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 a 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_2SO_4 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^+ form	H^+ form
Total exchange capacity, min.	eq/l kgr/ft³ as $CaCO_3$	2.0 43.7	1.8 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+ ♦ H+)	%	8	8
Particle density	g/ml	1.28	1.20
Shipping weight	g/l lbs/ft³	820 51	800 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 Backwash Co-current regeneration/displacement rinse Counter-current regeneration/displacement rinse	 5-60 m/h (2-24 gpm/ft²) See figure 1 1-10 m/h (0.4-4 gpm/ft²) 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 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 polydisper-sed 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

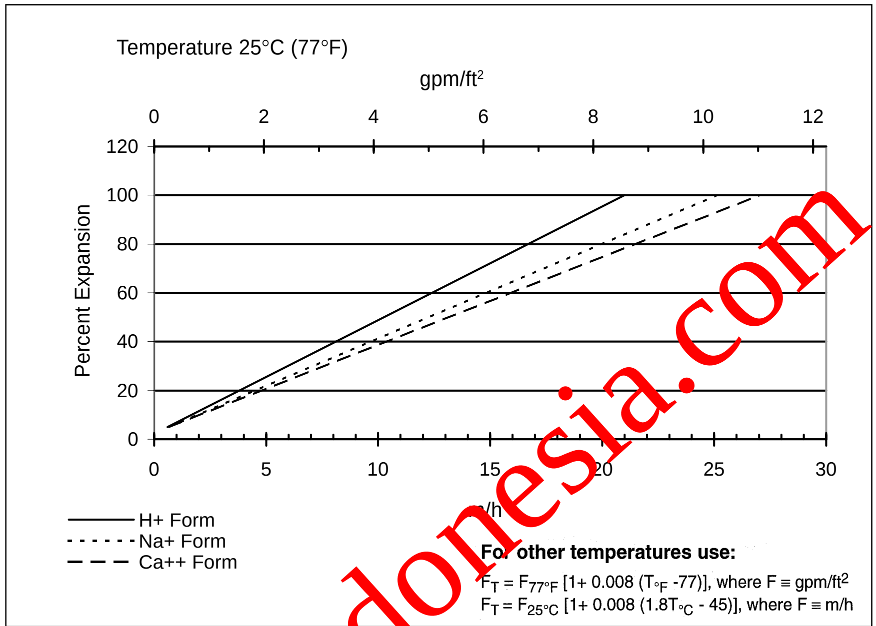
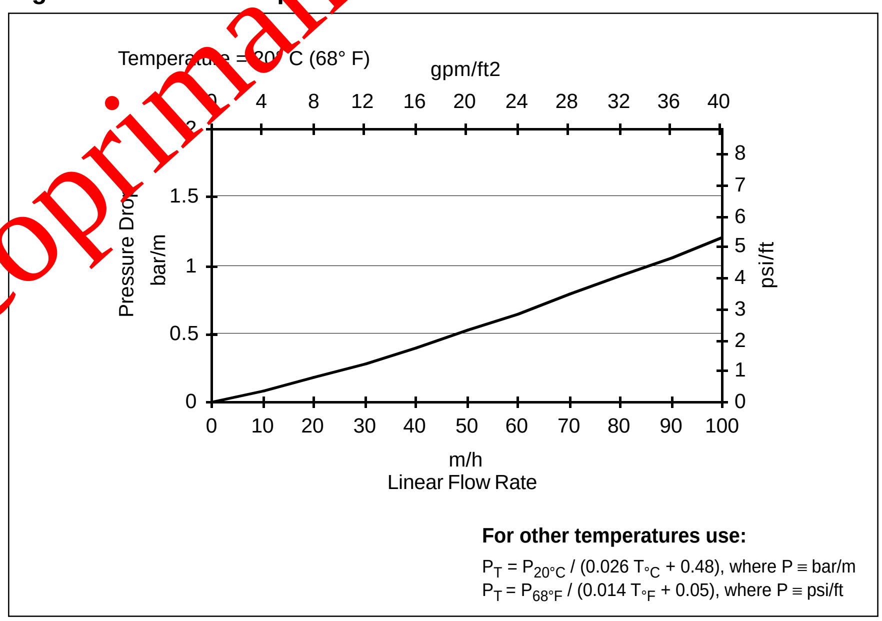


