Dow
Liquid Separations

# DOWEX MARATHON 11

## Ion Exchange Resin

### ENGINEERING INFORMATION

# **DOWEX MARATHON 11** Type 1 Strong Base Anion Exchange Resin

## General Information

DOWEX* MARATHON* 11 resin is a high capacity, high porosity, strong base type 1 anion exchange resin of uniform bead size distribution. Based on a styrene-divinylbenzene copolymer matrix, this gel type resin has proven to be an excellent choice for use in the anion exchange unit of multi-bed demineralizer trains, in mixed beds, or as an organic trap. It is especially recommended for treating waters that contain naturally occuring organic matter. Its unique porosity and high thermal stability provide for more complete removal of organics over long periods of service, resulting in consistently high quality water.

In addition to its organic removal properties, the uniform particle size offers a number of advantages compared to conventional (polydispersed) resins. The absence of large diameter beads and the high surface area to volume ratio enable rapid exchange kinetics during operation. This results in more complete regeneration of the resin, increased capacity and faster, more thorough rinse following regeneration.

Installed in front of the cation exchange unit, chloride form DOWEX MARATHON 11 resin acts as an organic screen, remo-ving organic molecules that would foul the working strong base anion resin. This results in dramatic increases in demineralization efficiency.

The excellent thermal stability of DOWEX MARATHON 11 resin (up to 100°C/212°F in the $Cl^-$ form), is superior to acrylic type resins which start to degrade at temperatures above 35°C/95°F, giving rise to capacity loss and long rinses. DOWEX MARATHON 11 resin is therefore better able to withstand high temperature brine cleaning and the use of heated caustic, resulting in better, long term performance for operating capacity and silica leakage.

This brochure gives operational data on the use of DOWEX MARATHON 11 resin in water demineralization using NaOH regenerant in both co-current or counter-current operation. It also covers the use of DOWEX MARATHON 11 resin as an organic trap using NaCl as the regenerant. The presented data permits the calculation of operational capacities and silica leakages for different influent waters at different temperatures and levels of regeneration.

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| Guaranteed Sales Specifications | | $Cl^-$ form |
|---|---|---|
| Total exchange capacity, min. | eq/l<br>kgr/ft$^3$ as $CaCO_3$ | 1.3<br>28.4 |
| Water content | % | 48 - 58 |
| Uniformity coefficient, max. | | 1.1 |

| Typical Physical and Chemical Properties | | $Cl^-$ form |
|---|---|---|
| Mean particle size[†] | µm | 550 ± 50 |
| Whole uncracked beads | % | 95 - 100 |
| Total swelling ($Cl^-$ ♦ $OH^-$) | % | 20 |
| Particle density | g/ml | 1.08 |
| Shipping weight | g/l<br>lbs/ft$^3$ | 670<br>42 |

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

[†]For additional particle size information, please refer to the Particle Size Distribution Cross Reference Chart (Form No. 177-01775/CH 171-476-E).

