PUROFINE®
ION EXCHANGE RESINS

ISO 9002
BSI
REGISTERED FIRM
FM 40352

PFC-100H

Strong Acid Cation Resin

Uniformly Sized
(For fast regeneration-efficient demineralization)

Technical Data

PRODUCT DESCRIPTION

Purofine PFC-100H is a gel type strong acid cation exchange resin which because of its *Special Narrow Size Distribution* has higher operating capacity and produces treated water with lower sodium leakage. These advantages are more apparent at lower regeneration levels, where the effect of *Superior Regeneration Efficiency* is more marked. It is also relatively less susceptible to fouling by heavy metals such as iron. These factors combine to produce better quality of treated water generally, while offering special advantages when operating at higher flow rates. Operation at higher flow rates results in the possibility to use a smaller plant with consequent savings in both resin and regenerant costs. Longer runs and higher throughputs can also be realized where small or shallow resin beds are required. These advantages arise from improved rates of ion exchange both in loading and regeneration.

Thus useful economies can be made both in operating and capital costs, and at the same time there are possibilities to produce treated water to higher quality specifications.

Typical Physical & Chemical Characteristics

Polymer Matrix Structure	Crosslinked Gel Polystyrene
Physical Form and Appearance	Dark Amber Spherical beads
Whole Bead Count	95% min.
Functional Group	$R\text{-}SO_3^-$
Ionic Form, as shipped	H^+
Shipping Weight (approx.)	785 g/l (49 lb/ft^3)
Screen Size Range: - Median Volume Diameter - Distribution	 560 +/- 40 microns 90% within +/- 100 microns
Screen Size Range: - U.S. Standard Screen	 25 - 40 mesh, wet
Particle Size Range	+0.710 mm <1%, -0.425 mm <1%
Moisture Retention, as shipped	51 - 55%
Swelling $Na^+ \rightarrow H^+$	5% max.
Specific Gravity, moist H^{+-} Form	1.20
Total Exchange Capacity, H^+ form, wet, volumetric dry, weight	 1.8 eq/l min. 4.9 eq/kg min.
Operating Temperature, H^+ Form	120ºC (248ºF) max.
Operating Temperature, Na^+ Form	150ºC (302ºF) max.
pH Range	no limitations

Standard Operating Conditions
(Co-Flow Demineralization of Water)

Operation	Rate	Solution	Minutes	Amount
Service	8 - 100 BV/h 1.0 - 12.5 gpm/ft^3	Influent water	per design	per design
Backwash	Refer to Fig. 2	Influent water 5º - 20ºC (40º - 70ºF)	5 - 20	1.5 - 4 BV 10 - 30 gal/ft^3
Regeneration	2 - 6 BV/h 0.25 - 0.75 gpm/ft^3	4 - 10% HCl 0.5 - 6% H_2SO_4	10 - 60	48 - 128 g/l 3 -8 lb/ft^3
Rinse, (slow)	2 - 6 BV/h 0.25 - 1.0 gpm/ft^3	Influent water	20 approx.	1 BV 8 gal/ft^3
Rinse, (fast)	8 - 40 BV/h 1.0 - 5.0 gpm/ft^3	Influent water	10 approx.	1 BV 8 gal/ft^3

Backwash Expansion 50% to 75%

Design Rising Space 100%

(This is not necessary for small cartridges operating on a filtered water supply)

"Gallons" refer to U.S. Gallon = 3.785 liters

REGENERATION

Although **Purofine PFC-100H** is supplied in the hydrogen form, it is recommended that it is given a regeneration cycle prior to use, to ensure that the resin and associated engineering equipment are thoroughly clean. If the resin is to be used to remove iron in more than trace quantities, hydrochloric acid should be used rather than sulphuric acid. This will help to avoid build up of trivalent (ferric) ions within the matrix, which can eventually block the ion exchange sites irreversibly. If sulphuric acid is to be used, stepwise regeneration is to be recommended. This will ensure the best utilization of the regenerant. Operating capacity data quoted later in this bulletin is based on stepwise regeneration. **Purofine PFC-100H** regenerates particularly efficiently, hence even more care should be taken to observe the recommended maximum concentrations in each of the steps. Fig. 11 gives the maximum allowable concentration in each step, according to the calcium content of the feed water.

