Purolite® C100 Sodium Cycle

This Engineering Bulletin features Purolite C100, a premium, industrial-grade gel polystyrenic strong acid cation exchange resin used for industrial water softening.

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About Purolite

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

Responding to our customers' needs, Purolite has a wide variety of products and the industry's largest technical sales force. Globally, we have strategically located research and development centers and application laboratories. Our ISO 9001 certified manufacturing facilities in the USA, United Kingdom, Romania and China combined with more than 40 sales offices in 30 countries ensure complete worldwide coverage.

Purolite has been part of Ecolab since 2021. A trusted partner at nearly three million commercial customer locations, Ecolab (ECL) is the global leader in water, hygiene and infection prevention solutions and services. Ecolab delivers comprehensive solutions, data-driven insights and personalized service to advance food safety, maintain clean and safe environments, optimize water and energy use, and improve operational efficiencies and sustainability for customers in the food, healthcare, hospitality and industrial markets in more than 170 countries around the world.

PREMIER PRODUCTS

The quality and consistency of our products are 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 team in the industry.

INNOVATIVE SOLUTIONS

Our continued investment in research and development means we are always perfecting and discovering innovative uses for ion exchange resins and adsorbents. We strive to make the impossible possible.

Purolite C100 Sodium Cycle

Contents

Introduction

Purolite C100 is a premium, industrial-grade gel polystyrenic strong acid cation exchange resin supplied in the sodium form. Its main application in sodium form is in industrial water softening. Due to its robust nature, Purolite C100 is also used as a cation exchanger in demineralization plants, where it is operated in the hydrogen form following full acid regeneration.

This document refers specifically to resin use in water softening to remove total hardness with sodium chloride (salt) regeneration. For its use as cation exchange resin in demineralization processes, please refer to the Purolite C100 Hydrogen Cycle Engineering Bulletins.

Purolite C100 has a standard particle size distribution, and it is primarily used in co-flow and traditional counter-flow regenerated softening units. It operates successfully over a wide range of operating conditions. It offers higher resistance to the attack by oxidizing agents, such as chlorine, compared to some other less robust softening resins, resulting in a longer resin life.

TABLE 1 Typical Physical and Chemical Characteristics

Characteristics	Description
Polymer Structure	Gel polystyrene crosslinked with divinylbenzene
Appearance	Spherical beads
Functional Group	Sulfonic Acid
Ionic Form	Na^+ form
Total Capacity (min.)	2.0 eq/L (43.7 Kgr/ft^3) (Na^+ form)
Moisture Retention	44–48% (Na^+ form)
Particle Size Range	300–1200 µm
Column < 300 µ (max.)	1%
Uniformity Coefficient (max.)	1.7
Reversible Swelling, $Ca^{2+} \rightarrow Na^+$ (max.)	9%
Specific Gravity	1.29
Shipping Weight (approx.)	800–840 g/L (50.0–52.5 lb/ft^3)
Temperature Limit	120 °C (248 °F)

Available Grades

Purolite C100 is available in different grades, all supplied in the Na^+ form.

- Purolite C100 is a standard grade resin with a Gaussian particle size distribution of 300–1200 µm. Its main application is in co-flow and traditional counter-flow regenerated softening and demineralization plants, where classification of the bed inside the operating vessel is possible.
- Purolite C100C is a modified grade with a particle size in the range 400–1200 µm for use in high flow rate applications where the standard grade resin would present an unacceptably high-pressure drop across the bed.
- Purofine® PFC100 is a uniform particle size product with a mean particle size of 570 µm and UC of 1.1–1.2, offering improved performance in softening and demineralization systems to capacity, leakage, pressure drop and rinse water requirements.
- Puropack® PPC100 is another uniform particle size product, offering similar advantages, but with a mean particle size of 650 µm. This product has been specifically developed for the Puropack system and other packed bed counter-flow designs employing either up-flow or down-flow service operations. Both Purofine PFC100 and Puropack PPC100 have also seen successful operations in short-cycle plants.
- Purolite C100DL is a specially designed, coarse grade resin with a particle size range of 630–120 µm. Its main application is in layered bed cation exchange units in conjunction with a DL grade Purolite weak acid cation resin such as Purolite C104DLPlus.
- Purolite C100S is a specially cleaned and trimmed food-grade resin with a particle size of 400–1200 µm for use in food processing, such as in the sugar industry.

Typical Operating Data

Service Operation

Hard water is typically pumped through the resin bed in service operation, retained within a pressure vessel. The vessel has top and bottom distribution/collection systems. These systems are designed to ensure that the raw water passes evenly through the ion exchange bed in service operation. As the water passes through the resin, the hardness (principally calcium and magnesium) is exchanged with sodium ions. Hence the treated softened water has a higher sodium content and a somewhat higher conductivity. When the resin is exhausted, it is then regenerated with a NaCl solution to put it back into the sodium form, ready for the next service operation. Therefore the internal systems must efficiently distribute and collect the regenerant brine solution, rinses, etc.

In service operation, optimum performance is achieved at service flow rates between 8 and 40 BV/h (bed volumes per hour) or 1 to 5 gpm/ft^3 (US gallons per minute per cubic foot of resin) within linear flow rates (velocities) of 10 to 50 m^3/m^2/h (m/h) or 4 to 20 gpm/ft^2 (US gallons per minute per square foot of vessel cross-section). In contrast, brine regeneration is carried out at flow rates of 2 to 4 BV/h or 0.25 to 0.5 gpm/ft^3. Internal distribution/collection systems can operate efficiently at higher service and lower regenerant flow rates within these limits. At very low service flow rates, channeling can occur within the resin bed resulting in poor plant performance and short capacity between regenerations. This is particularly likely when long service cycles are also employed at these low flow rates.