# Hydraulic Characteristics

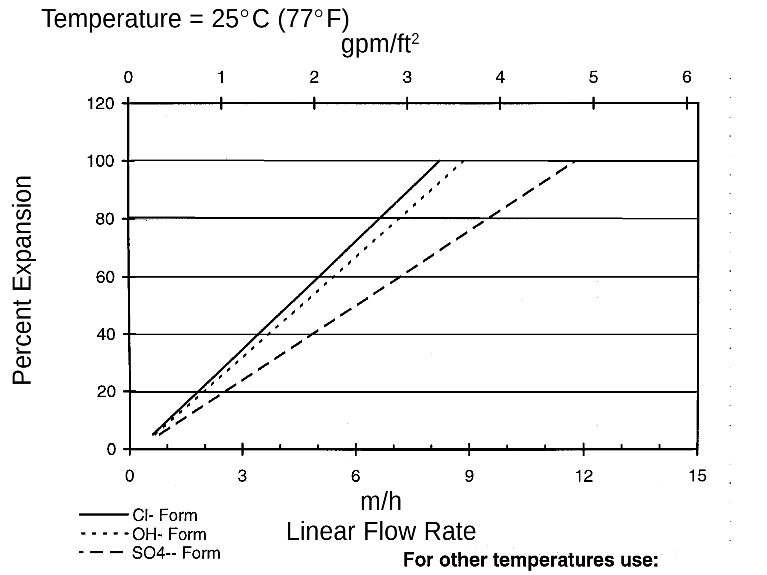
## Backwash Expansion

In co-current operation a backwash expansion precedes every regeneration. This expansion allows regrading of the resin, fines removal and avoids channelling during the subsequent service cycle. An expansion of 60-80% for 20 minutes is normally recommended to remove particulate matter from the resin bed. Occasionally, a longer backwash may be needed to fully remove contaminants. In counter-current operation, backwashing is only required if accumulated debris causes an excessive increase in pressure drop or to decompact the bed. Usually a back-wash is performed every 15 to 30 cycles in conventional counter-current regeneration.

Under the upflow conditions of backwashing, the resin will expand its volume according to Figure 1. The data in Figure 1 shows the expansion behavior as a function of both flow-rate and backwash water temperature.

The smaller, uniform size of DOWEX MARATHON 11 resin requires less flow to expand to the same height as a conventional polydispersed resin.

**Figure 1. Backwash Expansion**




**For other temperatures use:**

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

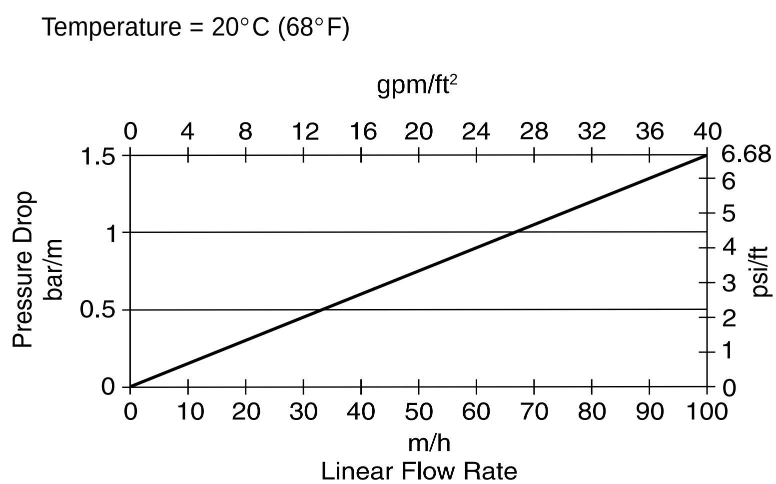
$F_T = F_{25°C}$ [1+ 0.008 (1.8$T_{°C}$ - 45)], where F ≡ m/h

## Pressure Drop Data

The pressure drop across a resin bed can vary depending on a number of factors. These include resin type, bead size, interstitial space (bed voidage), flow rate and temperature. The presence of smaller beads in conventional, polydispersed size resins results in some filling of the interstitial spaces between the larger beads, thereby increasing the head loss across the resin bed. In contrast, uniform size beads have a higher, more uniform voidage which compensates for the smaller mean bead diameter, resulting in similar head loss characteristics to the conventional resins.

The data in Figure 2 shows the pressure drop per unit bed depth as a function of both flow velocity and water temperature. These figures refer to new resin after backwashing and settling and should be considered indicative. The total head loss of a unit in operation will also depend on its design and the contribution of the internal laterals and resin strainers.

**Figure 2. Pressure drop**




**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

## Operating Characteristics

DOWEX MARATHON 11 resin regenerates more efficiently, resulting in added capacity compared to conventional, polydispersed resins under the same conditions. This should result in lower operating costs, reduced waste disposal and better water quality.

