

C-104
Weak Acid
Cation Exchange Resin

(For use in the deionization and softening of water and aqueous organic solutions)

Technical Data

PRODUCT DESCRIPTION

Purolite C-104 is a gel-type polyacrylic weak acid cation exchanger. The functional groups of the carboxylic type give high chemical efficiency in many applications, especially for the removal of bicarbonate alkalinity in water treatment, showing good rates of exchange. Its major use is in the dealcalization and softening of waters and thereby the ionic load on the subsequent strong acid resin bed can be reduced. Because it has a lower density than the conventional strong acid resins, **Purolite C-104** is ideal for use in layered beds (Doublite) which can be economically regenerated by an upflow countercurrent technique. This product has also been used to selectively recover transition metals from aqueous solutions. The resin is insoluble in acids, alkalies, and all common solvents. Its physical characteristics are outstanding,

and often permit its use where a macroporous resin might otherwise be indicated.

Hence **Purolite C-104** may be operated successfully at relatively high temperatures, e.g. in sugar treatment. However, the macroporous polyacrylic weak acid cation exchanger **Purolite C-106** is generally recommended where it is required to work between the acid and the highly-swollen alkali salt form (for example in the treatment of ammoniacal condensate waters or high solids softening).

Weakly acidic cation resins are increasingly being used in special applications including treatment of waste water streams in order to reduce environmental pollution.

Typical Physical & Chemical Characteristics	
Polymer Matrix Structure	Acrylic-Divinylbenzene
Physical Form and Appearance	Translucent Amber spherical beads
Whole Bead Count	95% min.
Functional Groups	R-COOH
Ionic Form, as shipped	H ⁺
Shipping Weight (approx.)	745 g/l (47 lb/ft ³)
Screen Size Range: - U.S. Standard Screen	16 - 50 mesh, wet
Particle Size Range	+1.2 mm <5%, -0.3 mm <1%
Moisture Retention, H ⁺ form	44 - 55%
Reversible Swelling H ⁺ → Na ⁺ H ⁺ → Ca ⁺⁺	85% 20% max.
Specific Gravity, moist H ⁺ Form moist Ca ⁺⁺ Form	1.18 1.20
Total Exchange Capacity, H ⁺ form, wet, volumetric dry, weight	4.3 eq/l min. 9.8 eq/kg min.
Operating Temperature, H ⁺ Form	120°C (248°F) max.
pH Range, Stability	0 - 14
pH Range, Operating	5 - 14

Standard Operating Conditions				
Operation	Rate	Solution	Minutes	Amount
Service	8 - 40 BV/h 1.0 - 5.0 gpm/ft ³	Influent water	per design	per design
Backwash	Refer to Fig. 2	Influent water 20°C (68°F)	5 - 20	2 - 8 BV 15 - 60 gal/ft ³
Regeneration	4 - 8 BV/h 0.5 - 1 gpm/ft ³	1 - 4% HCl	30 - 45	100 - 120% of theory
	8 - 20 BV/h 1 - 2.5 gpm/ft ³	0.5 - 1% H ₂ SO ₄		
Rinse, (slow)	same as regeneration	Water (influent or decationized)	15 approx.	2 - 4 BV 15 - 30 gal/ft ³
Rinse, (fast)	10 - 40 BV/h 1.25 - 5.0 gpm/ft ³	Water (influent or decationized)		3 - 6 BV 22 - 45 gal/ft ³
Backwash Expansion 50% to 75% Design Rising Space 100% Minimum bed depth 700 mm (30 inches) "Gallons" refer to U.S. Gallon = 3.785 liters				

REGENERATION

When **Purolite C-104** is exhausted with a high amount of hardness, it is best regenerated with hydrochloric acid to avoid precipitation. However, due to availability and cost, this may not be convenient, and sulphuric acid can be used. Operating capacity and treated water quality are essentially unaffected provided that the regenerant concentration is kept below 0.8%. Alternatively, stepwise regeneration can be used. This will reduce regenerant

volumes and consequently slightly reduce the acid consumed in neutralizing the alkalinity in the water used for regeneration. The maximum concentration of sulphuric acid recommended for stepwise regeneration procedures is 1.5%. The higher concentration should be used for the second half of the regenerant quantity. Concentrations higher than 1.5% can only be used when the hardness (particularly calcium) loading is low.

