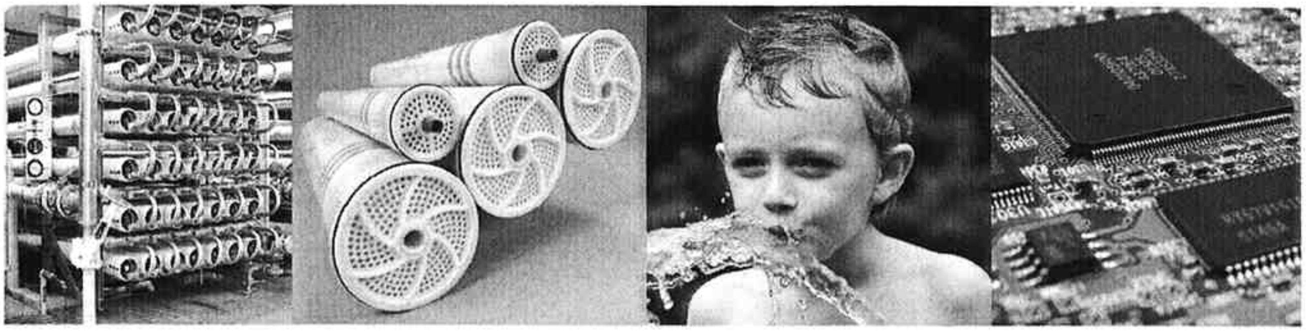
C

Fox Hills Treatment Details

ESPA®



The High Productivity Membrane

ESPA - Energy Saving Polyamide Membrane Elements

Hydranautics offers a complete line of energy saving polyamide ESPA reverse osmosis (RO) membrane elements for a wide range of water treatment applications, including: the treatment of well, surface or wastewater with high salt rejection requirements, high purity industrial applications, and seawater desalination plants requiring high boron rejection. Hydranautics has several installations around the world for these and other applications that combine their patented RO, NF, UF, and MF membrane technologies to create the perfect water treatment solution for their customer. One example is a large seawater RO plant on an island country in the Mediterranean that uses the combination of SWC5 and ESPA-B in the unique Hydranautics process - Integrated Membrane Solutions ® (IMS). The high performing SWC5 is ideal for use with ESPA-B membranes in the second pass in seawater and brackish water reverse osmosis plants that have stringent boron rejection requirements.

Energy Saving ESPA elements are available from Hydranautics in both 4-inch and 8-inch diameters by 40-inch long spiral wound configurations for many water treatment applications. Smaller diameter elements are also available from Hydranautics' licensed manufacturer Oltremare, located in Fano, Italy.

ESPA's unparalled performance characteristics can provide a significant cost savings due to the lower operating pressures required, while still providing optimal flow as well as high salt & boron rejection.

Product Offering:

ESPA1
The world's leading high productivity, energy-saving polyamide membrane

ESPA2
ESPA2 combines high productivity, energy savings and less salt passage all in one element

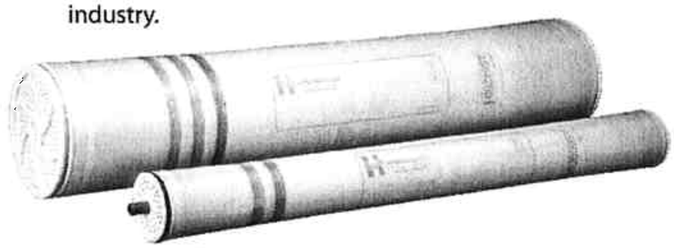
ESPA2+
Offers the same rejection characteristics as ESPA2 but with even higher flow rates

ESPA2-365
Ideal for industrial applications

ESPA3
One of the industry's leading brackish water RO elements

ESPA4
Highest productivity & rejection with next-generation performance

ESPA-B
Treat water challenged with naturally occurring high boron levels or groundwater contaminated with boron from manufacturing. ESPA-B is the highest boron rejecting, low pressure element in the industry.



NITTO DENKO

HYDRANAUTICS
www.membranes.com
A Nitto Denko Company

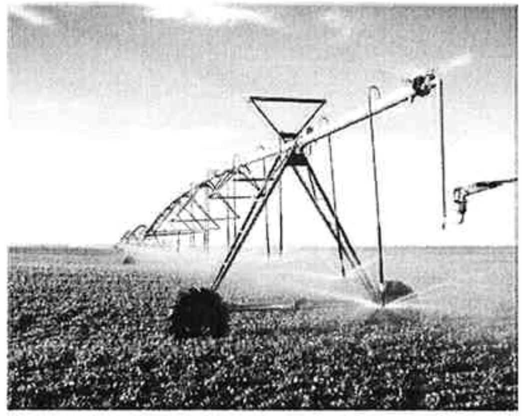
ESPA®

ESPA

Performance for Ultra Low Pressure Membranes

Element Type	Min. Salt Rej.,%	Nom. Salt Rej.,%	Permeate Flow GPD	(m3/d)
ESPA1-4040	99.0	99.3	2,600	(9.8)
ESPA2-4040	99.4	99.6	1,900	(7.2)
ESPA3-4040	98.0	98.5	3,000	(11.4)
ESPA4-4040	99.0	99.2	2,500	(9.4)
ESPA1	99.0	99.3	12,000	(45.4)
ESPA2	99.5	99.6	9,000	(34.1)
ESPA2-365	99.5	99.6	8,200	(31.0)
ESPA2+*	99.5	99.6	12,000	(45.4)
ESPA3	98.0	98.5	14,000	(53.0)
ESPA4**	99.0	99.2	12,000	(45.4)
ESPA-B*	99.0	99.2	8,600	(32.6)

*Boron Rej. @ pH = 10 is 93% for ESPA2+ and 96% for ESPA-B
**ESPA4 NaCl Solution tested at 500 PPM; tested at 100 psig



Selected ESPA Project References:

Ulu Pandan, Singapore	45 MGD (170,000 m3/d) of industrial water from a waste water source
West Basin, California	5 MGD (19,000 m3/d) of industrial water from a wastewater source
Orange County, California	70 MGD (265,000 m3/d) of reclaimed wastewater for a seawater intrusion barrier
Alameda County Water	8 MGD (30,000 m3/d) of potable water from a well water source

Test Conditions for ESPA

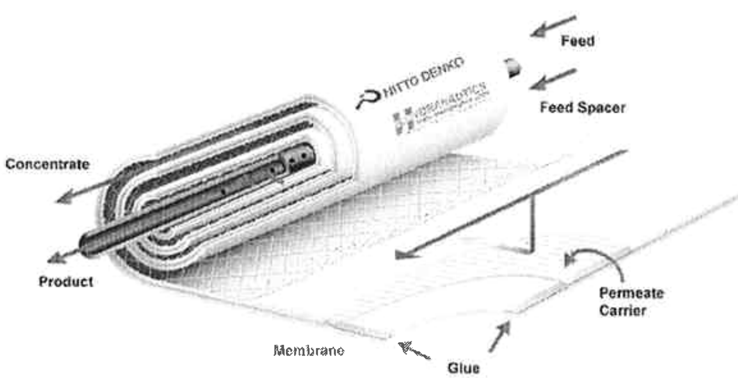
The stated performance is initial (data taken after 30 minutes of operation), based on the following conditions:

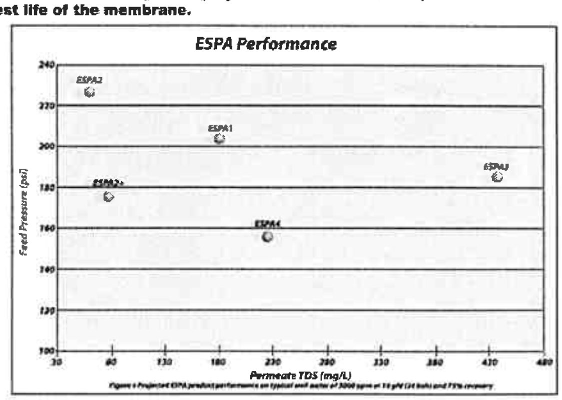
NaCl Solution, PPM*	1500
Applied Pressure ESPA, psig (MPa)	150 (1.05)
Applied Pressure ESPA4, psig (MPa)	100 (0.69)
Operating Temperature, °F(°C)	77° (25°)
Permeate Recovery	15%
pH Range	6.5-7.0

Application Data †

Maximum Applied Pressure psig (MPa)	600 (4.16)
Maximum Feed Flow, GPM (m³/h)	4 inch -16 (3.6), 8 inch -75 (17.0)
Maximum Operating Temperature, °F(°C)	113° (45°)
Feedwater pH Range**	3.0-10.0
Maximum Feedwater Turbidity, NTU	1.0
Maximum Feedwater SDI (15 mins)	5.0
Maximum Chlorine Concentration, PPM	<0.1
Minimum Ratio of Concentrate to Permeate Flow for any Element	5:1
Maximum Pressure Drop for Each Element, psig	10

*ESPA4 NaCl Solution tested at 500 PPM
**See technical literature for extended pH tolerance
†The limitations shown in the Application Data are for general use. The values may be more conservative for specific projects to ensure the best performance and the longest life of the membrane.





