

A-400
Strong-Base Type I
Anion Exchange Resin
(For efficient demineralization including silica)

Technical Data

PRODUCT DESCRIPTION

Purolite A-400 is a clear gel Type I strong-base anion exchanger with both high operating capacity and the ability to achieve low residual silica levels. Minimal quantities of caustic soda are required compared with those typical of the classical Type I (**Purolite A-600**) quaternary ammonium structure based on polystyrene. It has a clear gel structure, showing excellent regeneration efficiency and rinse characteristics. **Purolite A-400** functions well both in mixed bed (**MIXLITE**) and layered

bed (**DOUBLITE**) demineralizer systems, where specially tailored particle size ranges result in achieving or maintaining good separations. **Purolite A-400** has exceptional physical stability for a conventional gel-type resin which permits a long life without the development of excessive pressure drop; it also shows good kinetics of exchange, enabling very low concentration levels of both strong and weak acid anions to be achieved at practical flowrates.

Typical Physical & Chemical Characteristics	
Polymer Matrix Structure	Polystyrene cross-linked with Divinylbenzene
Physical Form and Appearance	Clear golden spherical beads
Whole Bead Count	90% min.
Functional Groups	Type I Quaternary Ammonium
Ionic Form, as shipped	Cl ⁻
Shipping Weight (approx.)	680 - 695 g/l (42.5 - 43.5 lb/ft ³)
Screen Size Range: - U.S. Standard Screen	16 - 50 mesh, wet
Particle Size Range	+1.2 mm <2%, -0.3 mm <1%
Moisture Retention, Cl ⁻ form	48 - 54%
Reverible Swelling Cl ⁻ → OH ⁻	20% max.
Specific Gravity, moist Cl ⁻ Form	1.08
Total Exchange Capacity, Cl ⁻ form, wet, volumetric dry, weight	1.3 eq/l min. 3.7 eq/kg min.
Operating Temperature, Cl ⁻ Form	100°C (212°F) max.
Operating Temperature, OH ⁻ Form	60°C (140°F) max.
pH Range, Stability, OH ⁻ Form	0 - 13
pH Range, Operating, OH ⁻ Form	0 - 8

Standard Operating Conditions (Two-stage Demineralization, Co-flow Regeneration)				
Operation	Rate	Solution	Minutes	Amount
Service	8 - 40 BV/h 1.0 - 5.0 gpm/ft ³	Decationized water	per design	per design
Backwash	5 - 7.5 m/h 2.0 - 3.0 gpm/ft ²	Decationized water 10° - 40°C (50° - 105°F)	5 - 20	1.5 - 3 BV 10 - 25 gal/ft ³
Regeneration	2 - 4 BV/h 0.25 - 0.50 gpm/ft ³	4 - 6% NaOH	30 - 60	64 - 160 g/l 4 - 10 lb/ft ³
Rinse, (slow)	2 - 7 BV/h 0.25 - 0.50 gpm/ft ³	Decationized water	30 approx.	2 - 4 BV 15 - 30 gal/ft ³
Rinse, (fast)	8 - 40 BV/h 1.0 - 5.0 gpm/ft ³	Decationized water	20 approx.	3 - 6 BV 25 - 45 gal/ft ³
Backwash Expansion 50% to 75%				
Design Rising Space 100%				
"Gallons" refer to U.S. Gallon = 3.785 litres				

OPERATING PERFORMANCE

(Co-flow Operation)

Although the total exchange capacity of **Purolite A-400** is greater than 1.3 equivalents per liter (=28.4 Kgr/ft³) of resin bed, normal operating capacities lie in the range between 0.5 and 0.9 equiv./l (10.9 and 19.7 kgr/ft³ respectively). The operating capacity actually obtained is dependent on:

- a) the regeneration level used,
- b) the ratio of sulphate + carbonate to total anions,
- c) the ratio of silica to total anions, where the NaOH regenerant temperature is less than about 30°C, 86°F.

The data required to estimate base operating capacities under conditions a) & b) are given in Figs. 7 & 8. The operating capacity also depends upon the end point silica leakage as well as on c) above. Figs. 9 & 10 give correction factors to calculate the operating capacity obtainable. Base values for silica leakage are indicated in Fig. 3. The reciprocal correction factor for the effect of the influent sodium concentration on silica residuals is shown in Fig. 5, and that for the temperature of regenerant is shown in Fig. 6. (The base silica leakage should be divided by these factors to obtain the actual silica leakage.)

