Dow
Water Solutions

DOWEX HCR-W2 and HGR-W2 Ion Exchange Resins

Engineering Information

General Information

DOWEX™ HCR-W2 and DOWEX HGR-W2 strong acid cation exchange resins are premium quality gel-type produced by the sulfonation of styrene divinylbenzene copolymers. The resins are designed to combine a high operational capacity with superior physical stability. This quality is assured by the specifications which call for average friability of over 350 g/bead (for beads in the size fraction between 0.6 and 0.85 mm) and a whole uncracked bead count of at least 95% after a quality control check of every production batch of resin. The amount of coarse and fine resin particles in the polydispersed particle size distribution are also closely controlled in the manufacturing process. Specifications assure that no more than 2% of the resin beads are larger than 16 mesh (1.2 mm) and no more than 1% are finer than 40 mesh (0.42 mm). This results in good hydraulic characteristics and enables effective separation from the anion resin when used in mixed bed applications. The combination of such characteristics make DOWEX HCR-W2 and DOWEX HGR-W2 the resins of choice whenever high performance is required in continuous operation modes and where resin transfer is necessary for external regeneration, crud removal or resin separation.

Many years of very successful field experience have made DOWEX HCR-W2 and DOWEX HGR-W2 resins a standard in industrial water treatment applications. The products are particularly suited for deep bed condensate polishing, where high capacity, physical stability and ion removal kinetics are important. For this and other mixed bed applications, the particle size and density characteristics of these resins assure fast and sharp separations when used in combination with DOWEX SBR C and DOWEX SBR-P C gel anion resins.

DOWEX HGR-W2 resin has a higher degree of cross-linking and is the preferred resin for more aggressive polisher conditions or when a higher resistance to oxidation by dissolved oxygen or chlorine is required. For optimal separation in mixed beds, especially in combination with an inert interface, DOWEX HGR-W2 resin is recommended because of its higher density. In other instances its higher total exchange capacity makes it the preferred resin for a particular application.

This brochure relates to water demineralization, using HCl or H_2SO_4 as regenerant in co-current and counter-current operation. The presented data allow the calculation of operational capacities and sodium leakages for different water qualities at different temperatures and levels of regeneration. Resins are available in both the sodium and hydrogen forms. The physical and chemical characteristics of the resins are listed in the table shown on page 3.

Guaranteed sales specifications		HCR-W2	HGR-W2
Ionic form as delivered		H^+	H^+
Total exchange capacity, min.	eq/L	1.8	2.0
	kgr/ft^3 as $CaCO_3$	39.3	43.7
Water content	%	48 - 54	47 - 51
Bead size distribution†			
> 1.2 mm, max. (16 mesh)	%	2	2
< 0.42 mm, max. (40 mesh)	%	1	1
Whole uncracked beads, min.	%	95	95
Crush strength			
Average, min.	g/bead	350	350
> 200 g/bead, min.	%	95	95
Ionic conversions, H^+ form, min.	%	99	99

Trace metals, ppm dry resin, max. (H^+ form)

Na	Fe	Cu	Al	Mg	Ca	Heavy metals (as Pb)
50	50	10	50	50	50	10

Typical physical and chemical properties		HCR-W2	HGR-W2
Total swelling ($Na^+ \rightarrow H^+$)	%	8	7
Particle density	g/mL	1.22	1.23
Shipping weight	g/L	785	800
	lbs/ft^3	49	50

Recommended operating conditions	HCR-W2	HGR-W2
Maximum operating temperature	120°C (250°F)	130°C (265°F)
pH range	0 - 14	0 - 14
Bed depth, min.	450 mm (1.5 ft)	450 mm (1.5 ft)
Flow rates:		
Service/fast rinse	5 - 50 m/h (2 - 20 gpm/ft^2)	5 - 50 m/h (2 - 20 gpm/ft^2)
Service/condensate polishing	40 - 150 m/h (16 - 60 gpm/ft^2)	40 - 150 m/h (16 - 60 gpm/ft^2)
Backwash	See Figure 1	See Figure 1
Regeneration/displacement rinse	1 - 10 m/h (0.4 - 4 gpm/ft^2)	1 - 10 m/h (0.4 - 4 gpm/ft^2)
Total rinse requirement	3 - 6 bed volumes	3 - 6 bed volumes
Regenerant	1 - 10% H_2SO_4 or 4 - 8% HCl	1 - 10% H_2SO_4, 4 - 8% HCl or 8 - 12% NaCl

