

Dow  
Liquid Separations

# **DOWEX MARATHON C**

## **Ion Exchange Resin**

**ENGINEERING INFORMATION**

# DOWEX MARATHON C Strong Acid Cation Exchange Resin

## General Information

DOWEX\* MARATHON\* C resin is a high capacity, gel strong acid cation exchange resin of uniform bead size distribution. It is based on a styrene-divinyl benzene copolymer matrix with sulfonate functional groups. DOWEX MARATHON C resin is specifically designed to give high throughput and economical operation in both water and non-water applications. Because of its uniform particle size, this resin offers

a number of advantages compared to conventional (polydispersed) resins. The small uniform bead size of DOWEX MARATHON C resin results in rapid exchange kinetics during operation, more complete regeneration of the resin, and faster, more thorough rinse following regeneration. Its high mechanical and osmotic strength due to its specially designed structure and small bead size gives it outstanding resistance to bead breakage.

This brochure relates to water demineralization, using HCl or H<sub>2</sub>SO<sub>4</sub> as regenerant in co-current or counter-current operation. The presented data allows the calculation of operational capacities and sodium leakages for different water qualities at different temperatures and levels of regeneration. Separate information is available on its use in softening applications. The resin is normally delivered in the hydrogen form but is also available in the sodium form.

Guaranteed Sales Specifications		Na <sup>+</sup> form	H <sup>+</sup> form
Total exchange capacity, min.	eq/l	2.0	1.8
	kg/ft <sup>3</sup> as CaCO <sub>3</sub>	43.7	39.3
Water content	%	42 - 48	50 - 56
Uniformity coefficient, max.		1.1	1.1

Typical Physical and Chemical Properties		Na <sup>+</sup> form	H <sup>+</sup> form
Mean particle size <sup>†</sup>	µm	585 ± 50	600 ± 50
Whole uncracked beads	%	95 - 100	95 - 100
Total swelling (Na <sup>+</sup> ♦ H <sup>+</sup> )	%	8	8
Particle density	g/ml	1.28	1.20
Shipping weight	g/l	820	800
	lbs/ft <sup>3</sup>	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 <sup>2</sup> )
Backwash	See figure 1
Co-current regeneration/displacement rinse	1-10 m/h (0.4-4 gpm/ft <sup>2</sup> )
Counter-current regeneration/displacement rinse	5-20 m/h (2-8 gpm/ft <sup>2</sup> )
Total rinse requirement	2-5 Bed volumes
Regenerant	1-8% H <sub>2</sub> SO <sub>4</sub> , 4-8% HCl or 8-12% NaCl

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

## Bed Expansion

A uniform bead resin requires less flow to expand to the same height as a conventional polydispersed resin. DOWEX MARATHON C resin has a smaller mean size, thereby reducing the backwash flow rate required even further. Backwash expansion characteristics for MARATHON C resin are displayed in Figure 1. Backwash expansion reclassifies the resin, removes any accumulated fines, and prevents channeling during the subsequent service cycle. An expansion of 60–80% for 20 minutes is normally recommended to remove particulate matter from the resin bed.

In co-current operation the resin is backwashed before every regeneration. Occasionally, extended backwash may be needed to fully remove contaminants. In counter-current operation, the strainers are cleaned by the regenerant flow. To retain the advantages of counter-current operation, it is essential not to disturb the resin. Backwashing is only desirable if accumulated debris causes an excessive increase in pressure drop or to decompact the bed. Usually, a backwash is performed every 15 to 30 cycles in conventional “blocked” counter-current regeneration systems.

## 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 (void volume), flow rate, and temperature. The presence of smaller beads in conventional polydispersed resins can result in filling of the interstitial spaces between the larger beads, thereby increasing the head loss pressure drop. Compared to conventional resins, uniform beads have a higher void volume which compensates for the smaller mean bead diameter, resulting in similar head loss characteristics to the conventional resins.

Figure 1. Backwash expansion vs. flow rate

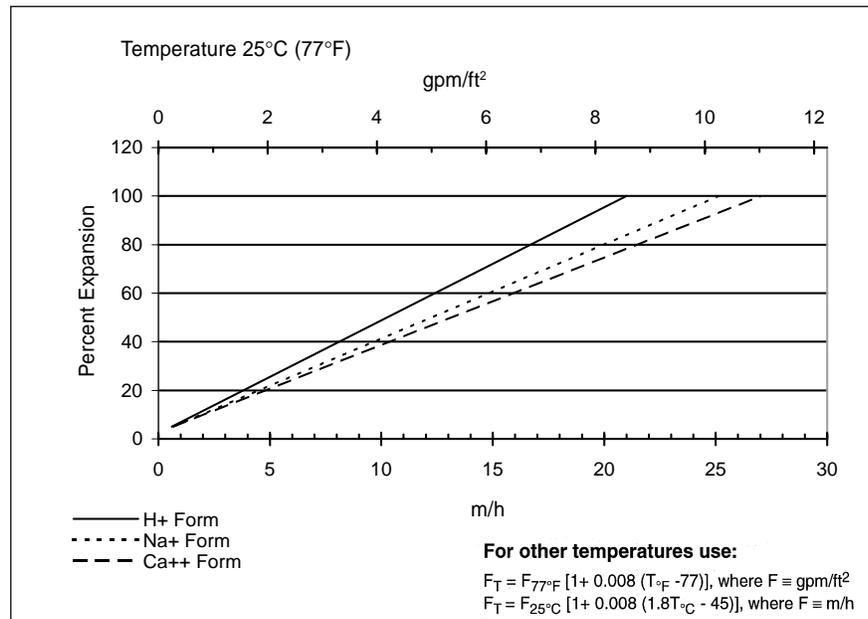
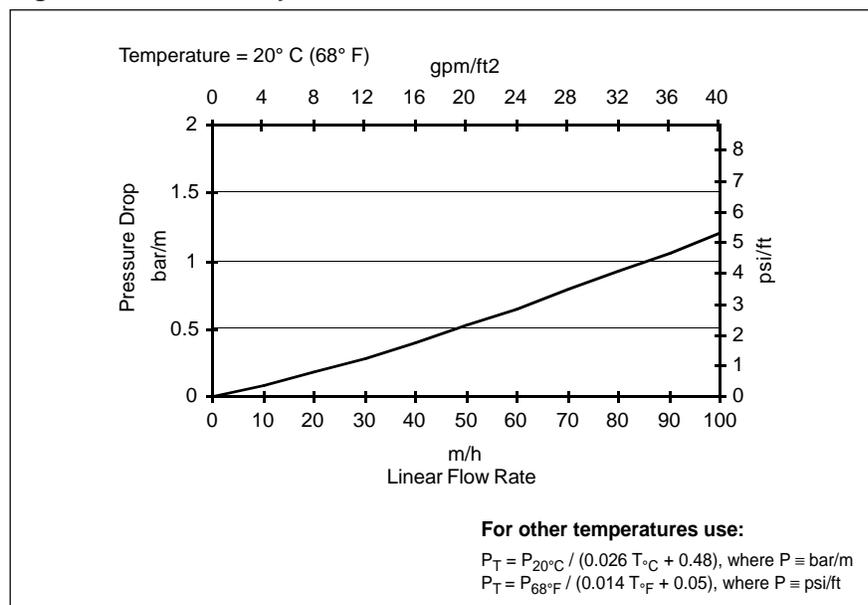