MIXED BED

While these graphs give a close approximation to the practical working of an individual column of **Purolite A-400**, mixed-bed operation can produce near-zero residuals. High quality water with a conductivity of 0.055µscm⁻¹ (18 megohm water), or better, can be obtained, provided that the inlet has previously been treated either using an efficient reverse osmosis system, or a two stage deionizer. This quality can be obtained even where there are traces of residual organics in the

deionized feed to the mixed bed. However, inefficiencies in separation of the cation and anion components, and consequent cross-contamination of the resins with traces of cations or anions respectively, may reduce the expected operating capacity by between 10 and 20%. For first time production of treated water of the highest quality, the user can select from our range of highly pre-regenerated mixed bed products (refer to our **NRW** and **PicoPure** series of products).

Standard Operating Conditions (Two-stage Demineralization, Counter-flow Regeneration)

Operation	Rate	Solution	Minutes	Amount
Service	8 - 40 BV/h 1.0 - 5.0 gpm/ft ³	Decationized water	per design	per design
Backwash	5 - 7.5 m/h 2.0 - 3.0 gpm/ft ²	Decationized water 10° - 40°C (50° - 105°F)	5 - 20	1.5 - 3 BV 11 - 22 gal/ft ³
Regeneration	2 - 4 BV/h 0.25 - 0.50 gpm/ft ³	3 - 6% NaOH	30 - 60	48 - 160 g/l 3 - 10 lb/ft ³
Rinse, (slow)	2 - 4 BV/h 0.25 - 0.50 gpm/ft ³	Decationized water	30 approx.	2 - 4 BV 15 - 30 gal/ft ³
Rinse, (fast)	8 - 40 BV/h 1.0 - 5.0 gpm/ft ³	Decationized water	20 approx.	3 - 6 BV 22 - 45 gal/ft ³
Backwash expansion recommended (when reqd.) 50% to 75%. It is generally recommended that the bed is at least loosened and suspended solids (if any), removed every 5 - 20 cycles. Design rising space (according to design) 10% min. "Gallons" refer to U.S. Gallon = 3.785 litres				

OPERATING PERFORMANCE (Counter-flow Operation)

Purolite A-400 is recommended where counter-flow operation is indicated - that is where low leakages and improved operating capacity are needed. Its high resistance to attrition under the recommended operation conditions ensures a treated water of the highest quality obtainable from this mode of operation. Such water can be low in both residual ions, and particulate matter. The treated water obtainable is especially suitable for further processing.

Purolite A-501P may be used where necessary to remove residual colloids. Polishing mixed bed units using either gel **Trilite**, (**Purolite C-100 x 10TL**, **C-**

100TL, **A-400TL**) or macroporous **Trilite** (**Purolite C-150TL**, **A-500TL**) systems may be combined with UV filter and ultrafiltration to produce ultrapure water.

The data required to estimate operating capacities under a general range of conditions are given in Figs. 11 & 12. Correction factors for silica end point leakage, and silica to total anions ratio are given in Figs 13 & 14. Base values for silica leakage are indicated in Fig. 4 while the reciprocal factors for the influent sodium concentration on silica residuals is shown in Fig. 5, and that for temperature correction given in Fig. 6.

REGENERATION

Purolite A-400 is supplied in the chloride form and must be regenerated with a good grade of sodium hydroxide. Efficient completion of the regeneration with a displacement rinse at the same flow rate, will ensure that rinse volumes required to produce treated water of satisfactory quality during the subsequent fast rinse stage are extremely low.

Where the ratio of silica to total anions in the feed solution is high, for example where the strong base anion unit is positioned after a weak base anion unit, the use of warm caustic soda will reduce silica leakage, and will prevent build-up of silica in the resin. For maximum efficiency the resin bed should be preheated prior to regeneration. This is particularly important where the temperature differential between the influent water and the regenerant is large. Rinsing with warm water is also recommended.