Figure 2. Pressure drop vs. flow rate



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 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 H_2SO_4 is used as regenerant, the maximum permitted concentration of H_2SO_4 is detemined by the percentage of calcium in the feed water, as shown in Figure 4. If H_2SO_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 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 g H_2SO_4/min per liter of resin at a concentration of 1% H_2SO_4, this will amount to a regenerant flow rate of 18 m³/h per m³ (2.2 gpm/ft³) 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.

Figure 3. Contribution to conductivity

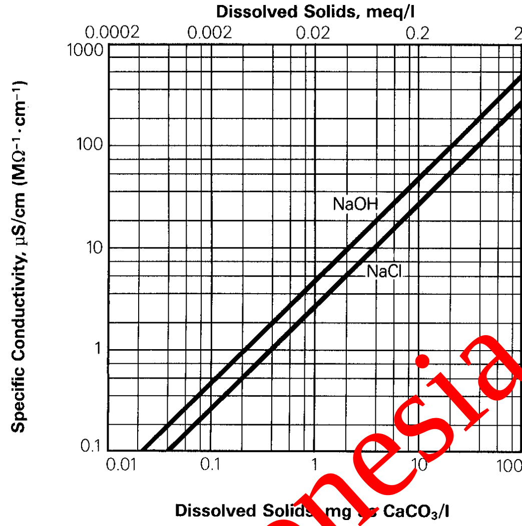
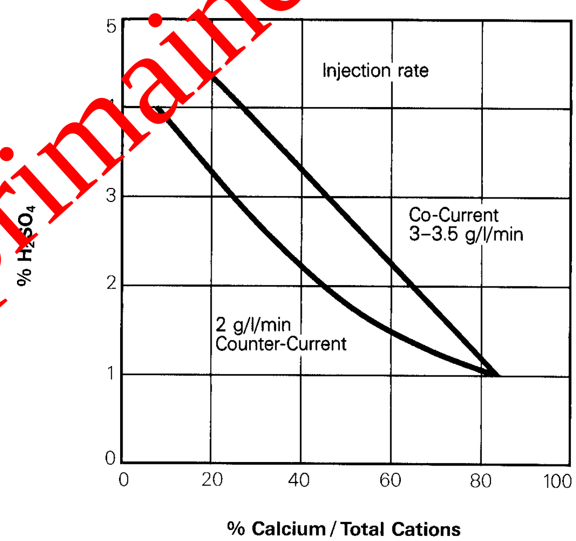


Figure 4. Permitted H_2SO_4 concentration



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_2SO_4 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_2SO_4 in co-flow are given in Figures 8 and 9.

Figure 5. Permitted H_2SO_4 concentrations (Step-wise)

Calcium % in feed water	H_2SO_4 % permitted	
Ca% < 15	H_2SO_4	3%
15 < Ca% < 50	H_2SO_4 H_2SO_4	1.5% for 30% 3% for 70%
50 < Ca% < 70	H_2SO_4 H_2SO_4	1.5% for 50% 3% for 50%
Ca% > 70	H_2SO_4	1% or use HCl