Figure 2. Pressure drop vs. flow rate



The data in Figure 2 shows the pressure drop per unit bed depth as a function of flow velocity. These figures are based on new resin which has been backwashed and settled and must be considered representative only. The total head

loss of a unit in operation will also depend on the design, in addition to other factors such as level of fines and suspended solids. It is substantially affected by the contribution of the strainers surrounded by resin.

## Operating Characteristics

DOWEX MARATHON C resin's uniform beads results in more efficient regeneration and increased operating capacity compared to conventional resins. This reduces both operating costs and waste disposal volumes.

The performance of the cation exchange resin is evaluated on the basis of the regeneration efficiency and the sodium leakage. Figure 3 indicates the contribution to conductivity due to sodium leakage. This leakage is expressed as NaOH as it appears in the effluent of a strong base resin. When a weak base resin follows the cation exchange unit, sodium will leak as NaCl and contribute to the conductivity accordingly. In this case, conductivity will also be due in part to  $\text{CO}_2$ , which should also be taken into account.

Sodium leakage will not only affect the conductivity of the final effluent, but also influences the silica leakage from a strong base resin. Data related to this influence are presented in the relevant anion exchange resin engineering brochures. Silica leakage and conductivity are the important features of the final demineralized water. The correct design of the cation exchange unit will therefore have a critical impact on the overall performance and the ion exchange plant.

When  $\text{H}_2\text{SO}_4$  is used as regenerant, the maximum permitted concentration of  $\text{H}_2\text{SO}_4$  is determined by the percentage of calcium in the feed water, as shown in Figure 4. If  $\text{H}_2\text{SO}_4$  concentration is too high, or the regeneration flow rate is too slow, calcium sulfate will be precipitated in the resin bed. A step-wise regeneration may be used to improve the regeneration efficiency. As this applies especially to high regeneration levels, it may be more attractive to use counter-current techniques in such cases. Concentrations of

Figure 3. Contribution to conductivity

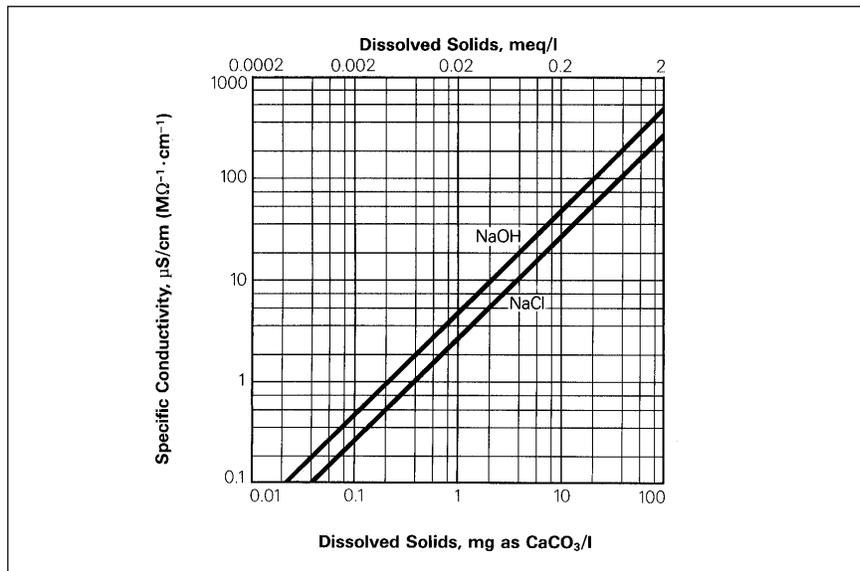
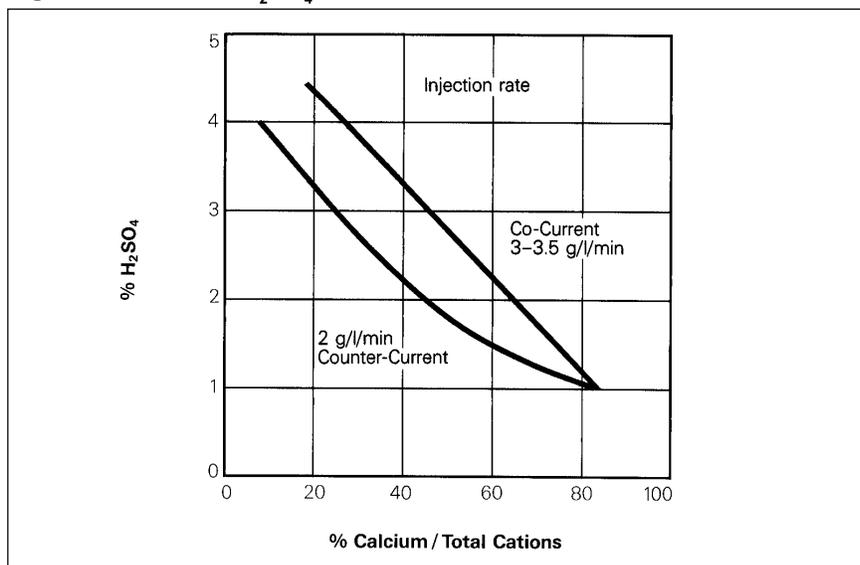