HYDRAULIC CHARACTERISTICS

The pressure drop (or headloss) across a properly classified bed of ion exchange resin depends on the particle size distribution, bed depth, and voids volume of the exchange material, as well as on the flowrate and viscosity (and hence on the temperature) of the influent solution. Factors affecting any of these parameters, for example the presence of particulate matter filtered out by the bed, abnormal compressibility of the resin, or the

incomplete classification of the bed, will have an adverse effect, and result in an increased headloss.

Depending on the quality of the influent water, the application and the design of the plant, service flow rates may vary from 10 - 40 bed volumes/hour (1-5 gpm/ft³). Typical pressure drop data is given in Fig. 1.

Fig. 1 PRESSURE DROP VS FLOW RATE

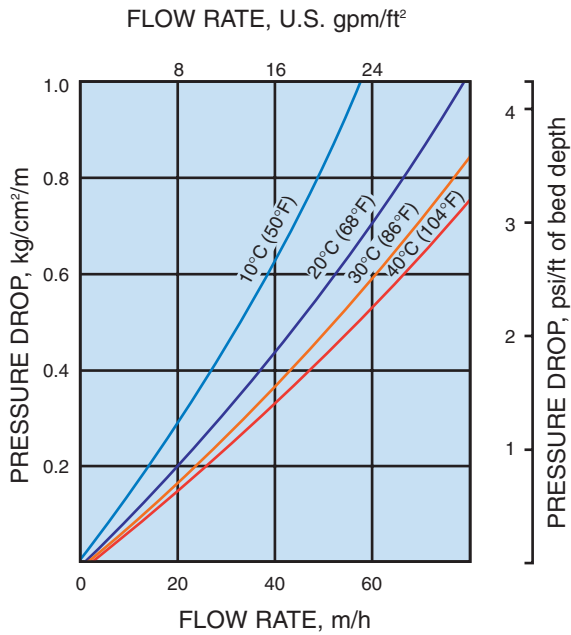
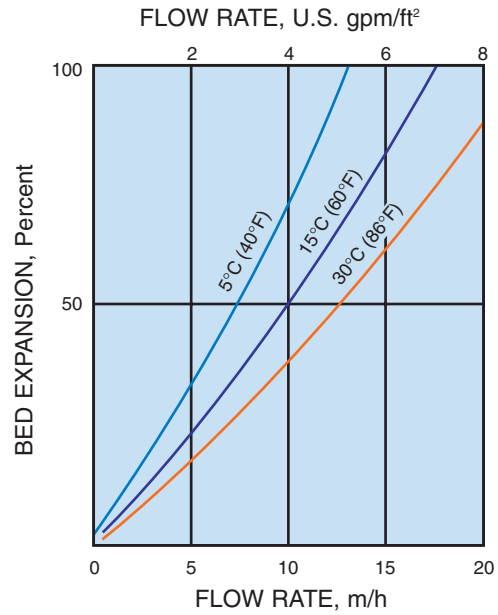


Fig. 2 BACKWASH EXPANSION
Ca/Mg EXHAUSTED FORM



During upflow backwash, the resin bed should be expanded in volume by between 50 and 70%. This operation will free it from any particulate matter, clear the bed of bubbles and voids, and reclassify the resin particles, ensuring minimum resistance to flow. Bed expansion increases with flow rate and decreases with temperature, as shown in Fig. 2. for the exhausted

(Ca⁺⁺/Mg⁺⁺) form of the resin. Bed expansion of the resin in the H⁺ form is generally higher by about 10 - 15% for a given flowrate, but a 50% increase in flowrate is required for a similar bed expansion in the more highly swollen Na⁺ form of **Purolite C-104**. Care should always be taken to avoid resin loss by 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