OPERATING PERFORMANCE

The operating performance of **Purofine PFC-100H** in the hydrogen cycle depends on:

a) The amount, concentration and type of regenerant acid used.

b) The flowrate of the influent water through the bed.

c) The proportion of sodium / total cations in the water to be treated, the proportion of magnesium over total hardness, and the alkalinity content.

In respect of a), b) and c) **Purofine PFC-100H** offers significant advantages compared with standard strong acid cation exchange resins. The size distribution allows for easier diffusion within the resin beads, which greatly improves the efficiency of regeneration, and consequently reduces acid usage and therefore, environmental pollution. The second major advantage of this **Purofine** resin is that the total bead surface area is increased by 20% approx. The elimination of the coarser beads typically found in standard type resins produces faster kinetics and thus results in a relative improvement in capacity, especially at higher flow rates, and where hardness and/or sodium contents are high.

These advantages are particularly useful in small standard demineralization plants, since economies of scale and reduction in regenerant costs can be realized. For larger industrial plants, exhaustion cycles should be designed to last for at least four hours. Under these more conventional conditions the advantages of **Purofine Cation Resins** in regenerability produce a significantly lower sodium leakage and hence the potential to produce a higher quality demineralized water after the subsequent treatment with the anion exchange resin. The advantages are greater the higher the operational flow rate, hence it is in the technologies of high purity water production, and treatment of water at high flow rate at lower regeneration levels where the greatest relative advantages of **Purofine cation hydrogen form resins** lie.

In order to achieve the best results, care must be taken to choose the optimum design conditions and those of operation. Particularly in downflow operation, the absence of larger beads present in the standard resins towards the bed outlet ensures a sharper exhaustion profile, which can result in lower leakage prior to break-through. Also there exists the possibility of operation at higher flow rates, and because of better utilization of ion exchange sites within each bead, especially at the base of the vessel, regeneration of **Purofine PFC-100H** is significantly more efficient.

The efficiency of regeneration is also improved for additional reasons. Diffusion from larger beads is the limiting factor in both the extent of regeneration, and the rinse volume required to remove excess regenerant containing the ions, responsible for exhaustion. This is particularly true where these ions are divalent (calcium and magnesium). Both these ions are more easily removed during regeneration where ionic concentration is highest. However all cation resins selectively hold divalent ions in dilute solution. Therefore once the displacement rinse is applied these ions diffusing out of beads toward the end of the regeneration will selectively displace regenerant ions as the ionic concentration within the bead is reduced. In beads of smaller diameter the diffusion path is shorter, hence a large proportion of these ions will have diffused out of the beads and consequently cannot return to previously regenerated sites.

The elimination of that proportion of beads smallest in diameter and volume increases the voids fraction and reduces the pressure drop (see section on "Hydraulic Characteristics").

These advantages also apply to counter-flow regeneration systems. However where regeneration is upflow, the smaller beads of the distribution are to be found at the outlet, hence the efficiency is good for the **Purolite** range and the advantages of **Purofine** resins in gross terms are reduced to some degree. Nevertheless when treatment to produce ultra-pure water from a high sodium feed is the prime requirement, this can be done more easily with **Purofine Resins**.

HYDRAULIC CHARACTERISTICS

The pressure drop (headloss) across a properly classified bed of ion-exchange resin depends on the particle size distribution, bed depth, and voids volume of the exchanger, and on the flowrate and viscosity (and hence on the temperature) of the influent solution. Anything affecting any of these parameters, for example the presence of particulate matter filtered out by the bed, abnormal compaction of the resin bed, or the incomplete classification of the resin spheres will have an adverse effect, and result in an increased headloss. Typical values of pressure drop across a bed of **Purofine PFC-100H** are given in Fig. 1, below, for a range of operating flowrates.