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

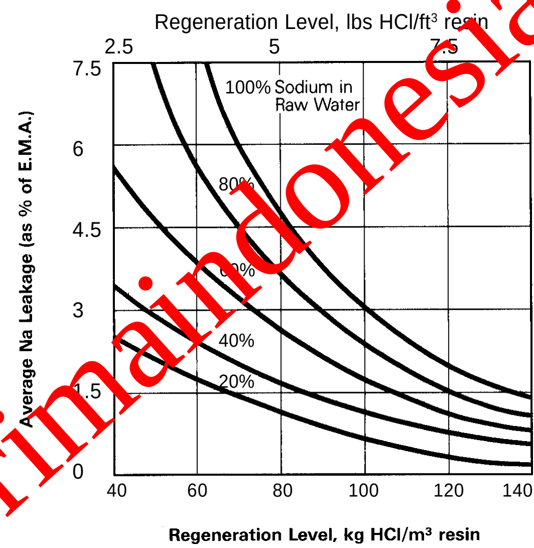
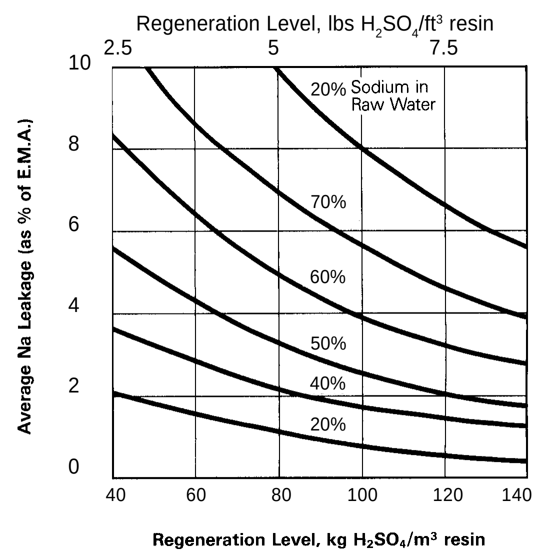


Figure 7. Average Na leakage in co-current operation with



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 x 21.8 = kgr/ft^3 as $CaCO_3$.

