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Dow
Liquid Separations

DOWEX HCR-S

Ion Exchange Resin

ENGINEERING INFORMATION

DOWEX HCR-S Strong Acid Cation Exchange Resin

General Information

DOWEX* HCR-S strong acid cation exchange resin is produced by the sulfonation of a styrene divinylbenzene copolymer of controlled size distribution.

The resin features a high capacity with a porosity to assure an exemplary kinetic behavior. It exhibits good physical, chemical and thermal stability. These characteristics make it the resin of choice for most water treatment applications. DOWEX HCR-S resin is used in softening as well as single or mixed bed demineralization.

In addition to the standard grade, DOWEX HCR-S MB (H) and DOWEX HCR-S PS are specially graded resins for use in mixed bed and counter-current regeneration applications respectively. DOWEX HCR-S D (H) is a dark colored resin designed to give good optical separation when used in a mixed bed.

This brochure relates to water demineralization, using HCl or H_2SO_4 as regenerants in co-current or counter-current operations. 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. DOWEX HCR-S resin is delivered in either the sodium form or the hydrogen form.

In cases where physical stability is of major concern, premium quality DOWEX HGR resin is available. This resin exhibits superior stability under stringent chemical or physical conditions of operation.

Typical Physical and Chemical Properties			
Ionic form as delivered		Na^+	H^+
Total exchange capacity, min.	eq/l	2.0	1.8
	kgr/ft³ as $CaCO_3$	43.7	39.3
Water content	%	44 - 48	50 - 56
Bead size distribution			
range	mm	0.3 - 1.2	0.3 - 1.2
>1.2 mm, max.	%	5	5
<0.3 mm, max.	%	1	1
Total swelling (Na → H), approx.	%	8	8
Whole uncracked beads, min.	%	90	90
Particle density, approx.	g/ml	1.30	1.22
Shipping weight, approx.	g/l	840	780
	lbs/ft³	52	49

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	5-50 m/h (2-20 gpm/ft²)
Backwash	See figure 1
Co-current regeneration/displacement rinse	1-10 m/h (0.4-4 gpm/ft²)
Total rinse requirement	3-6 Bed volumes
Regenerant	1-8% H_2SO_4, 4-8% HCl or 8-12% NaCl

Hydraulic Characteristics

Backwash Expansion

Under the upflow conditions of back-washing, the resin will expand its volume (see Figure 1). Such expansion allows the regrading of the resin, fines removal and avoids channeling during the subsequent service cycle. At the same time, accumulated particulate contamination is removed. An efficient backwash will require an expansion of over 50% of the original resin volume and up to 80-100% expansion is common.

In co-current operation, the resin is backwashed for a few minutes before every regeneration. Occasionally, a longer backwash may be needed to fully remove contaminants.

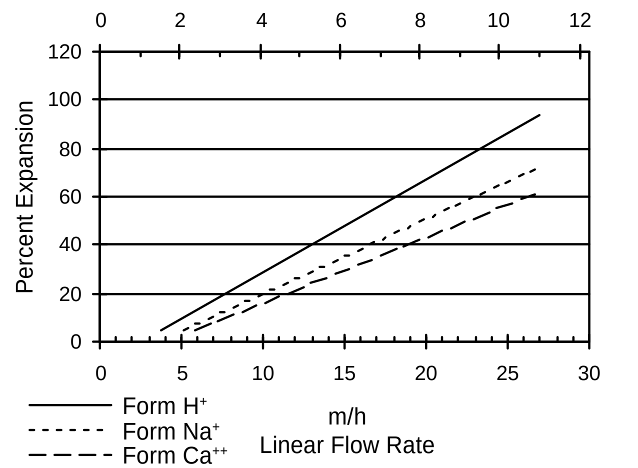
In counter-current operation the strainers are cleaned by the regenerant flow. To retain the advantages of counter-current operation it is essential not to disturb the resin. Backwashing is only desirable if accumulated debris causes an excessive increase in pressure drop or to decompact the bed. Usually, a backwash is performed every 15 to 30 cycles in conventional counter-current regeneration systems.