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E-mail: info@hydranautics.com, Website: www.membranes.com

Purchase mini elements from Hydranautics' licensed manufacturer:
Oltremare, Via Della Pineta, 23. 61032 Fano (PU) Italy
Tel: +39-0721-1796201 Fax: +39-0721-1796229
E-mail: info@oltremaremembrane.com Website: www.oltremaremembrane.com

Hydranautics RO System Design Software, v. 7.00 (c) 2000 1/24/2007

BASIC DESIGN

RO program licensed to:
Calculation created by: Lichtwardt

Project name: Gillette FH3		Permeate flow:	18.0 gpm
HP pump flow:	20.9 gpm	Raw water flow:	20.9 gpm
Recommended pump press.:	180.9 psi		
Feed pressure:	151.9 psi	Permeate recovery ratio:	86.0 %
Feedwater Temperature:	41.5 C(107F)		
Raw water pH:	8.75	Element age:	0.0 years
Acid dosage, ppm (100%):	0.0 H2SO4	Flux decline % per year:	7.0
Acidified feed CO2:	3.2	Salt passage increase, %/yr:	10.0
Average flux rate:	16.9 gfd	Feed type:	Well water

Stage	Perm. Flow gpm	Flow/Vessel Feed gpm	Flow/Vessel Conc gpm	Flux gfd	Beta	Conc.&Throt. Pressures psi	psi	Element Type	Elem. No.	Array
1-1	17.5	10.5	1.7	24.7	1.29	136.4	0.0	ESPA2-4040	12	2x6
1-2	0.5	3.4	2.9	1.5	1.00	126.4	0.0	ESPA2-4040	6	1x6

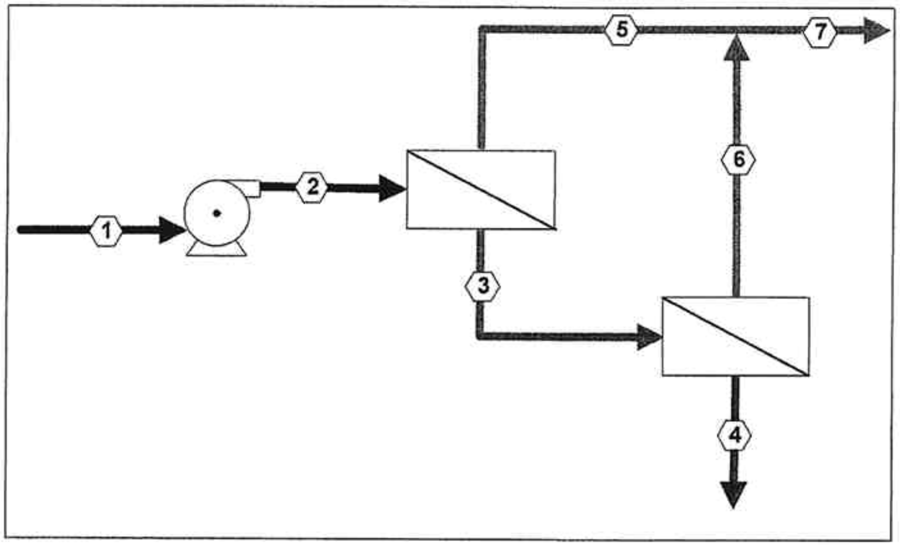
Ion	Raw water mg/l	Raw water CaCO3	Feed water mg/l	Feed water CaCO3	Permeate mg/l	Permeate CaCO3	Concentrate mg/l	Concentrate CaCO3
Ca	2.0	5.0	2.0	5.0	0.0	0.1	14.1	35.2
Mg	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Na	541.0	1176.1	541.0	1176.1	37.6	81.6	3633.6	7899.2
K	4.0	5.1	4.0	5.1	0.3	0.4	26.5	33.9
NH4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ba	0.190	0.1	0.190	0.1	0.003	0.0	1.340	1.0
Sr	0.000	0.0	0.000	0.0	0.000	0.0	0.000	0.0
CO3	70.0	116.7	70.0	116.7	0.0	0.0	268.7	447.8
HCO3	1190.0	975.4	1190.0	975.4	94.0	77.0	7924.8	6495.8
SO4	2.0	2.1	2.0	2.1	0.0	0.0	14.1	14.7
Cl	43.0	60.6	43.0	60.6	1.9	2.7	295.4	416.7
F	9.4	24.7	9.4	24.7	0.8	2.2	62.1	163.5
NO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SiO2	0.0		0.0		0.0		0.0	
TDS	1861.6		1861.6		134.6		12240.7	
pH	8.8		8.8		7.6		9.6	

	Raw water	Feed water	Concentrate
CaSO4 / Ksp * 100:	0%	0%	0%
SrSO4 / Ksp * 100:	0%	0%	0%
BaSO4 / Ksp * 100:	6%	6%	64%
SiO2 saturation:	0%	0%	0%
Langelier Saturation Index	0.91	0.91	3.35
Stiff & Davis Saturation Index	0.97	0.97	2.94
Ionic strength	0.02	0.02	0.16
Osmotic pressure	19.1 psi	19.1 psi	127.1 psi

These calculations are based on nominal element performance when operated on a feed water of acceptable quality. No guarantee of system performance is expressed or implied unless provided in writing by Hydranautics.

Gillette FH3 **1/24/2007**

TWO STAGE SYSTEM



		1	2	3	4	5	6	7
Flow	gpm	20.9	20.9	3.4	2.9	17.5	0.5	18.0
Pressure	psi	0.0	151.9	136.4	126.4	0.0	0.0	0.0
TDS (ppm)		1861.6	1861.6	11015.7	12240.7	57.3	2755.1	134.6

Hydranautics RO System Design Software, v. 7.00 (c) 2000 1/24/2007

BASIC DESIGN

RO program licensed to:
Calculation created by: Lichtwardt

Project name: Gillette FH3		Permeate flow:	18.0 gpm
HP Pump flow:	20.9 gpm	Raw water flow:	20.9 gpm
Recommended pump press.:	195.2 psi		
Feed pressure:	166.2 psi	Permeate recovery ratio:	86.0 %
Feedwater Temperature:	41.5 C(107F)		
Raw water pH:	8.75	Element age:	5.0 years
Acid dosage, ppm (100%):	0.0 H_2SO_4	Flux decline % per year:	7.0
Acidified feed CO_2:	3.2	Salt passage increase, %/yr:	10.0
Average flux rate:	16.9 gfd	Feed type:	Well water

Stage	Perm. Flow gpm	Flow/Vessel Feed gpm	Flow/Vessel Conc gpm	Flux gfd	Beta	Conc.&Throt. Pressures psi	Conc.&Throt. Pressures psi	Element Type	Elem. No.	Array
1-1	15.8	10.5	2.6	22.2	1.31	147.4	0.0	ESPA2-4040	12	2x6
1-2	2.2	5.2	2.9	6.3	1.04	135.1	0.0	ESPA2-4040	6	1x6

Ion	Raw water mg/l	Raw water CaCO3	Feed water mg/l	Feed water CaCO3	Permeate mg/l	Permeate CaCO3	Concentrate mg/l	Concentrate CaCO3
Ca	2.0	5.0	2.0	5.0	0.0	0.1	14.1	35.1
Mg	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Na	541.0	1176.1	541.0	1176.1	43.5	94.7	3596.8	7819.1
K	4.0	5.1	4.0	5.1	0.4	0.5	26.1	33.5
NH4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ba	0.190	0.1	0.190	0.1	0.003	0.0	1.337	1.0
Sr	0.000	0.0	0.000	0.0	0.000	0.0	0.000	0.0
CO3	70.0	116.7	70.0	116.7	0.0	0.0	265.6	442.6
HCO3	1190.0	975.4	1190.0	975.4	108.9	89.3	7833.0	6420.5
SO4	2.0	2.1	2.0	2.1	0.0	0.0	14.1	14.7
Cl	43.0	60.6	43.0	60.6	2.2	3.1	293.5	414.0
F	9.4	24.7	9.4	24.7	0.9	2.5	61.3	161.4
NO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SiO2	0.0		0.0		0.0		0.0	
TDS	1861.6		1861.6		156.1		12105.9	
pH	8.8		8.8		7.7		9.6	

	Raw water	Feed water	Concentrate
CaSO4 / Ksp * 100:	0%	0%	0%
SrSO4 / Ksp * 100:	0%	0%	0%
BaSO4 / Ksp * 100:	6%	6%	64%
SiO2 saturation:	0%	0%	0%
Langelier Saturation Index	0.91	0.91	3.34
Stiff & Davis Saturation Index	0.97	0.97	2.93
Ionic strength	0.02	0.02	0.16
Osmotic pressure	19.1 psi	19.1 psi	125.7 psi

These calculations are based on nominal element performance when operated on a feed water of acceptable quality. No guarantee of system performance is expressed or implied unless provided in writing by Hydranautics.

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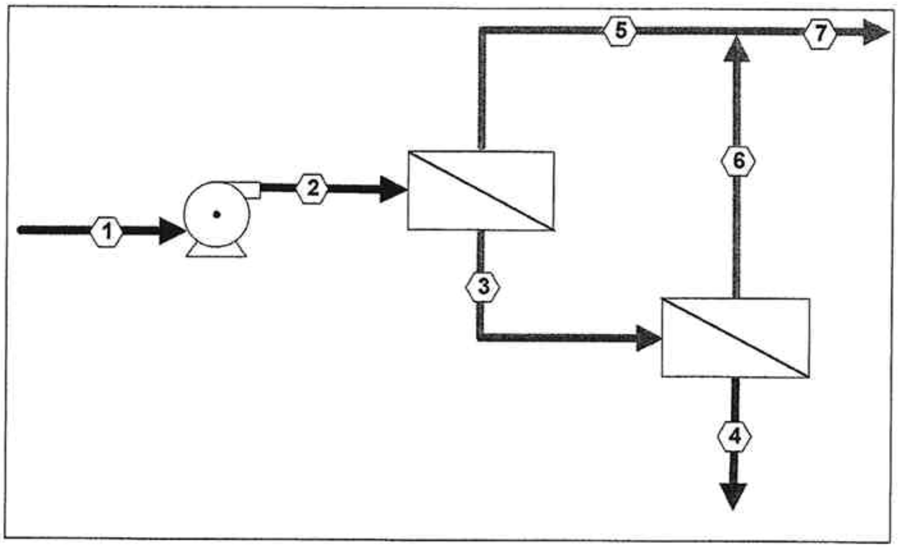
Gillette FH3

1/24/2007

TWO STAGE SYSTEM



		1	2	3	4	5	6	7
Flow	gpm	20.9	20.9	5.2	2.9	15.8	2.2	18.0
Pressure	psi	0.0	166.2	147.4	135.1	0.0	0.0	0.0
TDS (ppm)		1861.6	1861.6	7326.8	12105.9	65.1	794.2	156.1

C-2

RO Element
Sampling Cleaning Protocol

FILMTEC Membranes

Cleaning Procedures for FILMTEC FT30 Elements

The following are general recommendations for cleaning FILMTEC™ FT30 elements. More detailed procedures for cleaning a reverse osmosis (RO) system are typically included in the operating manual provided by the system supplier. It should be emphasized that frequent cleaning is not required for a properly designed and properly operated RO system, however because of the FT30 membrane's unique combination of pH range and temperature resistance, cleaning may be accomplished very effectively.