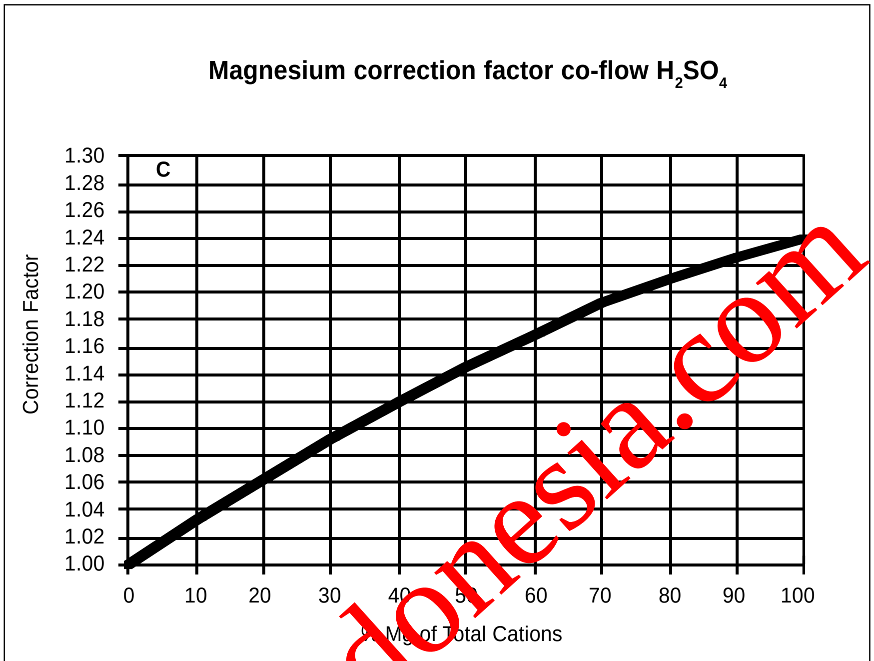
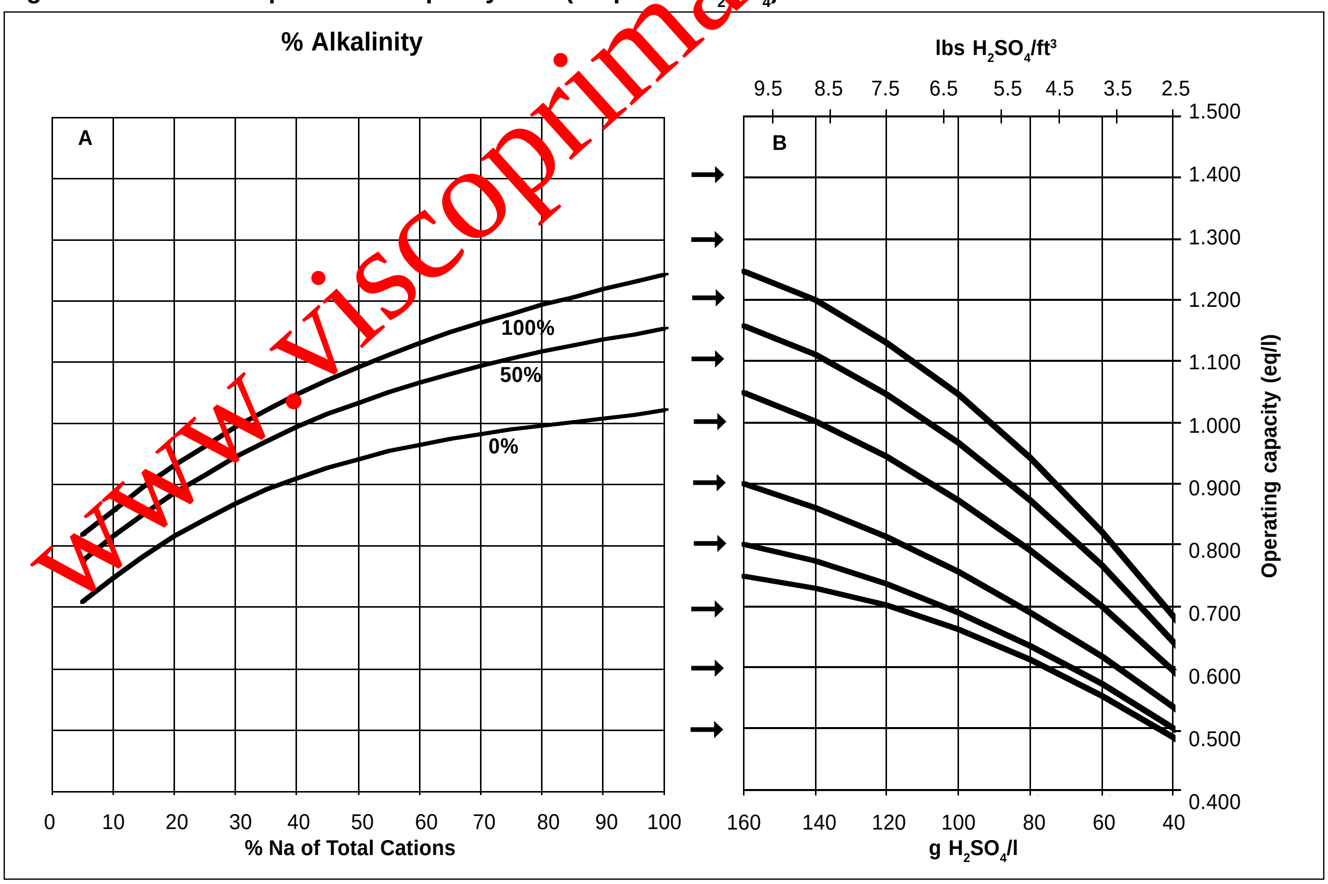


Figure 8. Co-current operational capacity data (Step-wise H_2SO_4)