Pressure Drop Data

The pressure drop through a resin bed primarily depends on the bed depth and the flow velocity of the water. It is further influenced by the particle size distribution of the resin and by the viscosity, and thus temperature, of the water. The data in Figure 2 shows the pressure drop per unit bed depth at various flow rates flow velocity for the standard graded resin (0.3-1.2 mm). An equation is also supplied which can be used for temperature compensation. These figures must be considered representative only. The total head loss of a unit in operation will also depend on its design and is substantially affected by the contribution of the strainers surrounded by resin.

Figure 1. Backwash expansion data

Temperature = 25°C (77°F)



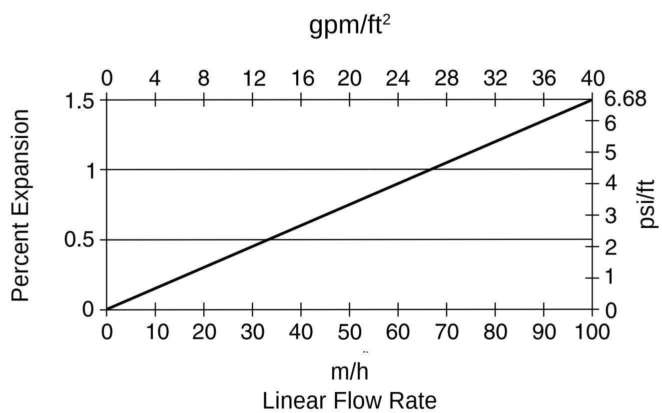
For other temperatures use:

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

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

Figure 2. Pressure drop data

Temperature = 25°C (77°F)



For other temperatures use:

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

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

Operating Characteristics

The engineering design of an ion exchange unit will depend on a number of factors such as feed water composition, desired capacity and water quality, and operational conditions. The following information considers these factors and allows a design to be made.

The performance of the cation exchange resin will be 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 anion 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 affect the conductivity of the final effluent and also influence the silica leakage from a strong base anion resin.

Data related to this influence is presented in the engineering leaflets of the corresponding anion exchange resins. 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 permitted concentration of H_2SO_4 is determined by the percentage of calcium in the feed water (see Figure 4). If the regenerant concentration is too high or the regeneration is performed too slowly, calcium sulfate will be deposited in the resin bed.

Step-wise regeneration may be used to improve the regeneration efficiency. As this applies especially

Figure 3. Na leakage expressed as conductivity at 25°C (77°F) after anion exchange

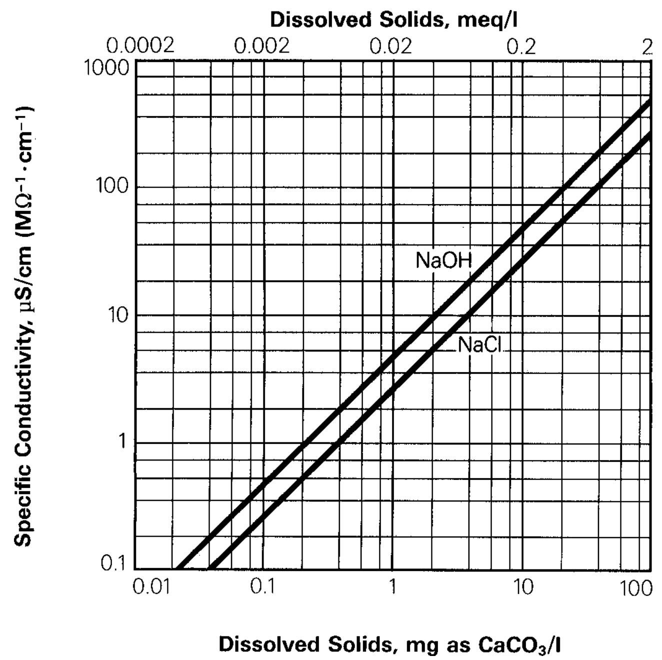
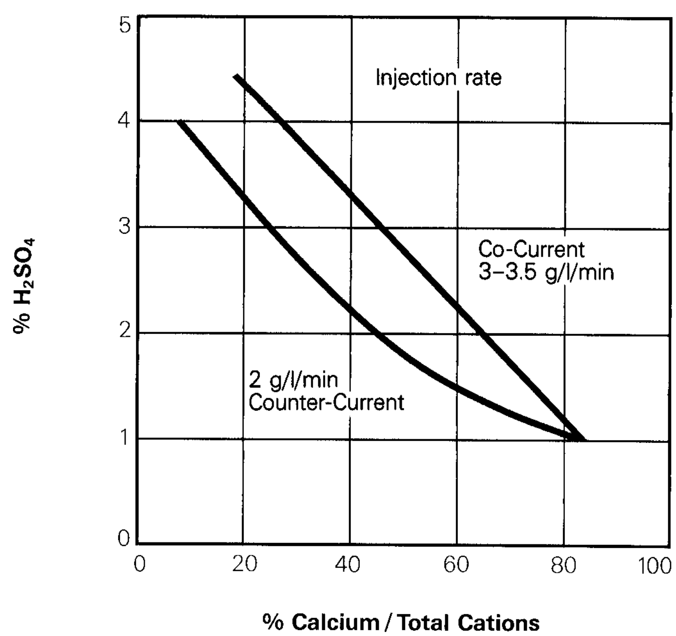