PROPERTIES OF WEAKLY ACIDIC CATION RESINS

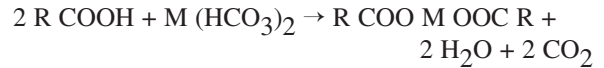
The behavior of weakly acidic cation resins is markedly different from strongly acidic cation resins which show essentially the same capacity for the uptake of cations over a wide pH range. The amounts of acid required to regenerate the latter to the hydrogen form are considerable, especially when they are loaded with multivalent ions, which are often preferentially held. In contrast, carboxylic groups are

almost completely nonionized in mildly acidic or neutral conditions. In pure water, a commercial monofunctional carboxylic resin such as **Purolite C-104** will have less than one in a hundred of its carboxylic groups ionized to give a hydrated hydrogen ion. Thus while it will show under appropriate conditions very high selectivity for multivalent ions, and indeed acts as a chelating

resin for certain of them, e.g. Fe⁺⁺⁺, UO₂⁺⁺, or Cu⁺⁺, it can readily be regenerated with near stoichiometric amounts of acid, providing a concentrated regenerant effluent as a result of excellent chemical efficiency.

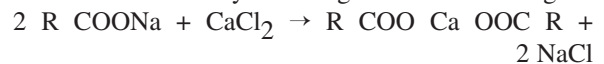
The analogous weak base resins have found widespread application in the removal of organic acids from sugar solutions, and in water treatment for the removal of mineral acids from the first (cation) stage of two-bed demineralization. Consequently, their use in lessening the load on the following strong base anion exchange bed, and thereby enabling higher quality water to be obtained without an increase in regenerant level, is well understood. Not so well understood, perhaps, is the corresponding use of the weak acid resins to lighten the load on the strong acid resin columns in multi-bed systems; although many raw waters for public water supplies contain appreciable amounts of multivalent ions, often in conjunction with bicarbonate alkalinity.

In the hydrogen form **Purolite C-104** eliminates all the hardness ions(M) associated with bicarbonate alkalinity by the reaction:



The aqueous carbon dioxide provides an acid of a strength significant compared to that of the resin, thus preventing the reaction from going to completion, as in the normal neutralization of bicarbonates. The net result is that hardness ions associated with mineral acids are not removed from the solution.

In the sodium form, there is a higher selectivity for (e.g.) calcium than is shown by the strong acid cation exchangers:



Regeneration of the exhausted form is virtually stoichiometric:



APPLICATIONS

Purolite C-104E is a specially prepared weak acid cation resin which has been purified to meet the taste and odor requirements for food and potable water applications. These resins can be so used with the minimum amount of pretreatment after a period of storage, and with no additional treatments during the operational life, provided the resins are in continuous use. However, it should be pointed out that, for reasons of health and safety, it is not permissible to render toxic water supplies potable by treatments which exceed the recommendations of the FDA or FIRA. Care should be taken to ensure that high quality regenerants are always used.

Exposure to strong oxidizing agents causes irreversible damage. Levels should be kept to a minimum.

When intermittently used, the resins should be stored in the fully regenerated form under water.

Special grades of **Purolite C-104** are also available for various applications. These special grades include **Purolite C-104DL**, for use in layered beds (Doublite systems). **Purolite C-104DL** is positioned above **Purolite C-100DL** or **Purolite C-100X10DL**. The system is used to optimize the hardness removal of an influent stream containing a high amount of bicarbonate alkalinity. The most efficient version uses counter current regeneration with dilute acid. Alternatively, a centre collector allows for separate regeneration of the two layers. **Purolite DL** systems are specially graded to optimize separation during backwash. **Purolite C-104S** is recommended for use in deionization of sugar solutions, and **Purolite C-104C** is recommended for high flow rate applications.

Standard grades are generally used for either softening or demineralization of water in a number of different ways. These are described in more detail under "operating capacity" as follows:

OPERATING CAPACITY

In the field of water treatment, the operating capacity of a unit containing a carboxylic resin is a function of a number of variables. Their significance depends on which mode of operation is to be used. The different modes to be considered are conveniently described as:

- a) dealkalization
- b) partial decationization
- c) acid cycle softening
- d) sodium cycle softening

The first and most important set of variables is related to the influent solution and the conditions under which it is being treated. The ionic composition (and particularly the pH), temperature, and flowrate are all independent variables.