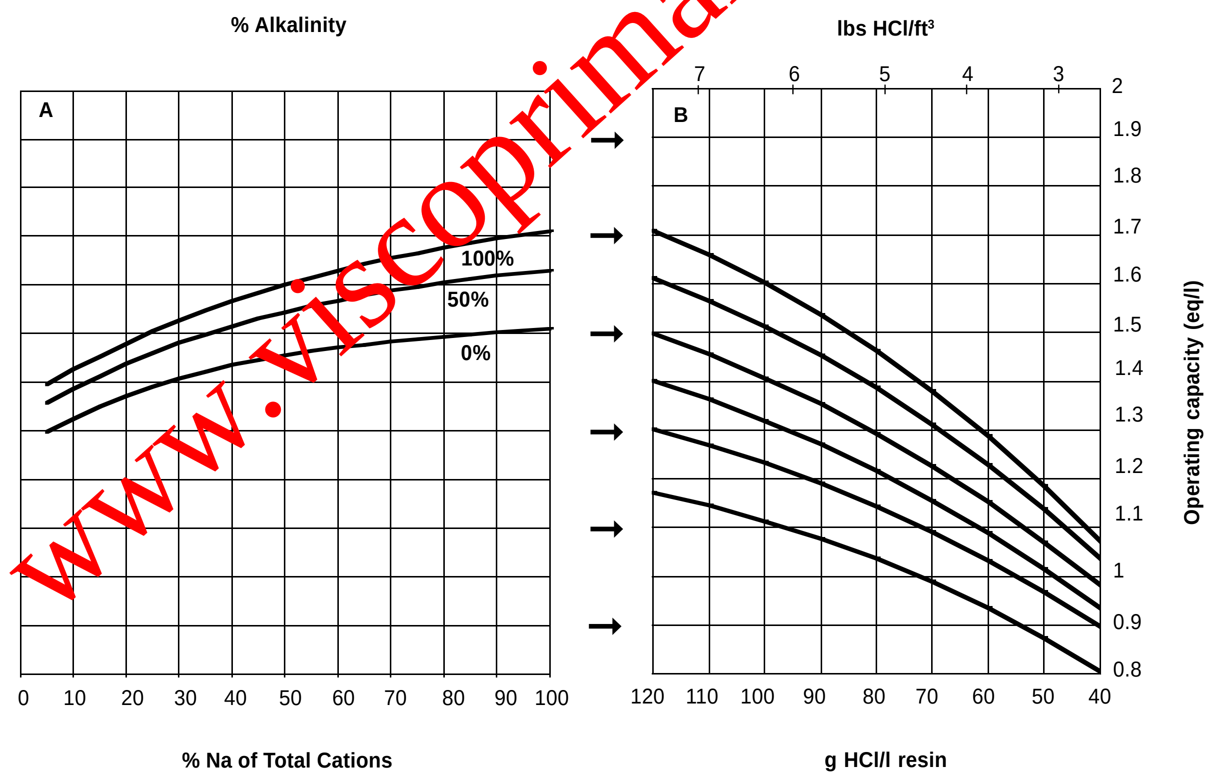
Co-current operational capacity data

(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: eq/l x 21.8 = kgr/ft³ 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 correc 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^3/h per m^3 (0.4 gpm/ft^3) of resin when 4% regenerant concentration is used.

Data operational capacities for DOWEX MARATHON C resin using HCl or H_2SO_4 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_2SO_4.