Figure 4. Permitted H_2SO_4 concentration



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. It is common to operate the first step at low acid concentration and high flow rates. Operation in this fashion reduces the risk of calcium precipitation in the bed. It also makes it practical to use a single speed acid pump. (The acid concentration is controlled by changing the volume of dilution water used). 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 m^3/h per m^3 of resin (2.2 gpm/ft^3).

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

Figures 6 and 7 show average sodium leakage from DOWEX HCR-S resin at different regeneration levels using HCl or H_2SO_4 as regenerants. These leakag es are expressed as percentages of equivalent mineral acidity (EMA). Leakage levels will be higher at the beginning and towards the end of the service 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 HCR-S using HCl or H_2SO_4 are given in Figures 8 and 9.

Figure 5. Permitted H_2SO_4 concentration (step-wise)

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

Figure 6. Average Na leakage from DOWEX HCR-S resin in co-current operation with HCl as regenerant

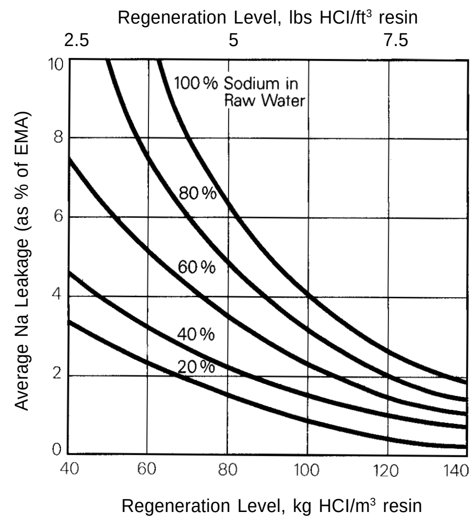
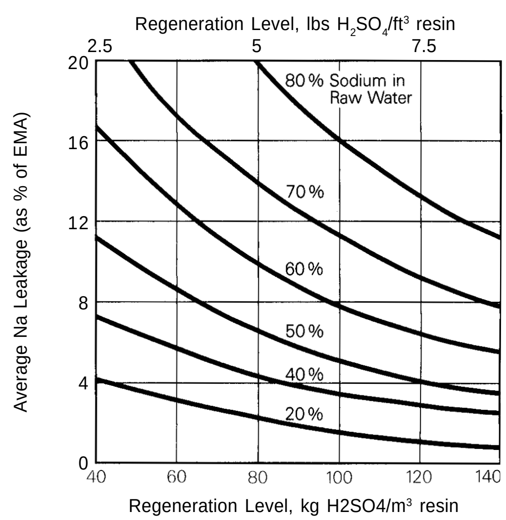


Figure 7. Average Na leakage from DOWEX HCR-S resin in co-current operation with H_2SO_4 as regenerant



