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PUROLITE®
ION EXCHANGE RESINS

**REG NO. 1840987**

**The Purolite Company and Purolite International Limited, Divisions of the Bro-Tech Group**

## SALES OFFICES & BUSINESS CENTRES


**UNITED KINGDOM** Sales & European Marketing
Purolite International Limited, Cowbridge Road,
Pontyclun, South Wales, CF72 8YL.
Tel: 44-1443-235411 Telefax: 44-1443-231113

**PRODUCTION & ADMINISTRATION**
Purolite International Limited, Cowbridge Road, Pontyclun,
South Wales CF72 8YL.
Tel: 44-1443-229 334 Telefax: 44-1443-222 336.

**FRANCE**
Purolite International Sarl, 11 Avenue Delcassé, 75008 Paris.
Tel: 33-1-42 56 45 63 Telefax: 33-1-45 63 38 26 Telex 648856

**GERMANY**
Purolite Deutschland GmbH, Harkort Strasse 25,
40880 Ratingen.
Tel: 49-2102-46033 Telefax: 49-2102-443663

**ITALY**
Purolite International S.r.l., Viale Coni Zugna 29,20144 Milano.
Tel: 39-2-48 18 145 Telefax: 39-2-48 01 23 59 Telex: 335827

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Radus Spolka z.o.o., ul. Przebendowskich 33, 81-543 Gdynia.
Tel: 48-58-297 695 / 248 509 Telefax: 48-58-248 118
Telex: 54457

**ROMANIA**
Purolite Romania, International Business Centre Modern,
Bulevardul Carol No.44-46, Etajul 5, Bucuresti, Sector 2.
Tel: 40-1-250 5053 / 250 5028 Telefax: 40-1-250 5999

**SPAIN**
Purolite Iberia SA, Parc Tecnologic Del Valles,
Centre Empreses Noves Tecnologies,
08290 Cerdanyola (Barcelona).
Tel: 34-3-582-0266/7 Telefax: 34-3-582-0268

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Purolite International Middle East, 12 Obour Gardens, 5th Floor,
Apt. 55, Salah Salem Street, Nasr City, Cairo.
Tel: 20-2-402 1477 / 403 1967 Telefax: 20-2-402 1478

**BRASIL**
Purolite do Brasil Ltda, Rua Orissanga No.26, Sala 14-10 andar,
Edifficio Rubl-Bairro Mirandopolis, 04052-030, Sau Paulo SP.
Tel: 55-11-5078 9583 Telefax: 55-11-5078-9583

**KOREA**
Purolite International (Korea), Dae Yeon Building, Room 403,
943-30 Daechi-Dong, Kangnam-Gu, Seoul, Korea.
Tel: 82-2-3453 7062/3 Telefax: 82-2-3453 7064

**WEBSITES - http://www.purolite.com**
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**U.S.A.**
The Purolite Company, 150 Monument Road, Bala Cynwyd,
PA 19004
Tel: 1-610-668-9090 Freephone: 800-343-1500
Telefax: 1-610-668-8139 Telex: 291718

**CANADA**
The Purolite Company, 625 Wabanaki Drive, Unit 2,
Kitchener, Ontario N2C 2G3.
Tel:1-519-896-6674 Freephone: 1-800-461 1500
Telefax: 1-519-896-6679

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Purolite International, Masarykova 190,
400 01 Usti Nad Labem, Czech Republic.
Tel: 420-47-560 38 05 / 420-47-560 38 25
Telefax: 420-47-560 38 05

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Purolite International, 10th Floor, 36 Lyusinovskaya Street,
Moscow 113093.
Tel: 7-095-564-8120 Telefax: 7-095-564-8121
Satellite Tel: 7-502-222 2120 Telefax: 7-502-222 2121

**RUSSIAN FEDERATION**
Purolite International Limited, 12 Building A, Tambovskaya Street,
St Petersburg, 192007 Russian Federation
Tel: 7-812 327 8350 Telefax: 7-812 327 9079

**KAZAKHSTAN**
Purolite RH Limited, Office 25, 157 Albaya Ave., Almaty 480009
Tel: 7-3272 608 449 Telefax: 7-3272 509 475

**UKRAINE**
Purolite International Limited, 2 Korolenko Street, Office No.5,
Dnepropetrovsk City, Ukraine 49070
Tel: 380-562 32 00 65 Telefax: 380-562 23 12 79

**SINGAPORE**
Purolite International (Singapore) PTE Limited, 300 Beach Road,
32-04 The Concourse, Singapore 199555.
Tel: 65-297- 0889/297 1453 Telefax: 65-297 1986

**CHINA**
Purolite China Co Limited, Chenguan County, Deqin City,
Zhejiang Province, 313200 P.R.China.
Tel: (86) 572-842-2908-819 Telefax: (86) 572-842-3954

**TAIWAN**
Purolite International Limited, 16F-2, No.191 Fu-Hsing N Road,
Taipei, Taiwan.
Tel: 886-2-546 7078 Telefax: 886-2-546 7069

**MEXICO**
Purolite International SA de CV, World Trade Center, Montecito
38 Piso 33, Mexico D.F.03810, Mexico.
Tel: 52 5488 0904 Telefax: 52 5488 0906




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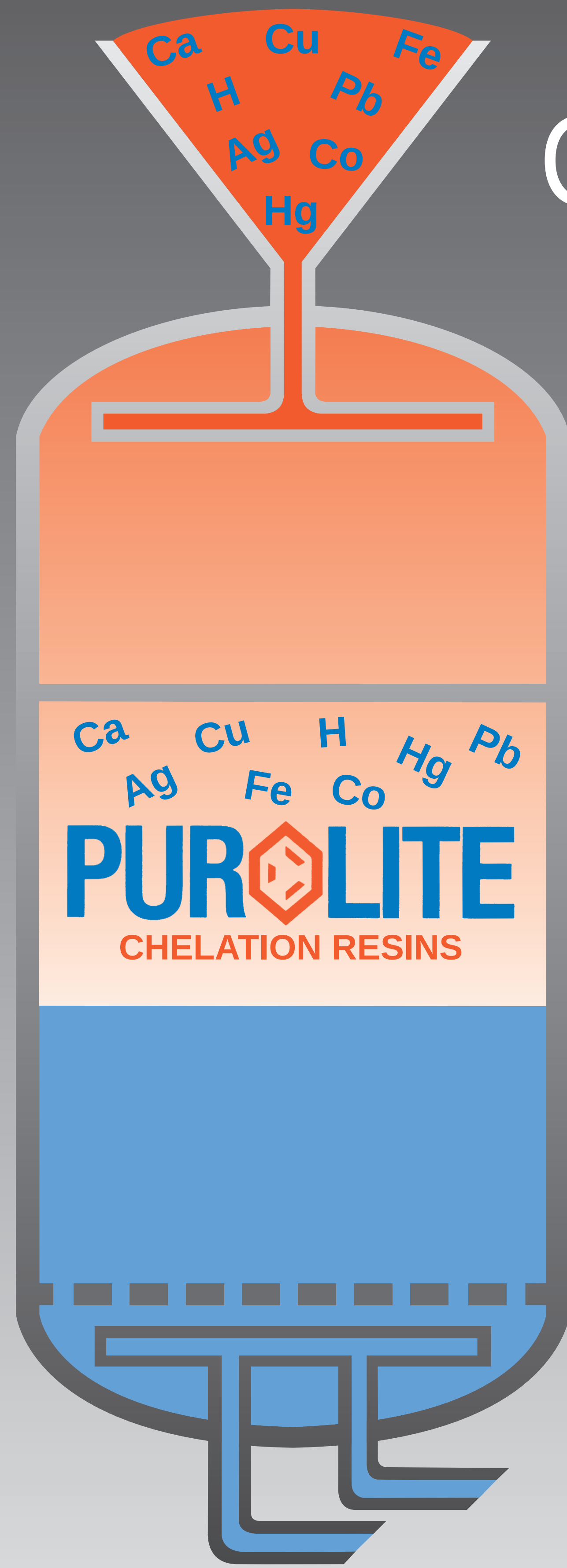



# CHELATION SYSTEMS

PUROLITE
ION EXCHANGE RESINS

Section VII. **COMMENTS**

The **Purolite Chelation Resins** described in this bulletin are the result of continued development of ion exchange products designed for many industrial processes. Further modifications of these products already exist in accordance with **Purolite's** policy to provide their customers with the superior resins for specific industrial processes.