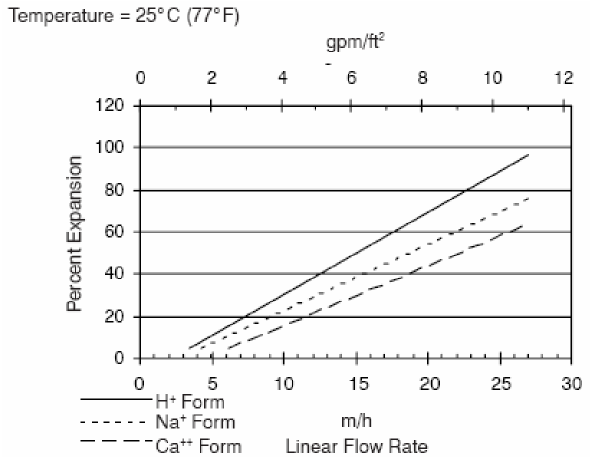
† For additional particle size information, please refer to the Particle Size Distribution Cross Reference Chart (Form no. 177-01775)

Hydraulic Characteristics

Backwash Expansion

Under the up-flow conditions of backwashing the resin will expand its volume (see Figures 1(a) and 1(b)). Such expansion allows the regrading of the resin, fines removal and avoids channeling during the subsequent service cycle. An efficient backwash will require an expansion of over 50% of the original resin volume. At the same time, accumulated particulates are removed. 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 the particulates. In counter-current operation the strainers are cleaned by the regenerant flow. To retain the advantages of counter-current ration 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 countercurrent regeneration.

Figure 1(a). Backwash expansion data for DOWEX HCR-W2 resin

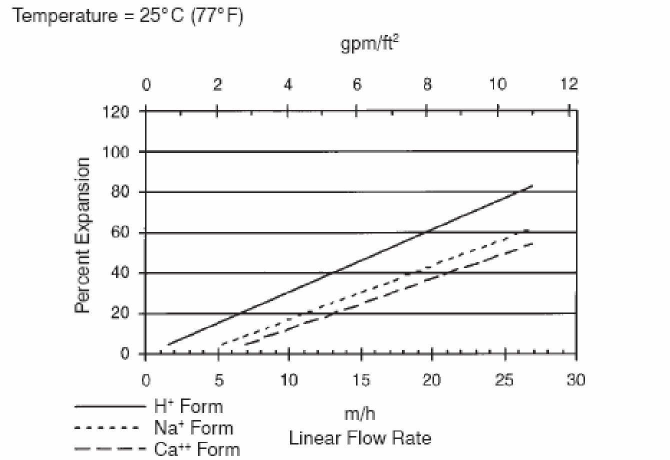


For other temperatures use:

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

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

Figure 1(b). Backwash expansion data for DOWEX HGR-W2 resin



For other temperatures use:

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

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

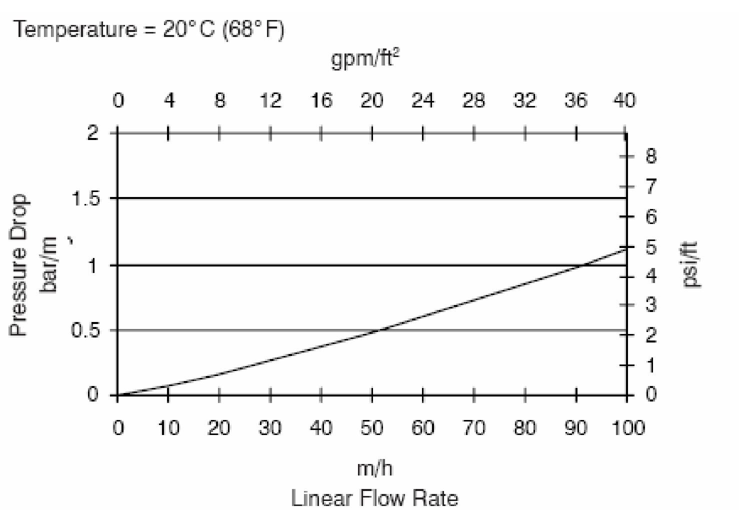
Pressure Drop Data

The pressure drop across a resin bed can vary depending on a number of factors. These include resin type, bead size and distribution, interstitial space (bed voidage), flow rate and temperature.

The data in Figure 2 shows the pressure drop per unit bed depth as a function of both flow velocity and water temperature for both DOWEX HCR-W2 and DOWEX HGR-W2 resins. This data refers 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. It is substantially affected by the contribution of the strainers surrounded by the resin.

DOWEX HCR-W2 and DOWEX HGR-W2 resins exhibit low pressure drop due to their optimized size distribution. This makes them particularly suitable for operation at high flow rates.