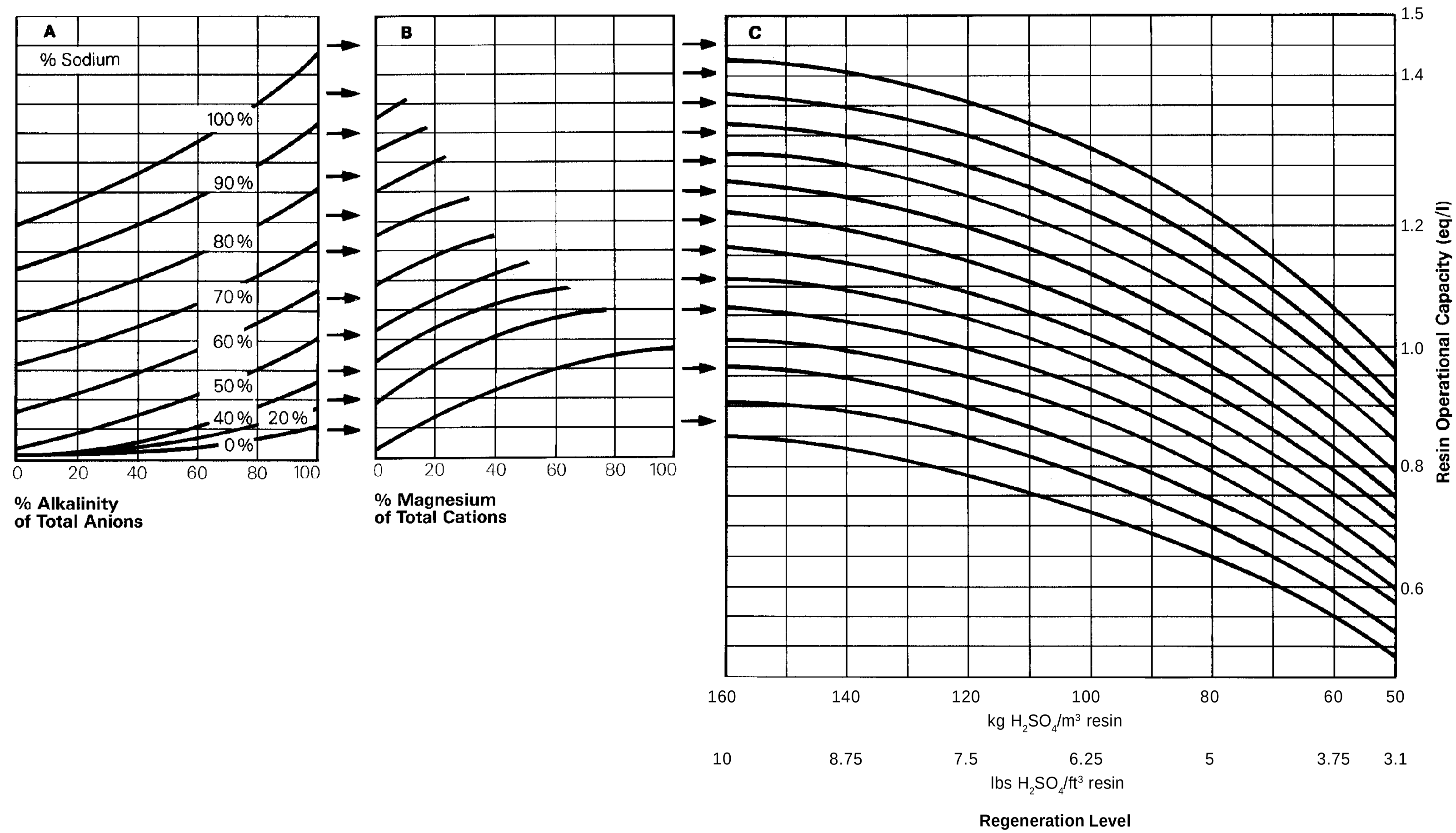
Co-current operational capacity data

(Step-wise concentration in H_2SO_4 regeneration)

Instructions:

1. Locate a point on the ordinate of graph A from percent sodium and percent alkalinity.
2. Transfer the ordinate point from graph A horizontally to graph B and follow the guideline to locate a new point on the ordinate according to the percent magnesium.
3. Transfer the ordinate point from graph B horizontally to graph C and repeat the procedure under point 2 according to chosen regeneration level. Read off the operational capacity on the right hand side of the diagram corresponding to this new ordinate.