Chelation Resins and the associated systems, have already been shown to be indispensible for production of solutions of the high purity needed in special processes. The efficiency of removal of particular species ultimately depends upon the property of selectivity. However, the advantage of high selectivity has to be taken into account when considering how best to remove the concentrated metal from the collecting medium. In some cases resin destruction is economic and useful. In others, it is the change of stability of the chelation complex with the change in conditions between exhaustion and regeneration which ensures near perfect fixation and excellent removal on regeneration. Changes in *p*H and ionic concentration are often the best means to ensure efficiency in both parts of the cycle. The use of electrolytic processes for regeneration can also be considered, particularly for the electrodeposition of precious metals.

The need for chelation materials with specific properties tailor made to suit particular industrial processes is now a commercial reality.

The expertise of **Purolite** is available, to give recommendations both on specific uses of the chelation products described in this bulletin, and to provide modified products for evaluation.

## APPLICATIONS

a) Extracting heavy metal ions from leach liquors, tailings runoff, or from industrial effluents. For example, lead may be removed from oil refinery waste liquors, solvents and aqueous wastes from the manufacture of paints and printing inks, or battery factory wastes.
b) Recovery of zinc from cooling-tower waters, etc. where it is used as a corrosion inhibitor.

c) Refining of metal salt solutions by selective removal of individual ions.

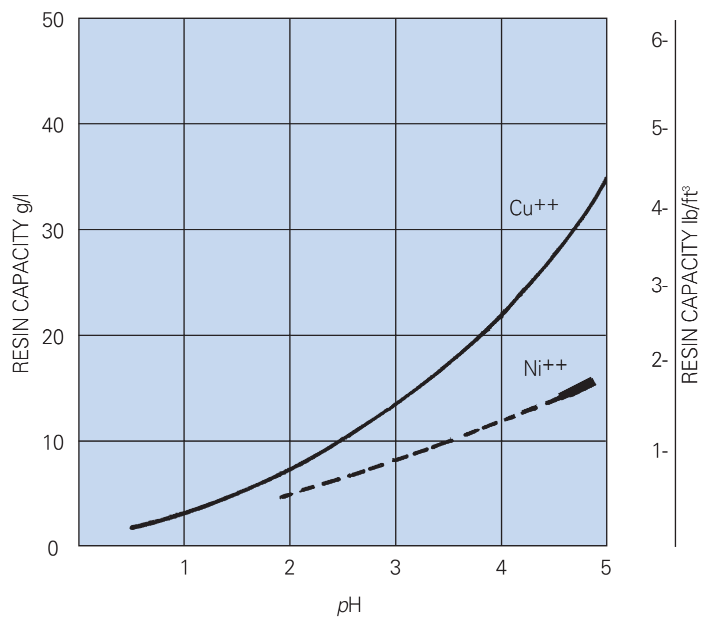
d) ''Polishing'' of aqueous organic and inorganic solutions for the removal of trace metals.

## OPERATING PERFORMANCE

Before attempting to use **Purolite S-950** for any industrial application, it is strongly recommended that laboratory column tests are carried out on the solution which is to be treated, so as to determine the operating performance in terms of both treated solution quantity and quality once the chosen equilibrium cycle conditions have been established. This may take several cycles.

The curves for copper and nickel for **Purolite S-950** given in fig. 3 may serve as a guide to the maximum exchange capacity obtainable from a feed of 2g/l metal as a function of *p*H. In practice, lower capacities will usually be obtained, depending, depending upon regeneration level chosen, having regard to the leakage of metal acceptable .

Fig. 3. RESIN CAPACITY






PUROLITE®
ION EXCHANGE RESINS

# Chelation Systems

## Technical Data

Section 1. **INTRODUCTION**

The removal of metals from process liquors is rapidly gaining in importance. The escalating costs of disposal of waste solutions, in order that they comply with increasingly tough regulation, have to be taken into account. Such costs have to be considered in conjunction with possible savings to be made from recovery.
**Purolite** offers a range of chelation resins which will selectively remove particular groups of metals from solution. After preliminary recovery by precipitation, on the one hand, or where plated metal objects have been given final rinses, on the other hand, these metals are usually present in waste solutions in concentrations of several parts per million. Such concentrations although low are found to be environmentally harmful In many cases.
The use of **Purolite Chelation Resins** for the purification of these waste aqueous streams to render them suitable for disposal through the domestic sewerage system, or direct disposal into suitable aquifers, affords a most suitable and economical means of treatment, which yields treated solutions containing almost undetectable (ppb) concentrations of the undesirable metals. The many-fold increase in concentration of the metals on the chelation resin makes possible the recovery of the metal for reprocessing or effective disposal in a less harmful form.

Modern industrial chemical processes often use sophisticated techniques which provide a more economical route to high quality products. One such process uses membrane cells for the electrolysis of brine to produce caustic soda and chlorine. The membrane cells require that the inlet brine contains less than 20ppb of calcium for efficient operation. **Purolite S-940** provides an ideal route to reduce calcium concentration in brine feed solutions from 1-15ppm, as found in conventionally purified solutions, to well within the required specification, for the smooth operation of this process.

As analytical techniques continue to improve, the study of the effect of trace levels of impurities on the economics of industrial processes is increasingly well understood. The very high selectivity of chelation resins means that these ion exchange resins will offer many further possibilities to remove harmful contaminants to provide solutions of the required purity.

