Used primarily for water dealkalization and demineralization, Purolite® C104Plus and Purolite® C104EPlus are premium industrial and food grade, porous, polyacrylic, weak acid cation exchange resins supplied in the hydrogen form. This Engineering Bulletin provides design and engineering information, as well as regeneration processes using hydrochloric or sulfuric acid.
This Engineering Bulletin presents information and engineering data for using Purolite® C104Plus and Purolite® C104EPlus in dealkalization plants or as part of the demineralization process. Information is also provided on regenerating the resin with hydrochloric acid or sulfuric acid. For more detailed information on any product or to find a product for an application not mentioned, please go to www.purolite.com or see the back cover to contact the closest Purolite regional office near you.

INTRODUCTION

Founded in 1981, Purolite is a leading manufacturer of ion exchange, catalyst, adsorbent and specialty resins. With global headquarters in the United States, Purolite is the only company that focuses 100% of its resources on the development and production of resin technology.

Responding to the needs of our customers, Purolite has built the largest technical sales force in the industry, the widest variety of products and five strategically located Research and Development groups. Our ISO 9001 certified manufacturing facilities in the U.S.A, Romania and China combined with more than 40 sales offices in 30 countries ensure complete worldwide coverage.

PREMIER PRODUCTS

The quality and consistency of our products is fundamental to our performance. Throughout all Purolite plants, production is carefully controlled to ensure that our products meet the most stringent criteria, regardless of where they are produced.

RELIABLE SERVICE

We are technical experts and problem solvers. Reliable and well trained, we understand the urgency required to keep businesses operating smoothly. Purolite employs the largest technical sales organization in the industry.

INNOVATIVE SOLUTIONS

Our continued investment in research & development means we are always perfecting and discovering innovative uses for ion exchange resins and adsorbents. We strive to make the impossible possible.
Purolite® C104Plus is an industrial grade, porous, polyacrylic, weak acid cation exchange resin. There are many applications for this type of resin, but dealkalization is the principal application in industrial water treatment. Dealkalization using ion exchange resins removes temporary hardness (calcium and magnesium ions that are present in almost all natural raw waters and are associated with bicarbonate or alkalinity) and can be performed in two ways. First, it can be done in conjunction with a degassing tower and water softener to produce lower TDS totally softened water. Here, the degasser also removes bicarbonate from the water, which has been converted to carbonic acid by the resin. Second, resin can be part of a demineralization plant where the resins not only remove temporary hardness but also reduce acid consumption, which leads to a reduction in system operating costs.

This document provides design information and engineering data for the above applications where the resin is regenerated with either sulfuric acid or hydrochloric acid upon exhaustion. Alternative processes, such as sodium cycle softening on high TDS waters and the removal of heavy metals from waste waters are also important applications for this resin, but they are not covered in this bulletin.

With all synthetic weak acid cation resins, the swelling and shrinkage between different ionic forms can be significant. The resin is normally supplied in the H+ form, and in conventional dealkalization it expands significantly into the exhausted calcium and magnesium forms. In applications where it is converted to the sodium the expansion is significantly greater. This expansion must be taken into account in design calculations.

| Table 1 – Typical physical and chemical characteristics |
|---------------------------------|------------------------------------------------------|
| Polymer structure | Porous cross-linked polyacrylic |
| Physical form | Spherical beads |
| Functional groups | Carboxylic acid |
| Ionic form, as shipped | H+ |
| Total capacity, H+ form | 4.5 eq/l (98.3 Kgr/ft³) minimum |
| Moisture retention, H+ form | 45 – 55% |
| Particle size range | 300 – 1600 μm (1% maximum < 300 μm) |
| Reversible swelling, H+ → Ca+ | Normal exhaustion 7% (approx.). Full conversion 20% maximum |
| Reversible swelling, H+ → Na+ | 70% (maximum) |
| Specific gravity, Na+ form | 1.19 (approximately) |
| Shipping weight, H+ form | 740 – 780 g/l (46.3 – 48.8 lb/ft³) |
| Maximum temperature limit | 120 °C (250 °F) |
Available grades