HYDRAULIC CHARACTERISTICS

The pressure drop (headloss) across a properly classified bed of ion-exchange resin depends on the particle size distribution, bed depth, and void volume of the exchanger, as well as 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 **Purolite A-400** are given in Fig.1, below, for a range of operating flowrates.

Fig. 1 PRESSURE DROP VS FLOW RATE

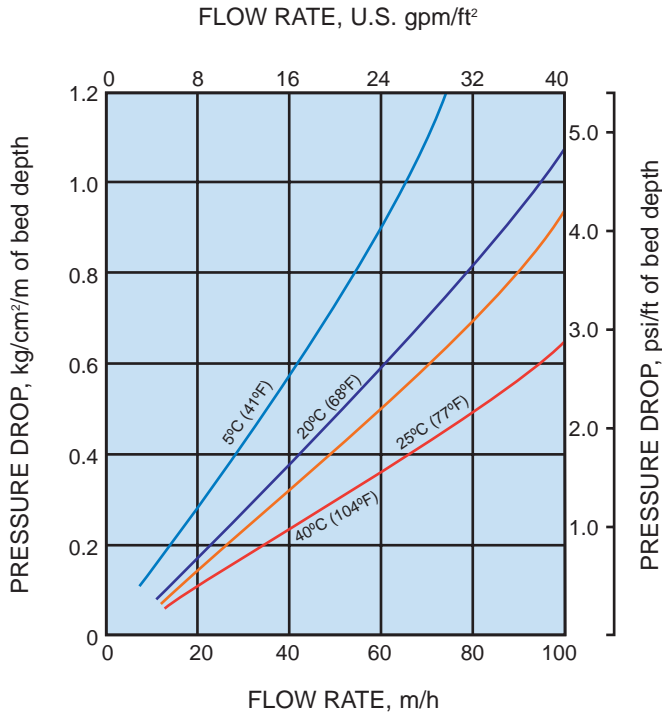
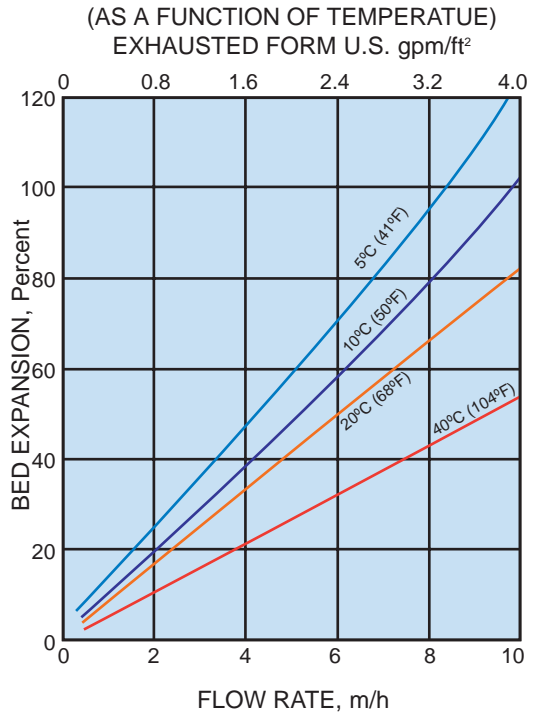


Fig. 2 BACKWASH EXPANSION



During backwash, the resin bed should be expanded in volume by 50 to 75%, at least, in order to free it from any particulate matter removed from the influent solution, to clear the bed of bubbles and irregular 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 carry over 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.

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 ₂ O/ft

CHEMICAL AND THERMAL STABILITY

Purolite A-400 is insoluble in dilute or moderately concentrated acids, alkalis, 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 resin and break down the crosslinking. This can reduce the ion exchange capacity or increase the moisture retention of the resin, decreasing its mechanical strength, and should be avoided. This resin, like all conventional polyvinylbenzyl quaternary ammonium resins is thermally unstable

in the hydroxide form under alkaline conditions, and at temperatures over about 70°C, 160°F, breaks down by two parallel mechanisms. The first results in nitrogen loss (and hence loss of capacity), while the second path results in the formation of weak-base groups. The recommended maximum operating temperature permits an economic half-life without significant loss of capacity. The salt forms of the resin are at least two orders of magnitude more stable, but can still break down at higher temperatures with loss of strong-base capacity.