The recommended operating conditions in the table shown on page 2 are intended as a guide and should not be found restrictive. Excellent results will be obtained when using any alkali concentration from 2 to 5%. Even 8% can be used under certain controlled conditions. The regenerant flow is based on presenting approximately 2 grams NaOH per liter of resin (0.1 lbs/$ft^3$) per minute. This appears to give the best performance using 4% NaOH, resulting in a regeneration flow rate of 3 $m^3$/h per $m^3$ of installed resin (0.4 gpm/$ft^3$).

The use of hot regenerant (up to 50°C/122°F) gives an increased operational capacity and is especially useful for waters with high organic and silica loading. Note that the highest efficiency is obtained by preheating the resin bed during the last bed volume of the preceding backwash, or with dilution water used for regeneration.

The engineering design, especially of the distribution and collection lateral systems, will be strongly influenced by the operational flow rates. The compatibility of this design with the needs of an efficient regeneration will be of the utmost importance and may change the regeneration recommendations in some aspects to obtain an optimal performance. In large plants for instance, a lower concentration and a proportionally higher regenerant flow rate may be appropriate to overcome problems of chemical distribution.

The performance of the anion exchange unit will be evaluated on the basis of its operational efficiency and effluent silica leakage. Most importantly, the resin must provide consistent long term performance and its capacity to do so will depend on its chemical and physical stability, and its resistance to fouling by organic material or silica polymerization. DOWEX MARATHON 11 resin, with its unique porosity, uniform bead size and chemical structure has the characteristics to provide such high performance.

**Figure 3. Silica leakage in co-current operation. Regeneration at 15-20° C (60-70° F)**

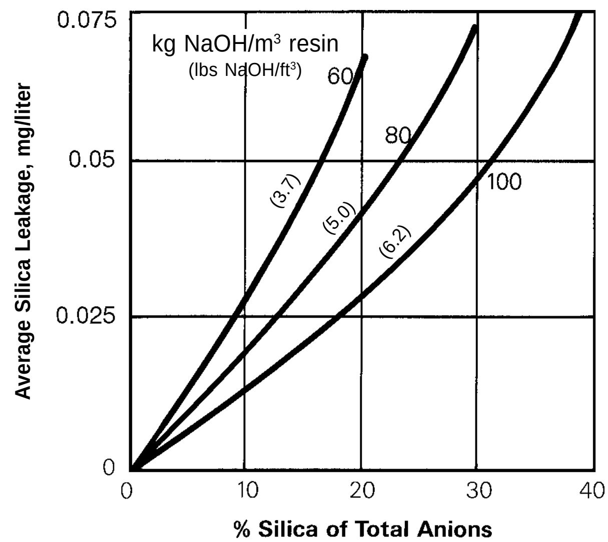
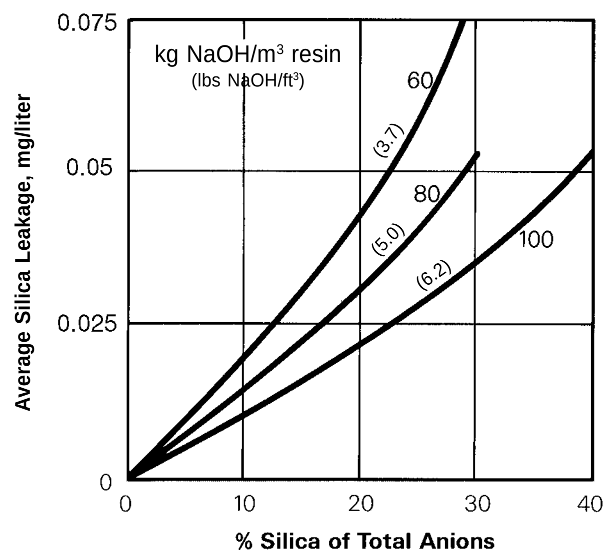



**Figure 4. Silica leakage in co-current operation. Regeneration at 35°C (95°F)**



## Co-Current Operation

Silica leakage levels are shown in Figures 3 to 6 as a function of the regenerant level and percent silica to total anions in the feed. As the silica leakage is mainly dependent on the leakage of sodium through the cation exchanger, a maximum leakage of 0.5 mg/l sodium should be maintained throughout the cycle in order to avoid hydrolysis of the silica from the resin. Lower sodium leakage levels are obtained using a counter-current regenerated cation exchange unit.