Purolite C104Plus is available from Purolite in the following grades:

Single bed applications

- Purolite® C104Plus is a standard grade resin with a Gaussian particle size distribution in the range of 300 – 1600 μm. Its principal application is in co-flow and traditional counter-flow regenerated plants where classification of the bed inside the operating vessel is possible (as in air hold-down, water hold-down and split-flow systems).
- Purolite® C104CPlus is a modified grade with a 425 – 1600 μm particle size range for use in high flow rate applications where standard-grade resin would present an unacceptable high pressure drop across the bed.
- Purofine® PFC104Plus is a uniform particle size product with a mean particle size of 570 μm and a uniformity coefficient of 1.1 – 1.2, offering improved capacity, leakage, pressure drop performance and rinse water requirements in softening and demineralization systems.
- Puropack® PPC104Plus is a uniform grade product, with a slightly higher uniformity coefficient. This product has been specifically developed for the Puropack system and other packed bed designs employing either up-flow or down-flow service operation. This resin is also widely used in co-flow and other counter-flow engineering designs where enhanced performance is required etc.

Dual layer (stratified bed) applications

- Purolite® C104DLPlus is a specially designed fine-grade resin with a particle size range of 300 – 850 μm. Its principal application is in layered bed cation units where no division plate is employed, and both the weak acid cation and strong acid cation resins are within the same column, but must remain separate during both service operation and regeneration. It is normally used in conjunction with coarse DL grade Purolite strong acid cation resins such as Purolite C100DLH and C100x10DLH to ensure the two components remain separate at all times.

When a division plate is used to keep both the strong acid and weak acid resins separate within a layered bed, Puropack® PPC104Plus and other strong acid packed bed grades such as PPC100H are most practical.

Specialty applications

- Purolite® C104EPlus is a “food grade” resin widely used in producing water for potable / food / soft drinks and brewing applications. It is available in most of the above grades and is manufactured to order.

In most conventional processes, the weak acid cation is always located upstream of the strong acid cation column. When the strong acid cation resin is a softener and regenerated with salt (brine solution), the degasser can be located either before or after the softener (strong acid cation bed).

However, when weak acid cation resin is part of a demineralization plant, the strong acid cation bed (which is also acid regenerated) is located after the weak acid cation bed—and always prior to the degasser tower when located in a separate unit. This is because the working capacity of a strong acid cation bed operating in the hydrogen cycle is higher when operating in the more acidic conditions downstream of the dealkalization unit and prior to the degasser.

As mentioned earlier, some systems can incorporate the strong acid cation with the weak acid cation resin in the same unit either as a double layer (stratified unit) with or without a division plate. These units must always be regenerated counter flow with the regenerant acid passing first through the strong acid cation resin. This way the design can use the excess acid from the strong acid cation to regenerate the more efficient weak acid cation and improve the overall efficiency even more.
When significant temporary hardness is present in raw water, the addition of a weak acid cation bed can result in savings in acid consumption and provide a short payback period despite the capital cost associated with adding the additional resin bed.

In groundwater, temporary hardness is commonly encountered when hardness and bicarbonate form a significant proportion of the cationic-anionic load. When the raw water being treated has an exceedingly high proportion of temporary hardness, then good quality demineralized water can also be achieved with a dealkalization unit followed only by a degasser tower and a working mixed bed.

Degassing Towers

Degassing towers are used as an efficient mechanical means of removing bicarbonate alkalinity from the raw water. Both weak acid cation and strong acid cation resins exchange with H+ ions. When the cations associated with the bicarbonate are removed, they convert all bicarbonate to carbonic acid. In the low pH conditions that exist after the cation bed(s), carbonic acid is unstable, and easily dissociates into carbon dioxide and water. A degassing tower consisting of a column with ceramic or plastic pall rings over which the decactionized water is sprayed and low pressure air is blown up through the tower makes full use of this instability. The packing and spray systems are designed to provide large surface area. When the water passes through a degassing tower, the low pressure air agitates the water and releases the carbon dioxide, reducing the concentration of carbon dioxide in the degassed water to a low level, typically below 5 mg/L.