Figure 2. Pressure drop data



For other temperatures use:

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

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

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Operating Characteristics

The suggested operating conditions in the table shown on page 3 are intended as a guide and should not be found restrictive. The engineering design of an ion exchange unit will be influenced by certain factors such as the operational flow rates, so the compatibility of the design with the needs of an efficient regeneration need to be considered and may change the suggested operating conditions given in the table in order to obtain an optimal system.

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 anion 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, and this must be taken into account.

Any sodium leakage will not only affect the conductivity of the final effluent, but also influence the silica leakage from a strong base anion resin. Data related to this influence are presented in the relevant engineering brochures of these 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 of 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 as shown in 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. 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 stepwise 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 (0.2 lbs H_2SO_4/min per ft^3) at a concentration of 1% H_2SO_4, this will amount to a regenerant flow rate of 18 m^3/h per m^3 (2.2 gpm/ft^3) of resin.

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

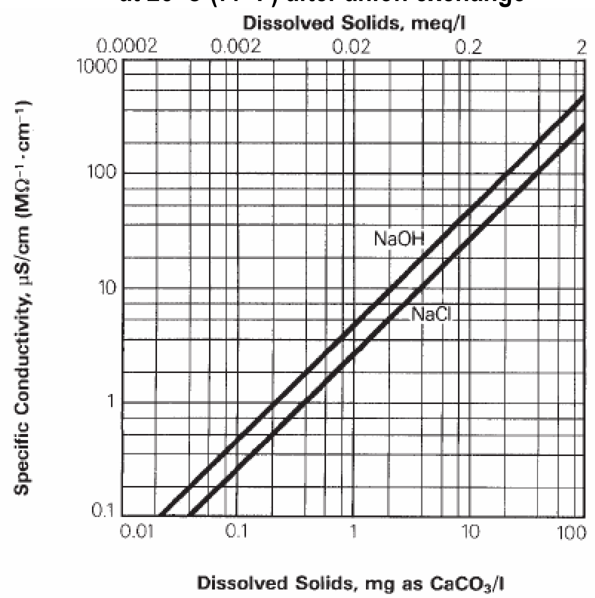


Figure 4. Permitted H_2SO_4 concentration

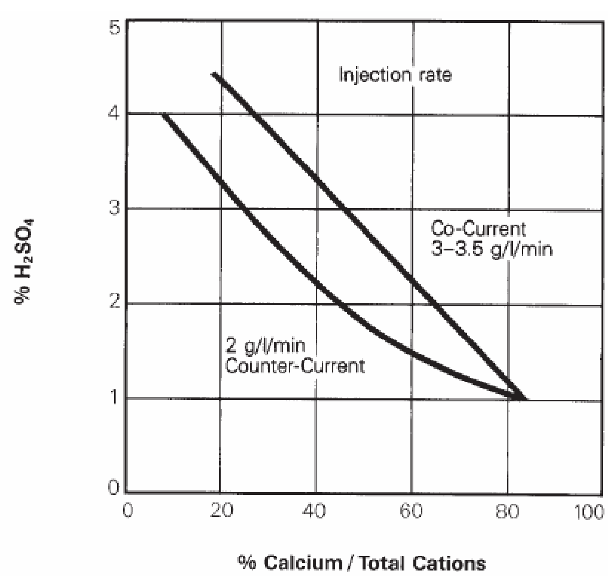


Figure 5. Permitted H_2SO_4 concentrations (step-wise)

Calcium % in feed water	H_2SO_4 % permitted	
Ca % < 15	H_2SO_4	3%
15 < Ca % < 50	H_2SO_4	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

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 with poorer regeneration than counter-current operation. It may nevertheless be preferred, especially when high sodium leakage levels are acceptable. Figures 6 and 7 show the average sodium leakage from DOWEX HCR-W2 and DOWEX HGR-W2 resins relative to different regeneration levels and using HCl or H_2SO_4 as regenerants. These leakages are expressed as percentages of equivalent mineral acidity (EMA). 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.