Figure 4. Permitted  $\text{H}_2\text{SO}_4$  concentration



sulfuric acid recommended for step-wise regeneration are given in Figure 5. At a constant presentation rate of regenerant, a higher flow rate will thus be used when regenerating at a low acid concentration. At a presentation rate of  $3 \text{ g H}_2\text{SO}_4/\text{min}$  per liter of resin at a concentration of 1%  $\text{H}_2\text{SO}_4$ , this will amount to a regenerant flow rate of  $18 \text{ m}^3/\text{h}$  per  $\text{m}^3$  ( $2.2 \text{ gpm}/\text{ft}^3$ ) of resin.

Hydrochloric acid may be used at concentrations of 4 to 8%, irrespective of the calcium content in the feed water. High concentrations of HCl and long regeneration times will be preferred when calcium and magnesium predominate. When sodium is the main constituent, HCl at 4 to 5% will give the best efficiency.

### Co-Current Operation

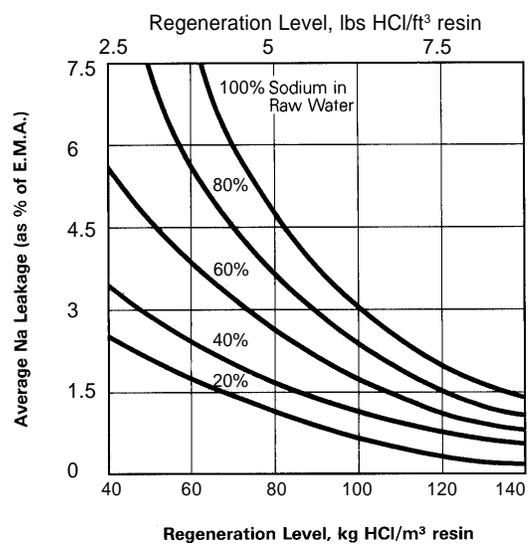
Co-current operation gives a lower quality water and poorer regeneration efficiency than counter-current operation. It may nevertheless be preferred, especially when low level sodium leakage levels may not be necessary. Figures 6 and 7 show the average sodium leakage from DOWEX MARATHON C resin relative to different regeneration levels and using HCl or H<sub>2</sub>SO<sub>4</sub> as regenerants. These leakages are expressed as percentages of equivalent mineral acidity (E.M.A.). Leakage levels will be higher at the beginning and towards the end of the cycle. When very high regeneration levels are required to obtain the desired leakage, it is advisable to consider counter-current operation.

Data on typical operational capacities for DOWEX MARATHON C resin using HCl or H<sub>2</sub>SO<sub>4</sub> in co-flow are given in Figures 8 and 9.

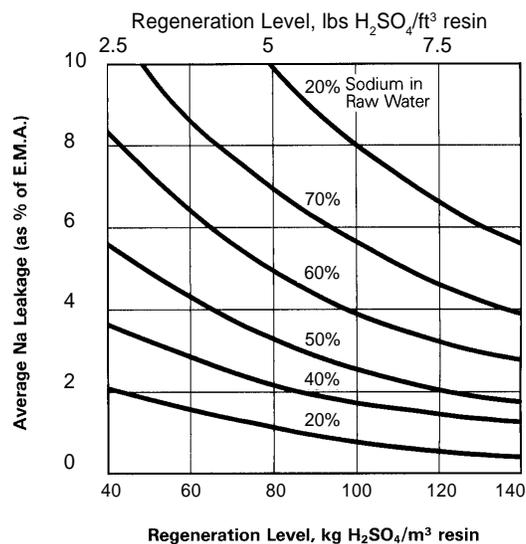
**Figure 5. Permitted H<sub>2</sub>SO<sub>4</sub> concentrations (Step-wise)**

Calcium % in feed water	H <sub>2</sub> SO <sub>4</sub> % permitted
Ca% < 15	H <sub>2</sub> SO <sub>4</sub> 3%
15 < Ca% < 50	H <sub>2</sub> SO <sub>4</sub> 1.5% for 30% H <sub>2</sub> SO <sub>4</sub> 3% for 70%
50 < Ca% < 70	H <sub>2</sub> SO <sub>4</sub> 1.5% for 50% H <sub>2</sub> SO <sub>4</sub> 3% for 50%
Ca% > 70	H <sub>2</sub> SO <sub>4</sub> 1% or use HCl