While some small industrial and domestic softeners operate with very shallow bed depths, bed depths below 610 mm (2 ft) should be avoided and preferably bed depths greater than 1000 mm (3 ft 3 in) employed. Vessel height and pressure drop are usually the controlling factors on the maximum height of the bed. For Purolite C100, we recommend that pressure drop across the bed be maintained at less than 150 kPa (22 psi), allowing for bed compaction and any solids loading across a classified bed. Bed depths greater than 2,000 mm (6 ft 6 in) are rarely encountered. The height to diameter ratio is vital in any ion exchange unit design.

Although smaller freeboards are sometimes encountered, we recommend a minimum of 75% freeboard (space) above the resin bed to allow at least 50% bed expansion during backwash. This usually is adequate for a co-flow regenerated vessel and assures a good hydraulic classification of the resin bed.

Service operation is usually terminated when hardness leakage is detected, volumetric throughput (water meter control) is reached, or on a timed basis (time clock control). Regeneration can be manually or automatically initiated via the control system.

While co-flow regenerated beds that regularly use backwash will tolerate some suspended solids in the influent water, this service bed should not be used as a mechanical filter. Proper pretreatment should be incorporated to achieve optimum performance of the resins.

Regeneration

The resin regeneration can be performed either by co-flow or counter-flow. The regeneration is termed co-flow when the regenerant flows through the resin bed in the same direction, usually downwards or "top to bottom," where the water flows during the service operation. When the regenerant flow is opposite to service flow, the term used is counter-flow regeneration. Other words such as co-current and counter-current also describe these two principal regeneration techniques.

When counter-flow regeneration is employed, it is essential that in the up-flow stage(s), the bed must remain static. Hence, packed beds, air hold down, split flow and water hold down are just some of the systems employed to achieve this requirement.

Co-Flow Regeneration

The co-flow regeneration technique usually is five steps and typically takes between one and two hours, depending on the detailed design. The influent water is generally adequate quality for this type of regeneration for all steps, including regenerant dilution.

The first step of co-flow regeneration is backwash. The backwash water enters the unit through the bottom collection/distribution system, loosening the bed and causing the bed to expand as the water passes up through it. The flow rate should be set for the freeboard available in the unit at the minimum water temperature. The backwash is designed to decompact the resin for better regenerant contact and remove any suspended solids that have been filtered out of the incoming supply and accumulated within the bed. The backwash water volume required will depend on the extent of solids loading. Where the bed only requires loosening for better regenerant contact, 1 FBV (freeboard volume) usually is sufficient. However the volume required can be considerably greater when filtered solids are present. After the backwash, a “bed settle” step is required.

The bed settle allows the resin to settle back and reform the static bed before regenerant injection. Depending on the size of the bed, freeboard and backwash rate used, this step can take between 3 and 8 minutes.

Regenerant injection at the correct flow rate and acid concentration are critical. Good contact between the NaCl solution (brine) and the resin is essential for optimum performance. Purolite recommends the brine be introduced at 10% concentration. Experience shows that a slight loss in performance can be expected at concentrations above and below this strength. The brine should be introduced at 2–4 BV/h (0.25 to 0.5 gpm/ft^3), and the regeneration level (amount of NaCl per liter of resin) employed will typically be between 80 and 160 g/L (5–16 lbs/ft^3).

The slow (regenerant displacement) rinse is always carried out at flow rates similar to the brine injection step. This ensures a uniform contact time between the resin and the regenerant solution and, second, that the rinse water follows the same route of the regenerant through the resin bed. As slow rinses are usually more efficient in removing the spent regenerant from the resin, the more slow rinsing employed can reduce the amount of final rinse required at the end of the regeneration. Typically 1–3 BV (7.5 to 22.5 gal/ft^3) of slow rinse is applied.

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

TABLE 2 **Typical Operating Conditions for Co-Flow Regeneration**

Step	Design Basis	Duration
Backwash	Set for minimum water temperature to give 50% bed expansion	1 FBV on clean water supplies; 2–3 FBV where solids are present
Bed Settle	To allow the bed to reform fully classified	3 to 8 minutes
NaCl Injection	50–250 g/L (3–15 lb/ft^3) applied as a 10% brine solution at 2–4 BV/h (0.25 to 0.5 gpm/ft^3)	Typically 20–45 minutes depending on regeneration level and flow rate
Slow Rinse	1–3 BV (7.5 to 22.5 gal/ft^3) at approx. regenerant flow rate	Typically 20–45 minutes depending on volume of water applied and flow rate
Final Rinse	3–6 BV (22.5 to 45 gal/ft^3) preferably at service flow rate or alternatively > 15 BV/h (2 gpm/ft^3)	Typically 10–20 minutes

(Key: BV = Bed Volume, BV/h = Bed Volume per hour, FBV = Free board volume above resin bed)

Counter-Flow Regeneration

While counter-flow regeneration can also be applied to Purolite C100, this technique is often used with other more specialized grades of Purolite cation resin to enhance the performance further. Consult your local Purolite sales office for guidance.

In counter-flow regeneration, bed depths below 1000 mm (3 ft 3 in) should be avoided and preferably beds above 1200 mm (4 ft) employed.

The traditional counter-flow regeneration technique is typically three steps instead of the five steps described earlier for co-flow regeneration. Depending on the detailed design, it typically takes between one and two hours. This type of regeneration requires water free from hardness for the brine makeup, injection and slow rinse steps in the published leakage is to be obtained. The softened water produced by the same plant is usually adequate. The required quantity is either set aside during the previous service run or, in the case of two-line units, supplied by the other online unit.