Fig. 1 PRESSURE DROP VS FLOW RATE

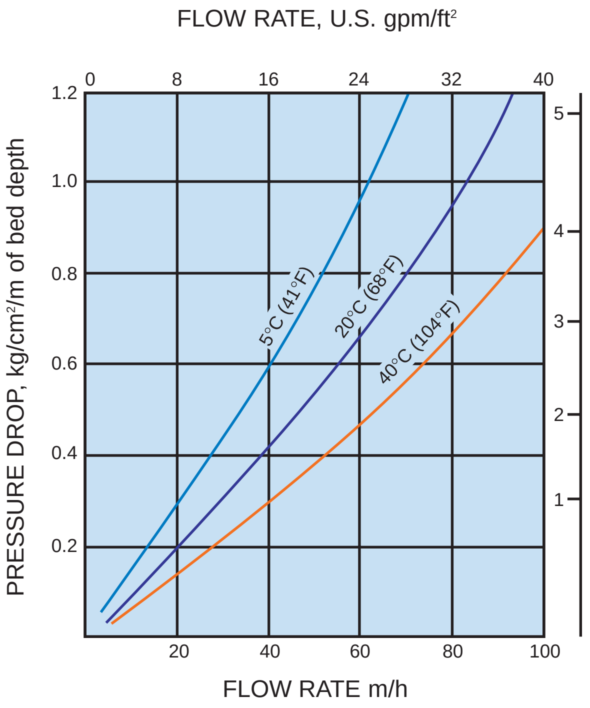
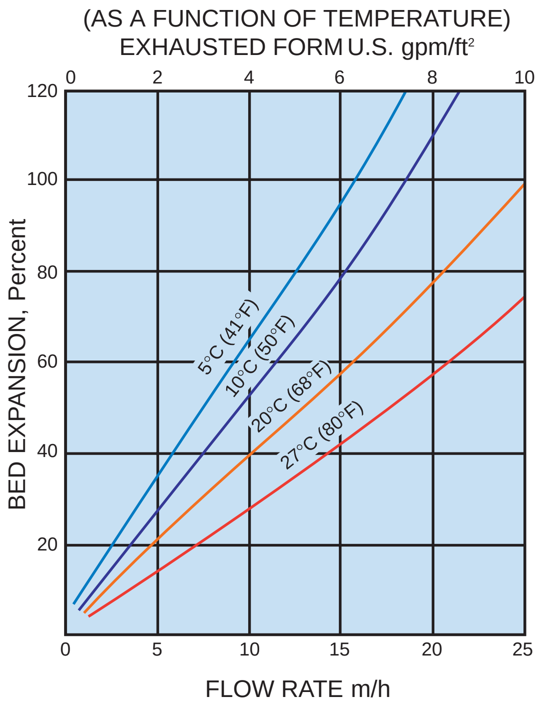


Fig. 2 BACKWASH EXPANSION



During upflow backwash, the resin bed should be expanded in volume by between 50 and 75% in order to free it from any particulate matter from the influent solution, to clear the bed of bubbles and voids, and to reclassify the resin particles as much as possible ensuring minimum resistance to flow.

Backwash should be commenced gradually to avoid an initial surge with consequent carryover of resin particles. Bed expansion increases with flow rate and decreases with temperature, as shown in Fig. 2. Care should always be taken to avoid resin loss by accidental over-expansion of the bed.

CHEMICAL AND THERMAL STABILITY

Purofine PFC-100H is insoluble in dilute or moderately concentrated acids, alkalies, and in all common solvents. However, exposure to significant amounts of free chlorine, "hypochlorite" ions, or other strong oxidizing agents over a period of time will degrade the structure and break down the crosslinking. This could reduce the ion exchange capacity, increase the moisture retention of the resin, and decrease its mechanical strength. Hence contact should be avoided. This resin, like all conventional crosslinked polystyrene type resins, is thermally more stable in the sodium, calcium and magnesium forms than it is in the hydrogen form, and is resistant at temperatures up to 150°C (300°F). In the hydrogen form the resin slowly self hydrolysis with some loss of capacity at temperatures above 120°C (250°F). It may be used at higher temperatures usefully, but the shortened resin lifetime should be taken into account when assessing process viability.

OPERATING CAPACITY CALCULATION

If the influent water analysis is known, and service flowrate, regeneration level, the treatment water quality / quantity are specified, the capacity and leakage curves may be used directly to determine the operating capacity of the resin. Hence the volume of resin required for the unit which is needed to produce the water quantity of the quality specified, may be calculated. Several factors may influence the choice of regeneration level and service flow rate such as the sodium leakage requirement in the treated water, the need to balance the excess regenerant from cation and anion units to give a neutral effluent, the need to optimize capital and running costs, the availability of regenerants, choice of convenient intervals between regenerations, and so on. In the following example the use of the operating capacity and leakage curves is illustrated for a specified treatment including regeneration level and flow rate.