Figure 10. Average Na leakage, HCl regeneration

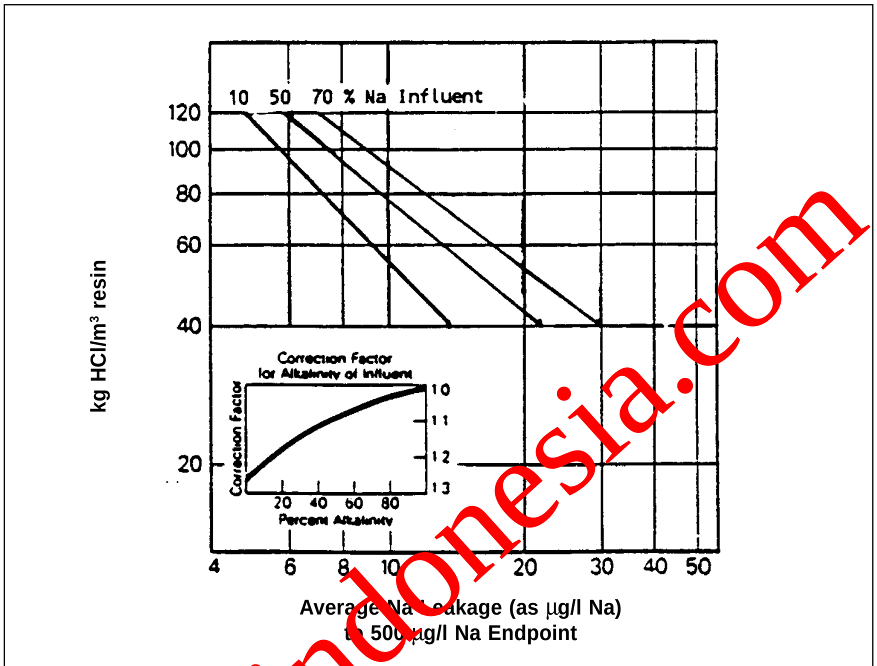
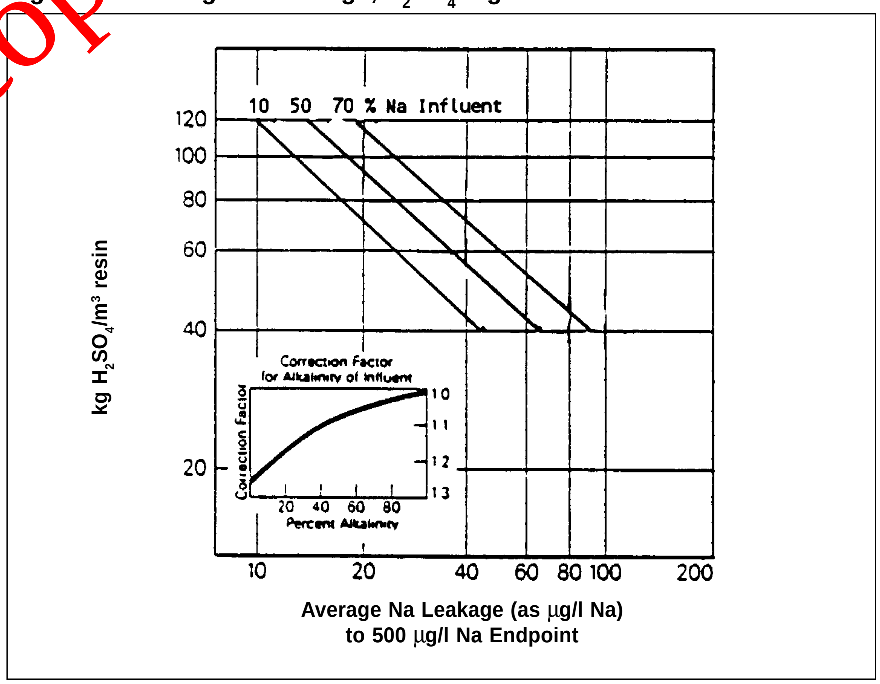


Figure 11. Average Na leakage, H_2SO_4 regeneration



Counter-current operational capacity data

(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.

