesota, the company has ceramic manufacturing operations in Halberstadt, Germany and manufactures polymeric membrane products at its Oceanside and Carlsbad, California facilities.

The Nanostone Water team is comprised of industry experts with deep domain expertise resulting from multiple decades of experience solving the world's most challenging separations problems. Our management team, research scientists, and application engineers bring a broad range of industry experience from companies such as GE Water & Process Technologies, Infilco Degramont, Hydraunatics, Koch Membranes, NanoH2O, and Osmonics.

Simply stated, our mission is to combine the power of a new generation of ceramic membranes with a robust portfolio of high performance polymeric membrane products to deliver the highest level of cost effectiveness and separations efficiency to our industrial process fluid and water treatment customers.

Ceramic Membrane and Module Production
Halberstadt, Germany

Membranes

Ceramic Membrane

Polymeric Membrane

Polymeric membranes are critical to a variety of industrial separations and purification processes ranging from food & beverage manufacturing to the purification of landfill leachate. The effectiveness of a membrane in any given application is highly dependent on the proper selection of polymer type, surface chemistry, pore size and morphology.

Nanostone Water offers over 37 unique microfiltration (MF), ultrafiltration (UF), nanofiltration (NF) and reverse osmosis (RO) polymeric membranes. We apply these membranes in a variety of module configurations and cross flow operations depending on flow volume, feed quality and discharge requirements.