INFLUENT WATER ANALYSIS

	meq/l	**ppm as $CaCO_3$**	**Total Anions %**
Ca	2.5	125	25
Mg	2.5	125	25
Na	5.0	250	50
Total	10.0	500	100
Alkalinity:		250	

% Alkalinity / Total Cations = 50

TREATMENT

Demineralization:
Regeneration with 4% HCl at : 64 g/l, (4 lb/ft^3)
Co-flow at flow rate : 40 BV/h, 5 gpm/ft^3
Start of run : FMA +5%
End of run : FMA -5%

CAPACITY CALCULATION

For a feed water with 25% calcium and 25% magnesium, divalent ions (Total Hardness) equals 50%.
Likewise monovalent ions (sodium) = 50%
Reference to Fig. 3 shows base operating capacity C_b for 64 g/l of HCl (4 lb/ft^3), and 50% monovalent ions
= 1.25 eq/1, 27.3 kgr/ft^3
Correction factor for percentage alkalinity of 50, at 4% HCl (Fig. 4)
C_1 = 0.96
Hence operating capacity
= $C_b \times C_1$
1.25 x 0.96 = 1.2 eq/l, 26.2 kgr/ft^3
Applying the customary engineering design factor of 0.9, the operating capacity obtainable
= 1.2 x 0.9 = 1.08 eq/l,
= 23.6 kgr/ft^3

SODIUM LEAKAGE

Base Sodium leakage B_s = for HCl at 64 g/l,(4 lb/ft^3) at 50% Alkalinity / Total Cations
= 0.7 ppm (Fig. 5)
Reciprocal correction factor for 50% Alkalinity
= 1.6 (Fig. 6)
Thus sodium leakage for 500 ppm total cations
= 0.7/1.6
= 0.4 ppm
A further correction factor K_2 applies as follows:
The total salt content of the feed expressed as ppm calcium carbonate, is divided by 500 to obtain final leakage.
In this case K_2 = 500/500 = 1
The above leakage 0.4 x 1 = 0.4 ppm Na

Note: Where sulphuric acid is used as regenerant, Figs. 7 - 10 apply in place of Figs. 3 - 6. In addition, a correction factor, C_2, for magnesium content of the total hardness should be applied to the operating capacity see Fig. 12.

If flowrates greater than 40 BV/h (5 gpm/ft^3) and / or where total cations are greater than 10 meq/l (500 ppm as $CaCO_3$ a flowrate correction should be applied. Please refer to your local sales office.

PLANT DESIGN

If, as may be the case, the sodium leakage is a prime requirement, the operating sodium leakage specified should be corrected by multiplying by K_1 (correction for sodium) and K_2 (Correction for total salt content to be considered) to derive the necessary base leakage B_s. Thus the regeneration level which gives B_s is found from fig. 5. The operating capacity is then calculated as given in the example above. It may of course be necessary to modify the first design calculation to take account of other factors as mentioned above: such as, flow rate should be within the required limits and there could be a need for neutral effluent. In fact this last point is often the most important. Silica leakage from the following anion quite often dictates the need for a higher acid regeneration level than is needed to obtain the required sodium leakage, since the acid is needed to neutralize the excess regenerant from the anion resin. In some cases repeated calculations to balance the respective sodium and silica leakages with corresponding regenerant levels of cation and anion resins can be worthwhile.

Conversion of Units

1 m/h (cubic meters per square meter per hour)	= 0.341 gpm/ft^2 = 0.409 U.S. gpm/ft^2
1 kg/cm^2/m (kilograms per square cm per meter of bed)	= 4.33 psi/ft = 1.03 atmos/m = 10 ft H_2O/ft