Cleaning Requirements

In normal operation, the membrane in reverse osmosis elements can become fouled by mineral scale, biological matter, colloidal particles and insoluble organic constituents. Deposits build up on the membrane surfaces during operation until they cause loss in normalized permeate flow, loss of normalized salt rejection, or both.

Elements should be cleaned when one or more of the below mentioned parameters are applicable:

- The normalized permeate flow drops 10%
- The normalized salt passage increases 5 - 10%
- The normalized pressure drop (feed pressure minus concentrate pressure) increases 10 - 15%

If you wait too long, cleaning may not restore the membrane element performance successfully. In addition, the time between cleanings becomes shorter as the membrane elements will foul or scale more rapidly.

Differential Pressure (ΔP) should be measured and recorded across each stage of the array of pressure vessels. If the feed channels within the element become plugged, the ΔP will increase. It should be noted that the permeate flux will drop if feedwater temperature decreases. This is normal and does not indicate membrane fouling.

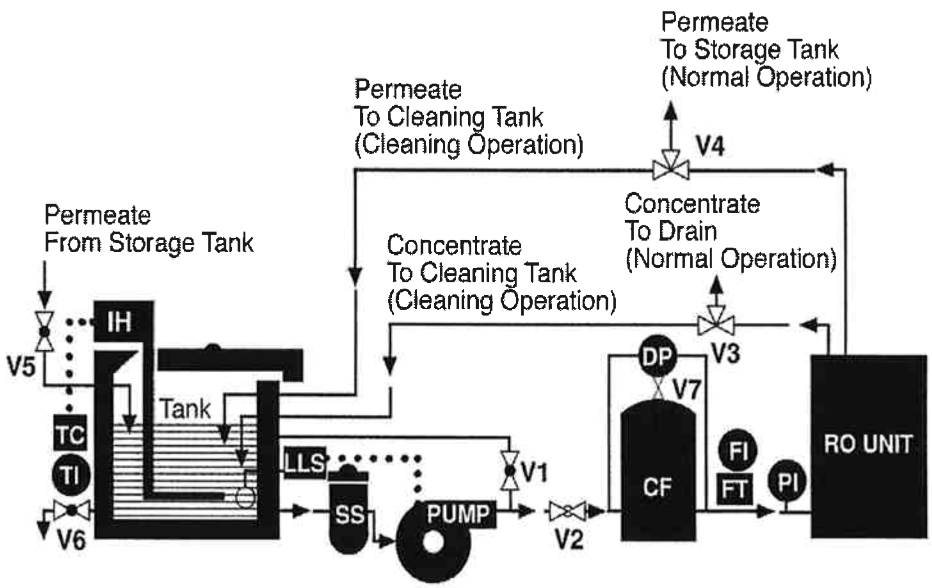
A malfunction in the pretreatment, pressure control, or increase in recovery can result in reduced product water output or an increase in salt passage. If a problem is observed, these causes should be considered first. The element(s) may not require cleaning. A computer program called FTNORM is available from FilmTec for normalizing performance data of FILMTEC RO membranes. This program can be used to assist in determining when to clean and can be downloaded from our web site (www.filmtec.com).

Form No. 609-23010-0605

Safety Precautions

1. When using any chemical indicated here in subsequent sections, follow accepted safety practices. Consult the chemical manufacturer for detailed information about safety, handling and disposal.
2. When preparing cleaning solutions, ensure that all chemicals are dissolved and well mixed before circulating the solutions through the elements.
3. It is recommended the elements be flushed with good-quality chlorine-free water (20°C minimum temperature) after cleaning. Permeate water or deionized water are recommended. Care should be taken to operate initially at reduced flow and pressure to flush the bulk of the cleaning solution from the elements before resuming normal operating pressures and flows. Despite this precaution, cleaning chemicals will be present on the permeate side following cleaning. Therefore, the permeate must be diverted to drain for at least 30 minutes or until the water is clear when starting up after cleaning.
4. During recirculation of cleaning solutions, the maximum temperature must not be exceeded. The maximum allowed temperature is dependent on pH and membrane type. Table 1 contains information on the maximum allowed temperatures.
5. For elements greater than six inches in diameter, the flow direction during cleaning must be the same as during normal operation to prevent element telescoping, because the vessel thrust ring is installed only on the reject end of the vessel. This is also recommended for smaller elements. Equipment for cleaning is illustrated below.

Cleaning System Flow Diagram



TANK	Chemical Mixing Tank, polypropylene or FRP	DP	Differential Pressure Gauge
IH	Immersion Heater (may be replaced by cooling coil for some site locations)	FI	Flow Indicator
TI	Temperature Indicator	FT	Flow Transmitter (optional)
TC	Temperature Control	PI	Pressure Indicator
LLS	Lower Level Switch to shut off pump	V1	Pump Recirculation Valve, CPVC
SS	Security Screen–100 mesh	V2	Flow Control Valve, CPVC
PUMP	Low-Pressure Pump, 316 SS or non-metallic composite	V3	Concentrate Valve, CPVC 3-way valve
CF	Cartridge Filter, 5-10 micron polypropylene with PVC, FRP, or SS housing	V4	Permeate Valve, CPVC 3-way valve
		V5	Permeate Inlet Valve, CPVC
		V6	Tank Drain Valve, PVC, or CPVC
		V7	Purge Valve, SS, PVC, or CPVC

* Trademark of The Dow Chemical Company

Suggested Equipment

The equipment for cleaning is shown in the Cleaning System Flow Diagram. The pH of cleaning solutions used with FILMTEC elements can be in the range of 1 to 13 (see Table 1), and therefore non-corroding materials should be used in the cleaning system.

1. The mixing tank should be constructed of polypropylene or fiberglass-reinforced plastic (FRP). The tank should be provided with a removable cover and a temperature gauge. The cleaning procedure is more effective when performed at a warm temperature, and it is recommended that the solution be maintained according to the pH and temperature guidelines listed in Table 1. It is not recommended to use a cleaning temperature below 20°C because of the very slow chemical kinetics at low temperatures. In addition, chemicals such as sodium lauryl sulfate might precipitate at low temperatures. Cooling may also be required in certain geographic regions, so both heating/cooling requirements must be considered during the design. A rough rule of thumb in sizing a cleaning tank is to use approximately the empty pressure vessels volume and then add the volume of the feed and return hoses or pipes. For example, to clean ten 8-inch diameter pressure vessels with six elements per vessel, the following calculations would apply:

A. Volume in Vessels

$V1 = \pi r^2 L$

$= 3.14\ (4\ in)^2\ (20\ ft)\ (7.48\ gal/ft^3)\ /\ (144\ in^2/ft^2)$

$V1 = 52\ gal/vessel\ (0.2\ m^3)$

$V10 = 52 \times 10 = 520\ gal\ (1.97\ m^3)$

B. Volume in Pipes, assume 50 ft. length total 4" Sch 80 pipe

$Vp = \pi r^2 L$

$= 3.14\ (1.91\ in)^2\ (50\ ft)\ (7.48\ gal/ft^3)\ /\ (144\ in^2/ft^2)$

$= 30\ gals\ (0.11\ m^3)$

$Vct = V_{10} + Vp = 520 + 30 = 550\ gal.$

Therefore, the cleaning tank should be about 550 gals (2.1 m^3).

2. The cleaning pump should be sized for the flows and pressures given in Table 2, making allowances for pressure loss in the piping and across the cartridge filter. The pump should be constructed of 316 SS or nonmetallic composite polyesters.
3. Appropriate valves, flow meters, and pressure gauges should be installed to adequately control the flow. Service lines may be either hard piped or hoses. In either case, the flow rate should be a moderate 10 ft/sec (3 m/sec) or less.

Cleaning Elements In Situ

There are six steps in the cleaning of elements:

1. Make up cleaning solution.
2. Low-flow pumping. Pump mixed, preheated cleaning solution to the vessel at conditions of low flow rate (about half of that shown in Table 2) and low pressure to displace the process water. Use only enough pressure to compensate for the pressure drop from feed to concentrate. The pressure should be low enough that essentially no or little permeate is produced. A low pressure minimizes redeposition of dirt on the membrane. Dump the concentrate, as necessary, to prevent dilution of the cleaning solution.
3. Recycle. After the process water is displaced, cleaning solution will be present in the concentrate stream. Then recycle the concentrate and permeate to the cleaning solution tank and allow the temperature to stabilize. Measure the pH of the solution and adjust the pH if needed.

* Trademark of The Dow Chemical Company

Table 1. pH range and temperature limits during cleaning

Element type	Max Temp 50°C (122°F) pH range	Max Temp 45°C (113°F) pH range	Max Temp 35°C(95 °F) pH range	Max Temp 25°C (77°F) pH range
BW30, BW30LE, LE, XLE, TW30, TW30HP, NF90	Please contact Dow for assistance	1 - 10.5	1 - 12	1 - 13
SW30HR, SW30HR LE, SW30XLE, SW30	Please contact Dow for assistance	1 - 10.5	1 - 12	1 - 13
NF200, NF270	Not allowed	3 - 10	1 - 11	1 - 12
SR90	Not allowed	3 - 10	1 - 11	1 - 12

Table 2. Recommended feed flow rate per pressure vessel during high flow rate recirculation

Feed Pressure[1] (psig)	(bar)	Element Diameter (inches)	Feed Flow Rate per Pressure Vessel (gpm)	(m3/hr)
20-60	1.5-4.0	2.5	3-5	0.7-1.2
20-60	1.5-4.0	4[2]	8-10	1.8-2.3
20-60	1.5-4.0	6	16-20	3.6-4.5
20-60	1.5-4.0	8	30-40	6.-9.1
20-60	1.5-4.0	8[3]	35-45	8.0-10.2

1. Dependent on number of elements in pressure vessel.
2. 4-inch full-fit elements should be cleaned at 12-14 gpm (2.7-3.2 m^3/hr).
3. For full-fit and 440 sq. ft. area elements.