Applications

Leachate / CTX / FGD

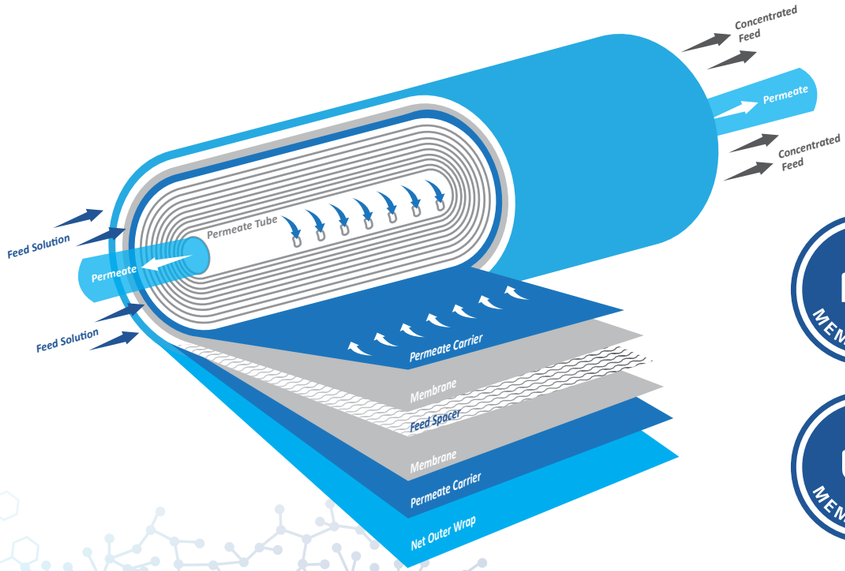
Electro Coating

Food & Beverage / Dairy

Industrial Water

Municipal Water

R&D



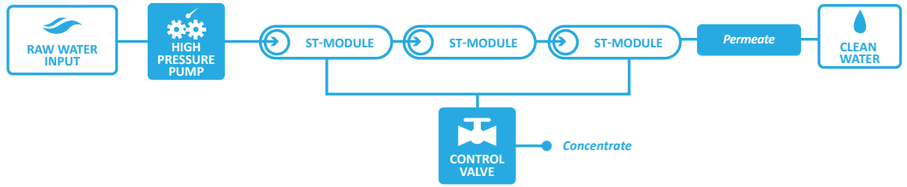
NF MEMBRANES

MF MEMBRANES

UF MEMBRANES

RO MEMBRANES

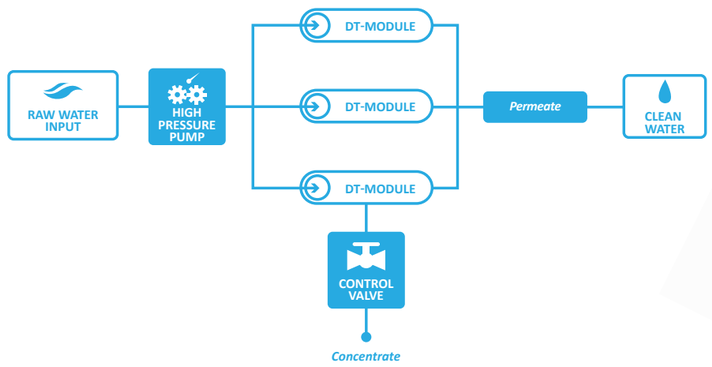
how the ST+ module works



The ST+ spiral-wound module is designed with a 34 mil parallel feed spacer in order to minimize contact between high fouling potential feeds and the membrane surface. The patented feed spacer geometry allows for a consistently low pressure drop across the vessel while dramatically reducing the build-up of fouling materials at the spacer-membrane interface.

The ST+ module has 26.5 m^2 (285.2 ft^2) of membrane area, designed for large volume applications, can be combined in sets of six in series circuits or three modules in parallel circuits. Available with Nanofiltration (NF) and Reverse Osmosis (RO) membranes, the ST+ design allows for unmatched high solids and organics separations in toughest high flow applications.

how the DTG module works



The DTG Module is a stacked disc type module and best for highly polluted feeds where the most stringent discharge requirements must be met. The DTG module allows for effective cleaning and consistent permeate quality across a variety of feed waters.

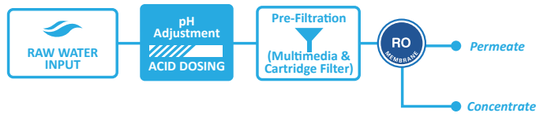
The DTG module has 9.3 m^2 (100.1 ft^2) of membrane area and can be combined in parallel circuits of up to 30 modules. Available with Reverse Osmosis (RO) membranes, the DTG module is the standard for the most difficult membrane applications.

Introduction to Landfill Leachate

Landfill leachate is a complex, high organic and heavy metal feed source that poses significant environmental risk if left untreated. Our clients require consistent permeate quality to meet stringent environmental regulations.

These applications are typically characterized by high organic (BOD/COD) loading and total suspended solids (TSS) content in wastewater needed proper treatment. The table below details the performance of a two-stage ST+ system at a landfill in Belgium.

Plant Parameter	Unit	Landfill ATTB, Belgium Two-Stage RO		
		Leachate Avg.	Permeate Avg.	Rejection (%)
Conductivity	µS/cm	14.800	64	99.6%
COD	mg/l	2094	< 15	> 99.3%
BOD_5	mg/l	458	0.77	99.8%
Ammonium (NH_4^+-N)	mg/l	664.6	5.03	99.2%
Total (P)	mg/l	6.14	< 0.05	> 99.2
Sodium (Na)	mg/l	1713	2.71	99.8%
Potassium (K)	mg/l	588	1.18	99.8%
Chloride (Cl)	mg/l	2583	3.98	99.8%
Sulfate (SO_4^{2-})	mg/l	94.1	< 0.5	> 99.5%
Boron (B)	mg/l	24.5	6.25	74.5%
Fluoride (F)	mg/l	5.5	< 0.2	> 96.4%
Cyanide (CN)	mg/l	0.04	< 0.02	> 50.0%
Iron (Fe)	mg/l	3.8	0.22	94.2%
Manganese (Mn)	mg/l	0.2	0.01	95.0%
Zinc (Zn)	mg/l	0.08	< 0.01	> 87.5%
Aluminium (Al)	mg/l	0.5	< 0.015	> 97.0%
Lead (Pb)	mg/l	0.022	< 0.006	> 72.7%
Chromium VI (Cr)	mg/l	0.098	< 0.02	> 79.6%
Arsenic (As)	mg/l	< 0.01	< 0.002	~ 80.0%
Cadmium (Cd)	mg/l	< 0.01	< 0.001	~ 90.0%
Nickel (Ni)	mg/l	0.17	< 0.001	> 99.4%
Copper (Cu)	mg/l	0.044	0.023	47.7%
Hydrocarbons	mg/l	2.200000	< 0.10	> 95.45%