Silica leakages around 0.05 mg/l can be obtained for a large percentage of the operating cycle, provided that $CO_2$ plus the silica do not exceed 30% of the total anions. This generally occurs when no weak base anion resin precedes the strong base anion exchanger, or when a degasifier is used to process the cation effluent ahead of the anion exchanger.

Irrespective of the $CO_2$ concentration, the figures given in the graphs 3 to 6 should be easily achieved. If silica exceeds 40% of the total anions, it is generally advised not to exhaust the strong base anion resin exclusively with silica.

If an anion exchange resin is heavily loaded with silica, warm NaOH is necessary to effectively remove it. The maximum permitted temperature is 60°C/140°F, but 50°C/122°F is more commonly used. In cases where a low silica residual is required, the use of counter-current regeneration may prove more economical than heating the regenerant.

The temperature of the water being treated will have an effect on the treated water quality, particularly if a plant is shut down in high ambient temperature. The resultant silica may increase to double the normal level until the water returns to normal temperature.

Data on typical co-current operational capacities for DOWEX MARATHON 11 resin are presented in Figure 7.

**Figure 5. Silica leakage in co-current operation. Regeneration at 50°C (120°F) above operational temperature**

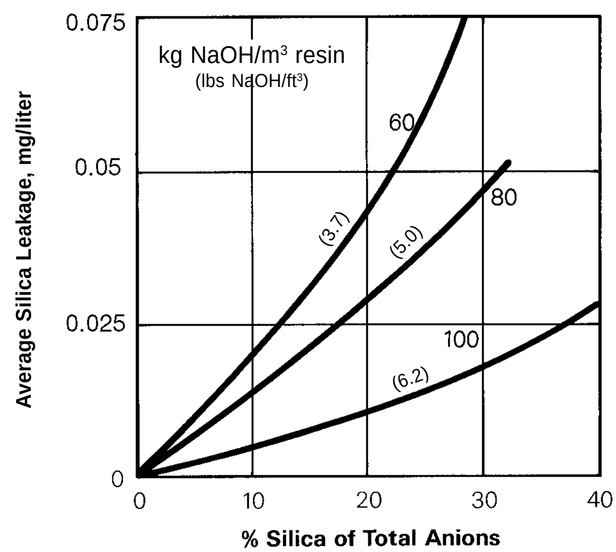
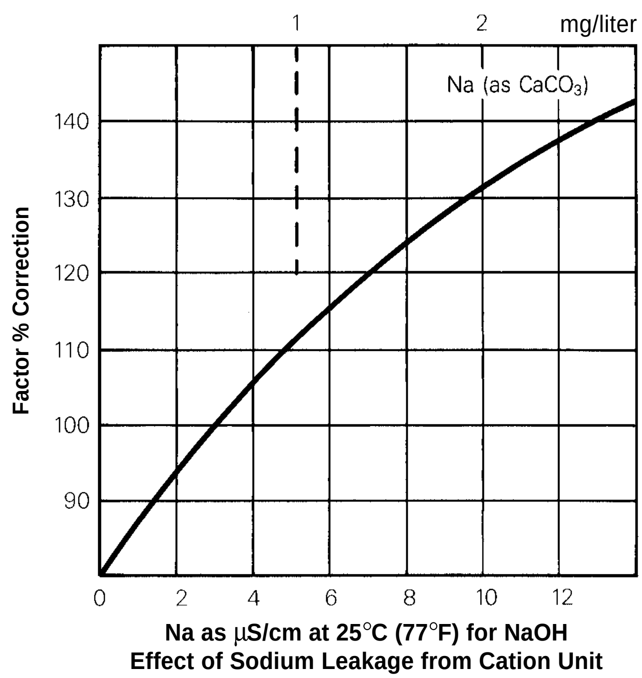