PUROFINE PFC-100H

CO-FLOW REGENERATION USING HYDROCHLORIC ACID

Fig. 3 BASE OPERATING CAPACITY

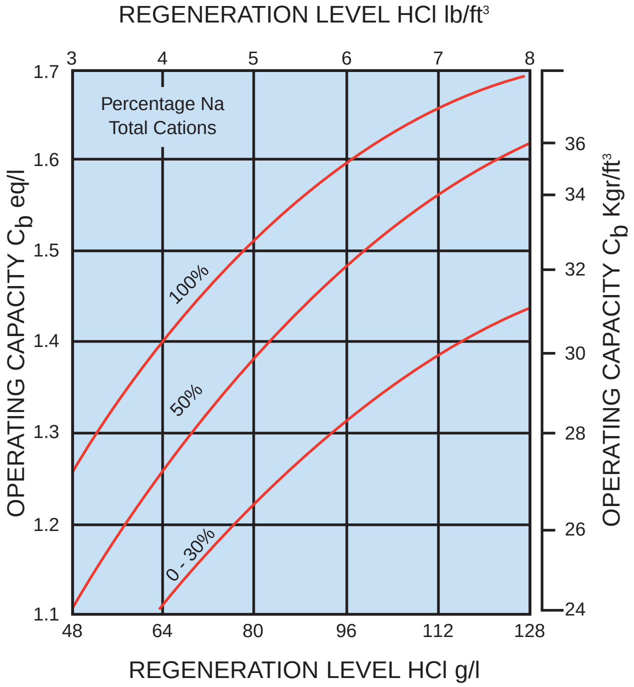
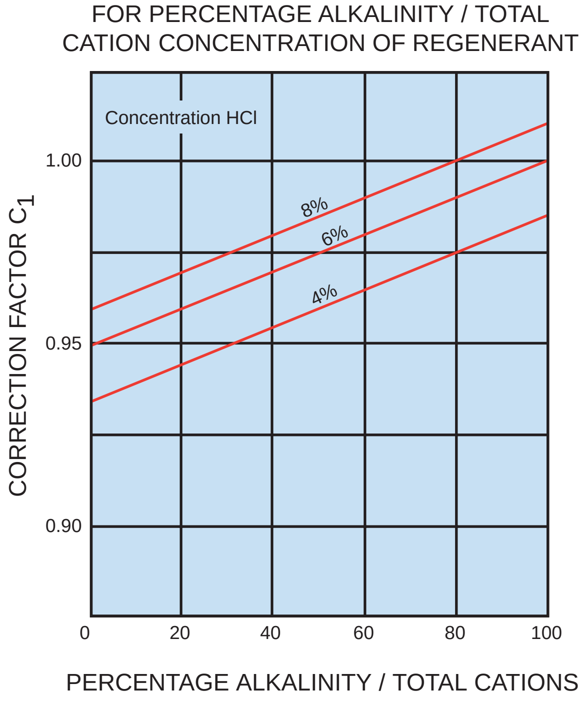


Fig. 4 CORRECTION FACTOR



PUROFINE PFC-100H
CO-FLOW REGENERATION USING HYDROCHLORIC ACID

Fig. 5 SODIUM LEAKAGE

BASED ON FEED OF 500 ppm as $CaCO_3$

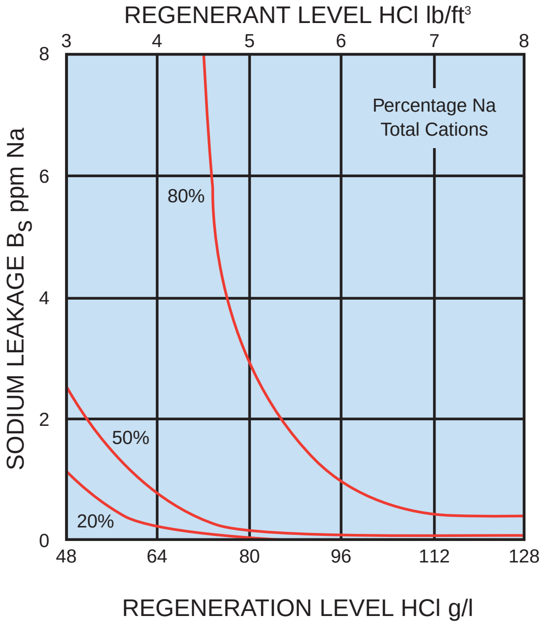
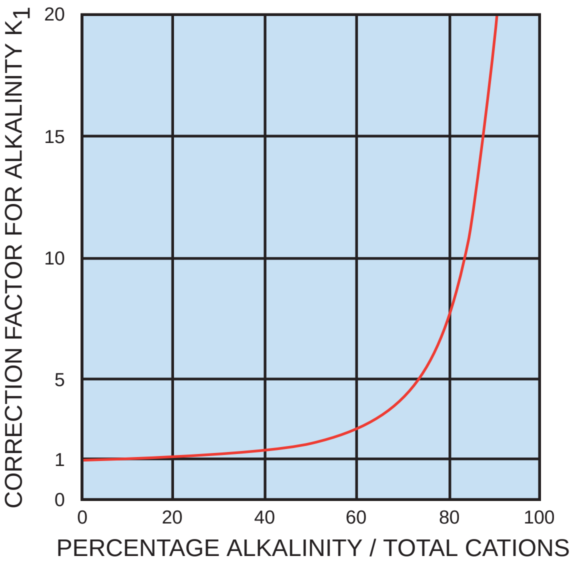