Therefore, a significant amount of the anionic load can be removed mechanically without using resin, which significantly reduces the load on any downstream strong base anion resin in the demineralization plant. The degassed water is collected in a sump for pumping through the next stage using stainless steel constructed pumps to cope with the aggressive nature of the low pH water.

Typical service operation – dealkalization unit

In service operation, water is normally pumped through the resin bed, which is retained within a pressure vessel. The vessel has top and bottom distribution/collection systems designed to ensure the water passes evenly through the ion exchange bed. As the water passes through the resin, the cations associated with the bicarbonate (alkalinity)—usually calcium and magnesium—are exchanged with hydrogen ions.

In most naturally occurring waters, the combined calcium and magnesium levels (total hardness), expressed as CaCO₃, is greater than the level of bicarbonate present, expressed as CaCO₂. This is ideal to efficiently remove temporary hardness and bicarbonate. However, in some cases, bicarbonate alkalinity is higher than total hardness, indicating the presence of sodium alkalinity. When sodium alkalinity occurs, the hardness-to-alkalinity ratio is noticeably less than 1, and the capacity of a weak acid cation resin falls dramatically making it a less attractive process.

Alkalinity

Dealkalized water (partial decationization) has higher hydrogen ion (H⁺) content when treated by a weak acid cation resin, and therefore lower pH. When going on-line after regeneration, pH is normally around 3 and increases through the service cycle to around 5.2 to 5.7, depending on the temporary hardness leakage.

When the resin is exhausted, it is regenerated with an acid solution to return the resin to hydrogen form. Once regenerated, it is ready for the next service operation.
Flow rate, vessel sizing and pressure drop

It is important for the unit to efficiently distribute and collect the water in service operation as well as during regeneration, especially since the regenerant and slow rinse flow rates can beat much lower flow rates.

Weak acid cation resin capacity is sensitive to flowrate. Although the resin can operate in service between 8 and 40 bed volumes per hour (BV/h) or 1 to 5 gpm/ft² within linear flow rates of 10 to 50 m³/m²/h (m³/h) or 4 to 20 gpm/ft², this is not the best way to operate this type of bed.

Optimum performance is achieved at slower flow rates and dealkalization units are normally designed to operate at service flow rates between 8 and 24 BV/h or 1 to 3 gpm/ft², with lower linear flow rates of 10 to 30 m³/m²/h (m³/h) or 4 to 12 gpm/ft². Channelling can occur within the resin bed at very low service flow rates resulting in poor plant performance and short capacity between regenerations. This often occurs in plants designed to have long service cycles.

The type of acid used for regeneration will also result in significant differences in acid regeneration concentration and flow rates.

Additionally, the ratio of height to diameter is important in unit design. While some small industrial demineralization plants operate with shallow bed depths, we recommend avoiding bed depths below 610 mm (2 ft) and using bed depths greater than 1,500 mm (4.9 ft).

Vessel height and pressure drop are control factors for the maximum height of the bed. For Purolite C104Plus and Purolite C104EPlus, we recommend pressure drop across the bed be maintained at less than 150 kPa (22 psi), having also made allowance for bed compaction and any solids loading across a classified bed. Bed depths greater than 2,500 mm (8.2 ft) are rarely encountered.

We recommend 75% freeboard above the resin bed to allow at least 50% expansion during backwash and ensure good hydraulic bed classification. Fully classified beds have a higher void fraction, which leads to lower pressure drop. This is particularly advantageous when high specific velocities are encountered. Many plants are built with less freeboard and do not adequately account for expansion.

Termination of service operation

The following factors are typically used to determine when to terminate service operation:

- Increased pH at the outlet of the column
- Conditions at the outlet of another column that initiate full-stream regeneration (hardness from the softener or conductivity, or silica from a downstream anion or working mixed bed).
- Volumetric throughput – Calculates the volume of water treated by the resin bed
- Service time elapsed

Throughput and service time dependent upon the incoming water analysis of the resin bed do not reach exhaustion before the volume of treated water or time is reached for the next regeneration. These are the least precise methods of control.