Section II.

| Resin Type | Functional Group | Matrix | Principal Applications |
|---|---|---|---|
| **Purolite** | | | |
| S-920 | Thiouronium | Macroporous styrene-divinyl-benzene | Mercury and precious metals removal from aqueous solutions |
| S-930 | Iminodiacetic | Macroporous styrene-divinyl-benzene | Effluent treatment, hydrometallurgy (Specific for heavy metals) |
| S-940 | Aminophosphonic | Macroporous styrene-divinyl-benzene | Brine purification (Removal of calcium etc) |
| S-950 | Aminophosphonic | Macroporous styrene-divinyl-benzene | Effluent treatment Hydrometallurgy |

# Contents





Fig. 1. PRESSURE DROP VS FLOW RATE

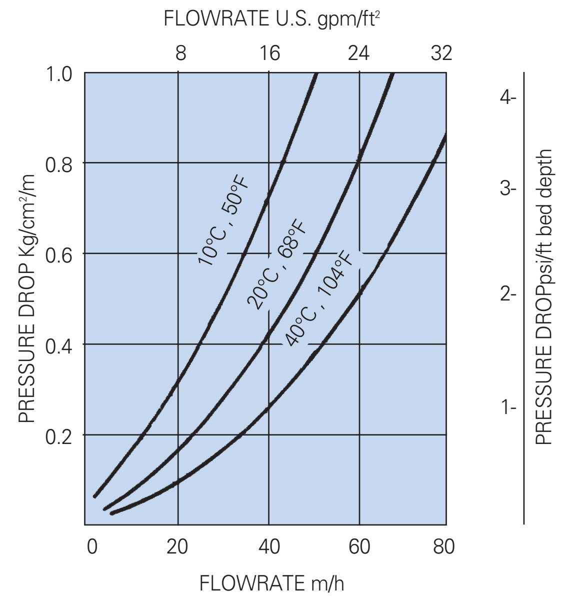
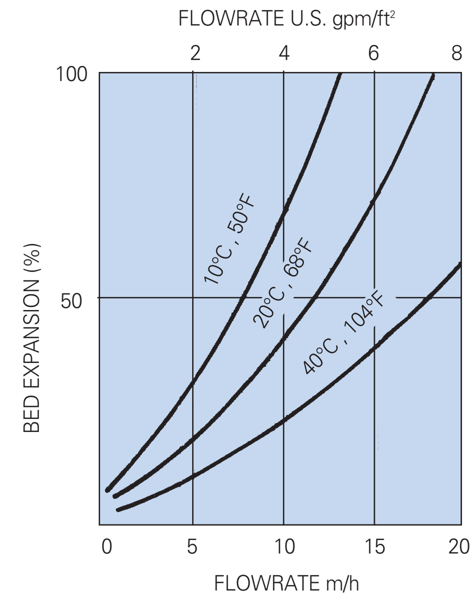



Fig. 2. BACKWASH EXPANSION (exhausted form)




During upflow backwash, the resin bed should be expanded in volume by between 50 and 75%, in order to free it from any particulate matter from the influent solution, to clear the bed of bubbles and voids, and to reclassify the resin particles as much as possible, ensuring minimum resistance to flow. Bed expansion increases with flow rate and decreases with temperature, as shown in Fig. 2. for a typical exhausted form of the resin. Care should always be taken to avoid resin loss by over-expansion of the bed.

**CONVERSION OF UNITS**

| | | | |
|---|---|---|---|
| 1 m/h (cubic metres per square metre per hour) | = | 0.341 | gpm./ft². |
| | = | 0.409 | U.S. gpm./ft². |
| 1Kg/cm² /m (Kilograms per square cm. per metre of bed) | = | 4.33 | psi/ft. |
| | = | 1.03 | atm./m/ |
| | = | 10 | ft. $H_2O$/ft |

## AFFINITY ORDER FOR TYPICAL CATIONS.

Like the **S-940**, the **S-9.50** affinity order varies as a function of solution *p*H.

Acidic *p*H:

$H^+ > Fe^{3+} > Pb^{2+} > Cu^{2+} > Zn^{2+}\ Al^{3+} > Mg^{2+} \geqslant Ca^{2+} \geqslant Cd^{2}+ > Ni^{2+} \geqslant Co^{2+} > Na^+$

Alkaline *p*H:

$Cd^{2+}\ Mg^{2+} > Ca^{2+} > Sr^{2+},\ Al^{3+} > Ba^{2+} \gg Na^+\ K^+$

It should be noted that **Purolite S-950** is capable of operating under acidic, neutral, or alkaline conditions; its operating capacity for any of the chelated ions is a function of pH, and consequently there are minimum values of pH below which removal of a given cation from the influent solution is not feasable. Relevant figures are given below:

| CATION SPECIES | CATION SPECIES |
|---|---|
| $CU^{2}+\ Pb^{2}+$ | 2 |
| $Zn^{2}+$ | 2.5 |
| $Cd^{2}+$, $Ca^{2}+$ | 3 |
| $Mg^{2}+$, $Ni^{2}+\ Co^{2}+$ | 4.5 |

## STANDARD OPERATING CONDITIONS

| Operation | Rate | Solution | Minutes | Amount |
|---|---|---|---|---|
| Service | 8- 16BV/h<br>1-2gpm/ft3 | For treatment | | |
| Backwash | 5-7m/h<br>2-3gpm/ft2 | Raw Water | 5-20 | 1.5-6BV<br>10-35 gal/ft3 |
| Regeneration | 3-4BV/h<br>0.4-0.5gpm/ft3 | Mineral Acids<br>(2N-3N) | 30-60 | 120-200g/l HC1<br>7.5-1 2.51b/ft3<br>200-300g/l $H_2SO_4$<br>12.5-20 lb/ft3 |
| Slow rinse | 3-4BV/h<br>0.4-0.5gpm/ft3 | Raw Water | 30-40 | 2-3BV<br>15-20gal/ft3 |
| Conversion to sodium form-as required: | | | | |
| | 3-4BV/h<br>0.4-0.5 gpm/ft3 | N NaOH<br>(Upflow)* | 30-60 | 60-120g/l<br>3.75-7.5 lb/ft3 |
| Rinse (slow) | 3-4BV/h<br>0.4-0.5gpm/ft3 | Soft Water | 20-40 | 2-4BV<br>15-30gal/ft3 |

Backwash expansion 75% (optimum)
Design rising space 100%
Minimum bed depth 1000mm "gallons"' refer to U.S. gallons = 3.785 Litres.

*The aim is to achieve the same pH as that of the incoming solution.

## CHEMICAL STABILITY

**Purolite S-950** is insoluble in acids, alkalies and all common solvents at normally encountered temperatures (although oxidizing agents like concentrated nitric and perchloric acid at elevated temperatures will destroy its structure and solubilise the resin. Care should be taken when using strong nitric acid, as explosive hazards have been reported on poly(styrene)-based anion exchange resins with this reagent). However exposure, even at ambient temperatures, to certain other strong oxidizing agents such as chlorine causes **irreversible damage to** this resin and must be kept to the **absolute minimum.**

## 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, and on the flowrate and viscosity (and hence on the temperature) of the influent solution. Anything affecting any of these parameters, for example the presence of particulate matter filtered out by the bed, abnormal compaction of the resin bed, or the incomplete classification of the resin spheres will have an adverse effect, and result in an increased headloss.

Service flow rates from 8-16 bed volumes per hour, depending on the application, may be regarded as the normal range used on this resin, Typical pressure drop figures to be expected for ordinary aqueous solutions, are given in Fig. 1.



PUROLITE®
ION EXCHANGE RESINS

# S-920
## Macroporous Thiouronium Chelating Resin

(For the selective removal of mercury and precious metals from aqueous solutions)

# Technical Data

Section III. **PRODUCT DESCRIPTION**

**Purolite S-920** is a macroporous polystyrenic based chelating resin, with thiouronium groups designed for the selective removal of mercury.and for the recovery of precious metals from the industrial effluents. The mercury, in particular, is strongly bound to the functional groups to form highly stable complexes, with high selective affinity compared with those of other heavy metals. These properties are largely unaffected by high chloride (or sulphate) content of the effluent. Effluent solutions which may typically contain 2-20ppm of mercury can be treated to reduce the concentration in solution to less than 0.005ppm. **Purolite S-920** can load up to 200g of mercury, or gold, or 60g approx. of platinum or palladium for each litre of resin, equivalent to 12.5, and 3.75 lb/ft$^3$ respectively. **Purolite S-920** is designed for the removal of low concentrations of soluble mercury salts from waste streams and for the recovery of precious metals from rinse waters in the galvanic and electronic industries. **Purolite S-920** is also used in hydrometallurgy for the separation of precious metals from acid liquors. Mercury and precious metals are so strongly held, and run lengths are so long (thousands of hours) that it is not normally considered economic to regenerate the resin for reuse.