4. Soak. Turn the pump off and allow the elements to soak. Sometimes a soak period of about 1 hour is sufficient. For difficult fouling an extended soak period is beneficial; soak the elements overnight for 10-15 hours. To maintain a high temperature during an extended soak period, use a slow recirculation rate (about 10 percent of that shown in Table 2).
5. High-flow pumping. Feed the cleaning solution at the rates shown in Table 2 for 30-60 minutes. The high flow rate flushes out the foulants removed from the membrane surface by the cleaning. If the elements are heavily fouled, a flow rate which is 50 percent higher than shown in Table 2 may aid cleaning. At higher flow rates, excessive pressure drop may be a problem. The maximum recommended pressure drops are 15 psi per element or 50 psi per multi-element vessel, whichever value is more limiting. Please note that the 15 psi per element or the 50 psi per multi-element vessel should NOT be used as a cleaning criteria. Cleaning is recommended when the pressure drop increases 15%. Pressure drop above 50 psi in a single stage may cause significant membrane damage.
6. Flush out. RO permeate or deionized water is recommended for flushing out the cleaning solution. Prefiltered raw water or feed water should be avoided as its components may react with the cleaning solution: precipitation of foulants may occur in the membrane elements. The minimum flush out temperature is 20°C.

Cleaning Tips

1. It is strongly recommended to clean the stages of the RO or NF system separately. This is to avoid having the removed foulant from stage 1 pushed into the 2nd stage resulting in minimal performance improvement from the cleaning. If the system consists of 3 stages, stage 2 and stage 3 should also be cleaned separately. For multi-stage systems, while each stage should be cleaned separately, the flushing and soaking operations may be done simultaneously in all stages. Fresh cleaning solution needs to be prepared when the cleaning solution becomes turbid and/or discolored. High-flow recirculation, however, should be carried out separately for each stage, so the flow rate is not too low in the first stage or too high in the last. This can be accomplished either by using one cleaning pump and operating one stage at a time, or by using a separate cleaning pump for each stage.

2. The fouling or scaling of elements typically consists of a combination of foulants and scalants, for instance a mixture of organic fouling, colloidal fouling and biofouling. Therefore, it is very critical that the first cleaning step is wisely chosen. FilmTec strongly recommends alkaline cleaning as the first cleaning step. Acid cleaning should only be applied as the first cleaning step if it is known that only calcium carbonate or iron oxide/hydroxide is present on the membrane elements.

   Acid cleaners typically react with silica, organics (for instance humic acids) and biofilm present on the membrane surface which may cause a further decline of the membrane performance. Sometimes, an alkaline cleaning may restore this decline that was caused by the acid cleaner, but often an extreme cleaning will be necessary. An extreme cleaning is carried out at pH and temperature conditions that are outside the membrane manufacturer's guidelines or by using cleaning chemicals that are not compatible with the membrane elements. An extreme cleaning should only be carried out as a last resort as it can result in membrane damage.

   If the RO system suffers from colloidal, organic fouling or biofouling in combination with calcium carbonate, then a two- step cleaning program will be needed: alkaline cleaning followed by an acid cleaning. The acid cleaning may be performed when the alkaline cleaning has effectively removed the organic fouling, colloidal fouling and biofouling.

3. Always measure the pH during cleaning. If the pH increases more than 0.5 pH units during acid cleaning, more acid needs to be added. If the pH decreases more than 0.5 pH units during alkaline cleaning, more caustic needs to be added.

4. Long soak times. It is possible for the solution to be fully saturated and the foulants can precipitate back onto the membrane surface. In addition, the temperature will drop during this period, therefore the soaking becomes less effective. It is recommended to circulate the solution regularly in order to maintain the temperature (temperature should not drop more than 5°C) and add chemicals if the pH needs to be adjusted.

5. Turbid or strong colored cleaning solutions should be replaced. The cleaning is repeated with a fresh cleaning solution.

6. If the system has to be shutdown for more than 24 hours, the elements should be stored in 1% w/w sodium metabisulfite solution.

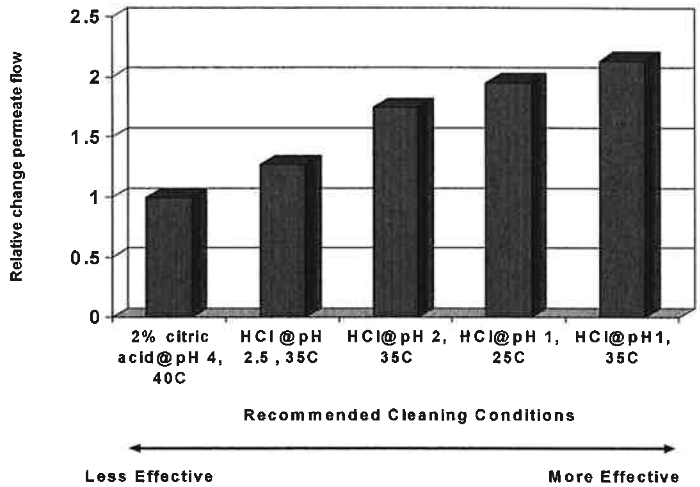
Effect of pH on foulant removal

In addition to applying the correct cleaning sequence (alkaline cleaning step first), selecting the correct pH is very critical for optimum foulant removal. If foulant is not successfully removed, the membrane system performance will decline faster as it is easier for the foulant to deposit on the membrane surface area. The time between cleanings will become shorter, resulting in shorter membrane element life and higher operating and maintenance costs.

Most effective cleaning allows longer system operating time between cleanings and results in the lowest operating costs.

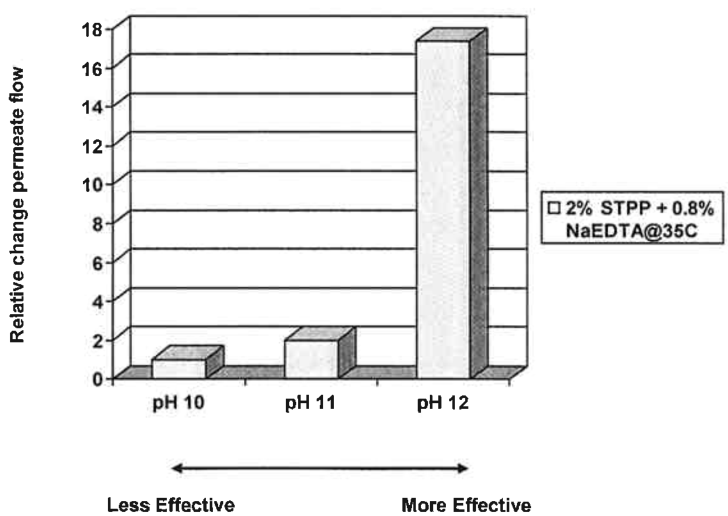
Figure 1 and 2 below show the importance of the selecting the right pH for successful cleaning.

Figure 1. Effect of pH on the removal of calcium carbonate



Calcium carbonate is best removed by cleaning with hydrochloric acid at pH 1-2.

Figure 2. Effect of pH on the removal of biofouling



Biofouling is best removed by cleaning at pH 12.

* Trademark of The Dow Chemical Company

Cleaning Chemicals

Table 3 lists suitable cleaning chemicals. Acid cleaners and alkaline cleaners are the standard cleaning chemicals. The acid cleaners are used to remove inorganic precipitates including iron, while the alkaline cleaners are used to remove organic fouling including biological matter. Sulfuric acid should never used for cleaning because of the risk of calcium sulfate precipitation. Reverse osmosis permeate or deionized water should be used for the preparation of cleaning solutions.

Table 3. Simple cleaning solutions for FT30 membrane

Cleaner / Foulant	0.1% (W) NaOH and pH 12, 35°C max. or 1.0% (W) Na_4EDTA and pH 12, 35°C max.	0.1% (W) NaOH and pH 12, 35°C max. or 0.025% (W) Na-DSS and pH 12, 35°C max.	0.2% (W) HCl, 25°C and pH 1 - 2	1.0% (W) $Na_2S_2O_4$, 25°C and pH 5	0.5% (W) H_3PO_4, 25 °C and pH 1 - 2	1.0% (W) NH_2SO_3H, 25°C and pH 3 - 4
Inorganic Salts (for example, $CaCO_3$)			Preferred	Alternative	Alternative	
Sulfate Scales ($CaSO_4$, $BaSO_4$)	OK					
Metal Oxides (for example, iron)				Preferred	Alternative	Alternative
Inorganic Colloids (silt)		Preferred				
Silica	Alternative	Preferred				
Biofilms	Alternative	Preferred				
Organic	Alternative	Preferred				

The temperatures and pH listed in table 3 are applicable for BW30, BW30LE, LE, XLE, TW30, TW30HP, SW30HR, SW30HR LE , SW30XLE, SW30 and NF90 membrane elements. For more information regarding the allowed temperatures and pH for cleaning, please refer to table 1.

Notes:

1. (W) denotes weight percent of active ingredient.
2. Foulant chemical symbols in order used: $CaCO_3$ is calcium carbonate; $CaSO_4$ is calcium sulfate; $BaSO_4$ is barium sulfate.
3. Cleaning chemical symbols in order used: NaOH is sodium hydroxide; Na_4EDTA is the tetra-sodium salt of ethylene diamine tetraacetic acid and is available from The Dow Chemical Company under the trademark VERSENE* 100 and VERSENE 220 crystals; Na-DSS is sodium salt of dodecylsulfate; Sodium Laurel Sulfate; HCl is hydrochloric acid (Muratic Acid); H_3PO_4 is phosphoric acid; NH_2SO_3H is sulfamic acid; $Na_2S_2O_4$ is sodium hydrosulfite.
4. For effective sulfate scale cleaning, the condition must be caught and treated early. Adding NaCl to the cleaning solution of NaOH and Na_4EDTA may help as sulfate solubility increases with increasing salinity. Successful cleaning of sulfate scales older than 1 week is doubtful.
5. Citric Acid is another cleaning alternative for metal oxides and calcium carbonate scale. It is less effective (see also figure 1 of this document). It may contribute to biofouling especially when it is not properly rinsed out.