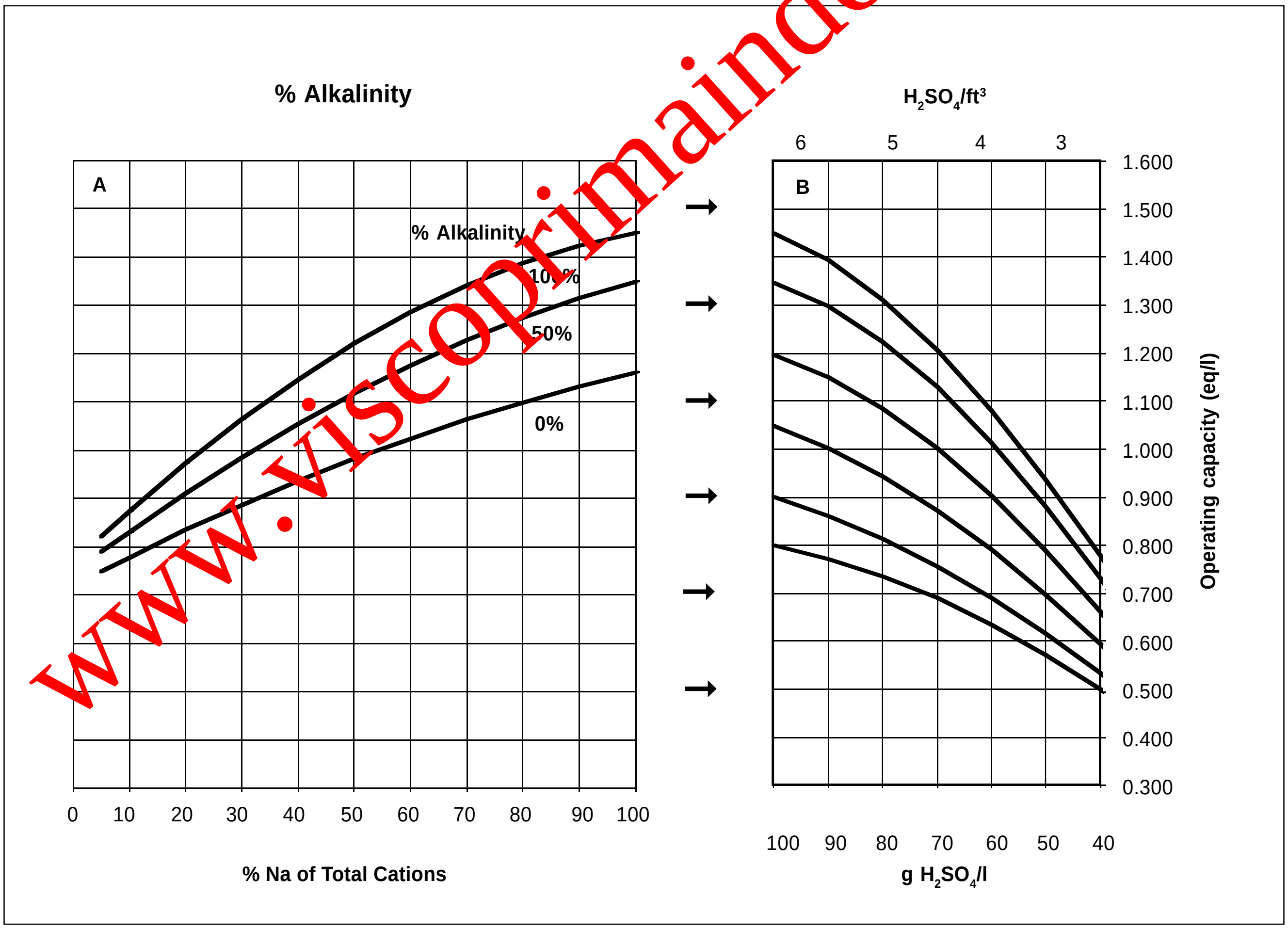
Note: eq/l x 21.8 = kgr/ft^3 as $CaCO_3$.

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^3 x Salinity (kgr/ft^3) = 0.55
- Temp. 15°C (60°F)

Figure 12. Counter-current operational capacity data (H_2SO_4 regeneration)



Counter-current operational capacity data

(HCl Regeneration)