In a counter-flow regenerated system, the backwash, which always represents the first step of co-flow regeneration, is not typically performed each cycle. Some engineering designs allow subsurface backwash or periodic full bed backwash inside the service unit or in separate external dedicated towers. In the vast majority of designs, backwash is not part of the normal regeneration, although the unit's design should include it. After a full bed backwash, the resin should be regenerated with double the usual amount of brine to restore full performance.

The regenerant brine should be introduced at 2 to 4 BV/h (0.25–0.5 gpm/ft^3), and the regeneration level (amount of NaCl per liter of resin) employed will typically be lower than for co-current regenerated units, typically between 50 and 150 g/L (3–9 lb/ft^3).

The slow (regenerant displacement) rinse is always carried out at flow rates similar to the brine injection step and in the same direction. This ensures a uniform contact time between the resin and the regenerant solution and, second, that the rinse water follows the same route of the regenerant through the resin bed. As slow rinses are usually more efficient in removing the spent regenerant from the resin, the more slow rinsing employed can reduce the final rinse required. Normally 1 to 2 BV (7.5–15 US gal/ft^3) of slow rinse is adequate.

The final rinse is often carried out at the service flow rate, and this also acts as a proving condition before returning to service after regeneration. Typically 2 to 4 BV/h (15–30 gal/ft^3) are required depending on the design of the distribution/collection system and the amount of slow rinsing previously performed.

TABLE 3 Typical Operating Conditions for Counter-Flow Regeneration

Step	Design Basis	Duration
NaCl Injection	50–150 g/L (3–10 lb/ft^3) applied as a 10% brine solution at 2–4 BV/h (0.25 to 0.5 US gpm/ft^3)	Typically 20–45 minutes, depending on regeneration level and flow rate
Slow Rinse	1–2 BV (7.5–15 gal/ft^3) at approx. regenerant flow rate	Typically 20–45 minutes, depending on volume of water applied and flow rate
Final Rinse	2–4 BV (15–30 gal/ft^3) preferably at service flow rate or alternatively > 15 BV/h (2 gpm/ft^3)	Typically 10–20 minutes

(Key: BV = Bed Volume, BV/h = Bed Volume per hour)

Performance Data

The following data are designed to help the design engineer to estimate the exchange capacity and hardness leakage achieved with Purolite C100 under different operating conditions. All the data shown result from years of industrial experience and are supplied in good faith. Still, the final performance will equally depend on the detailed design and operation of the system, the quality of the regenerant chemicals, and long-term maintenance of the plant. Some engineers using a basic, standard plant of simple design may wish to take a design margin (safety factor) concerning the published data to allow for less than ideal operation. Please note the data presented in this section are 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 (3 ft 11 in). For shallower bed depths, there may be a requirement to downrate the expected performance depending on the quality of the design.

The data supplied are divided into three groups: Figures 1 to 9 deal with capacity and leakage for co-flow regeneration, Figures 10 to 18 with capacity and leakage for counter-flow regeneration and Figures 19 to 20 with hydraulic data (backwash expansion and pressure drop). There is a base capacity and a base leakage curve within each of the first two groups, followed by other curves showing correction factors. To calculate the expected capacity or leakage, multiply the base capacity or leakage by the relevant correction factors.

For users interested in performing these engineering calculations electronically, Purolite's PRSM software is available via www.purolite.com at no charge.

The data presented in this bulletin can also be used to estimate the operating performances of resins such as Purolite C100C, Purolite C100S or Purolite C100DL.