Figure 6. Average Na leakage from DOWEX HCR-W2 and DOWEX HGR-W2 resins in co-current operation with HCl as regenerant

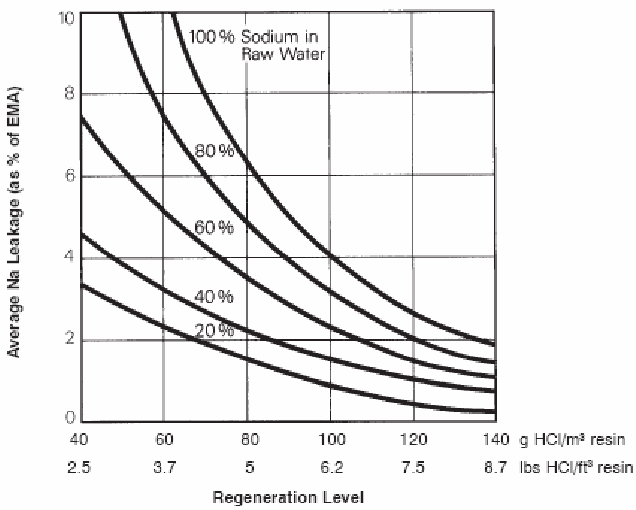
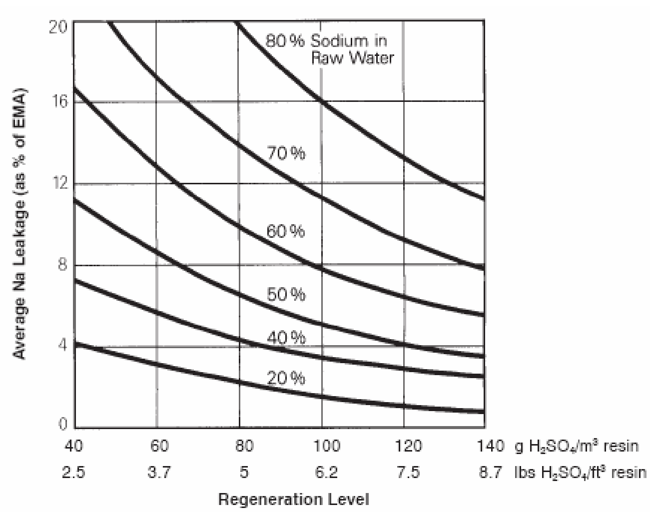


Figure 7. Average Na leakage from DOWEX HCR-W2 and DOWEX HGR-W2 resins in co-current operation with H_2SO_4 as regenerant