Figure 8. Co-current operational capacity data



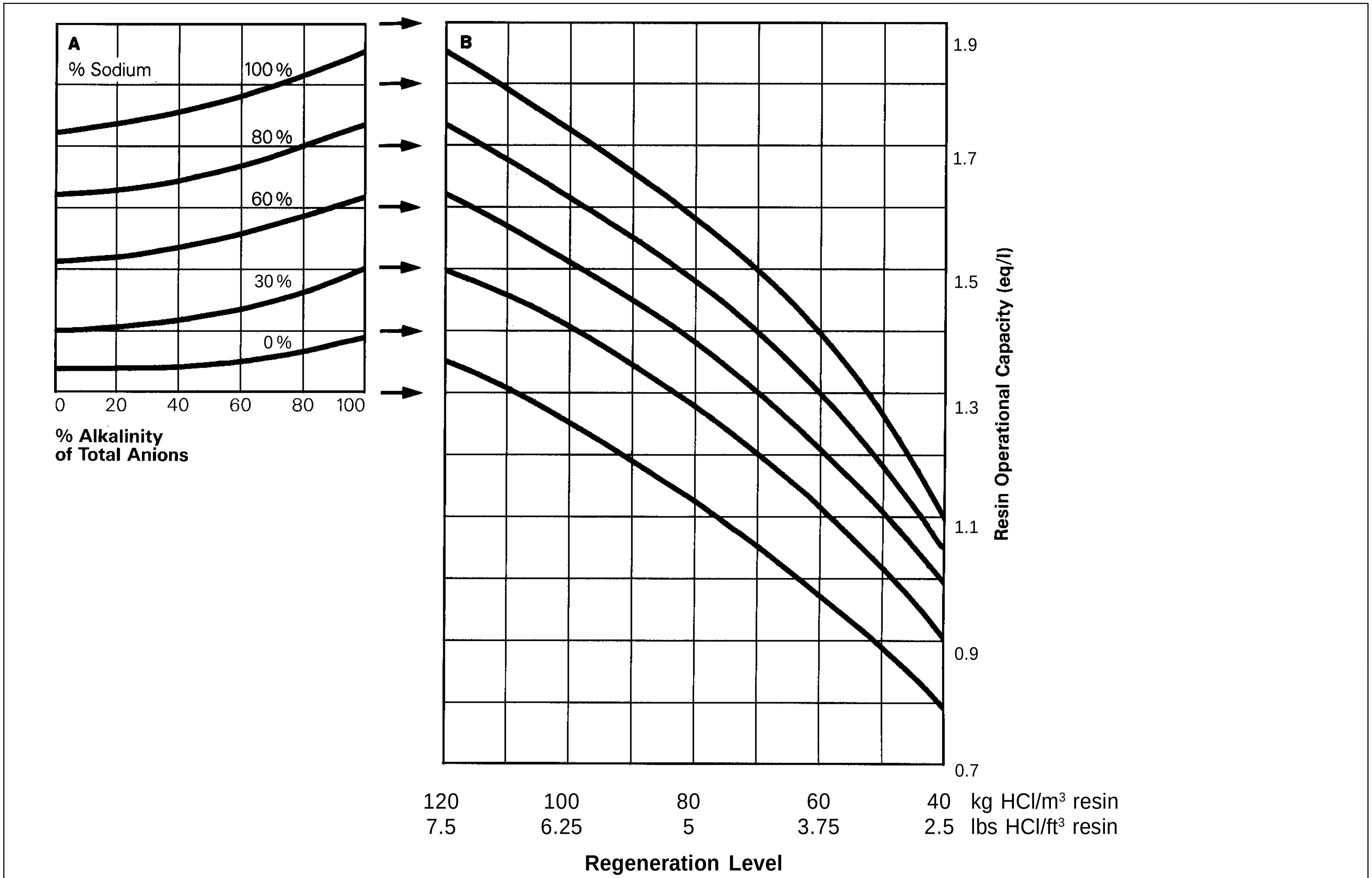
Co-current operational capacity data

(HCl regeneration)

Instructions:

1. Locate a point on the ordinate of graph A from percent sodium and percent 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.