FILMTEC Membranes
For more information about FILMTEC membranes, call the Dow Liquid Separations business:
North America: 1-800-447-4369
Latin America: (+55) 11-5188-9222
Europe: (+32) 3-450-2240
Pacific: +60 3 7958 3392
Japan: +813 5460 2100
China: +86 21 2301 9000
http://www.filmtec.com

C-3

CADIX Design Software Results
IX Option

Regeneration flow-sheet

Water demineralization-C:\Program Files\CADIX60\ProjKdx\Level 2 AC.k0 KDX07032 - NPD

Regeneration sequences		Flow m3/h	Velocity m/h	Time minutes	Water quality	Volume m3
HCl injection SAC	5.00 % 35 %	26.1 3.18	5.00	36.1	Demin	15.7
Acid displacement	2.03 BV	23.0	4.39	83.6	Demin	32.0
NaOH injection	4.00 % 50 %	35.9 1.89	4.00	46.7	Demin	28.0
NaOH displacement	3.15 BV	34.0	3.79	156	Demin	88.3
Rinse recycling		31.8		30.0		

Volume per regeneration 1,915 liters HCl 35% 1,468 liters NaOH 50%

Regeneration time	4.00 hours	***Service water***	164	m3
Cation regeneration time	120 min	Demineralized water	164	m3
Anion regeneration time	203 min	Decationized water		m3
Rinse recycling time	30.0 min	Filtered raw water		m3

Regeneration effluents neutralization

Gross ionic load on cation resins	18,059 eq	Gross ionic load on anion resins	17,319 eq
Equivalent acid used to regenerate	21,553 eq	Equivalent NaOH used to regenerate	27,987 eq
Acid in excess as Hydrogen ions	3,493 eq	Alkalinity in excess	18,659 eq

Amount for neutral effluent: 554 Kg HCl 100% 1,347 liters 35%

Design performance results

Water demineralization-C:\Program Files\CADIX60\ProjKdx\Level 2 AC.k0 KDX07032 - NPD

Resin range		**DOWEX MARATHON**	**DOWEX MARATHON**
Selected resins		**C-10**	**A**
Volume per line (reference)	liters	**15,750**	**28,000**
Reference ionic form		Sodium	Chloride
Volume per line (delivered)	liters	**17,000**	**28,000**
Ionic form as delivered		Hydrogen	Chloride
Net flow rate	m3/h	25.0	25.0
Net throughput	m3	600	600
Gross flow rate	m3/h	31.8	31.8
Gross throughput	m3	764	764
Time betw. 2 regenerations	hours	24.0	24.0
Operating capacity*	meq/l	1,148	619
Gross ionic load	eq	18,059	17,319
Organic load as KMnO4*	g/l		
Silica load as SiO2*	g/l		0.49
Regeneration chemicals		HCl	NaOH
Regeneration dosage*	g/l	50.0	40.0
Amount per regen. as 100%	kg	787	1,119
Regener. ratio to stoichio	%	119	162
Regeneration temperature	°C		42
Regeneration system		Packed Bed	Packed Bed
Vessel diameter	mm	2,600	3,400
Internal vessel area	m^2	5.23	8.97
Resin height as delivered	mm	3,250	3,119
Resin height as regenerated	mm	3,250	3,743
Resin height as exhausted	mm	3,088	3,556
Inert resin top layer		IF-59	IF-59
Inert resin height	mm	200	250
Inert resin volume	liters	1,050	2,250
Vessel cylindrical height	mm	3,500	4,050
Linear velocity	m/h	6.07	3.54
Pressure drop at 42°C	kPa	8.34	7.11
Filtered material load	kg/m^2	0.022	

** Design reference ionic form*
Packed Bed = Upward exhaustion - Downward regeneration

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Water demineralization plant design with
D O W E X Ion Exchange Resins

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Feed water analysis		***meq/l***		**Origin:** Unknown		
Calcium (Ca)	0.050	Chloride (Cl)	1.21	Silica as SiO2	mg/l	18.0
Magnesium (Mg)		Nitrate (NO3)		Free CO2	mg/l	
		Sulfate (SO4)	0.040	pH		8.8
Sodium (Na)	23.5	Other anions	0.50	Temperature	°C	42
Potassium (K)	0.10	FMA	1.75	Organics KMnO4	mg/l	0.0
				Non polar organics	%	
		P-Alkalinity	1.17	Suspended mat.	mg/l	0.15
Other cations		M-alkalinity	21.8	CO2 after degas	mg/l	
Total cations	**23.7**	**Total anions**	**23.9**	*(Including SiO2 + free CO2)*		

Average net flow rate per line	25.0 m3/h	
Time between two regenerations	24.0 hours	
Number of demineralization lines	2	
Demineralization layout	[SAC]-[SBA]	
Polishing unit	No	Number of polishing units 0

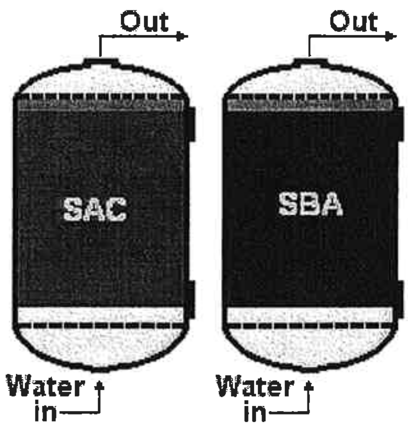
Demineralized water quality	***After primary line***				***After polishing stage***	
	Average		End-point			
	Required	Estimated	Required	Estimated		
Conductivity at 25°C	1.00	0.41	4.00	4.0		MicroSiemens/cm
Monovalent cations as Na	0.095	0.039	0.38	0.38		mgl
Silica as SiO2	0.050	0.020	0.10	0.10		mg/l
pH		8.0		9.0		
Organics as KMnO4		<1.00				mg/l

Chemicals used for regeneration HCl 35% NaOH 50%

Regeneration effluents neutralization required? No

Plant design layout

Water demineralization C:\Program Files\CADIX60\ProjKdx\Level 2 AC.k0 KDX07032 - NPD



Warning Messages Report

C-4

CADIX Design Software Results
IX-RO Option

Water softening plant design with
DOWEX Ion Exchange Resins

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Feed water analysis	**meq/l**			**Design results**
Calcium (Ca)	0.050	DOWEX Resin		**MARATHON C-10**
Magnesium (Mg)		Volume per vessel	liters	**5,800**
Sodium (Na)	23.5	Net flow rate	m3/h	410
Potassium (K)	0.10	Net throughput	m3	137,760
Other cations		Time between 2 regen.	hours	336
		Gross flow rate	m3/h	410
		Gross throughput	m3	137,789
Total cations	23.7	Oper. capacity	meq/l	1,190
		Regenerant chemical		NaCl 10%
Chloride (Cl)	1.21	Regenerant dosage	g/l	303
Nitrate (NO3)		Amount per reg. as 100%	kg	1,751
Sulfate (SO4)	0.040	Reg.ratio to stochiometry	%	435
Other anions	0.50	Ionic form as delivered		Sodium
FMA	1.75	Regeneration system		Packed Bed
P-alkalinity	1.17	Vessel diameter	mm	2,300
M-alkalinity	21.8	Vessel area (internal)	m²	4.10
		Resin height regenerated	mm	1,416
Total anions	23.9	Resin height exhausted	mm	1,345
		Inert resin type		IF-59
Silica as SiO2 mg/l	18.0	Inert resin height	mm	150
Temperature °C	42	Inert resin volume	liters	615
pH	8.8	Cylindrical height	mm	1,775
Free CO2 mg/l		Linear velocity	m/h	100
Organics as KMnO4 mg/l		Pressure drop at 42 °C	kPa	96.0
		Residual hardness	meq/l	0.0011

Regeneration sequences	m3/h	m/h	minutes	m3	Water
NaCl injection 10.0%	21.5	5.3	49	17.5	Raw (2)
Displacement	1.42	0.4	488	11.6	Raw (3)
Rinsing	410	100	3	17.4	Raw (4)
Total			**540**	**46.4**	

Regenerant waste composition (approx.)	**46.4** (2+3+4)	**29.0** (2+3)	m3
NaCl	29,056	46,490	mg/l
CaCl2	8,241	13,185	mg/l
MgCl2	0	0	mg/l
			mg/l

Plant design layout

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Water softening plant design with
D O W E X Ion Exchange Resins

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Feed water analysis	**meq/l**			**Design results**
Calcium (Ca)	0.050	DOWEX Resin		**MARATHON C-10**
Magnesium (Mg)		Volume per vessel	liters	**3,300**
Sodium (Na)	23.5	Net flow rate	m3/h	410
Potassium (K)	0.10	Net throughput	m3	68,880
Other cations		Time between 2 regen.	hours	168
		Gross flow rate	m3/h	410
		Gross throughput	m3	68,896
Total cations	23.7	Oper. capacity	meq/l	1,048
		Regenerant chemical		NaCl 10%
Chloride (Cl)	1.21	Regenerant dosage	g/l	303
Nitrate (NO3)		Amount per reg. as 100%	kg	994
Sulfate (SO4)	0.040	Reg.ratio to stochiometry	%	493
Other anions	0.50	Ionic form as delivered		Sodium
FMA	1.75	Regeneration system		Packed Bed
P-alkalinity	1.17	Vessel diameter	mm	2,100
M-alkalinity	21.8	Vessel area (internal)	m²	3.41
		Resin height regenerated	mm	968
Total anions	23.9	Resin height exhausted	mm	919
		Inert resin type		IF-59
Silica as SiO2 mg/l	18.0	Inert resin height	mm	150
Temperature °C	42	Inert resin volume	liters	512
pH	8.8	Cylindrical height	mm	1,275
Free CO2 mg/l		Linear velocity	m/h	120
Organics as KMnO4 mg/l		Pressure drop at 42 °C	kPa	81.2
		Residual hardness	meq/l	0.0011