**Purolite S-920** is more resistant to oxidation than many thiol based resins and contact with the atmosphere is not detrimental, however free chlorine and other strong oxidising agents may damage the resin and their removal from solution by filtering through activated carbon is recommended.

### Typical Chemical & Physical Characteristics

| | |
|---|---|
| Polymer Matrix Structure | Macroporous Styrene-divinylbenzene |
| Physical form & Appearance | Opaque Cream Spheres |
| Whole Bead Count | >95% |
| Functional Groups | Thiouronium |
| Ionic Form (as shipped) | $H^+$ |
| Shipping Weight | 700 - 735 g/l (44 - 46 lb/ft$^3$) |
| Screen Size range (British Standard Screen) | 14-52 mesh, wet |
| Particle Size range | + 1.2mm <5%, -0.3mm <1% |
| Moisture Retention, $H^+$ Form | 48-54% |
| Reversible Swelling, ($H^+ \rightarrow Hg^{++}$) | <5% |
| Specific Gravity. Moist $H^+$ Form | 1.12 |
| Specific Gravity. Moist $Hg^{++}$ Form | 1.40 |
| Total Exchange Capacity, $H^+$ Form (wet, volumetric) | 200g Hg/l, 12.5 lb/ft$^3$ |
| Max, Operating Temperature, $H^+$ Form | 80°C (176°F) |
| Operating *p*H Range | 1-13 |

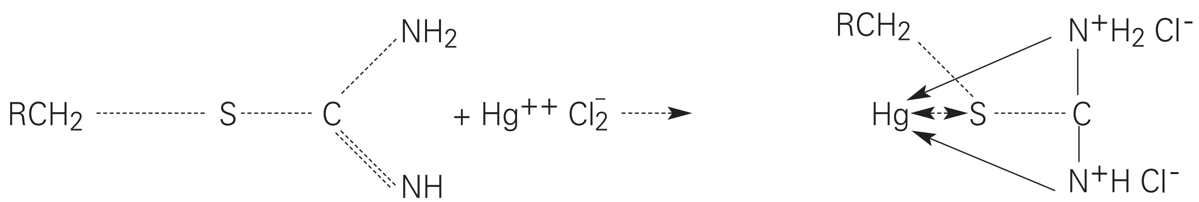
## STANDARD OPERATING CONDITIONS

It is recommended that **Purolite S-920** is used in a two column, lead and trail system. In this way, maximum loading of the resin is achieved. When use is for mercury uptake, it is usual to pretreat the solution with lime neutralisation and to fully oxidise the metals and sulphites with $H_2O_2$. This is followed by flocculation with an inorganic polyelectrolite, sedimentation, sand and activated carbon filtration .

| | |
|---|---|
| Recommended linear flow rate: | 6-18 m/h |
| Minimum bed depth: | 1000mm |
| Backwash flow rate: | 4-8 m/h (see fig. 2), for 20 min. |

## PRINCIPLE OF REACTION

Mercury Removal




The mercury is strongly complexed by the sulphur and nitrogen groups. When the resin is well rinsed with water before use, the mercury salt as a whole is accommodated on the resin. In most instances the *p*H of the water to be treated will lie in the range of 3-10, which is generally very suitable for highest mercury uptake and the lowest leakage - typically much less than 5ppb as Hg. *p*H may be reduced slightly by the mercury exchange (release of acid held by the weakly basic thiouronium groups) .

In general **Purolite S-920** will complex precious metals when they are present as free cations. The free cation state is governed by the *p*H of the solution.

## 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, and on the flowrate and viscosity (and hence on the temperature) of the influent solution. Anything affecting any of these parameters, for example the presence of a particulate matter filtered out by the bed, abnormal compaction of the resin bed, or the incomplete classification of the bed will have an adverse effect, and result in an increased headloss.

Service flow rates from 10-30 bed volumes per hour, depending on the application, may be regarded as the normal range used on this resin. Typical pressure drop figures to be expected for ordinary aqueous solutions, are given in Fig. 1.



PUROLITE®
ION EXCHANGE RESINS

# S-950
## Macroporous Aminophosphonic Chelating Resin
(For the selective removal of toxic metals from aqueous solutions)

# Technical Data

Section VI. **PRODUCT DESCRIPTION**

**Purolite S-950** is a macroporous amino-phosphonic acid chelating resin, designed for the removal of cations of toxic metals such as lead, copper and zinc from industrial effluents at low ph. At somewhat higher pH values, calcium, magnesium and barium, as well as the toxic metals cadmium, nickel, and cobalt are strongly complexed and may be separated from quite high concentrations of univalent cations.
Unlike **Purolite S-930,** the well known iminodiacetic acid resin, which is selective for heavy metal ions, but not for common divalent ions (calcium and magnesium), **Purolite S-950** is more highly selective (under the appropriate conditions) for a range of both heavy metal and common divalent ions. Hence its use may be recommended where it is necessary to remove calcium or magnesium in order to avoid possible precipitation, or where its selectivity for a particular range of metals offers advantages.

### Typical Chemical & Physical Characteristics

| | |
|---|---|
| Polymer Matrix Structure | Macroporous Styrene-divinylbenzene |
| Physical Form & Appearance | Opaque light brown spheres |
| Whole Bead Count | >95% |
| Functional Groups | $RCH_2$ N $HCH_2$ $P0_3$ |
| ionic Form (as shipped) | Na+ |
| Shipping Weight g/l | 710 - 745 g/l (44.5 - 46.5(lb./$ft^3$)) |
| Screen Size Range: British Standard Screen | 14-52 mesh, wet |
| U.S. Standard Screen | 16-50 mesh wet |
| Particle Size Range | +1.2mm <5%, -0.3mm <1% |
| Moisture Retention, Na+ Form | 60-68% |
| Reversible Swelling, (H+ → Na+) Max. | 45% |
| Specific Gravity, Moist Na+ Form | 1.13 |
| Total Exchange Capacity, Na+ Form (wet, volumetric) | 2.0 meq./ml., min. |
| (dry weight) | 5.5 meq./g., min. |
| Exchange Capacity (Na+ Form) | 24 g. Ca++/l (1.51b/$ft^3$)min at pH 9.5 |
| Max, Operating Temperature, Ca++ Form | 90°C (195°F) |
| pH Range (operating), H+ Form | 2-6 |
| Na+ Form | 6-11 |

During upflow backwash, the resin bed should be expanded in volume between 50 and 75%, in order to free it from any particulate matter from the influent solution, to clear the bed of bubbles and voids, and to reclassify the resin particles as much as possible, ensuring minimum resistance to flow. Bed expansion increases with flow rate and decreases with temperature, as shown in fig. 9 for a typical exhausted form of the resin. Care should always be taken to avoid resin loss by over-expansion of the bed.