OPERATING CAPACITY CALCULATION

If the influent water analysis is known, and service flowrate, regeneration level, the treated 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 silica 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	TREATMENT																								
<table style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 10%;"></th> <th style="text-align: center;">ppm CaCO₃</th> <th style="text-align: center;">meq/l</th> <th style="text-align: center;">Total Anions %</th> </tr> </thead> <tbody> <tr> <td>Cl</td> <td style="text-align: center;">45</td> <td style="text-align: center;">0.9</td> <td style="text-align: center;">41</td> </tr> <tr> <td>SO₄</td> <td style="text-align: center;">50</td> <td style="text-align: center;">1.0</td> <td style="text-align: center;">45</td> </tr> <tr> <td>SO₂</td> <td style="text-align: center;">5</td> <td style="text-align: center;">0.1</td> <td style="text-align: center;">5</td> </tr> <tr> <td>SiO₂</td> <td style="text-align: center;"><u>10</u></td> <td style="text-align: center;"><u>0.2</u></td> <td style="text-align: center;"><u>9</u></td> </tr> <tr> <td>Total</td> <td style="text-align: center;">110</td> <td style="text-align: center;">2.0</td> <td style="text-align: center;">100</td> </tr> </tbody> </table>		ppm CaCO ₃	meq/l	Total Anions %	Cl	45	0.9	41	SO ₄	50	1.0	45	SO ₂	5	0.1	5	SiO ₂	<u>10</u>	<u>0.2</u>	<u>9</u>	Total	110	2.0	100	<p>Regeneration with NaOH at : 80 g/l, (5 lb/ft³) Co-flow, at Temp : 25°C, 77°F Flow rate : 40 BV/h, 5 gpm/ft³ Sodium leakage : 0.40 ppm as CaCO₃ (ex-cation bed) End Point SiO₂ leakage = 100 ppb (above permanent leakage)</p>
	ppm CaCO ₃	meq/l	Total Anions %																						
Cl	45	0.9	41																						
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<p>CAPACITY CALCULATION</p> <p>For a feed with 45% sulphate and 5% CO₂, divalent ions equals 50%. Fig. 3 shows: Base operating capacity C_B for 80g/l (5lb/ft³) of NaOH, for 50% divalent ions at 25°C, 77°F</p> <p style="text-align: center;">= 0.58 eq/l, 12.7 Kgr/ft³.</p> <p>Correction Factors for end point silica leakage of 100 ppb, (Fig. 9)</p> <p style="text-align: center;">C₁ = 0.94</p> <p>and 9% SiO₂ (Fig. 10)</p> <p style="text-align: center;">C₂ = 0.99</p> <p>Hence operating capacity</p> <p style="text-align: center;">= C_B x C₁ x C₂</p> <p>0.58 x 0.94 x 0.99 = 0.54 eq/l, 11.8 Kgr/ft³.</p> <p>Applying the customary engineering design factor of 0.9, the operating capacity obtainable</p> <p style="text-align: center;">= 0.54 x 0.9 = 0.49 eq/l, = 10.6 Kgr/ft³</p>	<p>SILICA LEAKAGE</p> <p>Base silica B_S for 80g NaOH/l, (5lb/ft³) at 9% SiO₂/Total Anions</p> <p style="text-align: center;">= 15 ppb (Fig. 3)</p> <p>Correction factor* for Na leakage</p> <p style="text-align: center;">K₁ = 0.94 (Fig. 5)</p> <p>Correction factor* for NaOH Temp. at 9% SiO₂ (Fig. 6)</p> <p style="text-align: center;">K₂ = 0.72</p> <p>Operational silica leakage</p> <p style="text-align: center;">= B_S / K₁ x K₂ = 15 / 0.94 x 0.72 = 22 ppb</p> <p>NOTE:</p> <p>In cases where an intermediate regeneration level and % silica of total anions is required, please interpolate.</p> <p>* Reciprocal correction factors in this example</p>																								