**Figure 6. Leakage correction factor for sodium co-current operation**

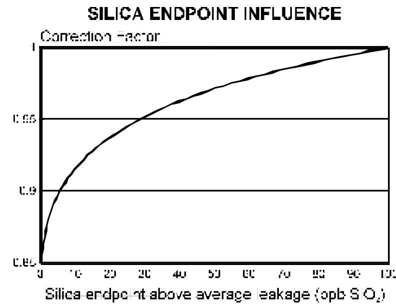


## Co-current operational capacity data

To calculate operational capacities:

1. Locate a point on the ordinate of graph A from carbon dioxide and chloride percentage of total anions.
2. Transfer the ordinate point from graph A horizontally to graph B and follow the guidelines on graph B to locate a new point on the ordinate according to the nitrate percentage of total anions.
3. Transfer the ordinate point from graph B horizontally to graph C and repeat the procedure under point 2 according to silica percentage of total anions.
4. Transfer the ordinate point from graph C horizontally to graph D and repeat the procedure under point 2 according to the chosen regeneration level.
5. Read off on the right hand side of the diagram the operational capacity corre-sponding to the ordinate point located on graph D.
6. For regeneration at different temperatures, modify the abscissa point on graph D according to the guidelines given at the top of graph E.

Note: eq/l x 21.8 = kgr/ft$^3$ as $CaCO_3$.



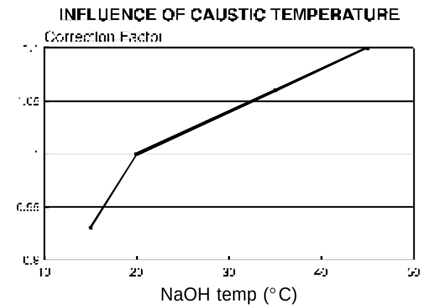
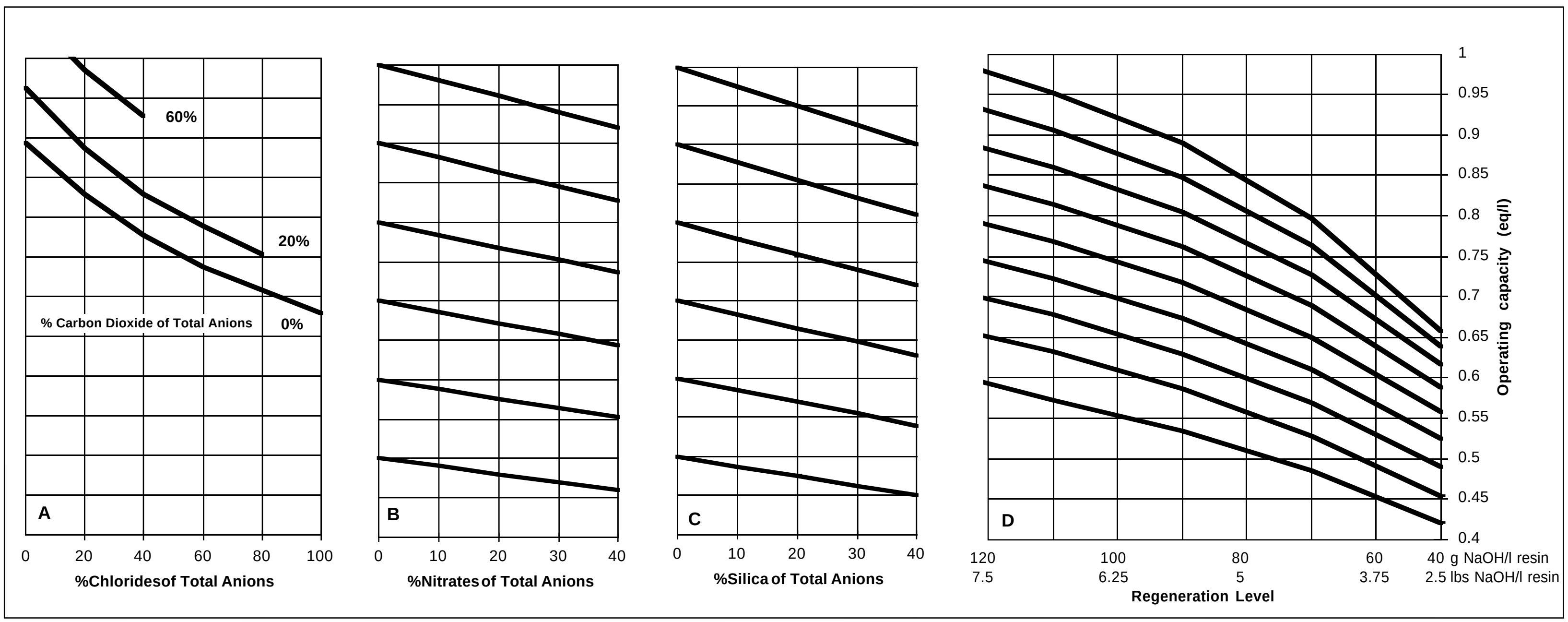