## Brine purification

### PRESSURE DROP AND BACKWASH

The pressure drop across a bed of resin when brine (300g/l) is the influent solution is considerably higher than that for more dilute solutions hence the curves given below should be used, see fig. 10.

The backwash expansion for the calcium form resin at the end of the brine purification is higher than that for the heavier metals, thus the curves in fig. 11 are applicable

Fig. 10 PRESSURE DROP VS FLOWRATE

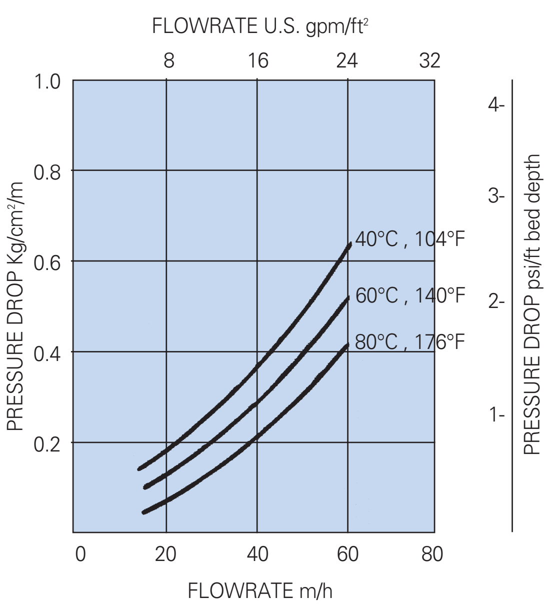



Fig. 11 BACKWASH EXPANSION

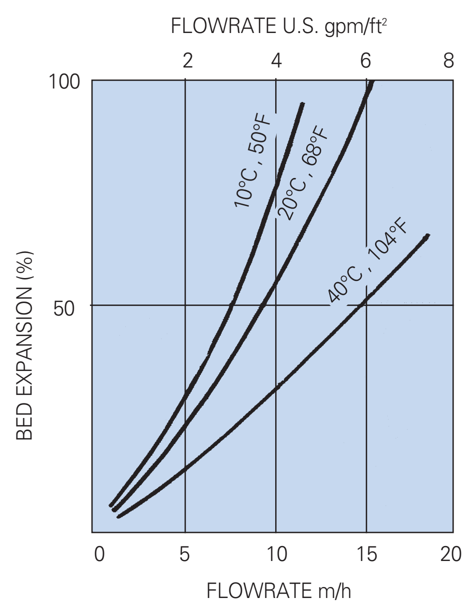





Fig. 1. PRESSURE DROP VS FLOW RATE

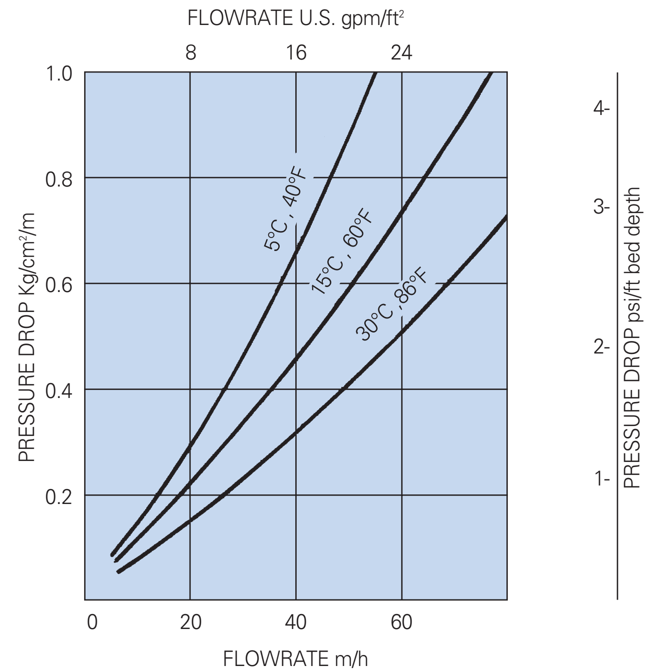
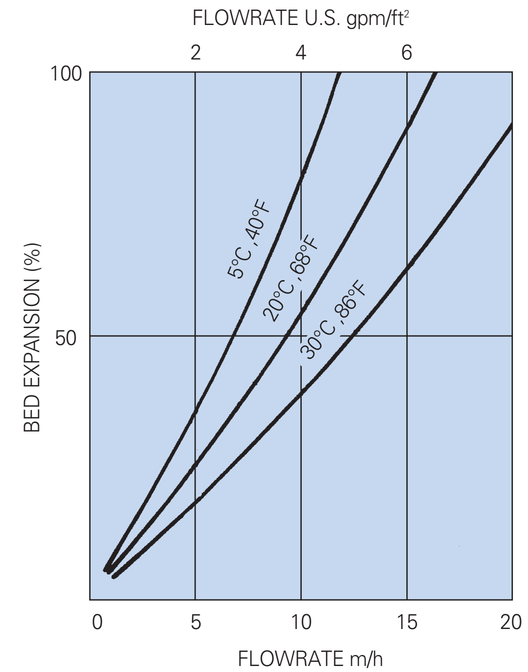



Fig. 2. BACKWASH EXPANSION (New resin)




During upflow backwash, the resin bed should be expanded in volume by between 50 and 75%, to clear the bed of bubbles and voids, and to classify the resin particles as much as possible, ensuring minimum resistance to flow. Bed expansion increases with flow rate and decreases with temperature, as shown in Fig. 2. This applies to unused resin. Since the resin is not regenerated, backwash at exhaustion is not required. Care should always be taken to avoid resin loss by over-expansion of the bed.

**CONVERSION OF UNITS**

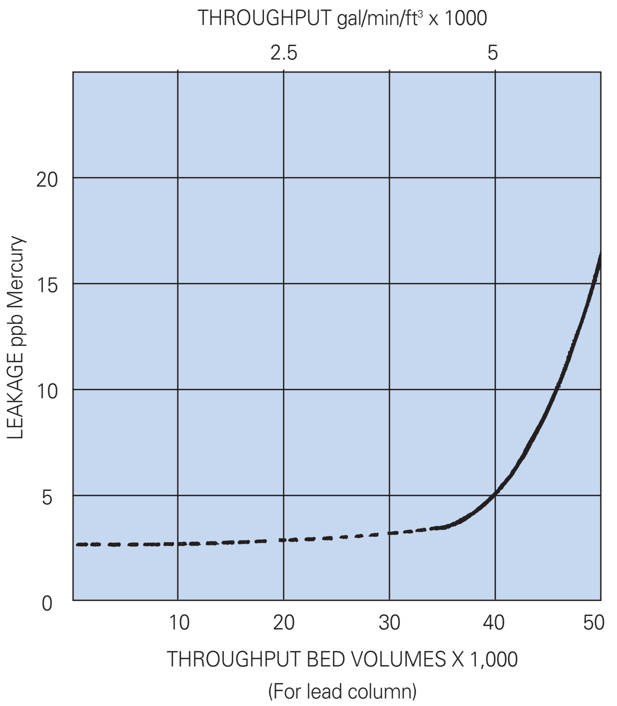
| | | | |
|---|---|---|---|
| 1 m/h (cubic metres per square metre per hour) | = | 0.341 | gpm./ft². |
| | = | 0.409 | U.S. gpm./ft². |
| 1Kg/cm² /m (Kilograms per square cm. per metre of bed) | = | 4.33 | psi/ft. |
| | = | 1.03 | atm./m |
| | = | 10 | ft. $H_2O$/ft |

### OPERATING PERFORMANCE

The operating capacity will be higher on the first cycle since both lead and trail columns will use new resin. This cycle will be complete when the lead column is saturated (that is when influent and effluent have reached equilibrium). The substantial leakage which occurs from the lead column towards the end of the cycle is of course taken out by the trail column. This uses capacity depending upon the conditions of operation. In subsequent runs the throughput obtained from the lead column will be reduced according to load previously taken up while the bed was in the trail position.