Figure 9. Co-current operational capacity data



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) and lower sodium leakage. 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, demineralized or decationized water must be used for diluting the regeneration chemicals and for the displacement rinse. The design must 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 resin has shown the best results for optimum regeneration efficiency. This results in a regenerant flow rate 3 m^3/h per m 3 (0.4 gpm/ft^3) of resin when a 4% regenerant concentration is used.

Data on typical operational capacities for DOWEX HCR-S 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 leakage level is divided by the alkalinity correction factor, which takes into account the alkalinity percentage of the influent. This corrected leakage value together with the percentage 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.

Figure 10. Average Na leakage for DOWEX HCR-S resin in counter-current operation and H_2SO_4 as regenerant (step-wise concentrations)

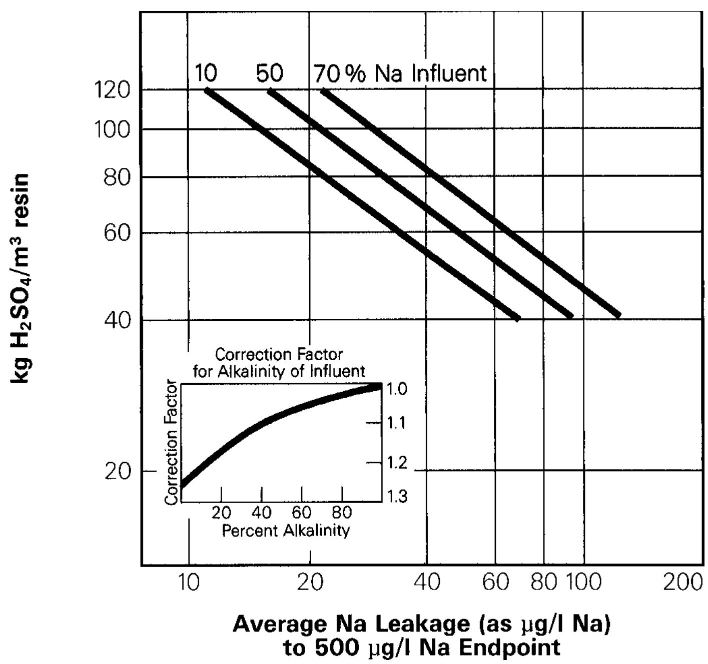
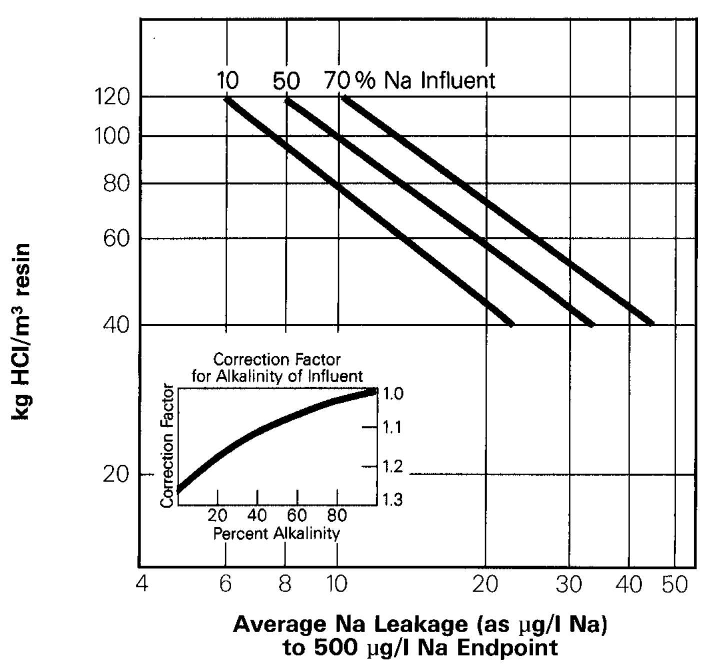


Figure 11. Average Na leakage for DOWEX HCR-S resin in counter-current operation and HCl as regenerant