The subsequent regeneration can be manually or automatically initiated via the control system.

While co-flow and traditionally designed stratified counter-flow regenerations plants allow backwashing of the resin bed within the service operation unit, the resin will only tolerate a very low level of suspended solids present in the incoming water supply. The resins should not be expected to work as a mechanical filter, and an adequate pre-treatment should always be included in the plant layout if optimum performance is to be achieved.
Variation in performance

Working capacity of Purolite C104Plus and C104EPlus is affected by:

- **Hardness-to-alkalinity ratio** –
  Greater than 1, preferable

- **Service flow rate** –
  Between 8 and 24 BV/h, preferable

- **Water temperature** –
  Low temperatures reduce capacity and plant designs should consider the minimum expected water temperature

Regeneration

Regeneration is termed co-flow when the regenerant flows through the resin bed in the same direction, normally downwards or “top to bottom,” in which the water flows during the service operation. When the regenerant flow is in the opposite direction to service flow, then the term used is counter-flow regeneration. Other terms such as co-current and counter-current are also used to describe these two principal regeneration techniques.

When counter-flow regeneration is employed, it is important to note that in the up flow stages (except backwash, if the design allows) the bed must remain static. Packed beds, air hold down, split flow and water hold down are just some of the systems employed to achieve this requirement. In some counter-flow regenerated systems the design allows service flow to be upward through the bed and regeneration downwards. In such cases it is therefore important that the bed must remain static throughout the up-flow service operation.

Thoroughfare regeneration for dual layer (stratified bed) applications

All acid required to regenerate both the weak acid and strong acid resins in double layer (stratified) units—with or without a division plate—as well as thoroughfare acid regeneration (when resins are located in separate units) is passed through the strong acid cation bed first in counter-flow regeneration mode.

As the loading onto the weak acid cation resin is usually high, this ensures the strong acid cation resin sees a much higher regeneration level than normal. High regeneration levels provide lower sodium leakage as well as higher working capacity without increasing operating costs. If one were to treat both resins separately, excess acid regenerant from each would pass to the effluent plant, costing much more in regenerant and producing much more waste.

In this design, however, the excess acid from the strong acid resin regeneration is designed so that it is still sufficient to pass through and regenerate the weak acid resin. As the weak acid resins only require a slight excess of acid to regenerate (typically 105 to 120%), the acid utilization is very high and highly efficient.

When weak acid cation resin is used in the same unit as the strong acid cation resin (double layer / stratified plants with or without a division plate), the regeneration must always be counter-flow. With the double layer design without a division plate, the regenerant must be in an up-flow direction as the strong acid resin is heavier than its weak acid counterpart and is located at the bottom of the combined bed. Where a division plate is used to separate resins within the same column, the compartment containing each component determines if the service flow is up-flow with down-flow regeneration, or down-flow service with up-flow regeneration.

Co-flow regeneration

Resin regeneration is normally performed co-flow both in dealkalization and demineralization plants where the weak acid cation resin is used in its own separate unit (counter flow regeneration offers little advantage compared to the advantages seen on a strong acid cation bed.)

The co-flow regeneration technique is normally made up of 5 steps and typically takes between 1 and 2 hours depending on the detailed design. For this type of regeneration, the influent water is typically of adequate quality for all steps, including regenerant dilution.
Backwash is the first step of co-flow regeneration. The backwash water enters the unit through the bottom collection / distribution system, loosening the bed and causing it to expand. The flow rate should be set for the freeboard available in the unit at the minimum water temperature. The backwash is designed to both decompact the resin for better regenerant contact, as well as for removing any suspended solids that are filtered out of the incoming supply and accumulate within the bed. Backwash water volume will depend on the extent of solids loading. If the bed only requires decompacting, then up to 1 FBV (free board volume) is normally sufficient. When filtered solids are present, however, the volume required is greater, typically 2 to 3 FBV.