The composition is usually expressed in terms of total hardness (TH) and temporary hardness, otherwise known as "bicarbonate alkalinity", together with the "equivalent mineral acidity" (EMA), which is in fact that portion of the total cations associated with the anions of

strong “mineral” acids. The total “alkalinity”, (ALK), of an influent water is yet another parameter, in this case the portion of the total cations associated with hydroxide and carbonate, as well as the bicarbonate anions. In the dealkalization mode, operating capacity is usually taken to a fixed breakthrough of typically 10% of influent alkalinity.

Reference to Fig. 3 shows that the operating capacity(Q) for removal of metal ions associated with alkalinity, (mode (a) above), is highly dependent upon the ratio of total hardness to alkalinity (α). This dependence arises because the selectivity of weakly acidic cation resins for hardness ions is high compared to that for monovalent cations, a property which affects the nature of the chromatographic front (i.e. whether self-sharpening or diffuse) in any column absorption or separation process. The ratio α determines whether the bicarbonate front moving down the column is associated with alkali metal cations, or alkaline earth metal cations (sodium or cal-

cium/magnesium in normal raw waters). The latter give a much sharper front, since the equilibrium is more favorable. The ratio, α , is thus a parameter of significance, (as can be seen from Fig. 3).

It is worth noting that α values around unity will tend to result in irreproducible operating capacities, arising from quite small fluctuations in influent composition. However, the use of the recommended regeneration level of 105% of the average operating capacity as standard is self-adjusting, because of the higher efficiency of both regeneration and loading profiles in the resin. Correction factors for the effect of temperature of the influent and for the effect of flow rate are given in Figs. 4 and 5 respectively.

Hence actual operating capacity is given by multiplying the capacity obtained in Fig. 3 by factors C_1 and C_2 from Figs. 4 and 5 in turn. The usual engineering design factor of 0.9 should also be applied.

REGENERANT QUANTITY

If Q is the operating capacity in eq/l, the amount of HCl needed to regenerate will be 38.3 Q grams of 100% HCl per liter of resin the amount of H_2SO_4 needed to regenerate will be 55.38 Q grams of 93% H_2SO_4 per liter of resin.

If Q is the operating capacity in Kgr/ft³ the amount of HCl needed will be 0.1092 Q Lbs of 100% HCl per cubic foot or 0.1572 Q Lbs of 93% H_2SO_4 per cubic foot of resin.

When sulphuric acid is used, the lower concentrations and more rapid flow rates are recommended to prevent precipitation of calcium sulphate in the resin bed. For the same resin, the recommended regeneration flow rates should be used. The resin bed should not be allowed to stand in a part-regenerated form in the presence of the regenerant sulphuric acid. If nitric acid is being considered for regeneration then please contact the technical group at Purolite.

It should be noted that higher capacities may be obtained depending upon the level of leakage of cations which is acceptable in the treated solution. This partial decationization (mode (b) above) can give operating capacities up to 20% higher than those given for standard dealkalization. It follows that alkalinity leakage will accompany the excess cation leakage.

Where softening of the influent is the objective, the use of weak acid cation resins should be considered as an alternative to conventional softening. It has the advantage that the total dissolved solids will be reduced at least by the level of temporary hardness in the influent. This

can produce a treated water more suitable for certain cleaning and washing processes than that obtained from traditional softening. Where the ratio α is less than unity, **Purolite C-104** will remove hardness to a low level and produce water with a pH between 3.5 - 8 when regenerated with acid as described above. The operating capacity obtainable is 3 eq/l (independent of α , but temperature and flow rate corrections still apply). This application is termed acid cycle softening, (mode (c) above). Where α is more than unity only partial softening (temporary hardness removal) is obtained. In order to obtain permanent hardness removal, standard softening using the **Purolite C-100** series of products should follow the acid cycle softening. Operating capacity is identical to that for dealkalization and standard softening respectively.

Alternatively, complete hardness removal can be achieved by means of a single bed of weak acid cation resin by using a two step regeneration process. The exhausted resin is first regenerated with relatively high levels of acid (150 g/l, 9 lbs/ft³), and this is followed by sodium carbonate (160 g/l, 10 lbs/ft³), (mode (d) above).