**Figure 7. Co-current operational capacity data**



## Counter-Current Operation

The advantages of counter-current operation over co-current operation are improved chemical efficiency (better capacity usage and decreased regeneration waste) and lower silica leakage. These advantages are further enhanced with the use of uniform particle sized resins. A low silica leakage from the anion exchanger requires an equally good preceding cation exchange unit, delivering water with a residual sodium level below 0.25 mg/l. With this quality of decationized water, one can expect a residual silica below 5 ppb for about 90% of the operational cycle. Data on silica leakage levels are presented in Figure 8 and the counter-flow bed depth correction factor is given in Figure 9.

Demineralized water is needed to dilute the regeneration chemicals and for the displacement rinse which has the same flow direction of the regeneration. The final rinse uses decationized water from the cation exchange unit in the flow direction of the service cycle.

The following steps are recommended to obtain low silica leakage with a type 1 strong base anion resin in counter-current operation:

1. Define bed depth and regeneration level from Figures 8 and 9 to design for the required silica leakage.
2. Assure a low sodium content in the feedwater.
3. Assure that regeneration chemicals are properly distributed over the entire resin bed and that no dilution occurs.
4. Minimize the organics in the feedwater, whether by proper pretreatment, organic scavenging or a preceding anion unit.

**Figure 8. Silica leakage in counter-current operation. Regeneration at 20°C (36°F) above operational temperature**

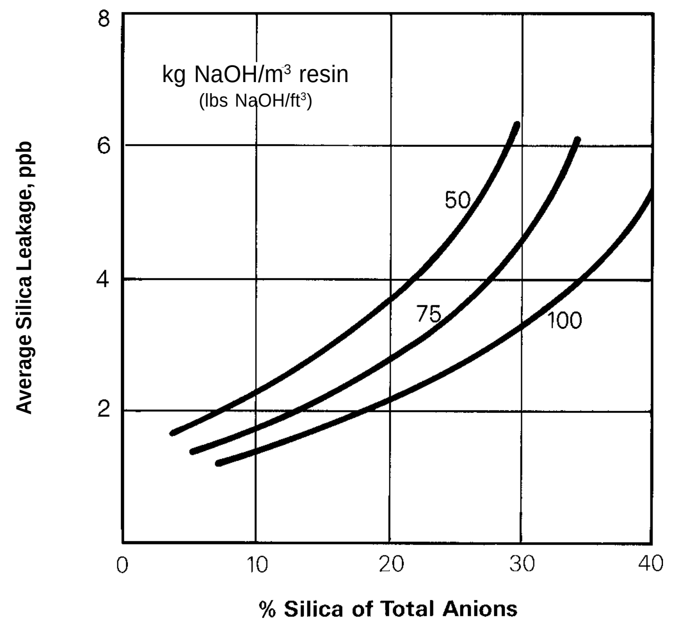
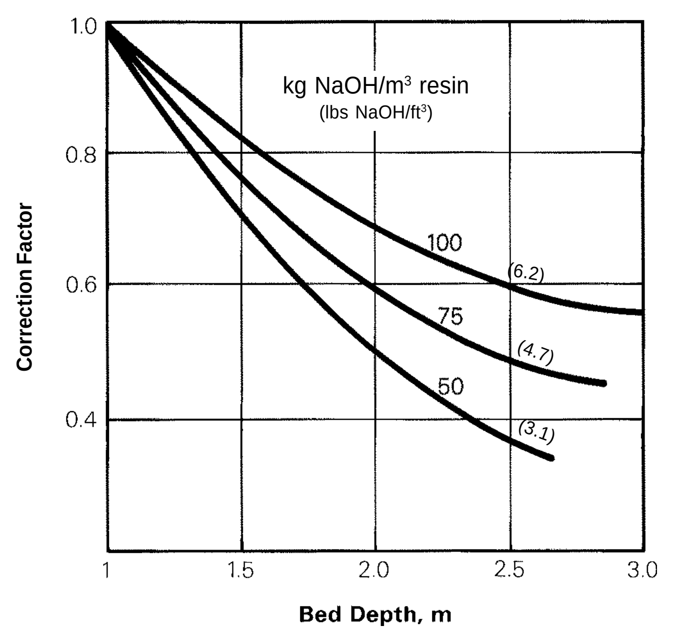