Bed settle is the next step required after the backwash. This step allows the resin to settle back and reform a static bed prior to regenerant injection. Depending on the size of the bed, freeboard, and backwash rate used, this step can take between 5 and 8 minutes.

Regenerant acid injection at the correct flow rate and acid concentration are critical after the resin settles. Good contact between the acid solution and the resin is essential for optimum performance.

The loading of a weak acid cation resin is often primarily calcium, with some magnesium present. The calcium and magnesium must be substantially removed during the regeneration process.

Care must be taken to regenerate weak acid cation resins with sulfuric acid as calcium sulfate precipitation occurs easily when sulfuric acid is either applied at too high a concentration or too slowly. This condition must be avoided. The lower the sulfuric acid concentration and the higher the flow rate, the lower the risk of precipitation occurring on regeneration. Temperature also plays a part in precipitation. In hot climates, regenerant may require lower concentrations and shorter contact times as increased temperature can increase the risk of precipitation. Operating guidelines for sulfuric acid injection based on the calcium content of the incoming water supply are covered later in this bulletin.

Minor precipitation problems can sometimes be treated with a hydrochloric acid soak to try to re-dissolve the calcium sulfate and recover the resin. If, however, the precipitation is severe, complete replacement of the resin is usually required because chemical clean-up is not a cost effective solution and not always fully effective.

Hydrochloric acid does not pose a risk for precipitation. The chloride salts of commonly encountered cations are far more soluble. Higher hydrochloric acid concentrations can be used, making HCl regeneration easier and quicker with less waste effluent produced.

For weak acid cation resins, the amount of chemical regenerant required is calculated from the anticipated working capacity and is calculated by applying a slight excess of acid compared to the work done by the bed in the service cycle. For strong acid cation resins, the amount of regenerant required is calculated directly from the regeneration level selected and is expressed in g/l or lb/ft³—the amount of regenerant required per litre or cubic foot of resin.

To improve overall regeneration efficiency and reduce the amount on effluent to drain on some double layer (stratified) designs that use large amounts of acid, it is possible to start with a low acid concentration that can be increased slightly during the injection period. This is referred to as step-wise regeneration.

Laboratory work shows only 5% excess acid is required to regenerate Purolite C104Plus and C104EPlus. Although this low excess is achieved on some full-scale plants, the design of some distribution / collection systems is not sophisticated enough to achieve optimum regeneration performance from the resin. As a result, less efficient plant designs will likely operate with a 10% to 15% excess acid applied.
After regenerant injection, the bed needs to rinsed free of acid and this is normally done in two stages.

The slow rinse (regenerant displacement) is done at flow rates similar to the acid injection and in the same direction. This ensures a uniform contact time between resin and regenerant, and that the rinse water follows the same route of the regenerant through the resin bed. Since slow rinses are more efficient in removing the spent regenerant, a longer slow rinse can reduce the amount of final rinse required. Normally 1 to 3 BV (7.5 – 22.5 gal/ft³) of slow rinse is applied.

The final rinse is often carried out at the service flow rate. This also acts as a proving condition prior to returning to service after regeneration. On some occasions, where flow restrictions occur, the plant final rinse is carried out at a rate lower than the service flow rate. Normally 3 to 6 BV (22.5 – 45 gal/ft³) are required depending on the design of the distribution / collection systems and the amount of slow rinsing previously performed.

Table 2 summarizes design parameters for co-flow regenerated weak acid cation resin in either a dealkalization plant or as a stand-alone co-flow regenerated weak acid cation bed in part of a demineralization plant.