Co-Flow Regeneration Charts

FIGURE 1

Base Capacity

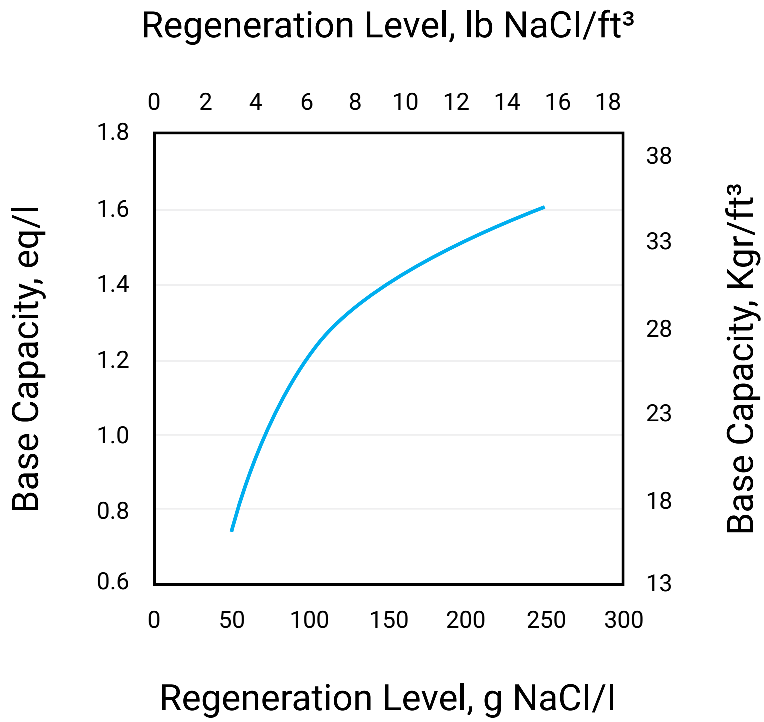


FIGURE 2

C1: Capacity Correction Factor for Influent TH

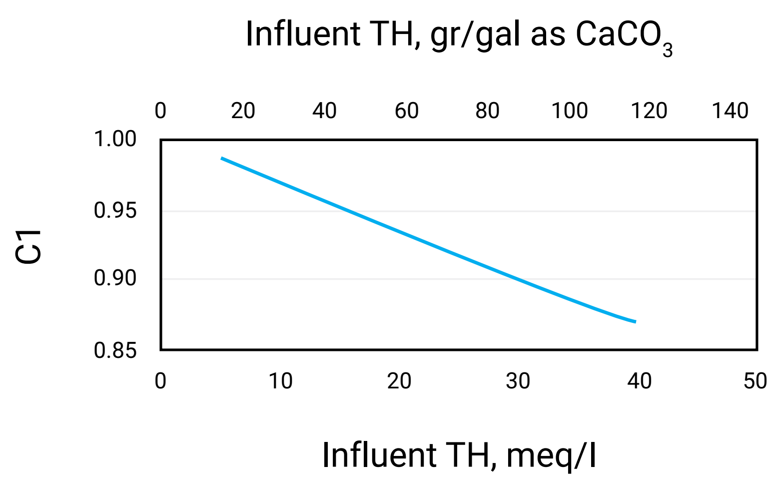


FIGURE 3

C2: Capacity Correction Factor for Service Flow Rate

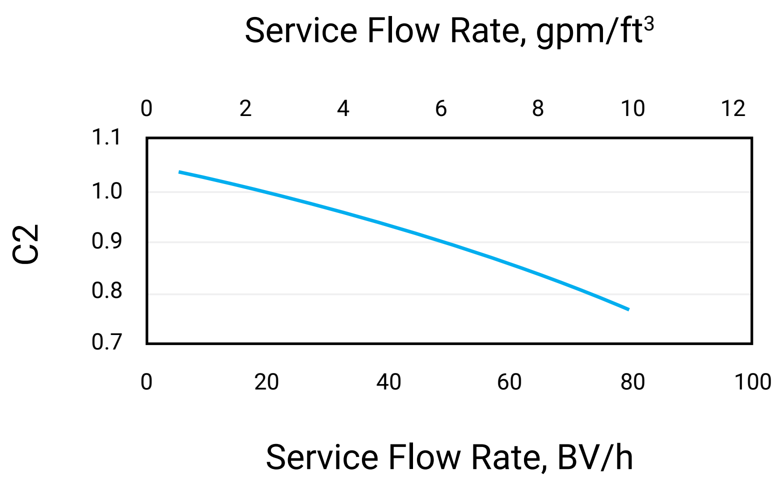


FIGURE 4

C3: Capacity Correction Factor for Influent Na

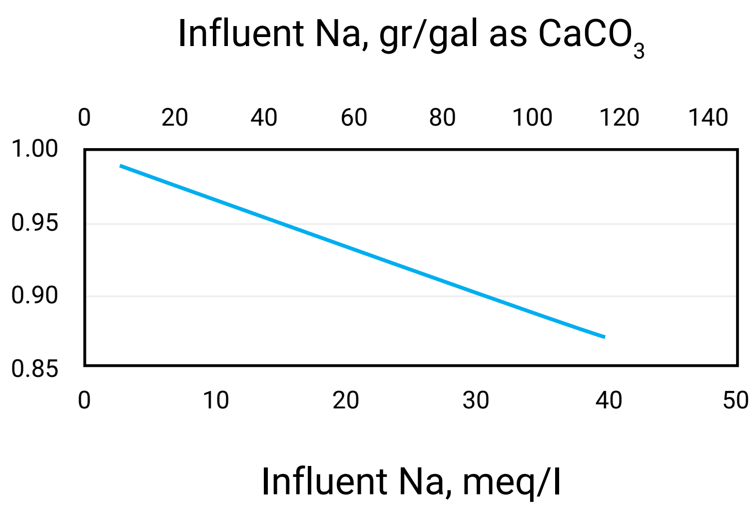


FIGURE 5