The Fig. 3. gives a typical exhaustion profile from the outlet of the trail column in terms of bed volumes throughput for the lead column. In a typical operation as shown the lead column is loaded with a total of 90g/l of mercury of which 70-85g/l may be loaded while the bed is in the lead position.

Fig. 3. OPERATING PROFILE: Typical from trail column




| | |
|---|---|
| Inlet Mercury | —2ppm |
| to Lead Column | |
| Temperature | 20°C |
| *p*H | 8.0 |
| Flow Rate | 8BV/h |

* Leakage values may be lower in dotted line region



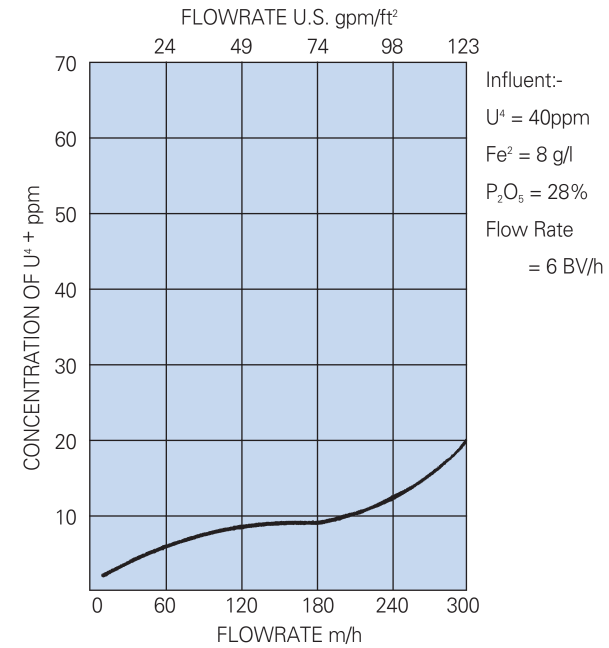
## GENERAL APPLICATIONS

**Purolite S-940** is also suitable for separation and recovery of heavy metals, including uranium. The leakage of uranium can depend on linear flow rate in the resin in pulp process (see Fig. 7).

- **Purolite S-940** has a high selectivity for heavy metals and transition metals, more particularly, lead, copper and zinc. The affinity for copper is higher than for zinc and hence it is possible to separate and concentrate these metals from a mixture in solution.

- **Purolite S-940 may be used** to purify solutions. For example, lead can be removed from industrial waste streams etc...

Fig. 7 EXTRACTION OF URANIUM




## 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, and on the flowrate and viscosity (and hence on the temperature) of the influent solution. Anything affecting any of these parameters, for example the presence of particulate matter filtered out by the bed, abnormal compaction of the bed, or the incomplete classification of the bed will have an adverse effect, and result in an increased headloss.

Service flow rates from 10-30 bed volumes per hour depending on the application, may be regarded as the normal range used on this resin. Typical pressure drop figures to be expected for ordinary aqueous solutions, are given in fig. 8 below.

Fig. 8 PRESSURE DROP VS FLOWRATE

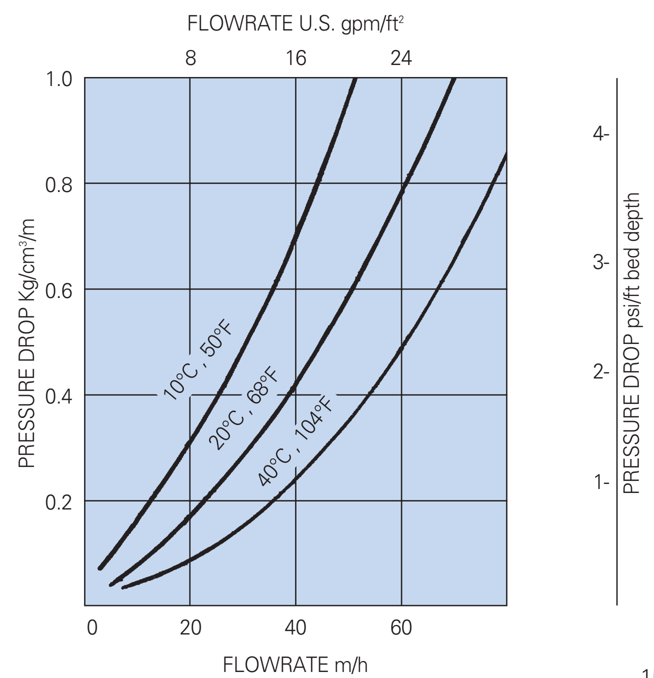



Fig. 9 BACKWASH EXPANSION (Exhausted Forms)