**Figure 6. Average Na leakage in co-current operation with**



**Figure 7. Average Na leakage in co-current operation with**



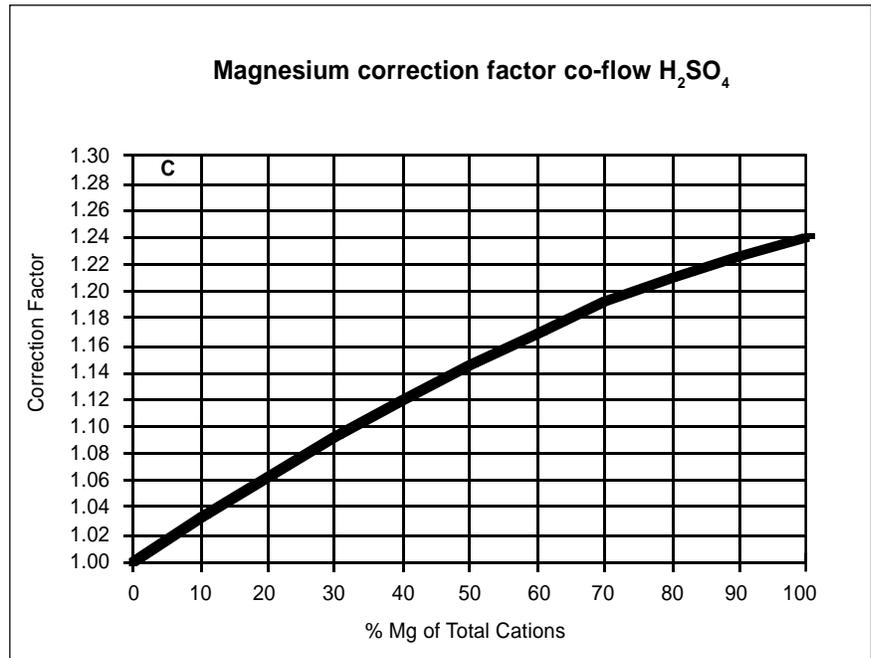
**Co-current operational capacity data**

(Step-wise Concentration in  $H_2SO_4$  Regeneration)

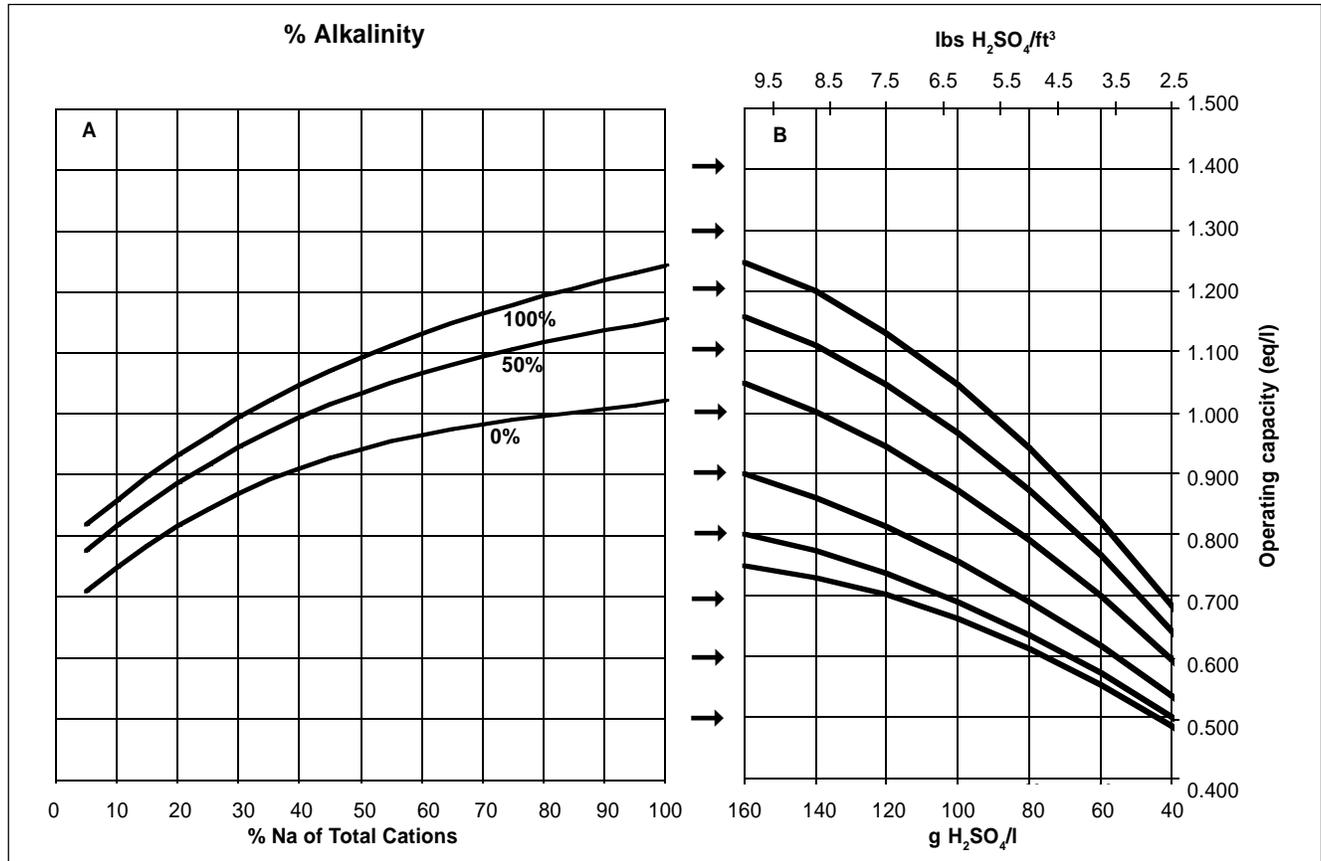
To calculate operational capacities:

1. Locate a point on the ordinate of graph A from % sodium and % alkalinity in the feed water.
2. Transfer the ordinate point from graph A horizontally to graph B and follow the guideline to the chosen regeneration level thus establishing a new ordinate.
3. Read off operational capacity on the right hand side of the diagram corresponding to this new ordinate.
4. Make a final correction to this operating capacity for the % magnesium in the feed by multiplying by the correction factor shown in Figure C.