C4: Capacity Correction Factor for Brine Concentration

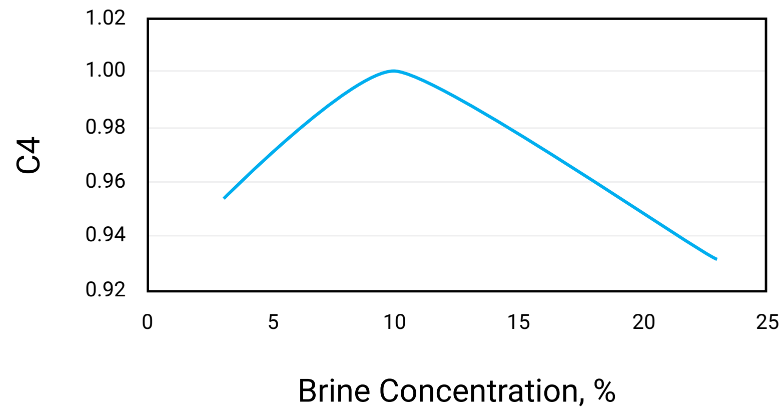


FIGURE 6

Base Hardness Leakage

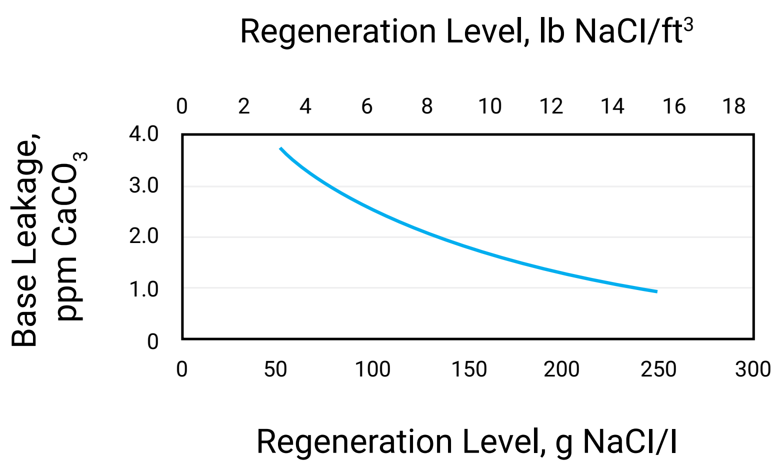


FIGURE 7

L1: Leakage Correction Factor for Na/Total Cations

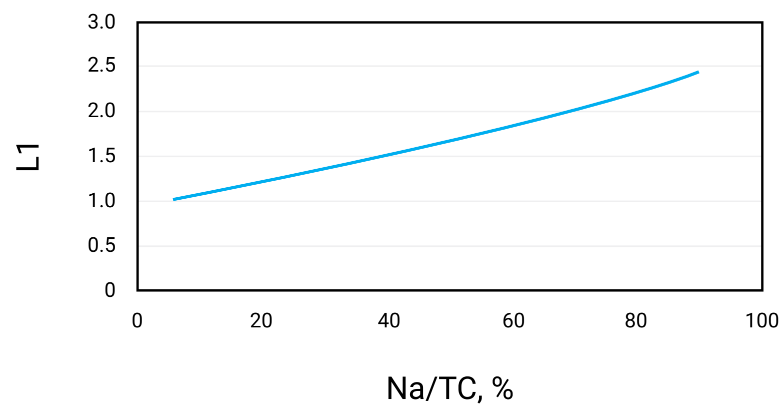


FIGURE 8

L2: Leakage Correction Factor for Total Hardness

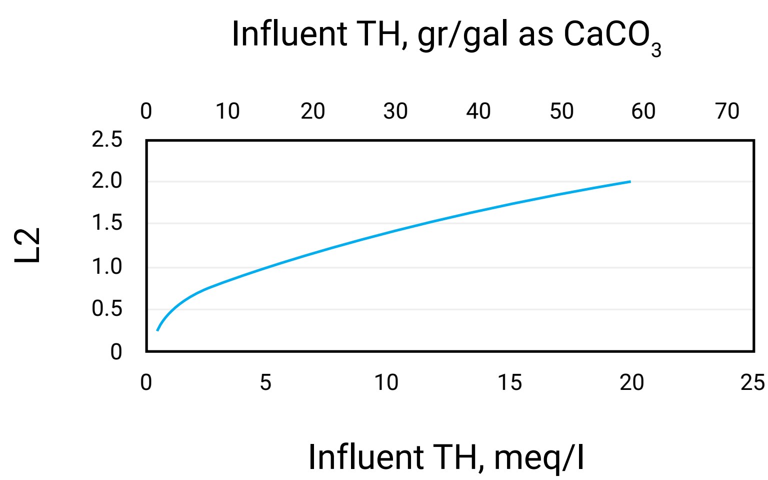
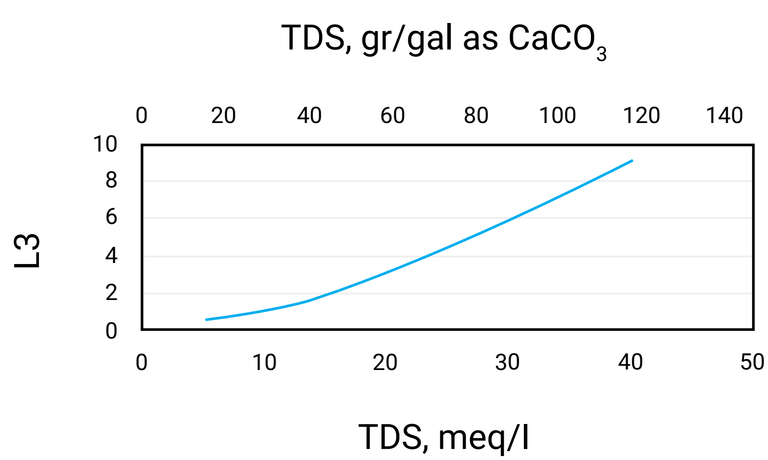