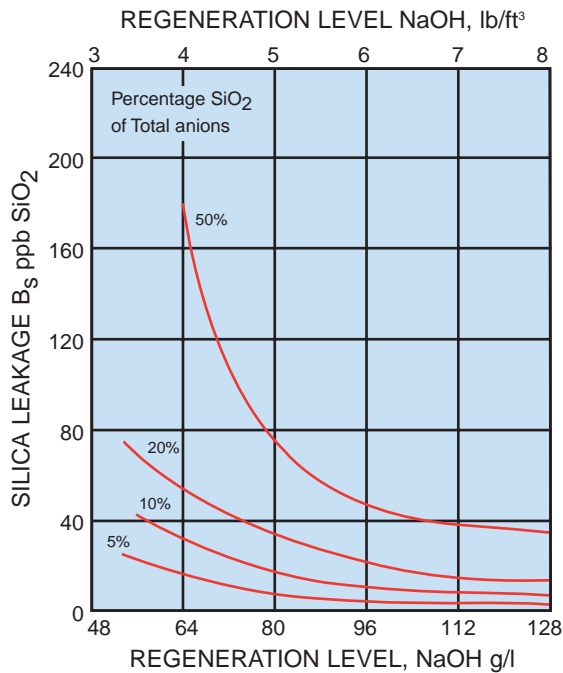
PLANT DESGN

If, as is often the case, silica leakage in the treated water is part of the specification, the operating silica leakage required should be corrected by multiplying by K_1 (correction for sodium) and K_2 (correction for temperature of regenerant) to derive the necessary base leakage B_L . Thus the regeneration level which gives B_S is found from interpolation of Figs. 3, 4, 7 or 8 as appropriate. The

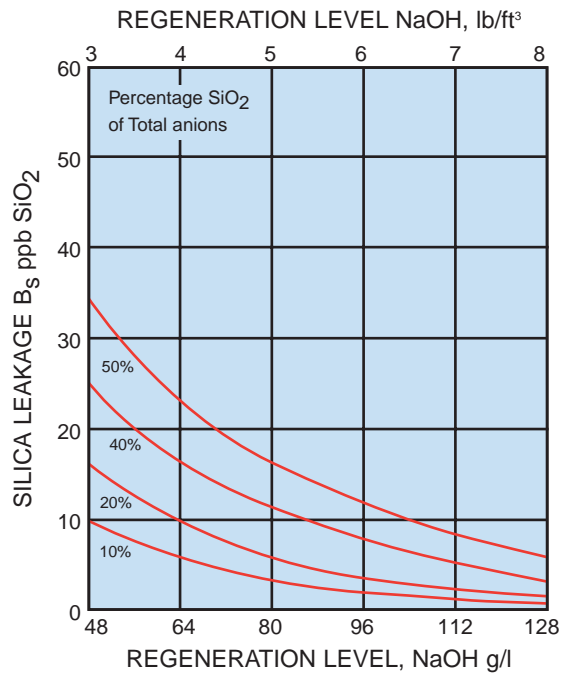
operating capacity is then calculated as in the example previously given. It may of course be necessary to modify the first design calculation to take account of factors other than those mentioned above: such as, flow rate to be within the required limits and neutral effluent requirements, or other possibilities.

PUROLITE A-400 - SILICA LEAKAGE (Co-flow Regeneration using Sodium hydroxide)

**Fig. 3 BASE SILICA LEAKAGE
CO-FLOW REGENERATION**



**Fig. 4 BASE SILICA LEAKAGE
COUNTER-FLOW REGENERATION**



Correction factors to Base Silica Leakage (Co-flow and Counter Flow regeneration)