Regeneration sequences	m3/h	m/h	minutes	m3	Water
NaCl injection 10.0%	17.1	5.0	35	9.94	Raw (2)
Displacement	1.13	0.3	350	6.57	Raw (3)
Rinsing	410	120	1	9.86	Raw (4)
Total			**386**	**26.4**	

Regenerant waste composition (approx.)	**26.4** (2+3+4)	**16.5** (2+3)	m3
NaCl	30,033	47,936	mg/l
CaCl2	7,242	11,559	mg/l
MgCl2	0	0	mg/l
			mg/l

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Plant design layout

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Water softening plant design with
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Feed water analysis	**meq/l**			**Design results**
Calcium (Ca)	0.050	DOWEX Resin		**MARATHON C-10**
Magnesium (Mg)		Volume per vessel	liters	**5,800**
Sodium (Na)	23.5	Net flow rate	m3/h	410
Potassium (K)	0.10	Net throughput	m3	137,760
Other cations		Time between 2 regen.	hours	336
		Gross flow rate	m3/h	410
		Gross throughput	m3	137,789
Total cations	23.7	Oper. capacity	meq/l	1,190
		Regenerant chemical		NaCl 10%
Chloride (Cl)	1.21	Regenerant dosage	g/l	303
Nitrate (NO3)		Amount per reg. as 100%	kg	1,751
Sulfate (SO4)	0.040	Reg.ratio to stochiometry	%	435
Other anions	0.50	Ionic form as delivered		Sodium
FMA	1.75	Regeneration system		Packed Bed
P-alkalinity	1.17	Vessel diameter	mm	2,300
M-alkalinity	21.8	Vessel area (internal)	m²	4.10
		Resin height regenerated	mm	1,416
Total anions	23.9	Resin height exhausted	mm	1,345
		Inert resin type		IF-59
Silica as SiO2 mg/l	18.0	Inert resin height	mm	150
Temperature °C	42	Inert resin volume	liters	615
pH	8.8	Cylindrical height	mm	1,775
Free CO2 mg/l		Linear velocity	m/h	100
Organics as KMnO4 mg/l		Pressure drop at 42 °C	kPa	96.0
		Residual hardness	meq/l	0.0011

Regeneration sequences	m3/h	m/h	minutes	m3	Water
NaCl injection 10.0%	21.5	5.3	49	17.5	Raw (2)
Displacement	1.42	0.4	488	11.6	Raw (3)
Rinsing	410	100	3	17.4	Raw (4)
Total			**540**	**46.4**	

Regenerant waste composition (approx.)	**46.4** (2+3+4)	**29.0** (2+3)	m3
NaCl	29,056	46,490	mg/l
CaCl2	8,241	13,185	mg/l
MgCl2	0	0	mg/l
			mg/l

Plant design layout

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Feed water analysis	**meq/l**			**Design results**
Calcium (Ca)	0.050	DOWEX Resin		**MARATHON C-10**
Magnesium (Mg)		Volume per vessel	liters	**3,300**
Sodium (Na)	23.5	Net flow rate	m3/h	410
Potassium (K)	0.10	Net throughput	m3	68,880
Other cations		Time between 2 regen.	hours	168
		Gross flow rate	m3/h	410
		Gross throughput	m3	68,896
Total cations	23.7	Oper. capacity	meq/l	1,048
		Regenerant chemical		NaCl 10%
Chloride (Cl)	1.21	Regenerant dosage	g/l	303
Nitrate (NO3)		Amount per reg. as 100%	kg	994
Sulfate (SO4)	0.040	Reg.ratio to stochiometry	%	493
Other anions	0.50	Ionic form as delivered		Sodium
FMA	1.75	Regeneration system		Packed Bed
P-alkalinity	1.17	Vessel diameter	mm	2,100
M-alkalinity	21.8	Vessel area (internal)	m²	3.41
		Resin height regenerated	mm	968
Total anions	23.9	Resin height exhausted	mm	919
		Inert resin type		IF-59
Silica as SiO2 mg/l	18.0	Inert resin height	mm	150
Temperature °C	42	Inert resin volume	liters	512
pH	8.8	Cylindrical height	mm	1,275
Free CO2 mg/l		Linear velocity	m/h	120
Organics as KMnO4 mg/l		Pressure drop at 42 °C	kPa	81.2
		Residual hardness	meq/l	0.0011

Regeneration sequences	m3/h	m/h	minutes	m3	Water
NaCl injection 10.0%	17.1	5.0	35	9.94	Raw (2)
Displacement	1.13	0.3	350	6.57	Raw (3)
Rinsing	410	120	1	9.86	Raw (4)
Total			**386**	**26.4**	

Regenerant waste composition (approx.)	**26.4** (2+3+4)	**16.5** (2+3)	m3
NaCl	30,033	47,936	mg/l
CaCl2	7,242	11,559	mg/l
MgCl2	0	0	mg/l
			mg/l

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Plant design layout

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DOWEX™ MARATHON™ A

A Uniform Particle Size, High Capacity, Strong Base Anion Exchange Resin for Demineralization Applications

Product	Type	Matrix	Functional group
DOWEX™ MARATHON™ A	Type I strong base anion	Styrene-DVB, gel	Quaternary amine

Guaranteed Sales Specifications		Cl^- form	OH^- form
Total exchange capacity, min.	eq/L	1.3	1.0
	kgr/ft^3 as $CaCO_3$	28.4	21.9
Water content	%	50 - 60	60 - 72
Uniformity coefficient, max.		1.1	1.1

Typical Physical and Chemical Properties		Cl^- form	OH^- form
Mean particle size†	µm	575 ± 50	610 ± 50
Whole uncracked beads	%	95 - 100	95 - 100
Total swelling ($Cl^- \rightarrow OH^-$)	%	20	20
Particle density	g/mL	1.08	1.06
Shipping weight, approx.	g/L	670	640
	lbs/ft^3	42	40

Recommended Operating Conditions

• Maximum operating temperature:	
OH^- form	60°C (140°F)
Cl^- form	100°C (212°F)
• pH range	0 - 14
• Bed depth, min.	800 mm (2.6 ft)
• Flow rates:	
Service/fast rinse	5 - 60 m/h (2 - 24 gpm/ft^2)
Backwash	See figure 1
Co-current regeneration/displacement rinse	1 - 10 m/h (0.4 - 4 gpm $/ft^2$)
Counter-current regeneration/displacement rinse	5 - 20 m/h (2 - 8 gpm $/ft^2$)
• Total rinse requirement	3 - 6 Bed volumes
• Regenerant:	
Type	2 - 5% NaOH
Temperature	Ambient or up to 50°C (122°F) for silica removal

† For additional particle size information, please refer to Particle Size Distribution Cross Reference Chart (Form No. 177-01775).

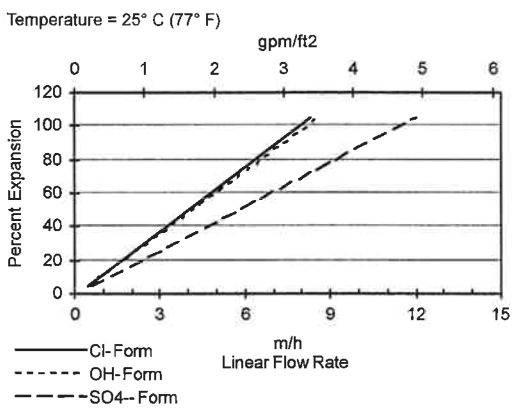
Typical Properties and Applications

DOWEX™ MARATHON™ A anion exchange resin is specifically designed to give high throughput and economical operation in primary demineralizer beds. Because of its uniform particle size, this resin offers a number of economic advantages over conventional (polydispersed) resins. The small uniform bead size of DOWEX MARATHON A resin results in rapid exchange kinetics during operation, more complete regeneration of the resin, and faster, more thorough rinse following regeneration. It can be used for all types of water but especially for waters that have a high percentage of silica and carbon dioxide.

Packaging

25 liter bags or 5 cubic feet fiber drums

Figure 1. Backwash Expansion Data

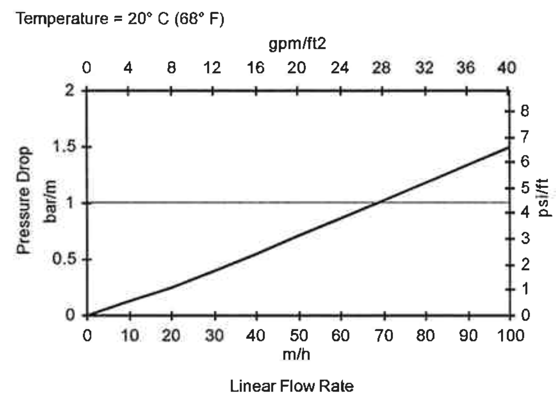


For other temperatures use:

$F_T=F_{77°F}[1+0.008(T_{°F}-77)]$, where F ≡ gpm/ft²

$F_T=F_{25°C}[1+0.008(1.8T_{°C}-45)]$, where F ≡ m/h

Figure 2. Pressure Drop Data



For other temperatures use:

$P_T=P_{20°C}/(0.026\,T_{°C}+0.48)$, where P ≡ bar/m

$P_T=P_{68°F}/(0.014\,T_{°F}+0.05)$, where P ≡ psi/ft

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

DOWEX™ Ion Exchange Resins
For more information about DOWEX resins, call the Dow Water Solutions business:

North America:	1-800-447-4369
Latin America:	(+55) 11-5188-9222
Europe:	(+32) 3-450-2240
Pacific:	+60 3 7958 3392
Japan:	+813 5460 2100
China:	+86 21 2301 9000

http://www.dowex.com

Warning: Oxidizing agents such as nitric acid attack organic ion exchange resins under certain conditions. This could lead to anything from slight resin degradation to a violent exothermic reaction (explosion). Before using strong oxidizing agents, consult sources knowledgeable in handling such materials.