FIGURE 9

L3: Leakage Correction Factor for Total Dissolved Solids



Counter-Flow Regeneration Charts

FIGURE 10

Base Capacity

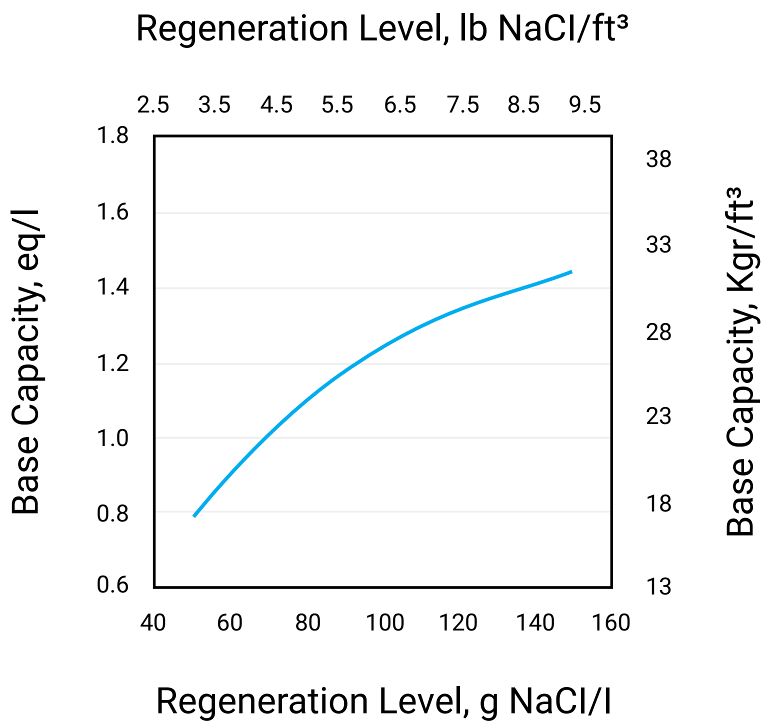


FIGURE 11

C1: Capacity Correction Factor for Total Hardness

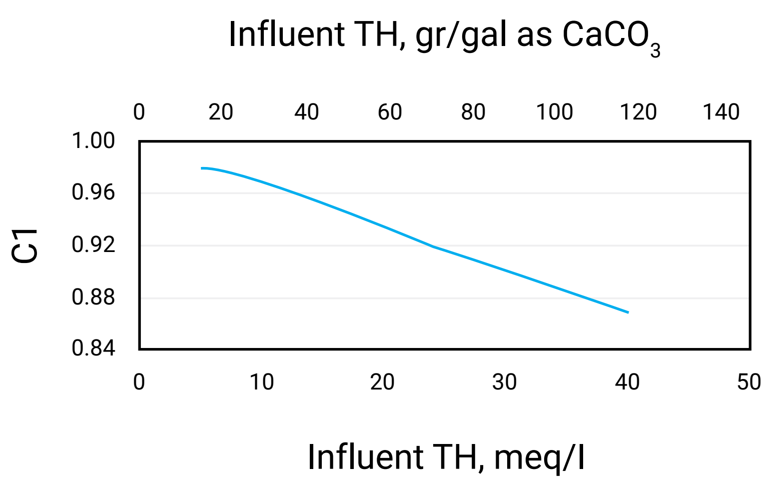


FIGURE 12

C2: Capacity Correction Factor for Service Flow Rate

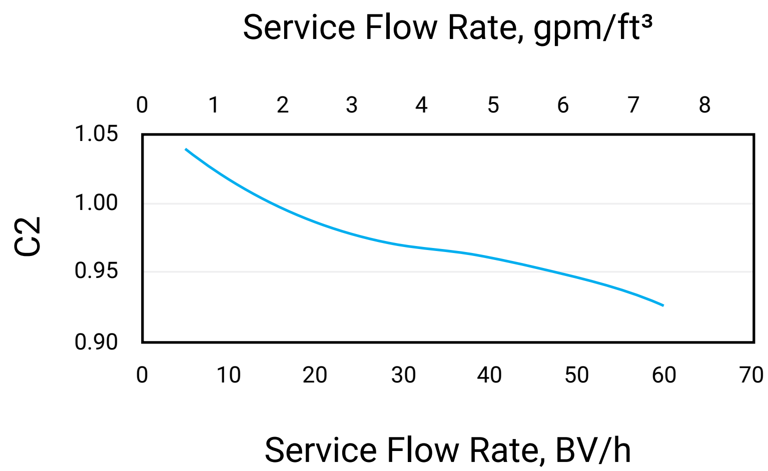


FIGURE 13

C3: Capacity Correction Factor for Resin Bed Depth