Fig. 5 SILICA LEAKAGE

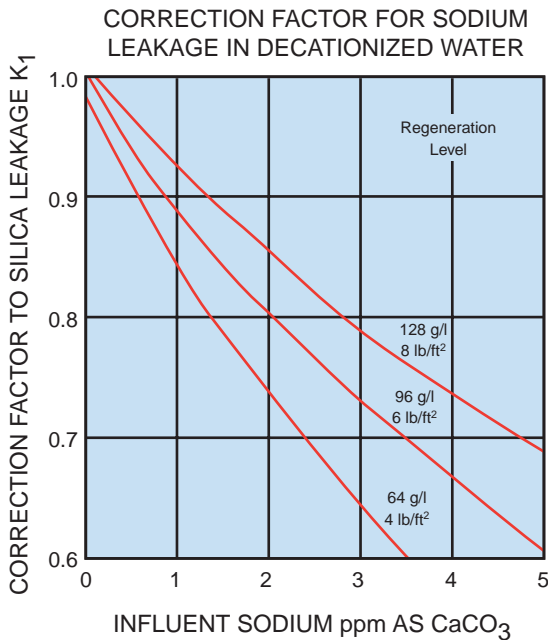
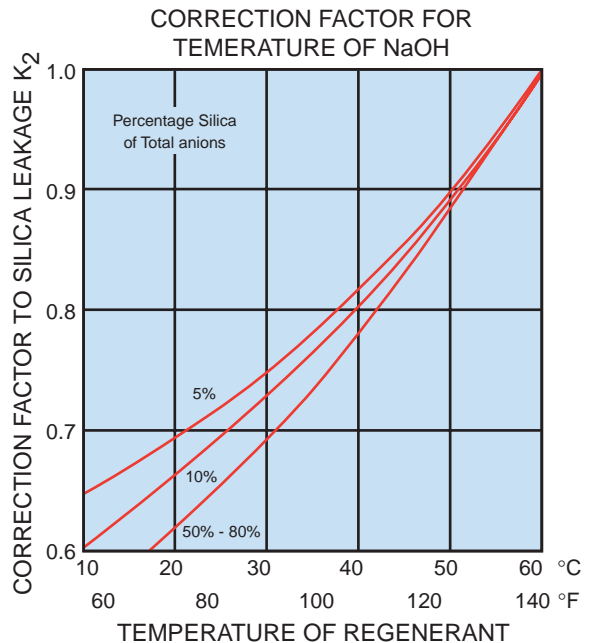


Fig. 6 SILICA LEAKAGE



PUROLITE A-400 (CO-FLOW REGENERATION)