**Figure 9. Correction factor for bed depth effect in counter-current operation**



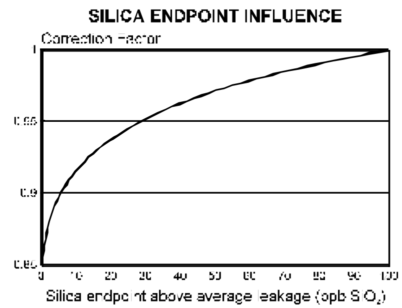
5. Avoid backwashing unless necessary to decompact the bed to avoid channelling.
6. Assure that the polishing zone of the bed is kept intact mechanically, during regeneration and service, and chemically by not overrunning the anion exchanger. Preferably terminate the service cycle prior to silica breakthrough.
7. Regenerate at a higher temperature than the operational temperature.
8. Avoid loading more than 15 g $SiO_2$ per liter of resin.

Data on counter-current operational capacities for DOWEX MARATHON 11 resin are presented in the Figure 10.

## Counter-current operational capacity data

To calculate operational capacities:

1. Locate a point on the ordinate of graph A from carbon dioxide and chloride percentage of total anions.
2. Transfer the ordinate point from graph A horizontally to graph B and follow the guidelines on graph B to locate a new point on the ordinate according to the nitrate percentage of total anions.
3. Transfer the ordinate point from graph B horizontally to graph C and repeat the procedure under point 2 according to silica percentage of total anions.
4. Transfer the ordinate point from graph C horizontally to graph D and repeat the procedure under point 2 according to the chosen regeneration level.
5. Read off on the right hand side of the diagram the operational capacity corresponding to the ordinate point located on graph D.
6. Now for regeneration at different temperatures modify the abscissa point on graph D according to the guidelines given at the top of graph E.