DOWEX MARATHON C-10

A Uniform Particle Size, High Capacity Cation Exchange Resin for Softening and Demineralization Applications

Product	Type	Matrix	Functional group
DOWEX* MARATHON* C-10	Strong acid cation	Styrene-DVB, gel	Sulfonic acid

Guaranteed Sales Specifications		Na^+ form	H^+ form
Total exchange capacity, min.	eq/L	2.2	1.9
	kgr/ft³ as $CaCO_3$	48.1	41.5
Water content	%	40 - 45	46 - 51
Uniformity coefficient, max.		1.1	1.1

Typical Physical and Chemical Properties		Na^+ form	H^+ form
Mean particle size†	µm	740 ± 50	760 ± 50
Whole uncracked beads	%	95 - 100	95 - 100
Total swelling ($Na^+ \rightarrow H^+$)	%	7	7
Particle density	g/mL	1.31	1.22
Shipping weight	g/L	845	810
	lbs/ft³	53	50

Recommended Operating Conditions

• Maximum operating temperature	130°C (265°F)
• pH range	0 - 14
• Bed depth, min.	800 mm (2.6 ft)
• Flow rates:	
Service/demineralizing and softening	5 - 50 m/h (2 - 20 gpm/ft²)
Service/sodium or amine cycle polishing	38 - 75 m/h (15 - 30 gpm/ft²)
Backwash	See Figure 1
Co-current regeneration/displacement rinse	1 - 10 m/h (0.4 - 4 gpm/ft²)
Counter-current regeneration/displacement rinse	5 - 20 m/h (2 - 8 gpm/ft²)
• Total rinse requirement	2 - 5 bed volumes
• Regenerant	1 - 8% H_2SO_4, 4 - 8% HCl or 8 - 12% NaCl

† For additional particle size information, please refer to Particle Size Distribution Cross Reference Chart (Form No. 177-01775)

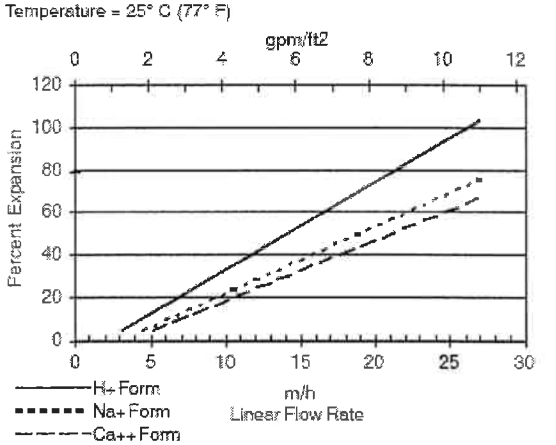
Typical Properties and Applications

DOWEX MARATHON C-10 strong acid cation exchange resin is a uniform particle size resin designed for demineralizing, softening, and single-bed condensate polishing applications. The uniform particle size beads exhibit more uniform exhaustion, regeneration, and backwash compared to conventionally sized resins. The higher level of crosslinking in DOWEX MARATHON C-10 resin also shows exceptional stability to compressive, osmotic, and oxidative stresses.

Packaging

25 liter bags, 1 cubic foot bags or 5 cubic foot fiber drums.

Figure 1. Backwash Expansion Data

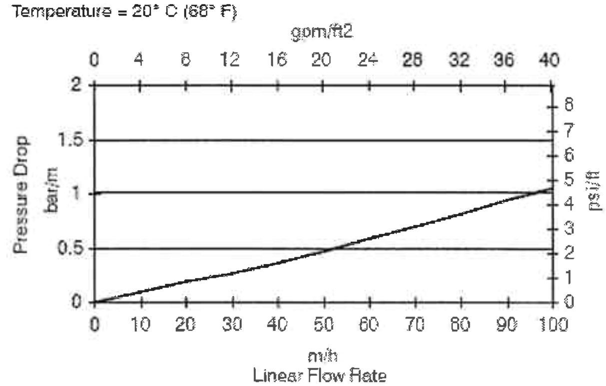


For other temperatures use:

$F_T = F_{77°F}\,[1 + 0.008\,(T_{°F} - 77)]$, where F ≡ gpm/ft²

$F_T = F_{25°C}\,[1 + 0.008\,(1.8T_{°C} - 45)]$, where F ≡ m/h

Figure 2. Pressure Drop Data



For other temperatures use:

$P_T = P_{20°C}\,/\,(0.026\,T_{°C} + 0.48)$, where P ≡ bar/m

$P_T = P_{68°F}\,/\,(0.014\,T_{°F} + 0.05)$, where P ≡ psi/ft

DOWEX Ion Exchange Resins
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DOWEX™ MARATHON™ C

A Uniform Particle Size, High Capacity Cation Exchange Resin for Softening and Demineralization Applications

Product	Type	Matrix	Functional group
DOWEX™ MARATHON™ C	Strong acid cation	Styrene-DVB, gel	Sulfonic acid

Guaranteed Sales Specifications		Na^+ form	H^+ form
Total exchange capacity, min.	eq/L	2.0	1.8
	kgr/ft^3 as $CaCO_3$	43.7	39.3
Water content	%	42 - 48	50 - 56
Uniformity coefficient, max.		1.1	1.1

Typical Physical and Chemical Properties		Na^+ form	H^+ form
Mean particle size†	μm	585 ± 50	600 ± 50
Whole uncracked beads	%	95 - 100	95 - 100
Total swelling ($Na^+ \rightarrow H^+$)	%	8	8
Particle density	g/mL	1.28	1.20
Shipping weight	g/L	820	800
	lbs/ft^3	51	50

Recommended Operating Conditions

- Maximum operating temperature — 120°C (250°F)
- pH range — 0 - 14
- Bed depth, min. — 800 mm (2.6 ft)
- Flow rates:
  - Service/fast rinse — 5 - 60 m/h (2 - 24 gpm/ft^2)
  - Backwash — see figure 1
  - Co-current regeneration/displacement rinse — 1 - 10 m/h (0.4 - 4 gpm /ft^2)
  - Counter-current regeneration/displacement rinse — 5 - 20 m/h (2 - 8 gpm /ft^2)
- Total rinse requirement — 2 - 5 Bed volumes
- Regenerant — 1 - 8% H_2SO_4, 4 - 8% HCl or 8 - 12% NaCl

† For additional particle size information, please refer to Particle Size Distribution Cross Reference Chart (Form No. 177-01775).

Typical Properties and Applications

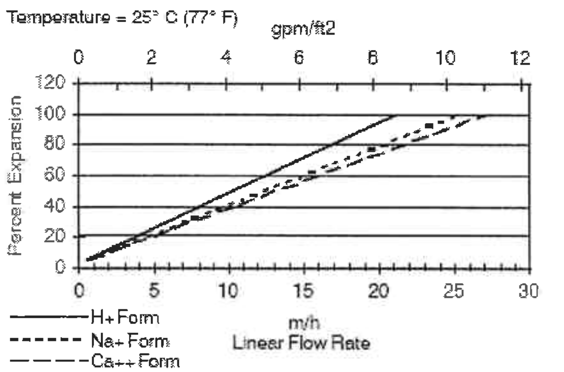
DOWEX™ MARATHON™ C strong acid cation exchange resin is a uniform particle size resin designed for demineralization applications. The small uniform beads exhibit faster kinetics than conventionally sized resins. The improved kinetics results in improved regeneration efficiency, higher operating capacity, reduced regenerant usage and less waste water.

DOWEX MARATHON C resin also shows outstanding stability to compressive and osmotic stress.

Packaging

25 liter bags or 5 cubic feet fiber drums

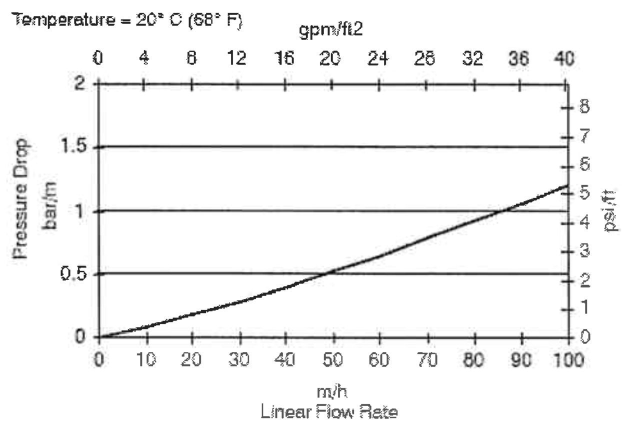
Figure 1. Backwash Expansion Data



For other temperatures use:

$F_T = F_{77°F}$ [1+ 0.008 ($T_{°F}$ -77)], where F ≡ gpm/ft^2
$F_T = F_{25°C}$ [1+ 0.008 (1.8$T_{°C}$ - 45)], where F ≡ m/h

Figure 2. Pressure Drop Data



For other temperatures use:

$P_T = P_{20°C}$ / (0.026 $T_{°C}$ + 0.48), where P ≡ bar/m
$P_T = P_{68°F}$ / (0.014 $T_{°F}$ + 0.05), where P ≡ psi/ft

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

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Form No. 177-01593-0407

DOWEX™ MAC-3

A Macroporous Weak Acid Cation Exchange Resin used for Water Softening, Dealkalization and Demineralization Applications

Product	Type	Matrix	Functional group
DOWEX™ MAC-3	Weak acid cation	Polyacrylic, macroporous	Carboxylic acid

Guaranteed Sales Specifications		H^+ form
Total exchange capacity, min.	eq/L	3.8
	kgr/ft^3 as $CaCO_3$	83.0
Bead size distribution range† 300 - 1,200 µm, min. (50 mesh - 16 mesh)	%	90

Typical Physical and Chemical Properties		H^+ form
Water content	%	44 - 50
Whole beads	%	95 - 100
Total swelling ($H^+ \rightarrow Na^+$)	%	~70
Particle density	g/mL	1.18
Shipping weight	g/L	750
	lbs/ft^3	47

Recommended Operating Conditions

• Maximum operating temperature	120°C (250°F)
• pH range	5 - 14
• Bed depth, min.	800 mm (2.6 ft)
• Flow rates:	
Service/fast rinse	5-50 m/h (2-20 gpm/ft^2)
Backwash	See figure 1
Regeneration/displacement rinse	1-10 m/h HCl (0.4-4 gpm /ft^2), 5-20 m/h H_2SO_4 (2-8 gpm /ft^2)
Rinse	5-20 m/h (2-8 gpm /ft^2)
• Total rinse requirement	3 - 6 Bed volumes
• Regenerant	1 - 5% HCl or 0.5 - 0.8% H_2SO_4

† For additional particle size information, please refer to Particle Size Distribution Cross Reference Chart (Form No. 177-01775).