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



**Figure 8. Co-current operational capacity data (Step-wise  $H_2SO_4$ )**



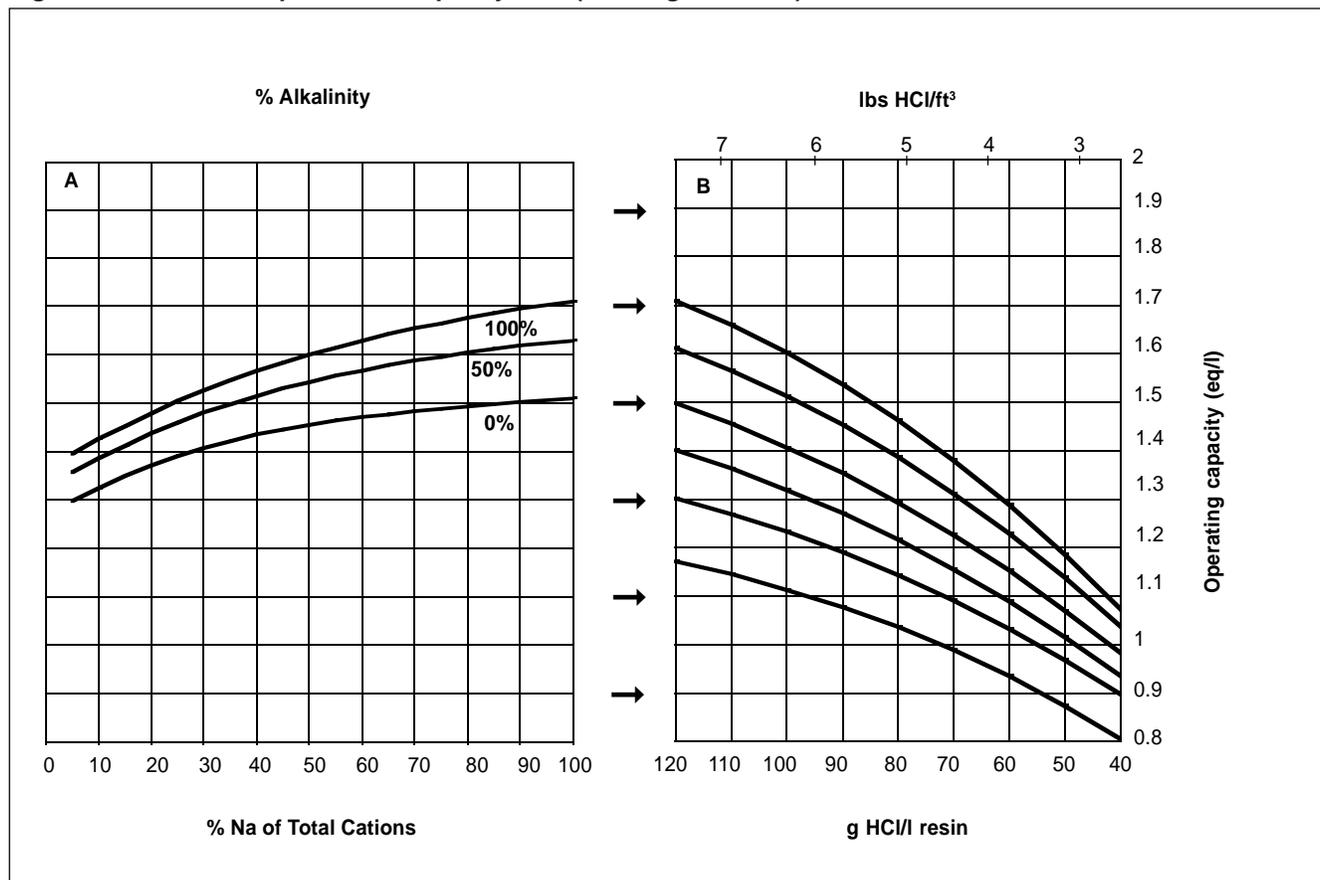
## Co-current operational capacity data

(HCl Regeneration)

To calculate operational capacities:

1. Locate a point on the ordinate of graph A from % sodium and % alkalinity.
  2. Transfer the ordinate point from graph A horizontally to graph B and follow the guideline to the chosen regeneration level thus establishing a new ordinate.
  3. Read off operational capacity on the right hand side of the diagram corresponding to this new ordinate.
- Note:  $\text{eq/l} \times 21.8 = \text{kg}/\text{ft}^3 \text{ as CaCO}_3$ .

Figure 9. Co-current operational capacity data (HCl Regeneration)



### Counter-current operation

The advantages of counter-current operation over co-current operation are well-known to be improved chemical efficiency (better capacity usage and decreased regeneration waste volume) and lower sodium leakage. These advantages are further enhanced by using small uniform bead size resins. Initial capital costs can be higher for a counter-current operation and more care has to be taken in the design of a unit as it has to be able to give the highest quality of treated water. Also, treated (or at least decationized) water must be used for diluting the regeneration chemicals and for the displacement rinse. The design must further ensure that the chemicals contact the resin at the correct concentration by avoiding any excessive dilution. In conventional counter-current regeneration, a presentation rate of 2 gram regenerant per minute and per liter of resin has shown the best results for optimum regeneration efficiency. This results in a regenerant flow rate of 3 m<sup>3</sup>/h per m<sup>3</sup> (0.4 gpm/ft<sup>3</sup>) of resin when 4% regenerant concentration is used.

Data operational capacities for DOWEX MARATHON C resin using HCl or H<sub>2</sub>SO<sub>4</sub> are given in Figures 12 and 13. Levels of average sodium leakage can be calculated from data presented in figures 10 and 11. The desired level of leakage is divided by the alkalinity correction factor, which takes into account the alkalinity percentage of the influent. This corrected leakage value together with the percent Na in the influent is now used to establish the required regeneration level. Conversely, the sodium leakage for a given regeneration level can be established by reading off a value, taking into account again the percentage Na in the influent, and by multiplying this value with the alkalinity correction factor. Lower Na leakages are obtained using step-wise regeneration with H<sub>2</sub>SO<sub>4</sub>.