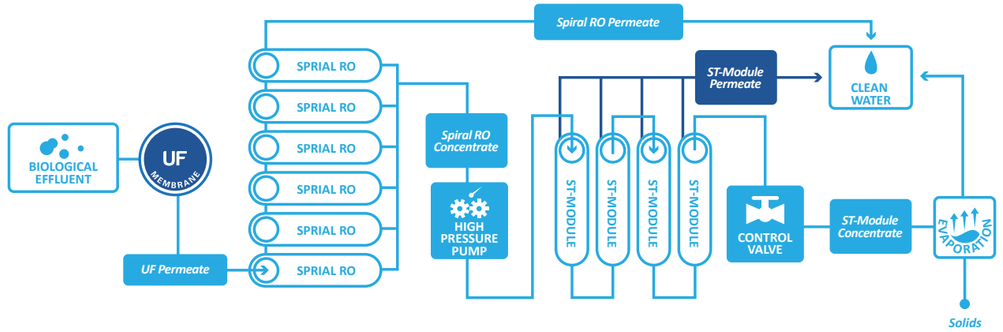


While this class of wastewater typically requires several treatment steps – high performance membranes are at the heart of meeting stringent discharge regulations including zero liquid discharge (ZLD) applications.

Depending on flow volume, feed quality and discharge requirements, Nanostone Water's application engineers can recommend the optimum module configuration and membrane to meet your needs. Contact us about your planned or current membrane system and we can help optimize overall throughput and membrane performance.

Introduction to Coal to Chemical (CTX)

With recent technological advancements, coal can now be economically converted into liquid fuels such as gasoline, diesel or any other petrochemical. The coal to chemical process consumes high volumes of water for cooling systems and a complex wastewater is produced in the liquefaction process. CTX waste effluents typically contain salts, minerals, sulfides, chlorides, ammonia, oil and grease, and cyanides. A typical coal-to-chemical wastewater treatment process is diagrammed below.

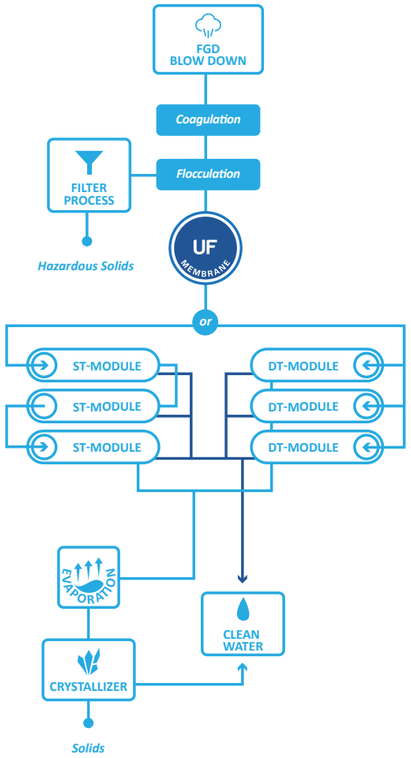


Wastewater produced in the CTX process is characterized by flow volumes with high organic loading and suspended solids. Based on a typical CTX wastewater stream, we've estimated the permeate quality following a single stage of ST+ modules:

Parameter	Unit	Water Quality Feed	Est. Permeate Quality First Stage*
pH	-	7.0-8.0	5.0-6.5
Temperature, design	°C	25	25
Conductivity	µS/cm	23.600	1100
TDS	mg/l	16.800	750
CODtotal	mgO2/l	300	10
Sodium (Na)	mg/l	5.800	90
Chloride (Cl)	mg/l	6.000	120
Total Suspended Solids	mg/l		<< 30
Nitrate (NO_3)	mg/l	2.650	< 500
Bicarbonate (HCO_3)	mg/l	72	80
Potassium (K)	mg/l	50	0.5
Magnesium (Mg)	mg/l	40	0.5
Sulfate (SO_4)	mg/l	1.800	20
Silicon dioxide (SiO_2)	mg/l	< 50**	< 1
Strontium (Sr)	mg/l	< 0.1	<< 0.1
Iron (Fe)	mg/l	< 1	<< 1
Aluminium (Al)	mg/l	< 0.1	<< 0.1
Fluorine (F)	mg/l	1.80	0.10
Calcium (Ca)	mg/l	40	0.5
Barium (Ba)	mg/l	< 0.1	<< 0.1
Manganese (Mn)	mg/l	< 0.1	<< 0.1

Introduction to Flue Gas Desulfurization (FGD)

Wet Flue Gas Desulfurization (FGD) is a process by which coal-fired power plants remove Sulphur Dioxide (SO^2) before emitting their flue gas into the atmosphere. The water intensive scrubbing process requires a durable treatment technology as FGD blowdown wastewaters have very high levels of chlorides (4,000 – 20,000 mg/L), trace concentrations of heavy metals (e.g. chromium, mercury, and selenium), high levels of nitrates (10-700 mg/L) and very high levels of total dissolved solids (20,000 to 60,000 mg/L). A typical FGD wastewater analysis is shown below.



Parameter	Unit	Typical Influent Range
TSS	mg/l	250-20000
TDS	mg/l	15000-35000
pH	-	4-6
Chloride (Cl)	mg/l	10000-25000
COD	mg/l	200-500
Udhayam (NH_4)	mg/l	20-60
Nitrate (NO_3)	mg/l	30-120
Calcium (Ca)	mg/l	300-5000
Magnesium (Mg)	mg/l	50-4000
Sulfate (SO_4)	mg/l	3000-5000
Fluorine (F)	mg/l	40-100
Aluminium (Al)	mg/l	20-200
Arsenic (As)	mg/l	0.5-0.8
Boron (B)	mg/l	1-10
Cadmium (Cd)	mg/l	0.05-0.1
Chromium (Cr)	mg/l	0.3-1
Iron (Fe)	mg/l	80-400
Selenium (Se)	mg/l	1-4
Silicon dioxide (SiO2)	mg/l	50-300

As a large membrane area solution for high-volume applications, the ST+ and ST++ modules can be used to significantly reduce treatment plant footprint and overall CAPEX.

Conventional processes, like coagulation/flocculation, softening and UF Filtration are used as pre-treatment to the RO in order to achieve Zero Liquid Discharge (ZLD). Nanostone ST+ or Disk Tube Grande (DTG) modules can be used to desalinate the wastewater and cost-effectively reduce the volume prior to evaporation. A typical FGD water treatment process is illustrated above.

ST+/ST++

Membrane Type

Model	ST+RO3	ST+RO4	ST+RO6
Nominal Rejection	98.50%	99.50%	99.50%
ST+ Permeate Flow Rate	30m³/d(5,280 gpd)	18m³/d (4,755 gpd)	12.5m³/d (3,330 gpd)
ST++ Permeate Flow Rate	60m³/d(10,560 gpd)	36m³/d (9,510 gpd)	25m³/d (6,660 gpd)
Minimum Rejection	98%*	99%**	99%**
pH Continuous	3-10	3-10	3-10
pH CIP**@50°C (122°F)	2-12	2-12	2-12
Max. Process Temperature	40°C (104°F)	45°C (113°F)	40°C (104°F)
Max CIP** Temperature	50°C (122°F)	50°C (122°F)	40°C (104°F)