Fig. 6 CORRECTION FACTOR TO SODIUM LEAKAGE ACCORDING TO ALKALINITY CONCENTRATION



PUROFINE PFC-100H
CO-FLOW REGENERATION STEPWISE USING SULPHURIC ACID

Fig. 7 BASE OPERATING CAPACITY

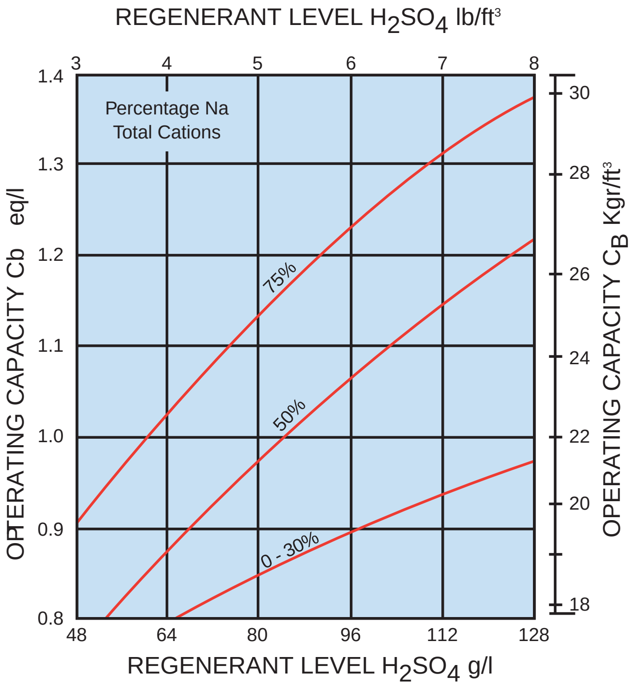
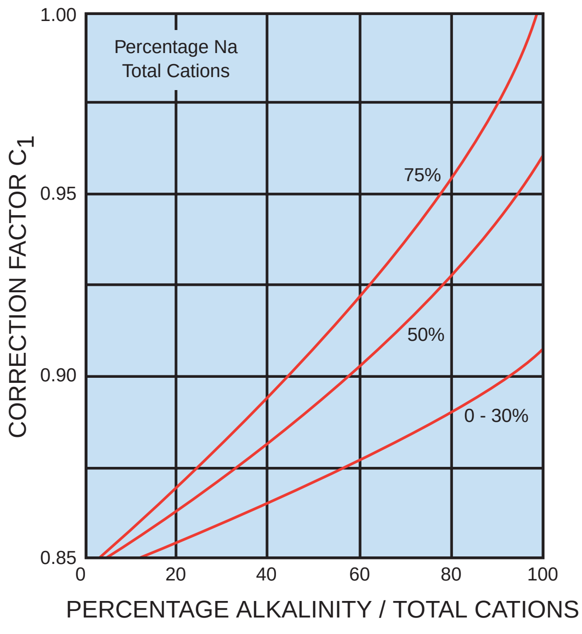