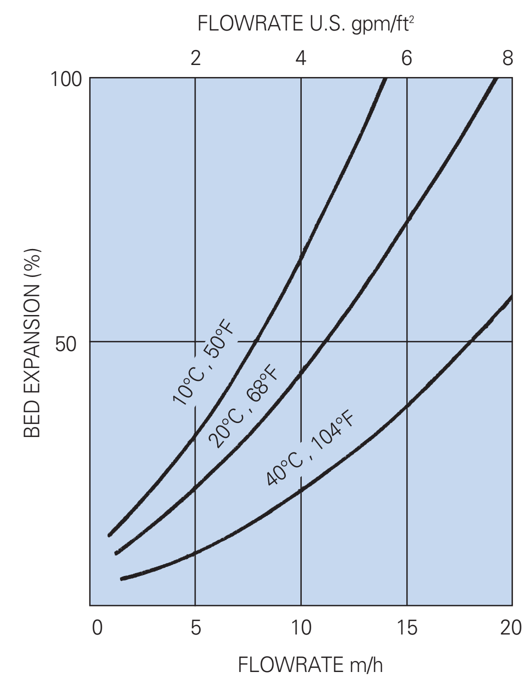


Fig. 3 CORRECTION FACTOR FOR TEMPERATURE

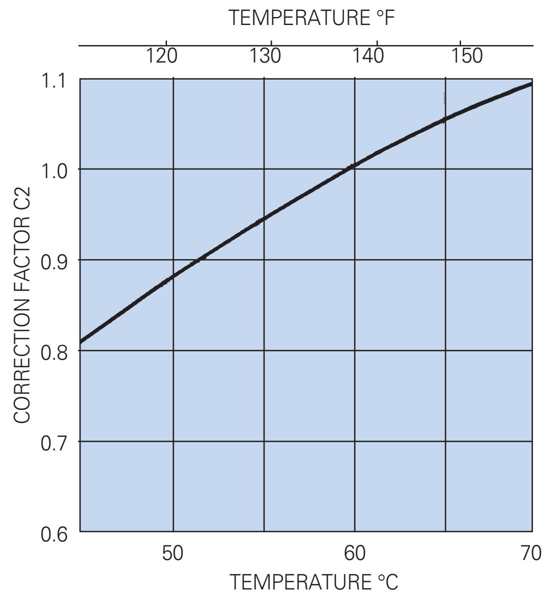



Fig. 4 CORRECTION FACTOR FOR FLOW RATE

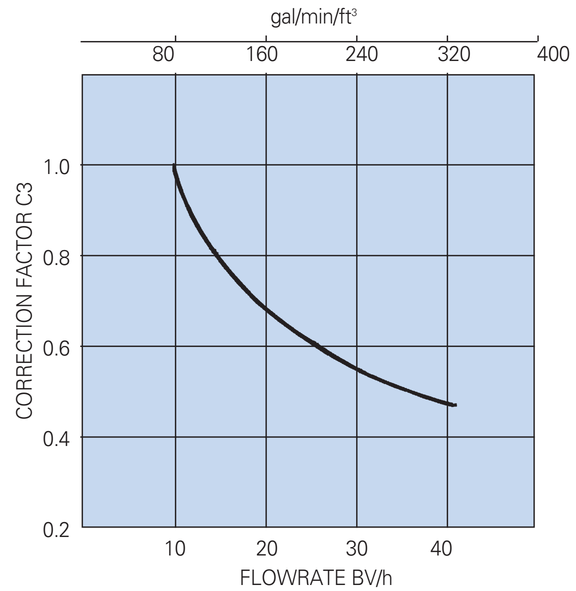



Fig. 5 TYPICAL LEAKAGE OF CALCIUM

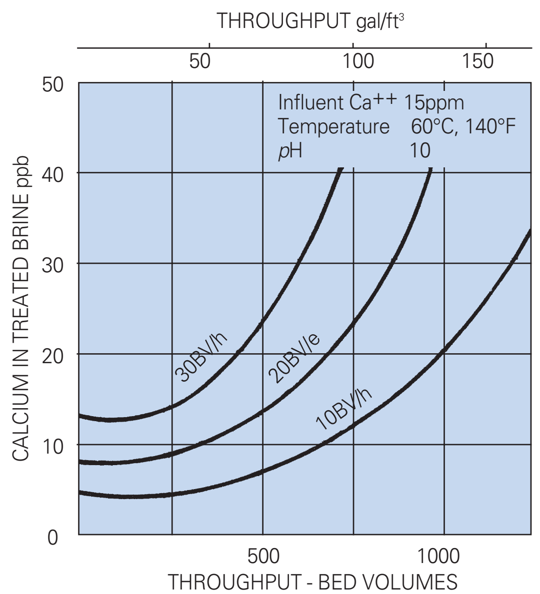
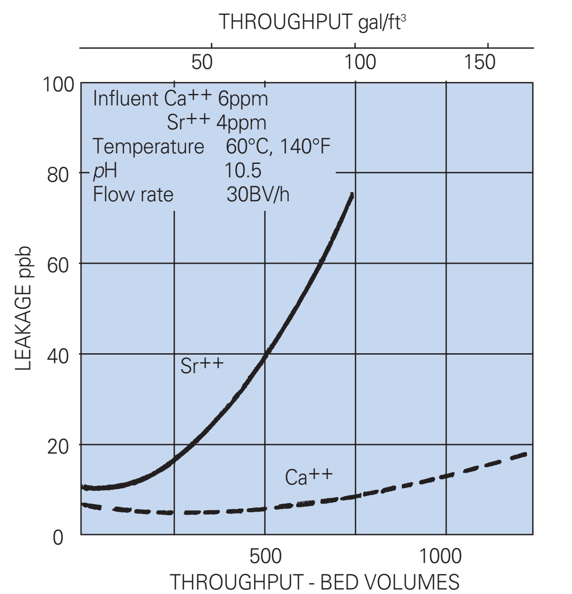



Fig. 6 TYPICAL LEAKAGE OF Mixed CATIONS




## CHEMICAL AND PHYSICAL STABILITY

**Purolite S-940** has been exhaustively tested to demonstrate that it will withstand temperatures above the maximum recommended limit of 90°C (194°F) in the presence of brine solutions at high ionic concentration (300g/l). It has also been shown that **Purolite S-940** is both chemically and physically stable to high concentrations of acid and alkali (20% of sulphuric acid and 20% of sodium hydroxide), which are stronger than would normally be used under the most severe conditions of operation. In tests for osmotic and physical stability using a specially developed rig* which incorporates mechanical stress and attrition, by pumping the resin against a retaining stainless steel mesh, the following results were typically obtained after 100 cycles of operation.

| Resin | % Perfect | % Cracks | % Pieces | % Mis shapes |
|---|---|---|---|---|
| **Purolite S-940** | **97** | **1** | **1** | **1** |
| **Purolite S-940 100 cycles** | **96** | **0** | **2** | **1** |

* Test Rig originally developed by the Scientific Services Division of the Electricity Generating Board of UK.



PUROLITE®
ION EXCHANGE RESINS

# S-930
## Macroporous Iminodiacetic Chelating Resin

(For the selective removal of heavy metals from aqueous solutions)

# Technical Data

Section IV. **PRODUCT DESCRIPTION**

**Purolite S-930** is a macroporous polystyrene based chelating resin, with iminodiacetic groups designed for the removal of cations of heavy metals from industrial effluents. These cations may be separated from high concentrations of univalent cations (typically sodium) and also from common divalent cations (such as calcium). Removal can be achieved both from weakly acidic and weakly basic solutions depending on the metals to be removed.

**Purolite S-930** finds use in processes for extraction and recovery of metals from ores, galvanic plating solutions, pickling baths, and effluents even in the presence of alkaline earth metals (calcium and magnesium).
Further important uses include the refining of the salt solutions of transition and precious metals and for the cleaning and purification of various organic or inorganic chemical products by removal of heavy metals contamination (usually from aqueous solution).

### Typical Chemical & Physical Characteristics

| | |
|---|---|
| Polymer Matrix Structure | Macroporous Styrene-divinylbenzene |
| Physical form & Appearance | Opaque Beige Spheres |
| Whole Bead Count | >90% |
| Functional Groups | Iminodiacetic |
| Ionic Form (as shipped) | $Na^+$ |
| Shipping Weight | 710 - 745 g/l (44.5 - 46.5 lb/ft³) |
| Screen Size range (British Standard Screen) | 14-52 mesh, wet |
| Particle Size range | + 1.0mm <10%, -0.3mm <1% |
| Moisture Retention, $H^+$ Form | 55-65% |
| Reversible Swelling, ($H^+ \rightarrow Na^+$) | <20% |
| Specific Gravity. Moist $H^+$ Form | 1.17 |
| Total Exchange Capacity, $H^+$ Form (wet, volumetric) | 1.1 eq./l., min. |
| $H^+$ Form | 35g of $Cu^{++}$/l., 2.2 lb/ft³ min. |
| $Na^+$ Form | 0.94 eq./l., min. |
| $Na^+$ Form | 30g of $Cu^{++}$/l., 1.9 lb/ft³ min. |
| Max, Operating Temperature, $H^+$ Form | 70°C (158°F) |
| *p*H Range (operating) $H^+$ Form | 2-6 |
| $Na^+$ Form | 6-11 |

## STANDARD OPERATING CONDITIONS

**Purolite S-930**:- These operating conditions are given as a general example. However regeneration conditions and flow rates should be chosen for the particular application. For further recommendations please contact your local sales office