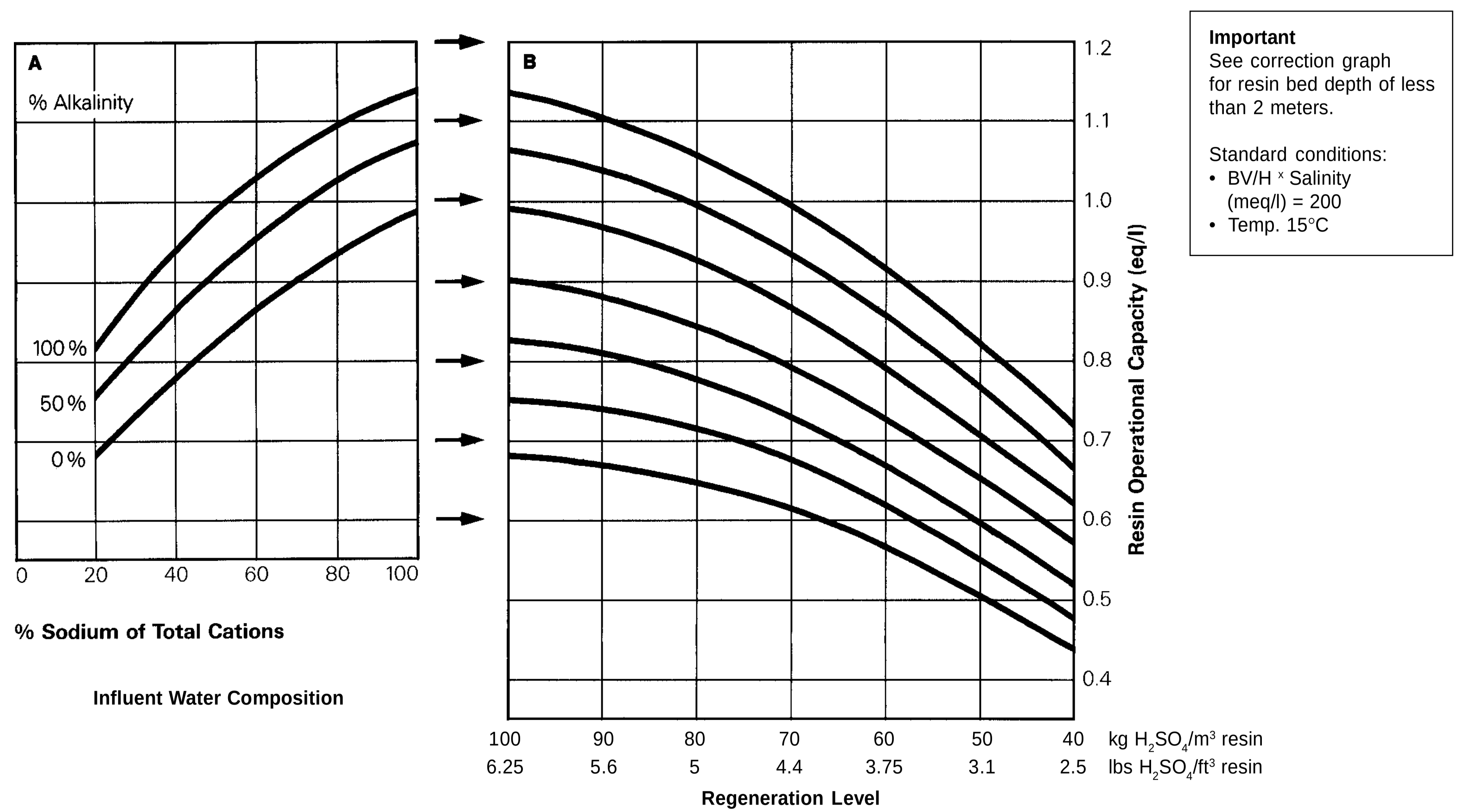
Counter-current operational capacity data

(H_2SO_4 regeneration)

Instructions:

1. Locate a point on the ordinate of graph A from percent sodium and percent 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.