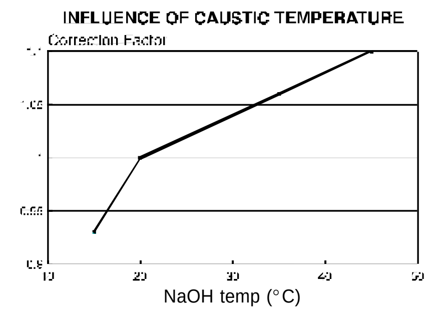
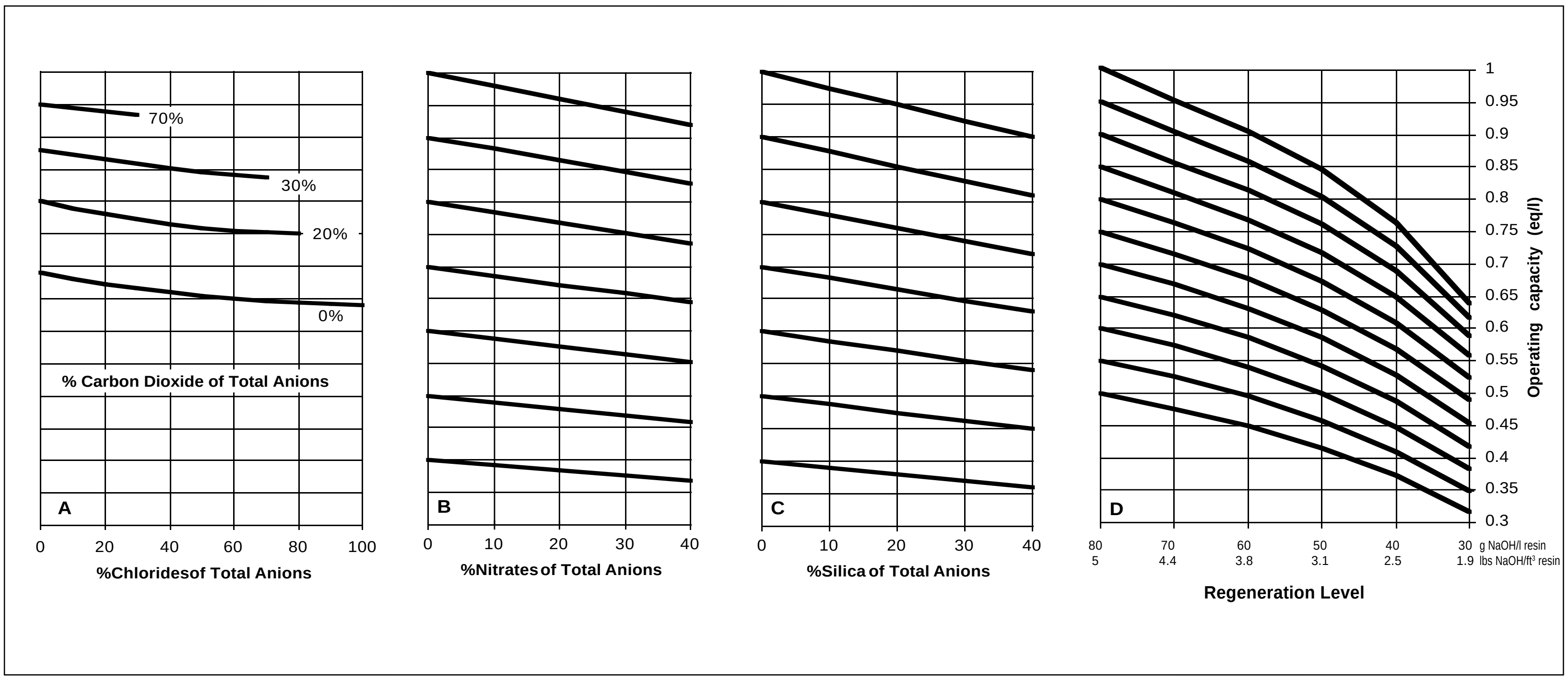




**Figure 10. Counter-current operational capacity data**



**DOWEX MARATHON 11 resin as an organic screen**

When used an organic screen ahead of a demineralization train, DOWEX MARATHON 11 is operated in the chloride form using alkaline brine as the regenerant (10% NaCl + 1% NaOH). It is common to run the organic screen as a co-flow unit. The recommended operating conditions are given in the table shown on page 2.

A regenerant dosage of 150 g NaCl with 15 g NaOH per liter resin (10 lbs/$ft^3$ NaCl, 1 lb/$ft^3$ NaOH) is recommended. The unit should be designed such that the maximum organic loading on the resin is 7 g/l organics (end-of cycle) expressed as $KMnO_4$ consumption. The capacity and leakage will depend on the nature and composition of the organics in the influent feedwater.

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† Toll-free telephone number for the following countries: Austria, Belgium, Denmark, Finland, France, Germany, Hungary, Ireland, Italy, The Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, and the United Kingdom

**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.




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