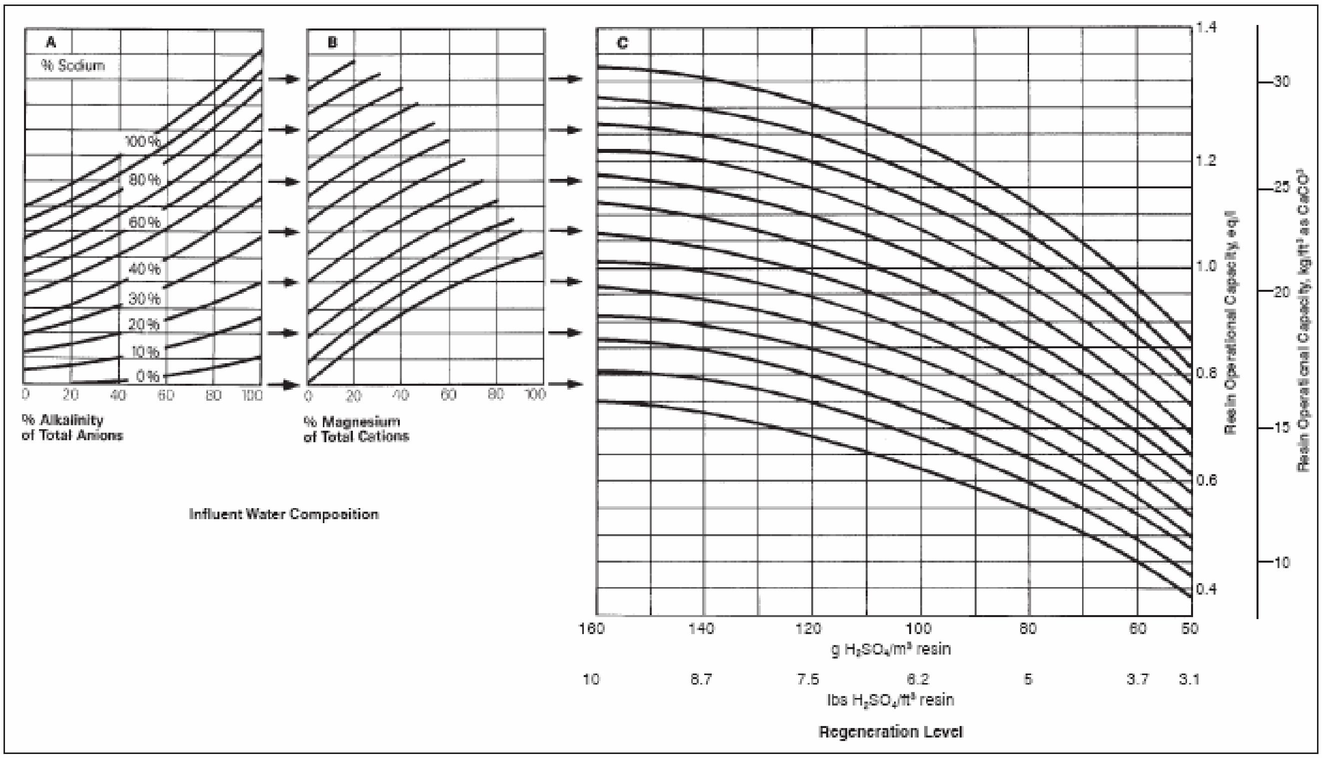


Data on co-flow operational capacities for DOWEX HCR-W2 and DOWEX HGR-W2 resins using HCl or H_2SO_4 for different water qualities are given in Figures 8 and 9.

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 % sodium and % 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 % 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

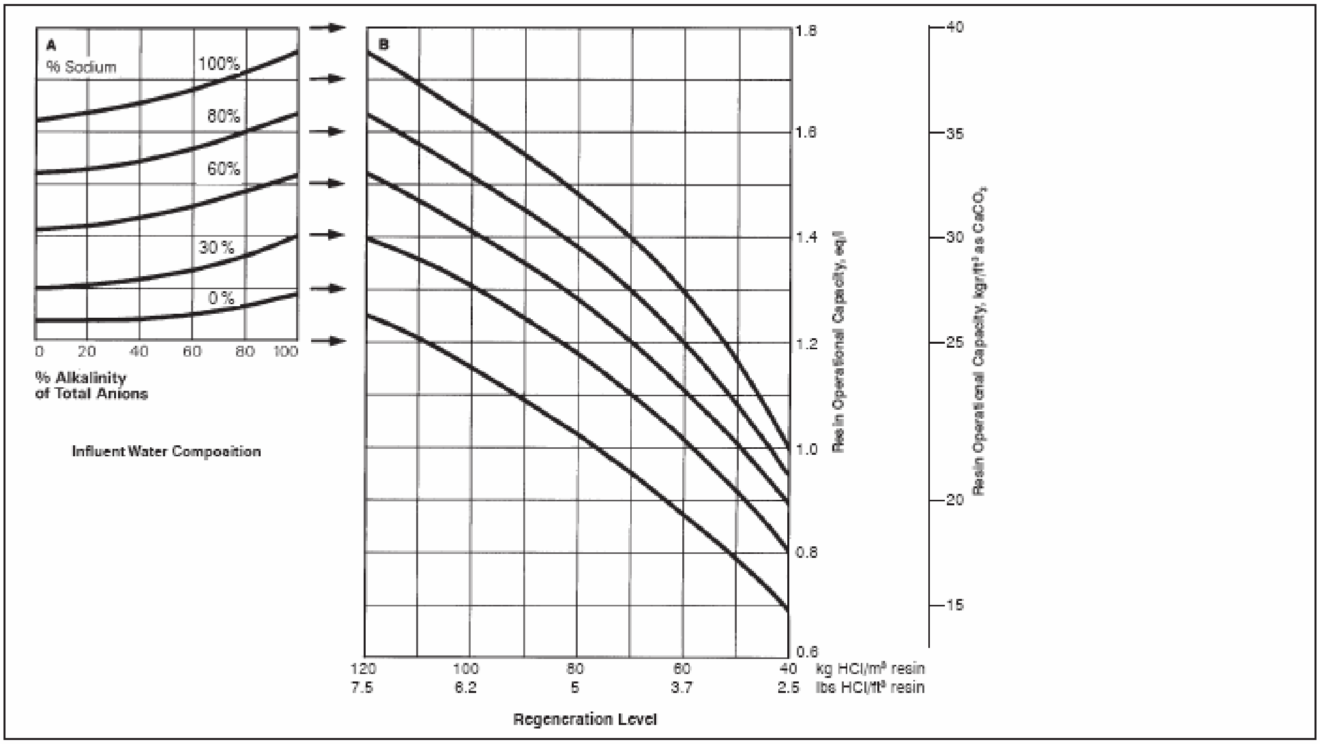


Co-current operational capacity data (HCl regeneration)

Instructions:

1. Locate a point on the ordinate of graph A from % 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.

Figure 9. Co-current operational capacity date (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 regenerant 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, treated (or at least 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 (0.1 lbs/min per ft^3) 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.

Average sodium leakage levels 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.

Data on operational capacities for DOWEX HCR-W2 and DOWEX HGR-W2 resins using HCl or H_2SO_4 are given in Figures 10 and 11.