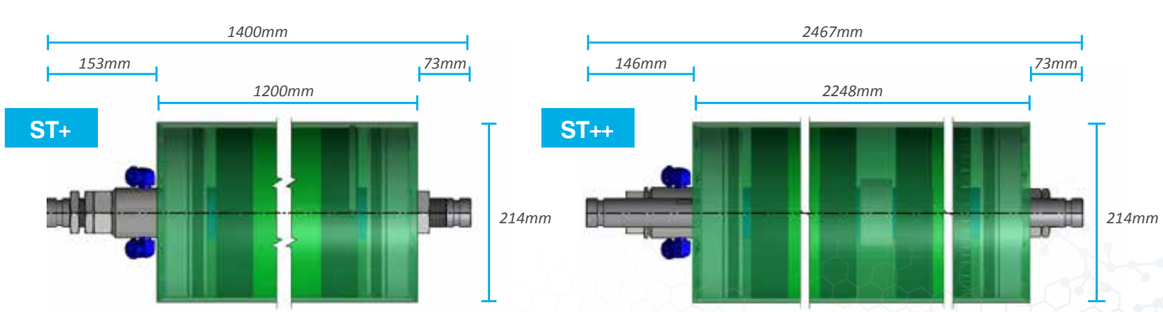
NF membranes are also available.

*** Contact Nanostone Water for more information if pH CIP requirements fall outside of these limits.*
‡ Performance specifications shown are nominal values. Individual module permeate flowrates may vary by ±15% from the values shown. RO3 Test Conditions: 2,000 mg/L NaCl Solution at 15.5 bar (225psi) applied pressure, 15% recovery, 25°C (77°F) and pH 8. RO4 Test Conditions: 32,000 mg/l NaCl Solution at 55.2 bar (800 psi) applied pressure.

Element Physical Specifications

Model	ST+	ST++
Construction*	Spiral Wound Module Construction with ST+ Element	Spiral Wound Module Construction with two ST+ Elements
Element Length	1016 mm (40 in.)	1016 mm (40 in.) x 2
Element Diameter	200 mm (8 in.)	200 mm (8 in.)
Permeate Tube Outer Diameter	60.325 mm (2.375 in.)	60.325 mm (2.375 in.)
Membrane Area	26.5 m² (285.24 ft²)	57.2 m² (615.7 ft²)
Feed Spacer Thickness	34mil	34 mil
Element Dry Weight	15kg (33lbs)	15kg (33lbs) x 2
Max. ΔP	0.7 bar (10.2 psi)	2 bar (29 psi)
Max. Overall Pressure	90 bar (1,305 psi)	90 bar (1,305 psi)
Module Length	1405 mm (55 in.)	2248 mm (88.5 in.)
Module Diameter	214 mm (8.4 in.)	214 mm (8.4 in.)
Connections - Feed in/out	victaulic 1 in.	victaulic 1 in.
Connections - Permeate out	2 x quick coupling for hose 11.6 x 9 mm	2 x quick coupling for hose 11.6 x 9 mm