Figure 12. Counter-current operational capacity data



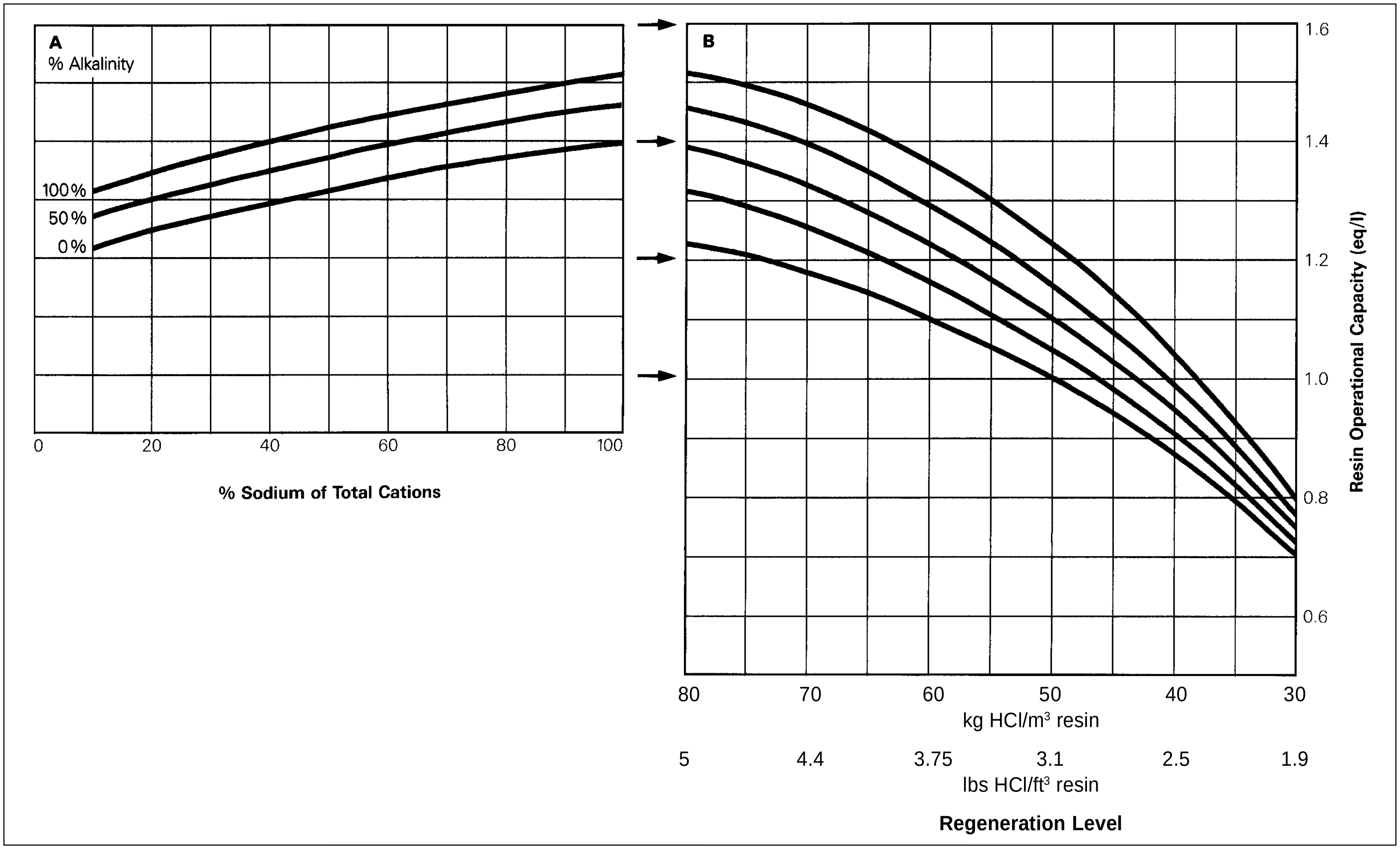
Counter-current operational capacity data

(HCl regeneration)

Instructions:

1. Locate a point on the ordinate of graph A from percent sodium and percent 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.

Figure 13. Counter-current operational capacity data



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 sulfuric acid as regenerant.

The effect of bed depth is shown in Figure 14.

Effect of bed depth on counter-current capacity

Instructions:

1. Locate a point on the ordinate of graph A from amount of EMA and chosen regeneration level.

2. Transfer the ordinate point from graph A horizontally to graph B and follow the guideline to locate a new point according to the percent sodium of EMA.

3. Transfer the ordinate point from graph B horizontally to graph C and repeat the procedure under point 2 according to the desired bed depth and read off the reduction in capacity.

Figure 14. Effect of bed depth