<table>
<thead>
<tr>
<th>STEP</th>
<th>DESIGN BASIS</th>
<th>DURATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Backwash</td>
<td>Set for minimum water temperature to give 50% bed expansion</td>
<td>1 FBV on clean water supplies and 2 – 3 FBV where solids are present</td>
</tr>
<tr>
<td>Bed settle</td>
<td>To allow the bed to reform fully classified</td>
<td>5 – 8 minutes</td>
</tr>
<tr>
<td>Acid injection</td>
<td>Typically 5 – 15% excess acid compared to the expected resin capacity</td>
<td>Typically 20 – 30 minutes depending on regeneration level and flow rate</td>
</tr>
<tr>
<td></td>
<td>For hydrochloric acid regeneration, this is applied at approximately</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4% HCl concentration at 2 – 4 BV/h (0.25 – 0.5 gpm/ft²).</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The volume of regenerant must exceed resin volume.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>For sulfuric acid regeneration this is applied at 0.5 to 1% at 8 – 20 BV/h</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(1 – 2.5 gpm/ft²).</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.7% at 12 – 16 BV/h (1.5 – 2 gpm/ft²) is normally encountered in operating</td>
<td></td>
</tr>
<tr>
<td></td>
<td>plants. Refer to Figure 7 for more guidance.</td>
<td></td>
</tr>
<tr>
<td>Slow rinse</td>
<td>2 – 3 BV (15 to 22.5 gal/ft³) at approximately regenerant flow rate</td>
<td>Typically 30 – 40 minutes depending on volume of water applied and flow rate</td>
</tr>
<tr>
<td>Final rinse</td>
<td>3 – 6 BV (22.5 – 45 gal/ft³) preferably at service flow rate or alternatively</td>
<td>Typically 10 – 20 minutes. The less slow rinse employed the more final rinse required</td>
</tr>
<tr>
<td></td>
<td>&gt; 15 BV/h (2 gpm/ft²)</td>
<td></td>
</tr>
</tbody>
</table>

Key: BV = Bed Volume, BV/h = Bed Volume per hour; FBV = Free Board Volume above resin bed
Counter-flow regeneration of double layer (stratified) beds

Counter-flow regeneration techniques normally have fewer steps than those described for co-flow regeneration and typically take between 1 and 1½ hours depending on the detailed design. This type of regeneration requires the use of cation free water to achieve optimal performance. Decationized or demineralized water must be used for the acid dilution / injection and slow rinse steps to achieve the published sodium leakage from the strong acid cation resin. The water is either set aside during the previous service run or, in case of multi stream plants, it can be supplied by one of the other on-line streams. When decationized water is stored for regeneration, some plants use a dedicated tank, but when a degassing tower is part of the process, the degassing tower sump is normally used. When demineralized water is used, then the client’s treated water tank or a separate tank is utilized.

The backwash step, which is always the first step of co-flow regeneration, is not normally performed each cycle in a counter-flow regenerated system. Because of this, a means of carrying out periodic full bed backwashes—either inside the service unit or in external dedicated vessels—should be included in the plant design. Some engineering designs allow for sub-surface back washes to be carried out each cycle, but such partial backwashes should not be intended as a replacement of periodic full-bed backwashes. After a full-bed backwash, the resin should always be regenerated with double the normal amount of acid to restore full counter-flow performance.

Similar to co-flow regeneration, special care should be taken with counter-flow regeneration to prevent calcium sulfate precipitation due to acid concentration and injection flow rate. In counter-flow regeneration, the acid enters the bed from the opposite direction to the raw water and therefore encounters the sodium and potassium loaded strong acid cation resin before reaching the magnesium and calcium loaded weak acid cation resin. For these and other reasons, counter-flow regeneration conditions must be tailored to the plant design. It is also common for engineering companies to have their own proven sets of conditions for a design. Purolite’s recommendations on acid concentrations and flow rates are therefore provided as general guidance only.

In counter-flow regeneration bed depths below 1,000 mm (3 ft 3 in) should be avoided. Beds in excess of 1,200 mm (4 ft) are preferred.

The regeneration level is calculated taking into account the known loading on to the weak acid cation bed so that sufficient excess acid from the counter flow regeneration of the strong acid cation is still available. Sulfuric acid must be introduced at lower than normal concentrations to ensure calcium sulfate precipitation does not occur when using sulfuric acid.