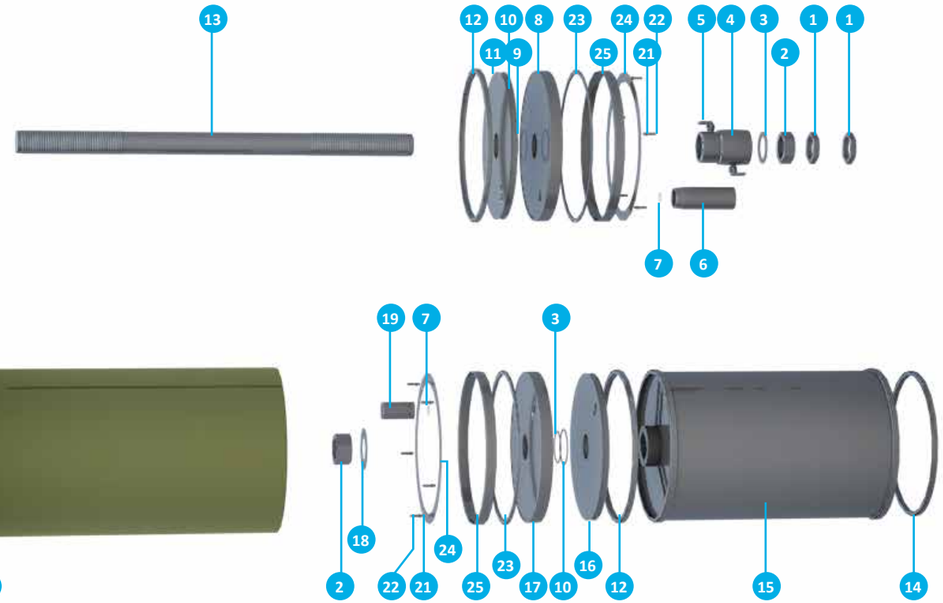
** Brine seal to be installed in flow direction on the low pressure side/element outlet side.*



ST+ and ST++ Module Components

Item Description	Reference Number
Pre-loading disk	24
Pressure Vessel	20
Tie rod	13
Spacer Tube Element	15
Tie rod lock nut	1
Full nut tie rod	2
O-ring 35 x 4 - NBR70	3
Permeate collector	4
Male elbow	5
Bottom HP connector	6
O-ring 30 x 4 - NBR70	7
O-ring 50 x 4 - NBR70	9

Item Description	Reference Number
O-ring 60 x 4 - Viton 90 sh	10
Top seal flange ST-module	16
Lip seal	12 / 14
Bottom seal flange POM-C white	11
Washer	18
Top HP connection	19
Top Flange	17
Bottom Flange	8
O-ring 190.0 x 5.0 - NBR 70 Sh	23
Spacer ring	25
Spring washer B8 DIN 137 - A2	21
Hexagonal screw M 8 x 16	22
Materials only for ST++	
Connecting Bush for ST++ Module	Not Shown



Key Advantages

- Patented technology
- Open spacer spiral wound UF/NF/RO element
- Proven technology for leachate - 300+ installations globally
- Low fouling - parallel spacer
- Up to 120 bar operating pressure
- 90%+ recovery rates
- Only cartridge filtration needed
- Allows high solids and organics in feed - 250 TSS, up to 30,000 ppm COD
- Membrane area of 1 ST module is 3 times higher than 1 DT module
- Used in a variety of industrial applications

DTG Modules

Membrane Type

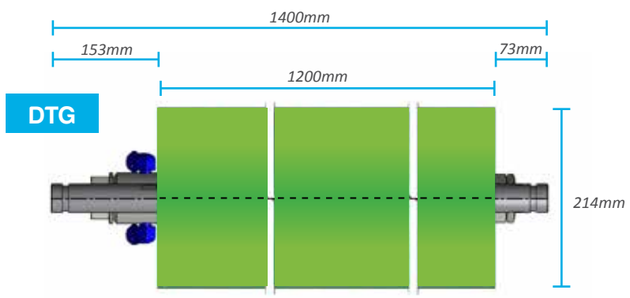
Model	DTG-RO4
Permeate Flow Rate	18m³/d (4,755 gpd)
Nominal Rejection	99.50%
Minimum Rejection	99%
pH Continuous	3-11
pH CIP**@50°C (122°F)	2-12
Max. Process Temperature	45°C (113°F)
Max CIP** Temperature	50°C (122°F)

*** Contact Nanostone Water for more information if pH CIP requirements fall outside of these limits.*
‡ Performance specifications shown are nominal values. Individual module permeate flowrates may vary by ±15% from the values shown. RO3 Test Conditions: 2,000 mg/L NaCl Solution at 15.5 bar (225psi) applied pressure, 15% recovery, 25°C (77°F) and pH 8. RO4 Test Conditions: 32,000 mg/l NaCl Solution at 55.2 bar (800 psi) applied pressure.