Fig. 8 CORRECTION FACTOR

FOR % ALKALINITY / TOTAL CATIONS



PUROFINE PFC-100H
CO-FLOW REGENERATION STEPWISE USING SULPHURIC ACID

Fig. 9 SODIUM LEAKAGE

BASED ON FEED OF 500 ppm as $CaCO_3$

REGENERANT LEVEL H_2SO_4 lb/ft³

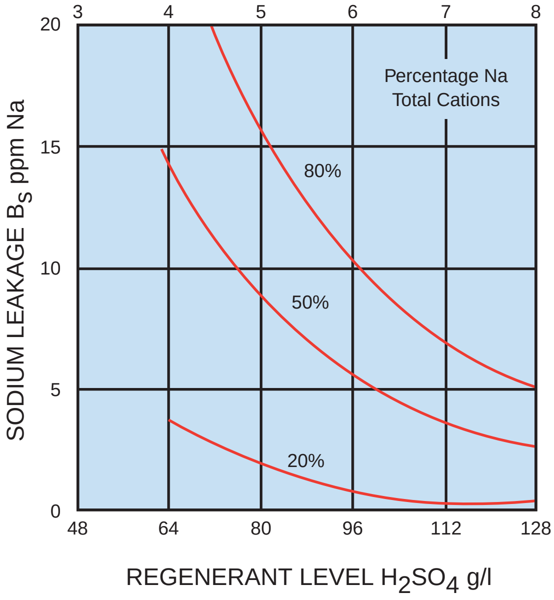


Fig. 10 CORRECTION FACTOR TO BASE SODIUM LEAKAGE

ACCORDING TO PERCENTAGE ALKALINITY

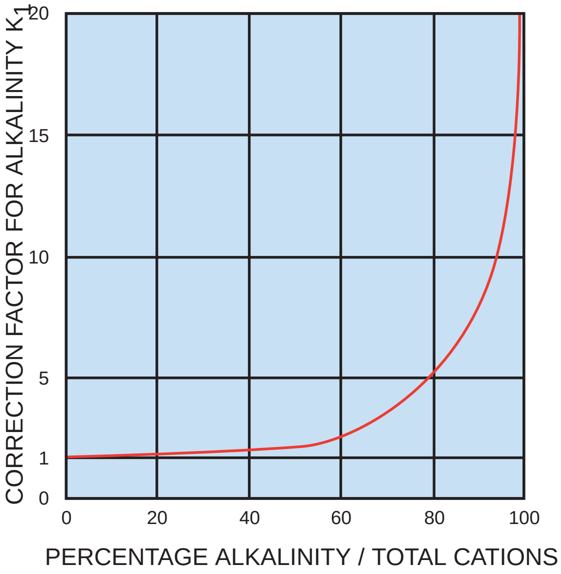


Fig. 11 SULPHURIC ACID CONCENTRATION STEPWISE STRENGTH

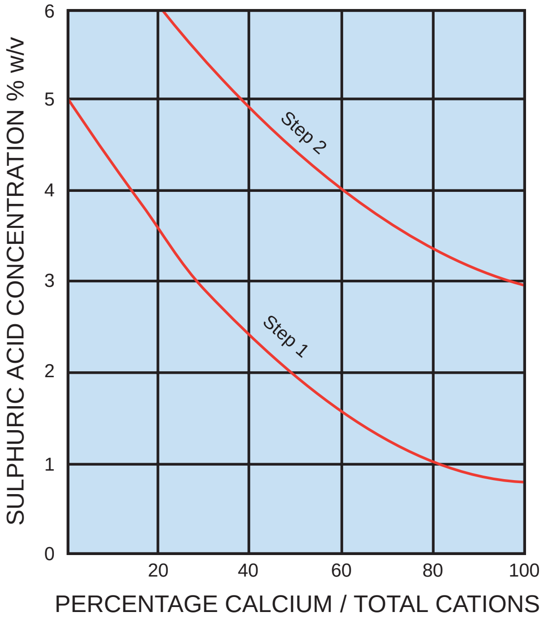
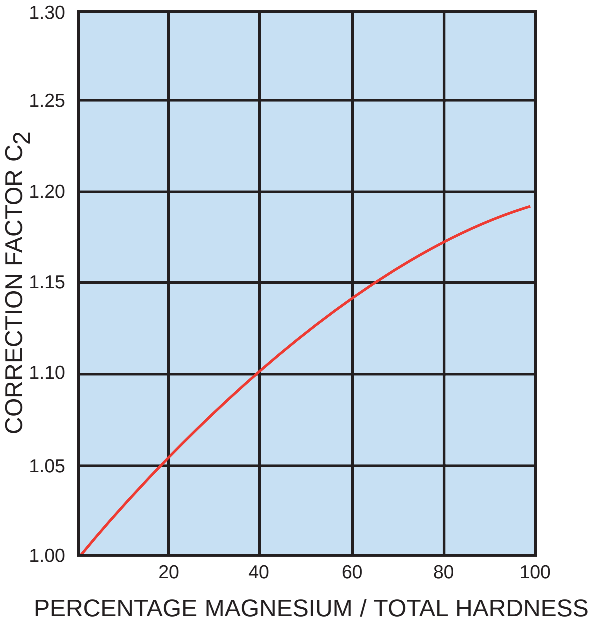


Fig. 12 CAPACITY CORRECTION FACTOR FROM PERCENTAGE MAGNESIUM IN FEED SOLUTION



REGENERANT QUANTITIES:
STEP 1 = 1/3 OF REGENERANT
(MINIMUM QUANTITY 30 g/l OF RESIN)
STEP 2 = REMAINDER

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ION EXCHANGE RESINS

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