Form No. 177-01603-0407

Typical Properties and Applications

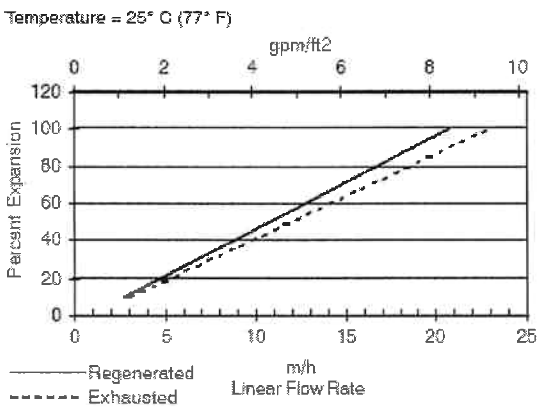
DOWEX™ MAC-3 weak acid cation resin has high exchange capacity, excellent regeneration efficiency, very good resistance to osmotic shock, plus good chemical and physical stability.

DOWEX MAC-3 resin is effective in removal of temporary hardness (hardness associated with alkalinity) and dealkalization. It is also used for recovery of metals. DOWEX MAC-3 resin can be supplied on request for use in food and potable water applications in accordance to the TOC (Total Organic Carbon) requirements of the major European legislations. In such cases, a recommendation is given for resin conditioning before use.

Packaging

25 liter bags or 5 cubic feet fiber drums

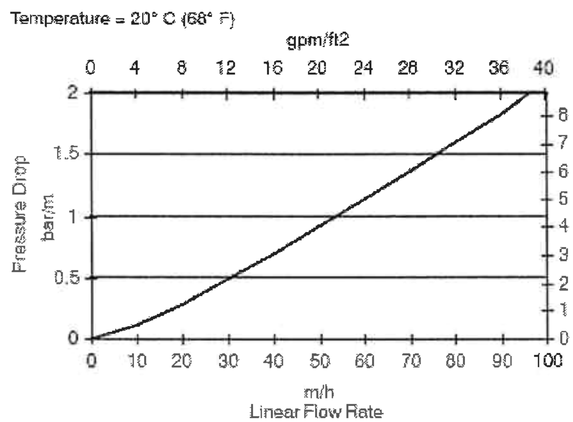
Figure 1. Backwash Expansion Data



For other temperatures use:

$F_T = F_{77°F} [1 + 0.008 (T_{°F} - 77)]$, where $F \equiv gpm/ft^2$
$F_T = F_{25°C} [1 + 0.008 (1.8T_{°C} - 45)]$, where $F \equiv m/h$

Figure 2. Pressure Drop Data



For other temperatures use:

$P_T = P_{20°C} / (0.026\, T_{°C} + 0.48)$, where $P \equiv bar/m$
$P_T = P_{68°F} / (0.014\, T_{°F} + 0.05)$, where $P \equiv psi/ft$

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

DOWEX™ Ion Exchange Resins
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North America:	1-800-447-4369
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http://www.dowex.com

Form No. 177-01603-0407

DOWEX™ MARATHON™ MSC

A Uniform Particle Size, High Capacity Macroporous Cation Exchange Resin for Water Demineralization Applications

Product	Type	Matrix	Functional group
DOWEX™ MARATHON™ MSC	Strong acid cation	Styrene-DVB, macroporous	Sulfonic acid

Guaranteed Sales Specifications		Na^+ form	H^+ form
Total exchange capacity, min.	eq/L	1.7	1.6
	kgr/ft³ as $CaCO_3$	37.1	35.0
Water content	%	44 - 50	50 - 56
Uniformity coefficient, max.		1.1	1.1

Typical Physical and Chemical Properties		Na^+ form	H^+ form
Mean particle size†	µm	550 ± 50	575 ± 50
Whole beads	%	95 - 100	95 - 100
Total swelling ($Na^+ \rightarrow H^+$)	%	4	4
Particle density	g/mL	1.28	1.20
Shipping weight	g/L	800	760
	lbs/ft³	50	47

Recommended Operating Conditions

- Maximum operating temperature — 150°C (300°F)
- pH range — 0 - 14
- Bed depth, min. — 800 mm (2.6 ft)
- Flow rates:
  - Service/fast rinse — 5-50 m/h (2-20 gpm/ft²)
  - Backwash — see Figure 1
  - Co-current regeneration/displacement rinse — 1-10 m/h (0.4-4 gpm /ft²)
  - Counter-current regeneration/displacement rinse — 5-20 m/h (2-8 gpm /ft²)
- Total rinse requirement — 3 - 6 Bed volumes
- Regenerant — 1-10% H_2SO_4, 4-8% HCl or 8-12% NaCl

† For additional particle size information, please refer to Particle Size Distribution Cross Reference Chart (Form No. 177-01775).

Form No. 177-01786-0307

Typical Properties and Applications

DOWEX™ MARATHON™ MSC strong acid cation resin is a highly cross-linked resin with high porosity giving excellent osmotic shock resistance and chemical and thermal stability.

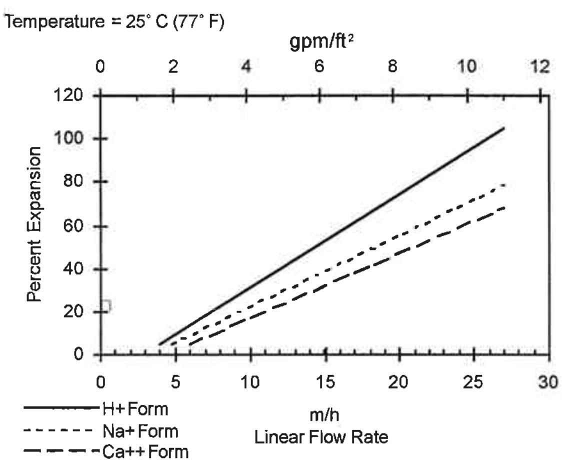
The resin has a variety of uses, such as:

- Hot process softening
- Demineralization
- Adsorbent
- Processes with oxidizing conditions
- Recovery of metals from plating baths

Packaging

25 liter bags or 5 cubic feet fiber drums

Figure 1. Backwash Expansion Data

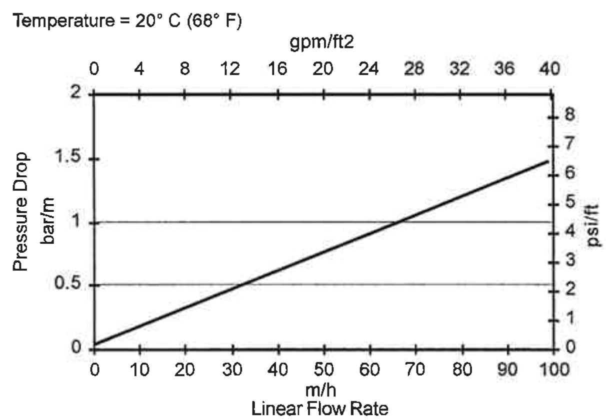


For other temperatures use:

$F_T = F_{77°F}$ [1+ 0.008 ($T_{°F}$ -77)], where F = gpm/ft²

$F_T = F_{25°C}$ [1+ 0.008 ($1.8T_{°C}$ - 45)], where F = m/h

Figure 2. Pressure Drop Data



For other temperatures use:

$P_T = P_{20°C}$ / (0.026 $T_{°C}$ + 0.48), where P ≡ bar/m

$P_T = P_{68°F}$ / (0.014 $T_{°F}$ + 0.05), where P ≡ psi/ft

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Form No. 177-01786-0307

C-5

Acid/Antiscalant Product Information

Optimum Flow™

Antiscalant/Dispersant/Antifoulant

Membrane System Support Program

Pretreat Plus™ 0100

Pretreat Plus™ - 0100 is a highly effective antiscalant, specially formulated for feedwaters with the highest levels of metal oxides, silica, and scale-forming minerals. It is effective over a wide range of concentrations, and does not flocculate dissolved polymers such as residual coagulants or iron or aluminum-rich silica. Use of this product is recommended for reducing the operating and capital costs of reverse osmosis (RO), nanofiltration (NF) and ultrafiltration (UF) systems. A special utility is in its application as a substitute for pretreatment with ion exchange beds.

Product Benefits:

- **Effective in retarding polymerization and precipitation of silica**
- **Effectively controls inorganic scales over a large concentration range.**
- **Certified under ANSI/NSF Standard 60 for drinking water production.**
- **Compatible with major manufacturer's RO, NF, and UF membranes.**
- **Does not flocculate dissolved iron/aluminum oxide/silica complexes.**
- **Effective in controlling calcium carbonate and calcium sulfate scales.**
- **Effective in feedwaters with pH range 5.0 – 10.0**
- **Efficacious for controlling aluminum, iron, and heavy metal salts.**

Specification: Liquid

Appearance:	**Clear, colorless**
pH:	**1.5 ± 0.8**
Specific Gravity:	**1.08 ± 0.05**

Specification: Powder

Appearance:	**Colorless**
pH (1% in water):	**11 –12**

Application:

Pretreat Plus™ 0100 should be injected into the feedstream prior to the static mixer and cartridge filter. Effective pH range is 5 –10. If frozen, may be thawed and mixed before use. Stability is excellent, but best used within 12 months.

Dosing Recommendations:

In the useful dosage range of 1 –15 mg/L (neat), control of a wide range of inorganic scales at up to 100 x saturation values or higher is possible. By monitoring the concentrate stream and trend charts, optimal dosage can be achieved for the control of scales including that from calcium carbonate, calcium sulfate, barium sulfate, strontium sulfate, iron hydroxide, aluminum hydroxide and silica.

Packaging:

Standard and custom sizes, pails, drums, and totes.

***MSDS available upon request.**

King Lee Technologies
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