Element Physical Specifications

Model	DTG-RO4
Construction*	Disk tube
Membrane Area	9.3 m²
Max. ΔP	9 bar (130.5 psi)
Max. Overall Pressure	65 bar
Module Length	1400 mm (55 in.)
Module Diameter	214 mm (8.4 in.)
High pressure raw water in/out	12 mm Swagelock
Permeate out	1 x quick coupling for hose 11.6 x 9 mm
Min. Module Permeate Flow Rate	250 lph (1.1 gpd)
Max. Permeate Conductivity	650 µS

** Brine seal to be installed in flow direction on the low pressure side/element outlet side.*



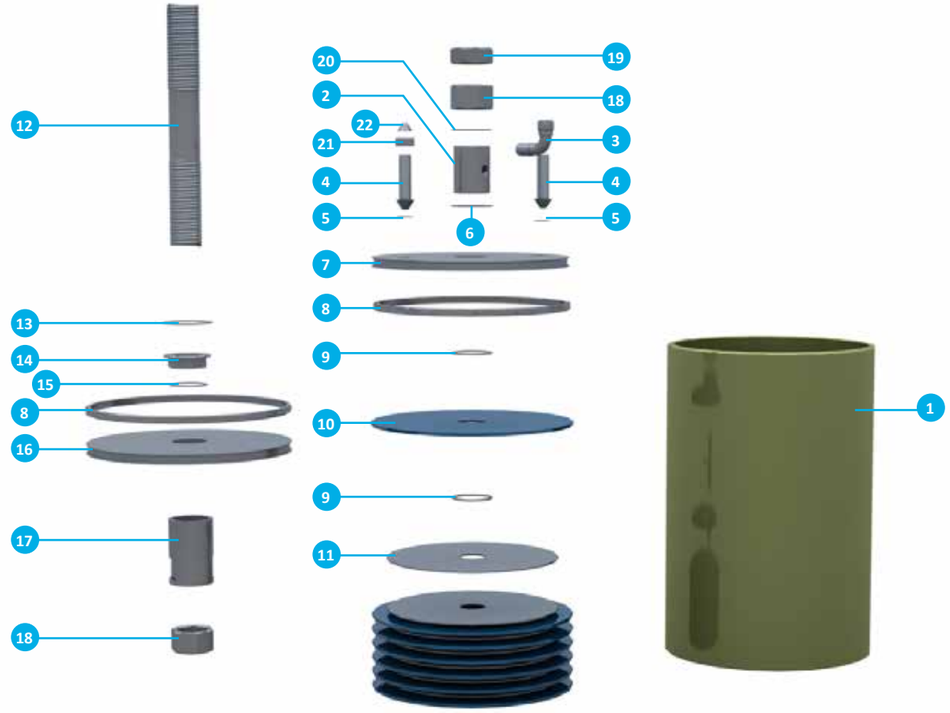
Key Advantages

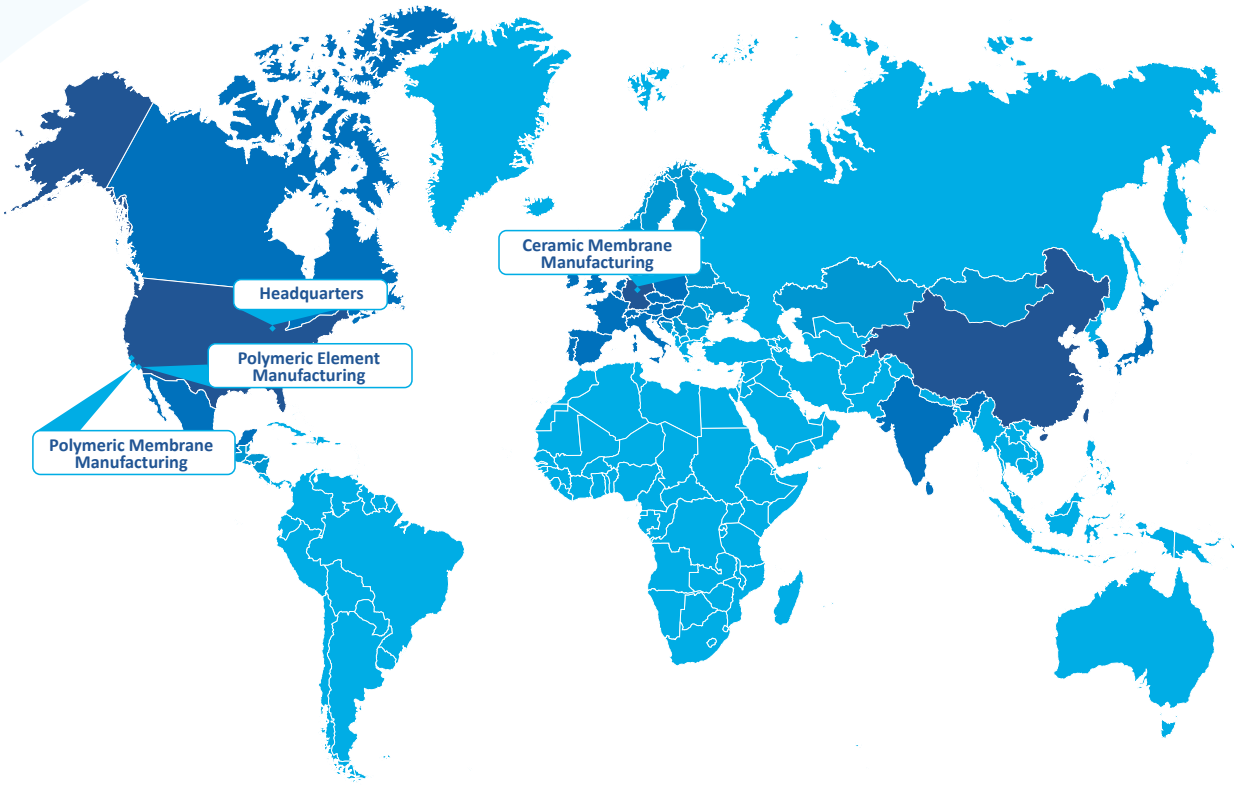
- High salt rejection and high recovery rates (up to 90-95%)
- Meets discharge standards around the world
- Special hydrodynamic design that enables low concentration polarization
- An open channel structure that minimizes fouling and scaling
- Typical membrane life is about 5 years in high solids applications
- Flexible to include pre-filtration or post-evaporation as required
- Enables small footprint in comparison to a combined process

DTG Module Components

Item Description	Reference Number
Pressure Vessel 1200mm DT/DTG	1
Connecting Flange DTG	7
RO4 Membrane Cushions	11
The Rod (35 x 1400)	12
Seal bush DTG	14
End Flange DTG	16
Generic parts	1
Permeate Collector DT/DTG	2
Male elbow	3
HP Connection DT/DTG	4
O-Ring HP Connection DT/DTG	5
O-Ring DT/DTG	6

Item Description	Reference Number
Lip seal	8
O-Ring Hydraulic disk	9
Hydraulic disk DT/DTG	10
O-Ring	13
O-Ring DT/DTG	15
Tie Rod Spacer	17
Full nut tie rod	18
Tie rod lock nut	19
O-ring 35 x 4 - NBR70	20
Union Nut	21
Front Ferrule	22





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