Fig. 7 BASE OPERATING CAPACITY

FOR REGENERANT TEMPERATURE OF 25°C* (75°F)
REGENERATION LEVEL NaOH, lb/ft³

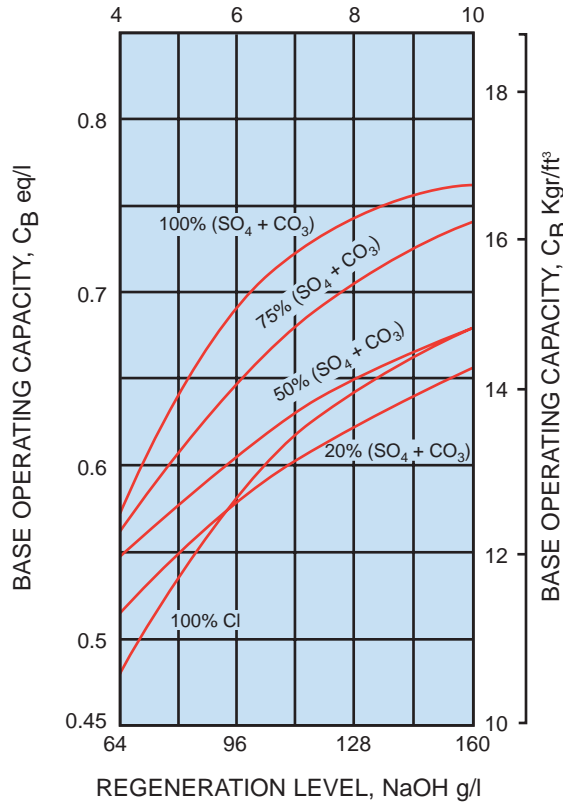


Fig. 8 BASE OPERATING CAPACITY

FOR REGENERANT TEMPERATURE OF 45°C* (120°F)
REGENERATION LEVEL NaOH, lb/ft³

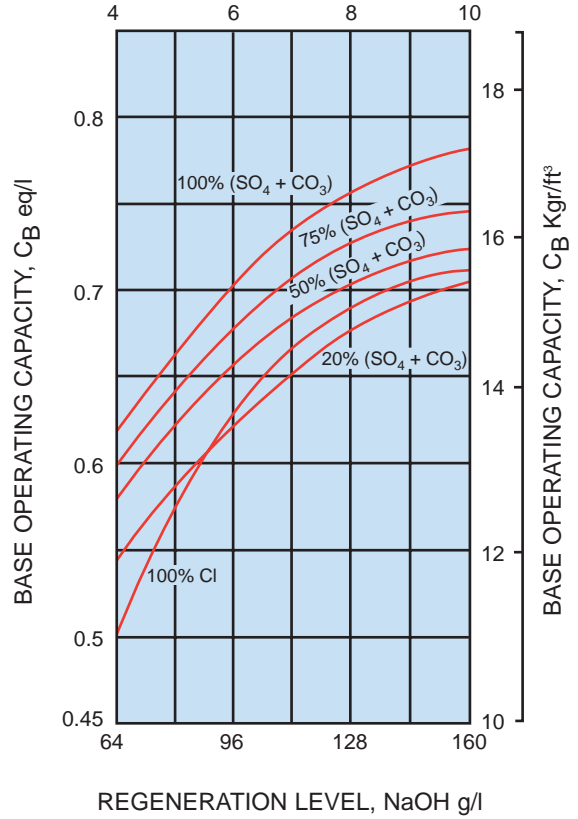


Fig. 9 CORRECTION FACTOR

FOR SILICA END POINT LEAKAGE

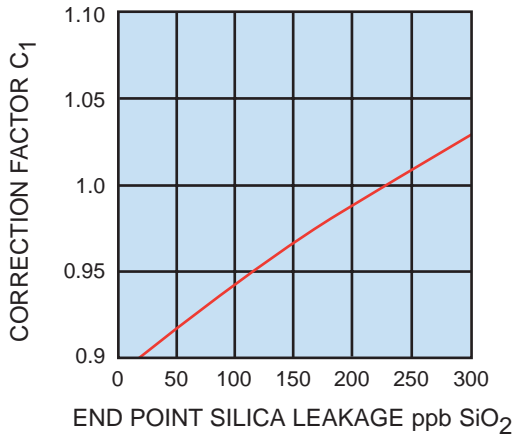
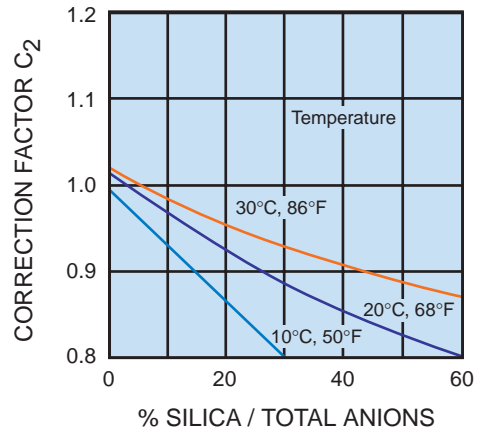


Fig. 10 CORRECTION FACTOR

FOR % SILICA / TOTAL ANIONS**



*Interpolate for temperatures between 25°C and 45°C

**Applicable to Regeneration at temperatures up to 30°C, 86°F. Correction for higher temperatures not required

PUROLITE A-400 (COUNTER-FLOW REGENERATION)