Figure 10. Average Na leakage, HCl regeneration

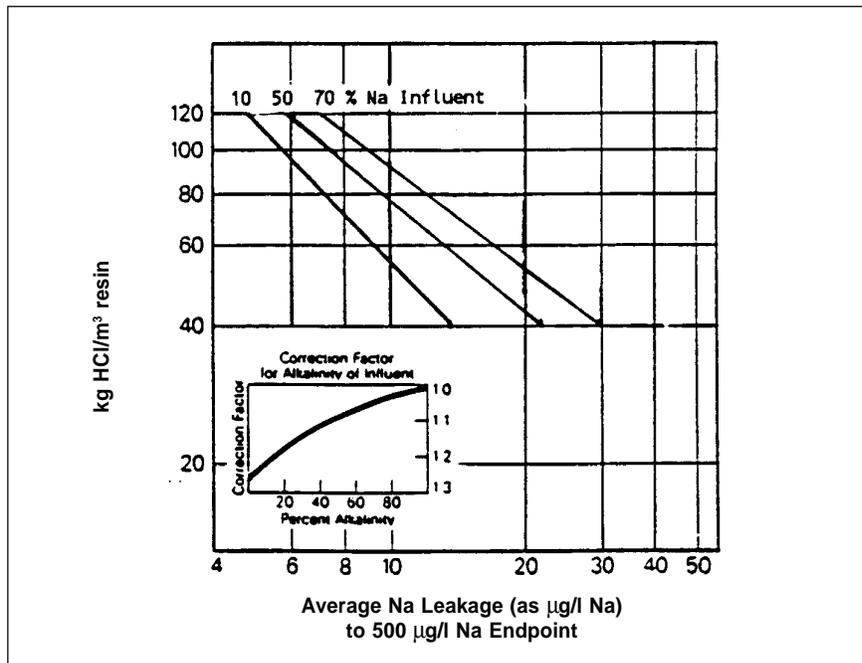
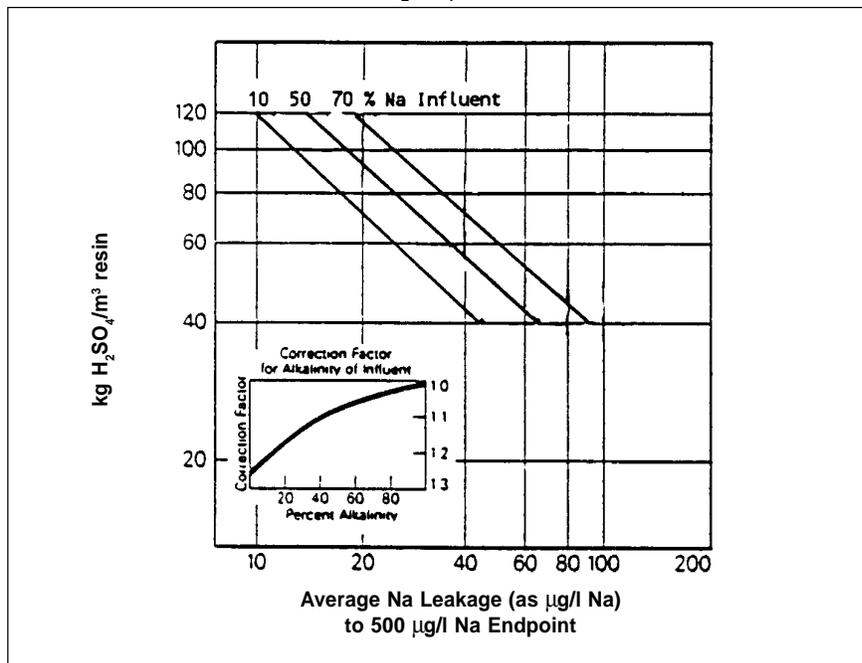


Figure 11. Average Na leakage, H<sub>2</sub>SO<sub>4</sub> regeneration



**Counter-current operational capacity data**

(H<sub>2</sub>SO<sub>4</sub> Regeneration)

To calculate operational capacities:

1. Locate a point on the ordinate of graph A from % sodium and % alkalinity in the feed water.
2. Transfer the ordinate point from graph A horizontally to graph B and follow the guideline to the chosen regeneration level thus establishing a new ordinate.

3. Read off operational capacity on the right hand side of the diagram corresponding to this new ordinate.

Note: eq/l x 21.8 = kgr/ft<sup>3</sup> as CaCO<sub>3</sub>.