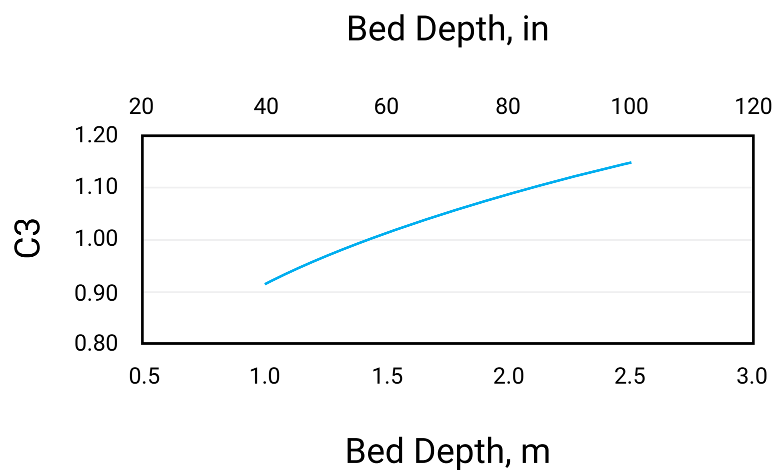


FIGURE 14

C4: Capacity Correction Factor for Brine Concentration

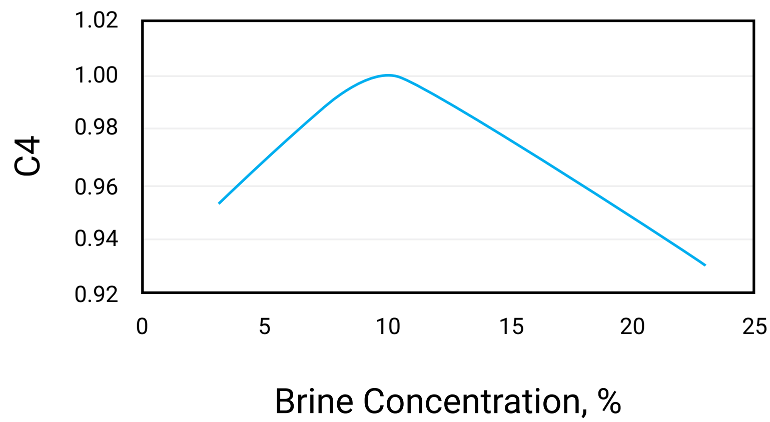


FIGURE 15

Base Hardness Leakage

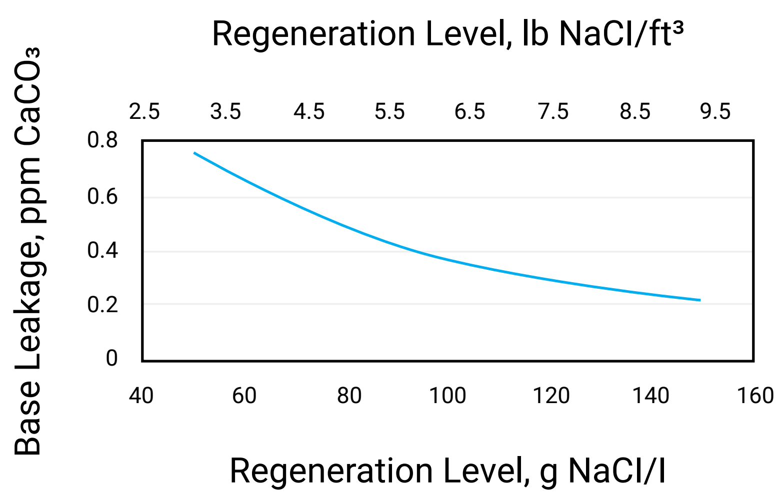


FIGURE 16

L1: Leakage Correction Factor for Na/Total Cations

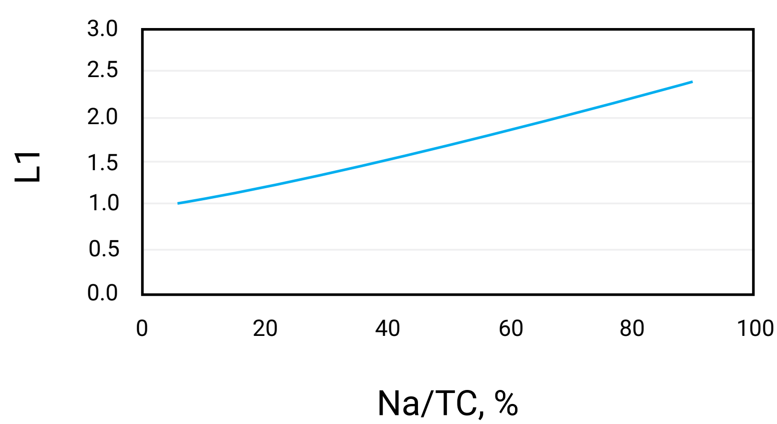


FIGURE 17

L2: Leakage Correction Factor for Total Hardness

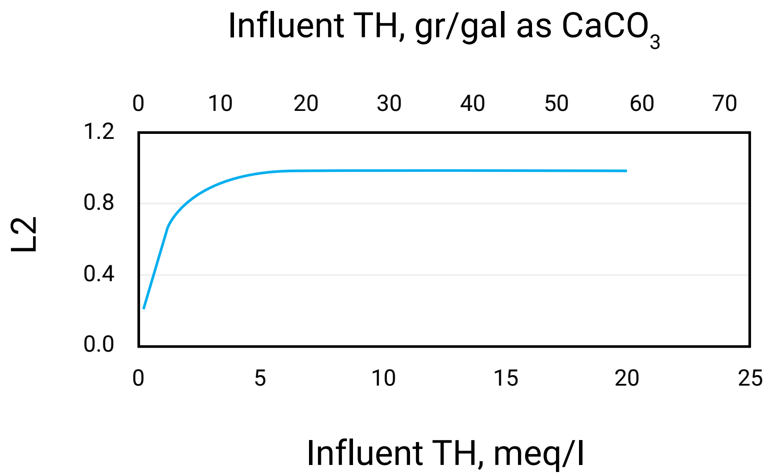
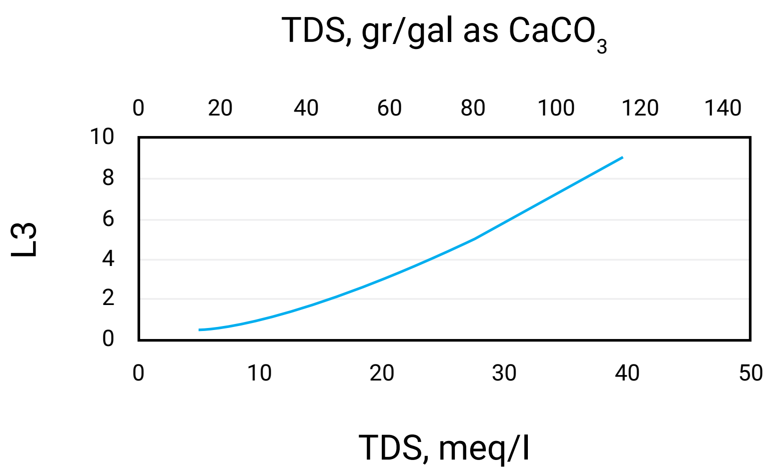