The slow (regenerant displacement) rinse is always carried out at flow rates similar to the acid injection step and in the same direction. This is to ensure uniform contact time between the resin and the regenerant solution, and that the rinse water follows the same route of the regenerant through the resin bed. Since slow rinse is usually more efficient in removing the spent regenerant from the resin than fast rinse, using more slow rinse can reduce the amount of final rinse required. Normally 1 to 2 BV (7.5 - 15 gal/ft²) of slow rinse are adequate.

The final rinse is often carried out at the service flow rate. This also acts as a proving condition prior to returning to service after regeneration. Normally 2 to 4 BV (15 - 30 gal/ft²) are required depending on the design of the distribution / collection system and the amount of slow rinsing previously performed.

In demineralization plants it is increasingly common to use closed-loop recycle rinses around the double layer (stratified) cation and anion units on counter-flow regenerated systems. This offers two advantages: it reduces the amount of waste water produced by the plant and it allows the design to include a proving pre-service rinse prior to placing the line back in service. Where anion resins sometimes develop long rinses due to organic fouling, a recycle rinse system can significantly reduce water consumption.
Calculating the correct regenerant quantity

The information below explains how to calculate the amount of acid required for a given design.

Regenerant injection at the correct flow rate and acid concentration is critical as good contact between the acid solution and the resin is essential for optimum performance. The quantity of acid required is calculated from the expected working capacity from the resin.

For this example if we assume a working capacity of 1.5 eq/l (75 g/l as CaCO₃) then the amount of acid required per litre of resin assuming 110% excess is 1.5 x 1.10 = 1.65 eq/l (82.5 g/l as CaCO₃). To convert to 100% hydrochloric acid from CaCO₃ divide by 1.37. This gives a hydrochloric acid regeneration level of 60.22 g/l. To convert to 100% sulfuric acid from CaCO₃ divide by 1.02. This gives a sulfuric acid regeneration level of 80.88 g/l.

Please note all regeneration levels are expressed for the pure chemical (100%) strength. In order to calculate the exact volume of regenerant required per regeneration on the plant you need to know the concentration of the acid available on site.

Performance data

The following graphs and correction factors are designed to help the design engineer to estimate the exchange capacity and hardness leakage achieved with Purolite C104Plus and Purolite C104EPlus under different operating conditions. All the data shown are the result of years of industrial experience and are supplied in good faith. The final performance will depend on the detailed design and operation of the system, the quality of the regenerant chemicals as well as the long term maintenance of the plant. Some engineers will want to take a safety margin by adding slightly more resin to the bed. Those using a standard plant of simple design may wish to take a larger design margin (safety factor) with regard to the published data to allow for less than ideal operation. Please note the data presented in this section is specific to co-flow regenerated designs with bed depths over 1,000 mm (3 ft, 3 in) and counter-flow regenerated designs with bed depths over 1,200 mm (6 ft, 6 in). Shallow bed depths may require downgrading expected performance depending on the quality of the design.

The data shown here can be used to size the weak acid component in a Double layer (Stratified) unit. However, these designs can often take into account spare capacity in the strong acid cation resin if the permanent hardness and sodium loading on to that portion is relatively small. This allows you to over-run on the weak acid cation component giving even better overall performance from the unit.

For users interested in performing these engineering calculations electronically, Purolite’s PureDesign™ software is available for download at www.purolite.com.
Figure 1 – Backwash expansion

![Backwash expansion graph](image1)

Figure 2 – Pressure drop

![Pressure drop graph](image2)
Figure 3 – Base operating capacity

Figure 4 – C1 capacity correction factor for temperature
C1 – Capacity correction factor for temperature
Total hardness / Total alkalinity = 0.5

Water Temperature, °F

Water Temperature, °C

Total Cations = 6 meq/l  Total Cations = 2 meq/l
Figure 5 – C1 capacity correction factor for temperature

Ca – Capacity correction factor for temperature
Total hardness / Total alkalinity = 1.5

Figure 6 – C2 capacity correction factor for cycle time
Figure 7 – Recommended $\text{H}_2\text{SO}_4$ concentration

Refer to PureDesign™ for leakage information.