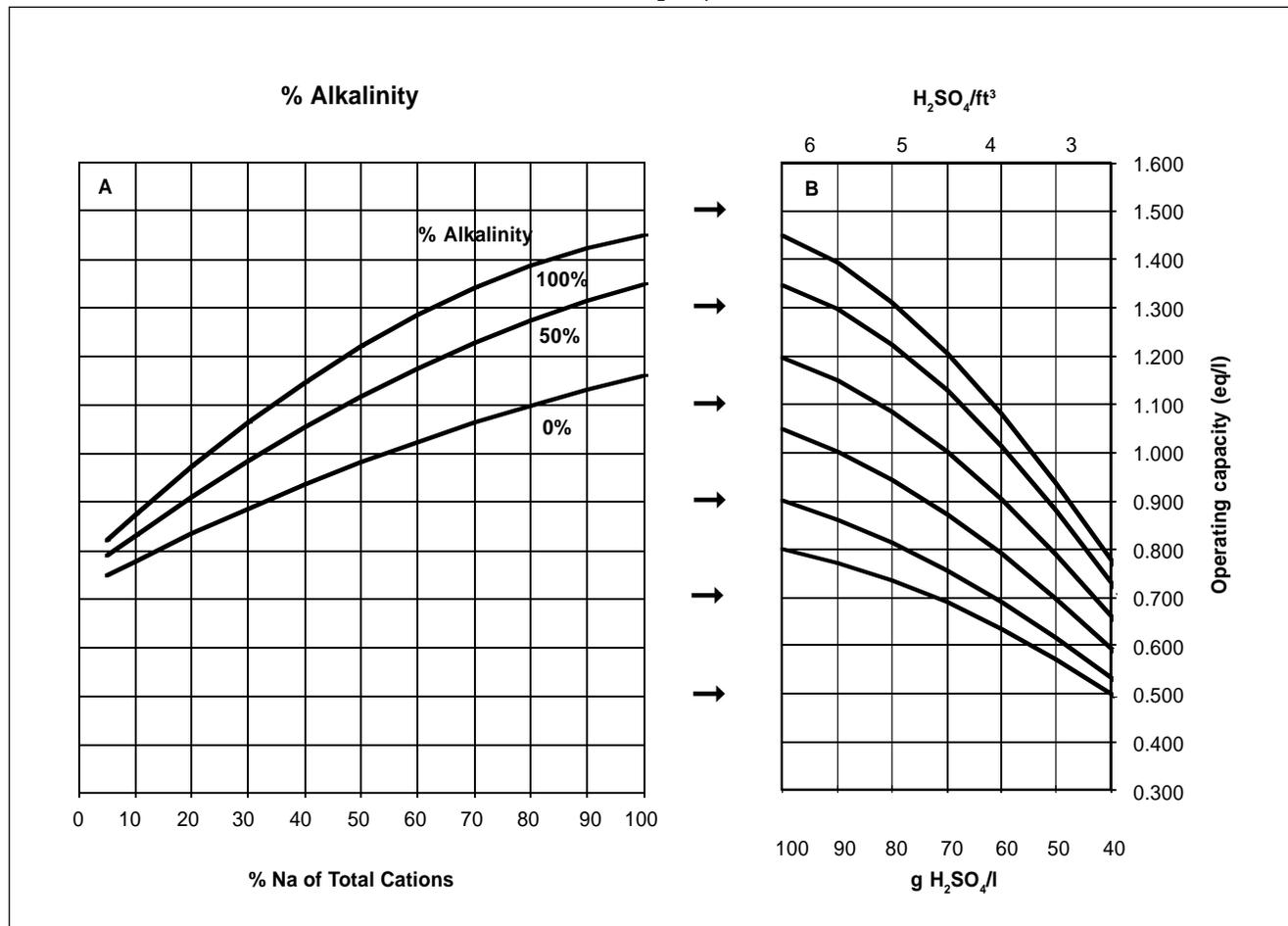
Important:

See correction graph for resin bed depth of less than 2 meters (6.5 ft).

Standard conditions:

- BV/H x Salinity (meq/l) = 200
- gpm/ft<sup>3</sup> x Salinity (kgr/ft<sup>3</sup>) = 0.55
- Temp. 15°C (60°F)

**Figure 12. Counter-current operational capacity data (H<sub>2</sub>SO<sub>4</sub> regeneration)**



**Counter-current operational capacity data**

(HCl Regeneration)

To calculate operational capacities:

1. Locate a point on the ordinate of graph A from % sodium and % alkalinity in the feed water.
2. Transfer the ordinate point from graph A horizontally to graph B and follow the guideline to the chosen regeneration level thus establishing a new ordinate.

3. Read off operational capacity on the right hand side of the diagram corresponding to this new ordinate.

Note:  $\text{eq/l} \times 21.8 = \text{kg}/\text{ft}_3 \text{ as CaCO}_3$ .

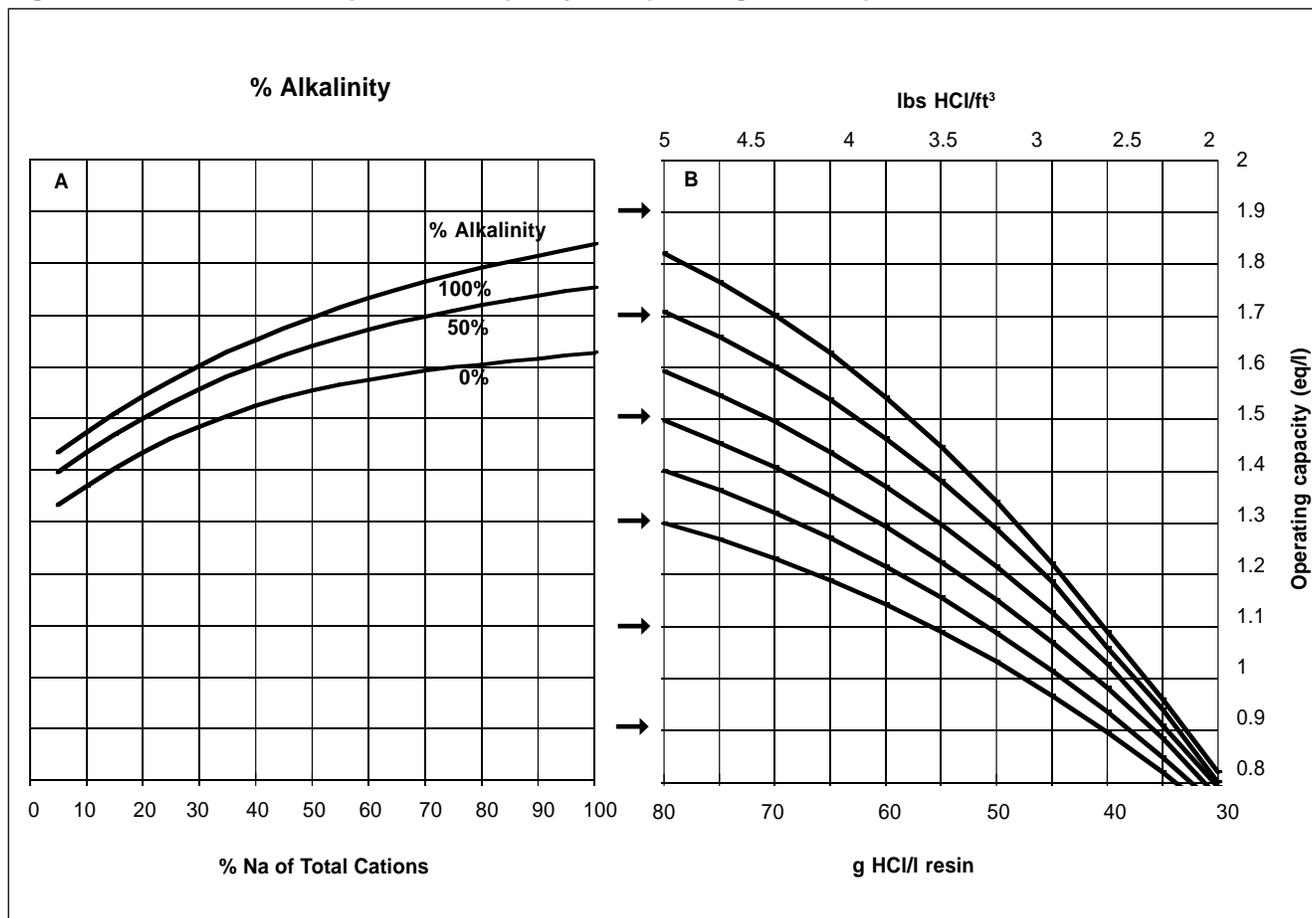
Important:

If alkalinity is less than 30%, use 1.5 m (5 ft) bed depth or not less than 50 g/l (3 lbs/ft<sup>3</sup> HCl).

Standard conditions:

- $\text{BV}/\text{H} \times \text{Salinity (meq/l)} = 200$
- $\text{gpm}/\text{ft}^3 \times \text{Salinity (kgr}/\text{ft}^3) = 0.55$
- Temp. 15°C (60°F)

**Figure 13. Counter-current operational capacity data (HCl Regeneration)**

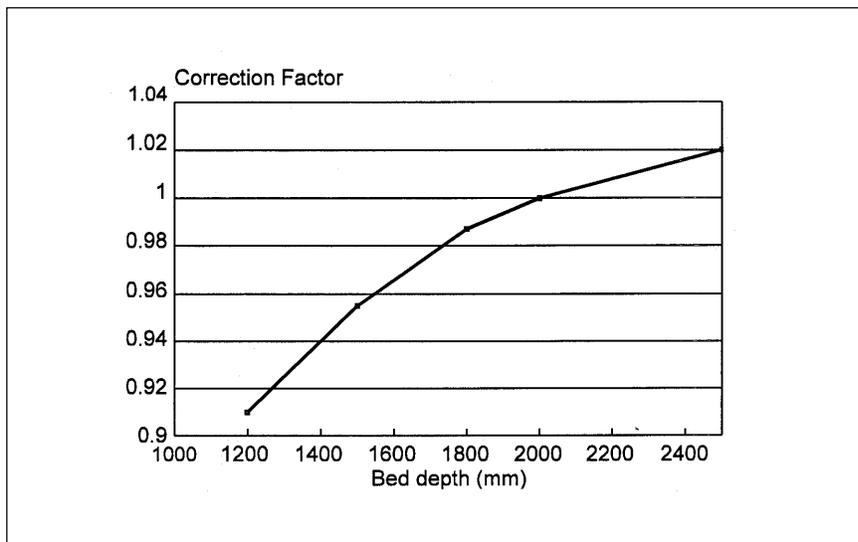


### The bed depth effect

The geometry of an ion exchange plant affects the capacity and the quality of the produced water. A bed depth of about 1 m (3.3 ft) is ideal for co-current operation but little difference exists going from 0.75 m to 2 m bed depth (30" to 6.5 ft). A flow velocity of 20-30 m/h (8-12 gpm/ft<sup>2</sup>) may give slightly better performance than operating at 50-60 m/h (20-24 gpm/ft<sup>2</sup>). On the other hand, there is great advantage to gain from using a deep bed in counter-current operation with H<sub>2</sub>SO<sub>4</sub> as regenerant. The high physical strength of DOWEX MARATHON C resin allows it to be used in deep beds, thereby obtaining better capacity usage and water quality.

The bed depth effect is given in Figure 14 for bed depths from 1 to 2.5 m (3.3 to 8.2ft)

Figure 14. Effect of bed depth on capacity (counter-current) of DOWEX MARATHON C resin



## Dow Liquid Separations Offices.

For more information call Dow Liquid Separations:

### Dow Europe

Dow Customer Information Group  
Liquid Separations  
Prins Boudewijnlaan 41  
B-2650 Edegem  
Belgium  
Tel. +32 3 450 2240  
Tel. +800 3 694 6367 †  
Fax +32 3 450 2815  
E-mail: dowcig@dow.com

### Dow Pacific

Dow Chemical Japan Ltd.  
Liquid Separations  
Tennoz Central Tower  
2-24 Higashi Shinagawa 2-chome  
Shinagawa-ku, Tokyo 140-8617  
Japan  
Tel. (813) 5460 2100  
Fax (813) 5460 6246

### Dow Pacific

Dow Chemical Australia Ltd.  
Liquid Separations  
Level 5  
20 Rodborough Road  
French's Forest, NSW 2086  
Australia  
Tel. 61-2-9776-3226  
Fax 61-2-9776-3299

### Dow Latin America

Dow Quimica S.A.  
Liquid Separations  
Rua Alexandre Dumas, 1671  
Sao Paulo – SP – Brazil  
CEP 04717-903  
Tel. 55-11-5188 9277  
Fax 55-11-5188 9919

### Dow North America

The Dow Chemical Company  
Liquid Separations  
Customer Information Group  
P.O. Box 1206  
Midland, MI 48641-1206  
USA  
Tel. 1-800-447-4369  
Fax (989) 832-1465

### Internet

<http://www.dowex.com>

† 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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