Softening in the sodium cycle requires that the acid-regenerated form is converted directly to the working sodium form. Since **Purolite C-104** has an expansion of around 90% when converted from the hydrogen form to the sodium form, the resin is not specifically recommended for use in this mode. **Purolite C-106** is the resin of choice especially for high solids softening (Expansion only 60%).

Fig. 3 OPERATING CAPACITY VS TH/ALK RATIO, α

AT 20°C, FLOWRATE 15BV/h, INFLUENT ALK = 4 meq/l

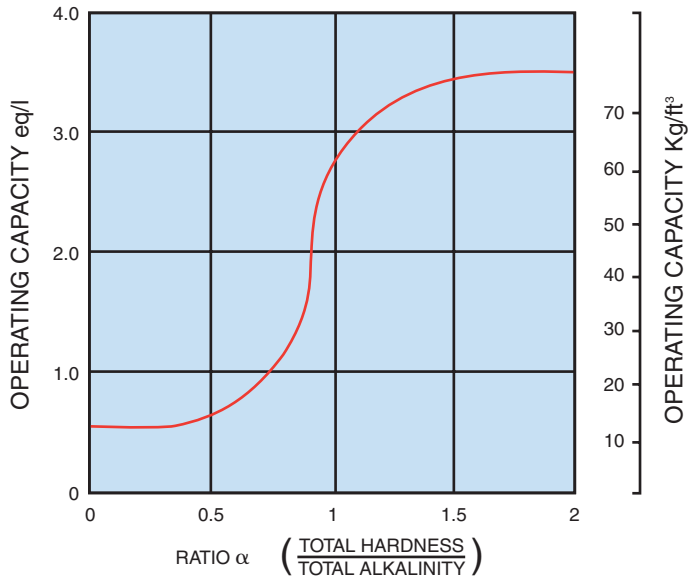


Fig. 4 TEMPERATURE CORRECTION FACTOR

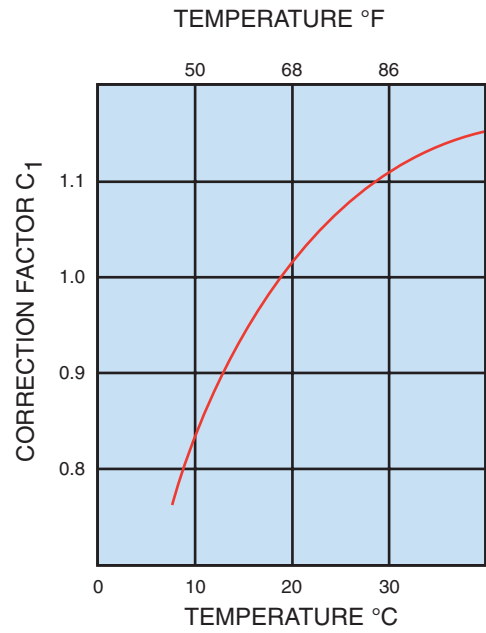
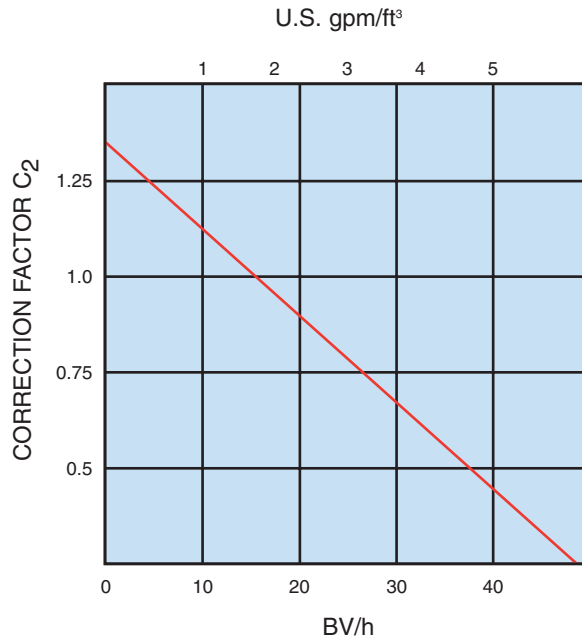


Fig. 5 FLOWRATE CORRECTION FACTOR



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