Fig. 11 BASE OPERATING CAPACITY

FOR REGENERANT TEMPERATURE OF 25°C* (75°F)
REGENERATION LEVEL NaOH, lb/ft³

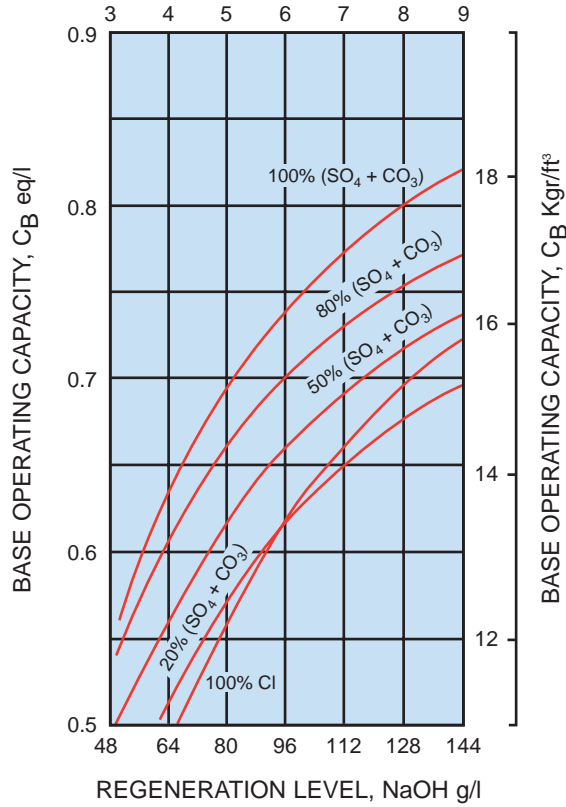


Fig. 12 BASE OPERATING CAPACITY

FOR REGENERANT TEMPERATURE OF 45°C* (120°F)
REGENERATION LEVEL NaOH, lb/ft³

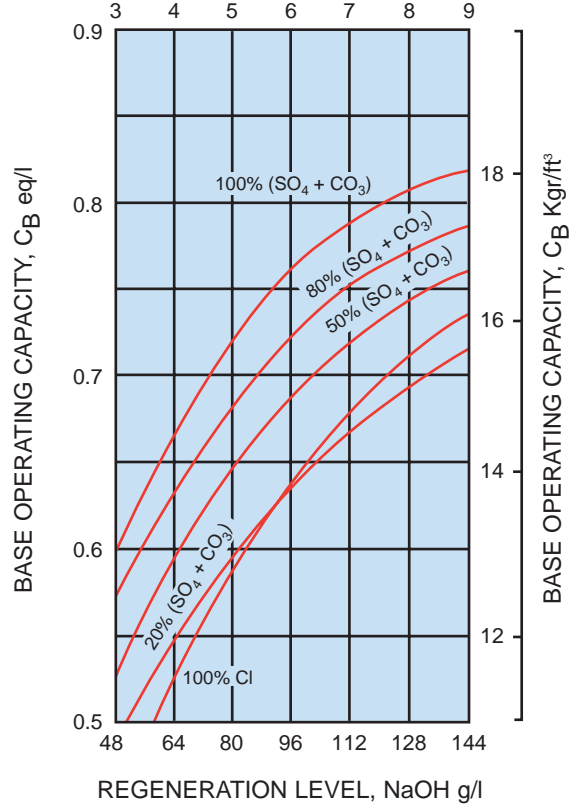


Fig. 13 CORRECTION FACTOR

FOR SILICA END POINT LEAKAGE

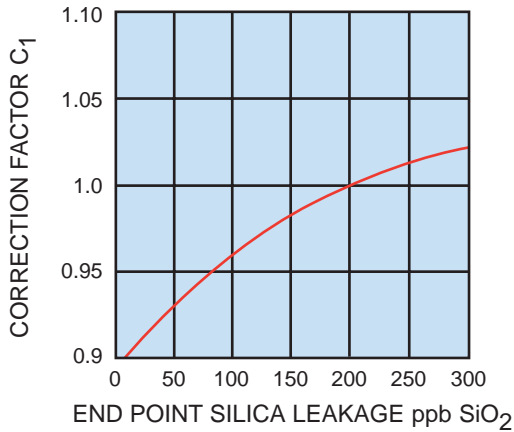
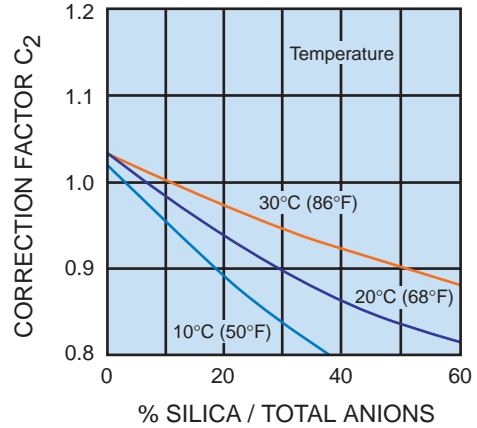


Fig. 14 CORRECTION FACTOR

FOR % SILICA / TOTAL ANIONS**



*Interpolate for temperatures between 25°C and 45°C

**Applicable to Regeneration at temperatures up to 30°C, 86°F. Correction for higher temperatures not required

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