FIGURE 18

L3: Leakage Correction Factor for Total Dissolved Solids



Hydraulic Characteristics Charts

FIGURE 19

Backwash Expansion

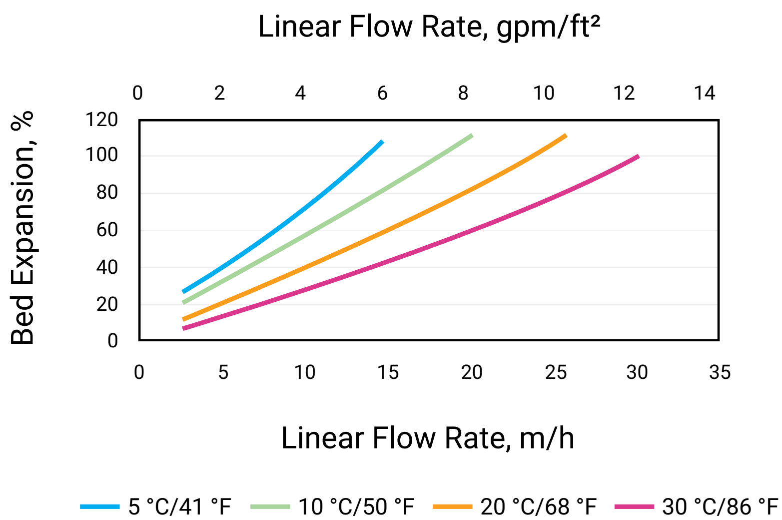
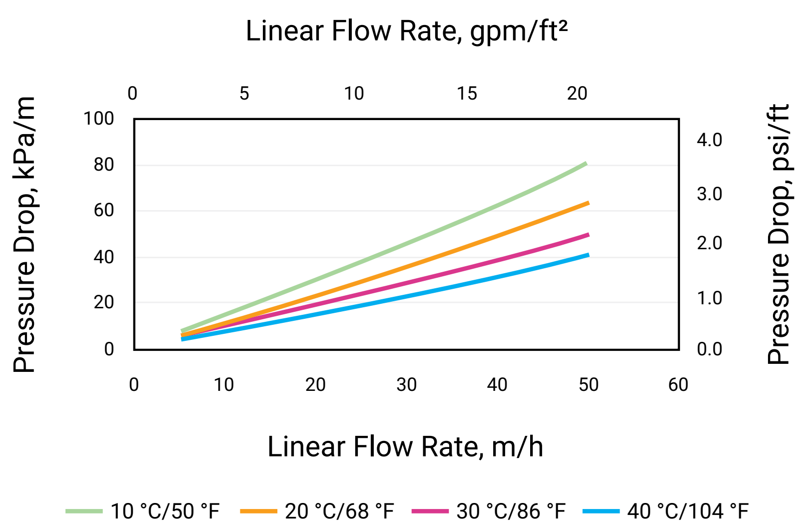


FIGURE 20

Pressure Drop



Additional Information & Application Notes

Safety

Strong oxidants, such as nitric acid, may cause violent reactions with ion exchange resins under certain conditions. The use of strong oxidants must be done under the care and supervision of persons knowledgeable in handling these types of materials.

MSDS/SDS

Material Safety Data Sheets/Safety Data Sheets are available on Purolite's website, www.purolite.com. MSDS sheets should be consulted for additional information on product safety, handling and disposal.

Storage and Transportation

Information on the proper storage and transportation can be found on Purolite's website, www.purolite.com.

Notice

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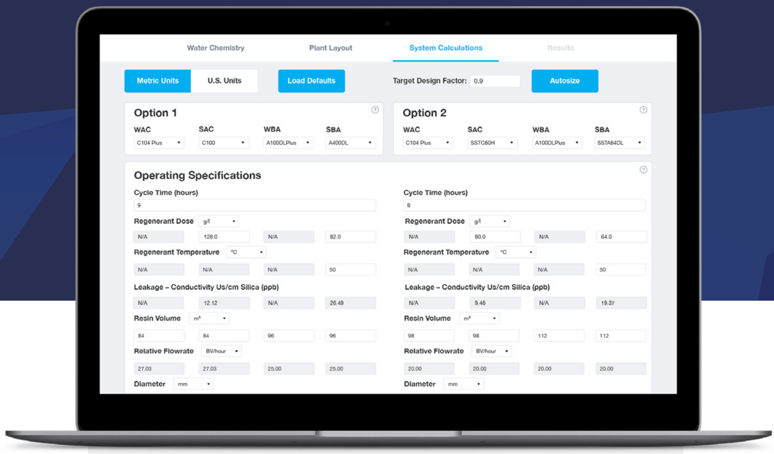
Notes

Customized Resin Simulation at Your Fingertips

PRSM™
Purolite Resin System Modeling

PRSM is a free program that models all aspects of plant design associated with ion exchange resin performance and operation.



Plan your next ion exchange resin project with better accuracy and less effort through Purolite's Resin System Modeling platform (PRSM™). This powerful web application for resin plant simulation contains seven specific system modules that instantly consider hundreds of variables. Whether you are designing a new plant or modeling an existing plant, Purolite's expert engineers are giving you the access you need to get the results you can trust.

Key Insight Every Step of the Way

Predict

Calculate the effect of your site's unique variables

Compare

Side-by-side product and plant configuration performance evaluation

Optimize

Add operation and product cost analysis to better understand the value of product options

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Technical Help – Reach out directly to Purolite engineers for advice

Cloud Backup – Easy and secure retrieval of projects

Reporting – Print/save a pdf of the entire design including all engineering details

ROI Payback Calculations – Contrast performance vs. standard resins

Efficiency Evaluation – Compare operating costs of existing ion exchange plant vs. new design

Schedules – Obtain detailed regenerant schedules for cation and anion resins

Page, Topic and Calculation Help – View detailed notes and suggestions for the optimal design

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