Figure 10. Average Na leakage for DOWEX HCR-W2 and DOWEX HGR-W2 resins in counter-current operation and H_2SO_4 as regenerant (step-wise concentrations)

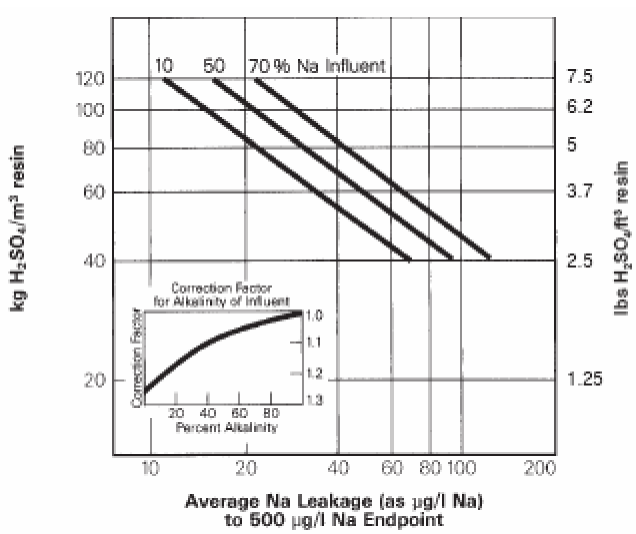
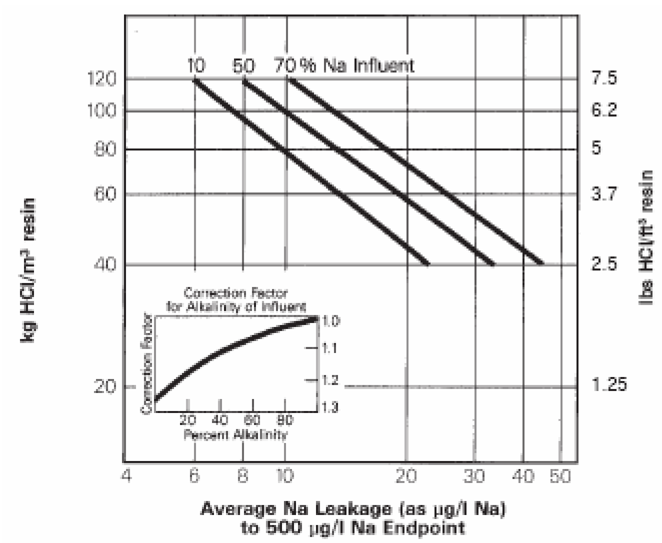


Figure 11. Average Na leakage for DOWEX HCR-W2 and DOWEX HGR-W2 resins in counter-current operation and HCl as regenerant



Counter-current operational capacity data (H_2SO_4 regeneration)

Instructions:

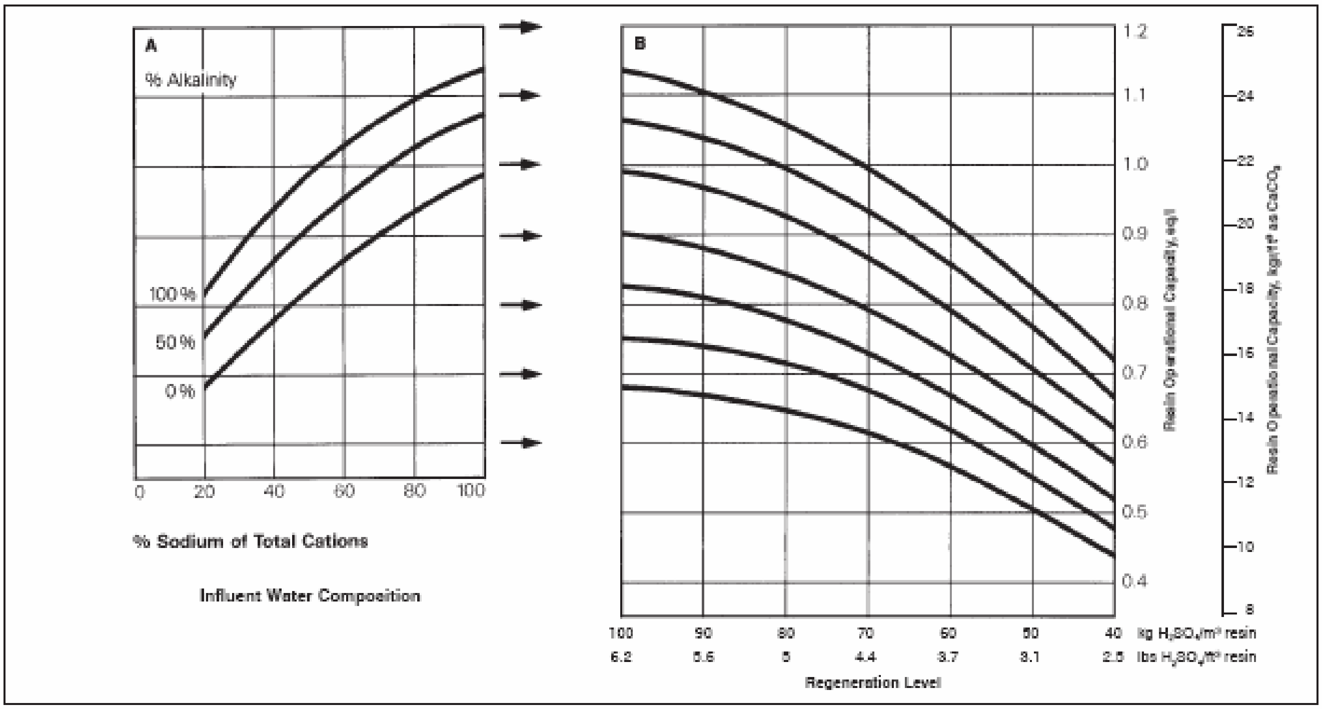
1. Locate a point on the ordinate of graph A from % sodium and % alkalinity.
2. Transfer the ordinate point from graph A horizontally to graph B and follow the guideline to the chosen regeneration level thus establishing a new ordinate.
3. Read off operational capacity on the right hand side of the diagram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