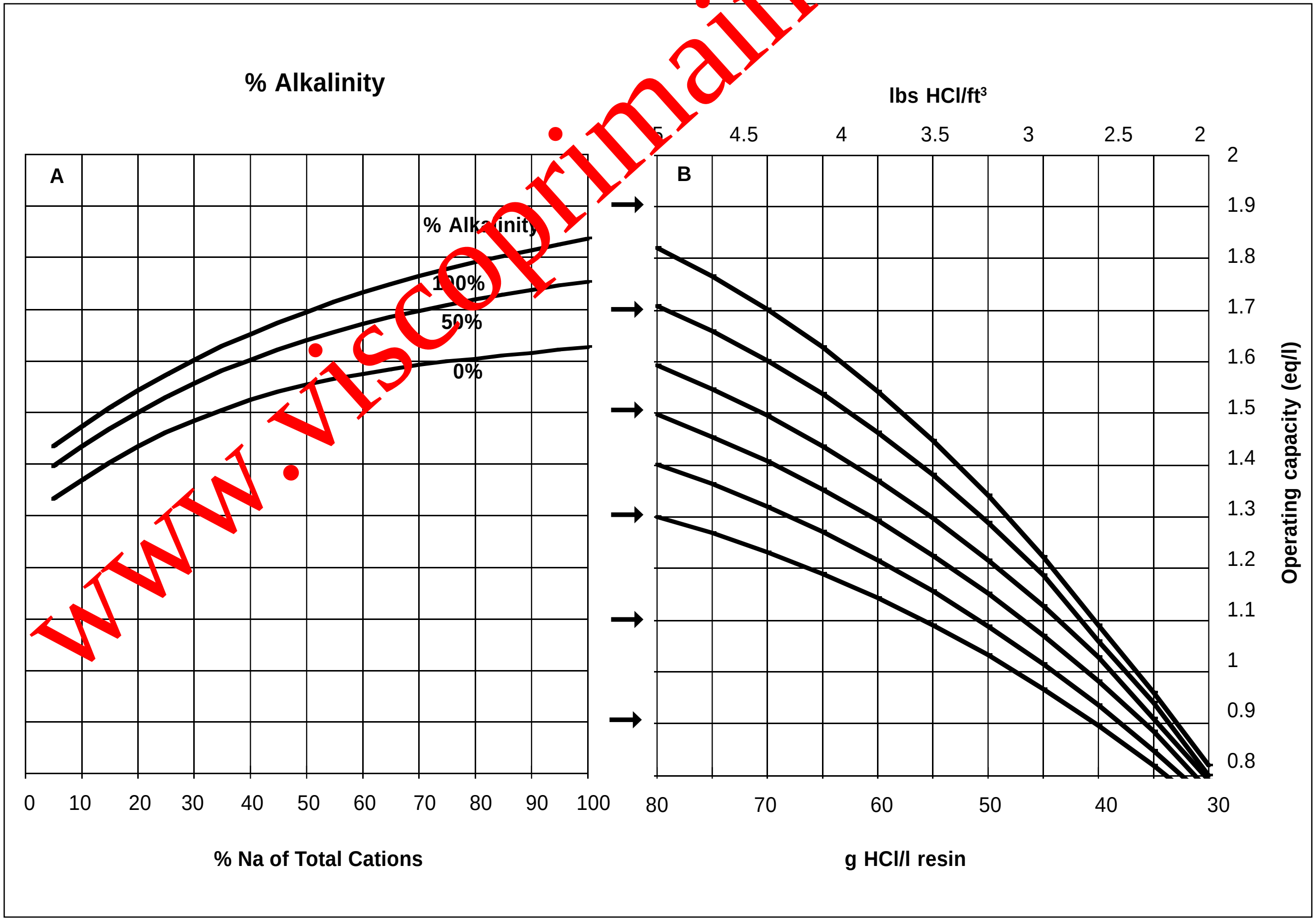
To calculate operational capacities:
1. Locate a point on the ordinate of graph A from % sodium and % alkalinity in the feed water.
2. Transfer the ordinate point from graph A horizontally to graph B and follow the guideline to the chosen regeneration level thus establishing a new ordinate.
3. Read off operational capacity on the right hand side of the diagram corresponding to this new ordinate.

Note: eq/l x 21.8 = kgr/ft_3 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^3 HCl).

Standard conditions:
- BV/H x Salinity (meq/l) = 200
- gpm/ft^3 x Salinity (kgr/ft^3) = 0.55
- Temp. 15°C (60°F)

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

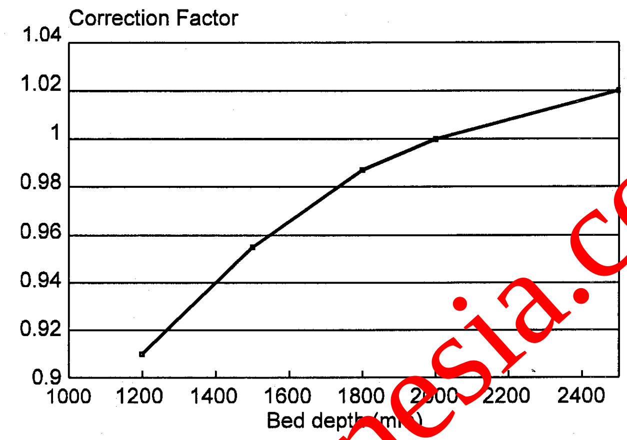


The bed depth effect

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^2)may give slightly better performance than operating at 50-60 m/h (20-24 gpm/ft^2). On the other hand, there is great advantage to gain from using a deep bed in counter-current operation with H_2SO_4 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



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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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