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

Standard conditions:

- BV/H × salinity (meq/l) = 200
- gpm/ft^3 × salinity (kgr/ft^3) = 0.55
- Temp. 15°C (60°F)

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



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Counter-current operational capacity data (HCl regeneration)

Instructions:

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.

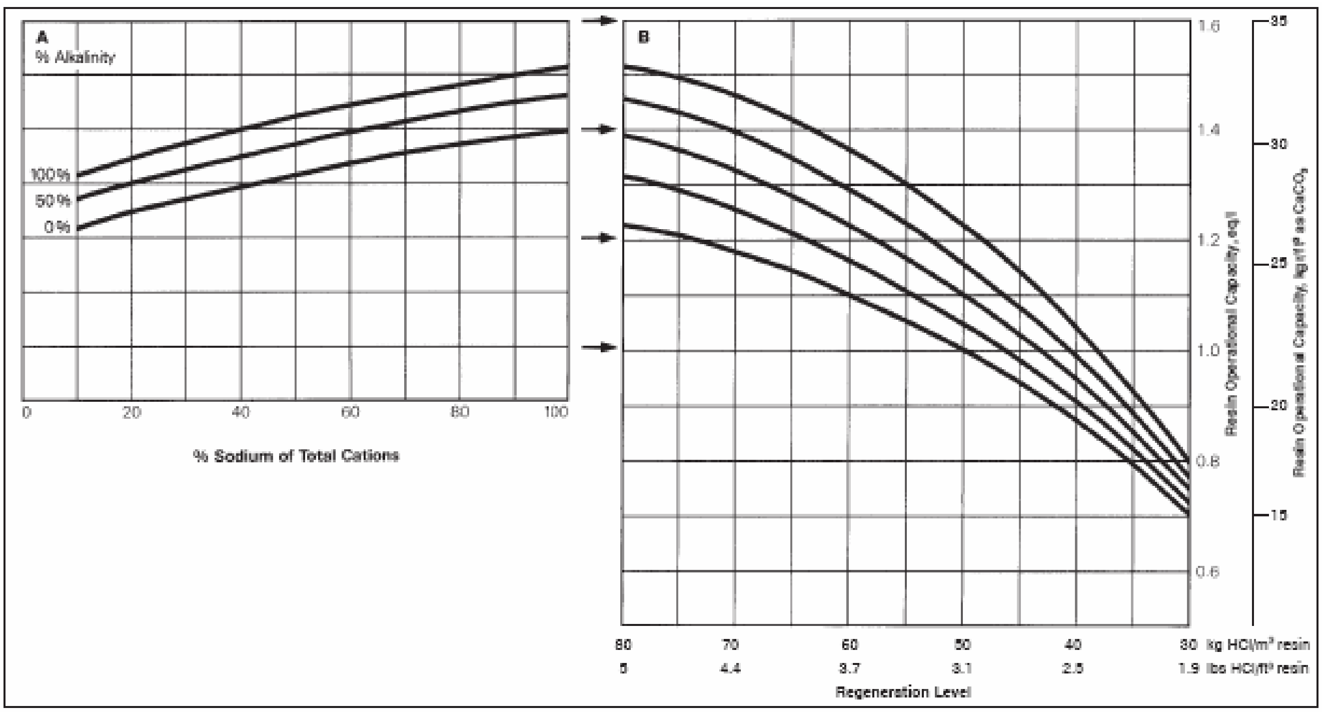
Important:

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 × salinity (meq/l) = 200
- gpm/ft^3 × salinity (kgr/ft^3) = 0.55
- Temp. 15°C (60°F)

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



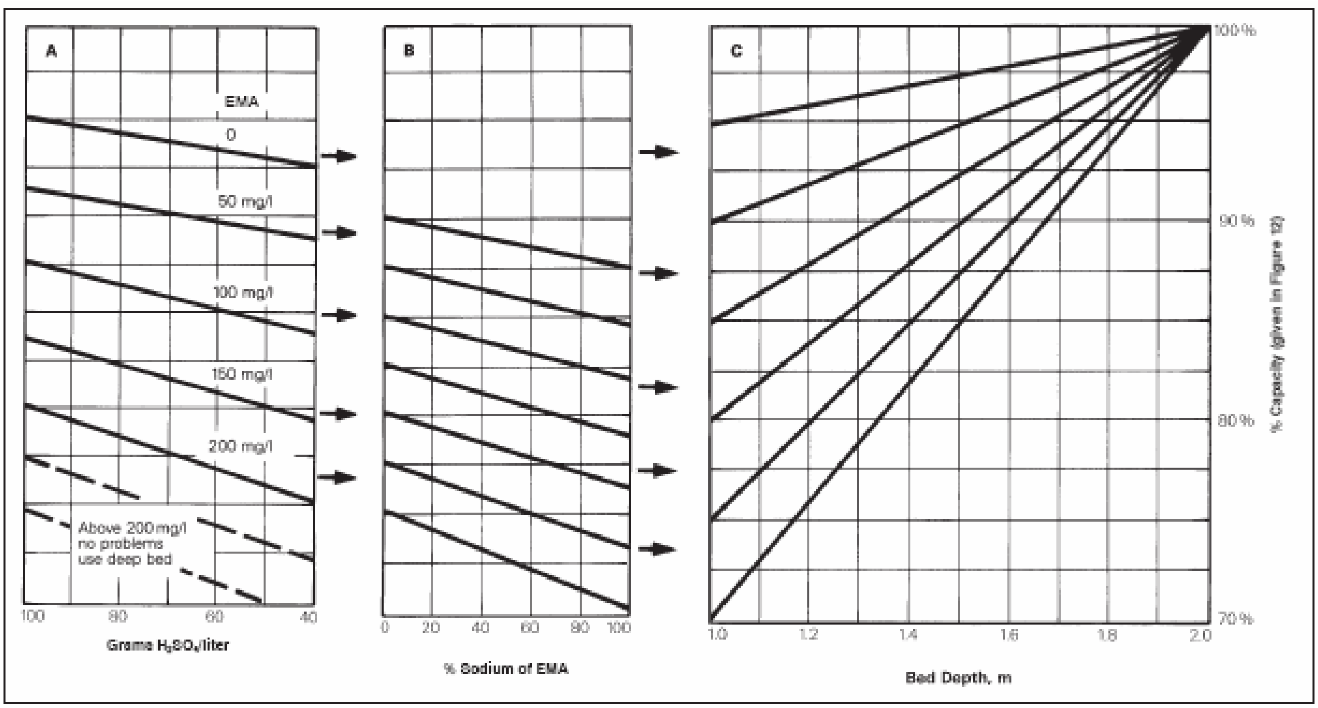
The Bed Depth Effect
The geometry of an ion exchange plant affects the plant capacity and the quality of the produced water. A bed depth of about 1 m (3.3 ft) is ideal for co-current operation but little difference exists going from 0.75 m to 2 m bed depth (30" to 6.5 ft). A flow velocity of 20-30 m/h (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 HCR-W2 and DOWEX HGR-W2 resins allow them to be used in deep beds, thereby obtaining better capacity usage and water quality.

The bed depth effect is given in Figure 14.

Effect of bed depth on capacity (counter-current)
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 % 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.

Important:
The minimum bed depth when using 60 g/l (2.7 lbs/ft^3) H_2SO_4 is 1.5 m (5 ft).

Figure 14. Effect of bed depth on capacity



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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

Notice: 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.

Form No. 177-01726-0905