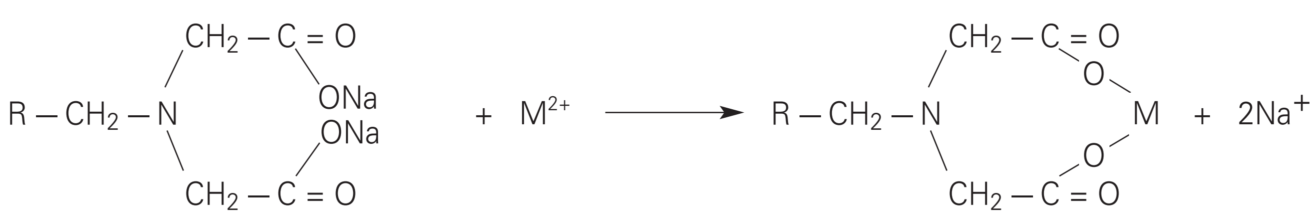
| Operation | Rate | Solution | Minutes | Amount |
|---|---|---|---|---|
| Service | 8 - 16BV/h<br>1-2gpm/ft³ | For treatment | | |
| Backwash | 5-7m/h<br>2-3gpm/ft² | Raw Water | 5-20 | 1.5-6BV/h<br>10-35 gal/ft³ |
| Regeneration | 3-4BV/h<br>0.4-0.5gpm/ft³ | Mineral Acids<br>(2N-3N) | 30-60 | 140-200g/l HCL or<br>12.5-20lb/ft³<br>200-320g/l $H_2SO_4$ |
| Slow rinse | 3-4BV/h<br>0.4-0.5gpm/ft³ | Raw Water | 30-40 | 2-3BV/h<br>15-25gal/ft³ |
| Conversion to sodium form as required:- | | | | |
| | 3-4BV/h<br>0.4-0.5gpm/ft³ | $^1/_2$N NaOH<br>(Upflow)* | 40-60 | 40-60g/l<br>2.5-3.75lb/ft³ |
| Rinse | 3-4BV/h<br>0.4-0.5gpm/ft³ | Soft or Demin<br>Water | 20-40 | 2-4BV/h<br>15-30gal/ft³ |

Backwash expansion 75% (optimum)
Design rising space 100%
Minimum bed depth 1000m
"gallons refer to U.S. gallons = 3.785 Litres.

*The aim is to achieve the same pH as that of the incoming solution.

## PRINCIPLE OF REACTION

The iminodiacetic functional groups, in either the sodium or the hydrogen form, will chelate heavy metals by ion attraction to the dicarboxylic functionality and electron donation from the nitrogen:




## APPLICATIONS

**Purolite S-930** is particularly suitable for the removal of heavy metals (as weakly acidic chelated complexes) which are held according to the following order of selectivity.
Cu≫Ni>Zn≥Co≥Cd>Fe(II)>Mn>Ca
The macroporous resin structure ensures excellent diffusion of ions thus affording



## PRINCIPLE APPLICATION

The various applications of **Purolite S-940** are too numerous to cover individually in detail. Brine softening is the major application. Chlorine gas and alkali metal hydroxides are produced by the electrolysis of brine solutions in chlor-alkali cells. The industrial process has used three main types of these cells - mercury, diaphragm, and membrane electrolytic cells. The membrane cells are the most economic and are supported by the most sophisticated technology in their operation. All types need periodic maintenance as a result of the impurities in the brine, especially Ca and Mg. Membrane cells require the highest purity brine which should contain less than 20ppb calcium and less than 50-100ppb Sr according to the process specification.

**Purolite S-940** is sufficiently selective for strontium to allow for its containment in the polishing column when the lead column is operated to a calcium leakage endpoint. This applies for Sr values up to 20% of the feed Ca concentration by weight.
In this way it is possible to operate at a steady lower voltage, thus saving energy and increasing production.
Purification of brine (removal of divalent and trivalent cations) to the exacting standards required is achieved by using **Purolite S-940** which will remove the majority of contaminant metals, even under very difficult conditions: saturated salt (more than 300g/l of NaCl), alkaline pH, elevated temperature.

## OPERATING PERFORMANCE

The operating capacity expressed in g $Ca^{2+}$ per litre increases with:
- *p*H, optimum >9 (see fig. 1 )
- influent calcium concentration, (see correction factor in fig. 2)
- temperature of feed, which is best maintained at above 60°C (see fig. 3)
- Reduction in flow rate, (see fig. 4)
  10-20BV/h is recommended, though rates up to 30BV/h are feasible.

The permanent leakage obtained in treating brine using **Purolite S-940** is generally very Low: for example < 50ppb for strontium and < 20ppb for calcium and magnesium, see fig. 5 and 6.

Fig. 1 CAPACITY FOR CALCIUM REMOVAL (as a function of *p*H)

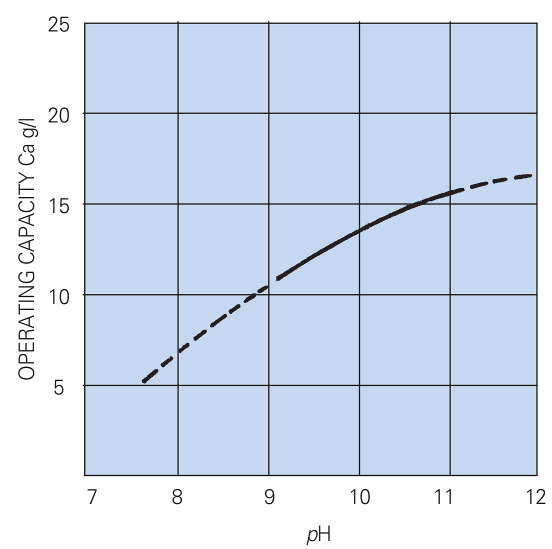
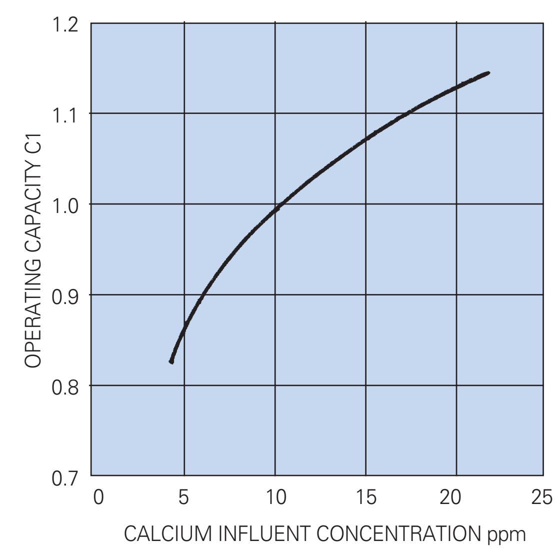



Fig. 2 CORRECTION FACTOR FOR INFLUENT CALCIUM CONCENTRATION



## STANDARD OPERATING CONDITIONS

| Operation | Rate | Solution | Minutes | Relative Volume Change | Amount (Temp) |
|---|---|---|---|---|---|
| Service | 8-30BV/h<br>1-4gpm/ft³ | Brine | * | 1.25 | * (at 60—90°C) |
| Brine Displacement | 4 BV/h<br>0.5gpm/ft³ | Soft water | 60—90 | 1.30 | 4—6BV (room temp, RT)<br>30—45 gals /ft³ |
| Backwash | 8-12m/h<br>3-5 gpm/ft² | Soft water | 30 | - | - (RT) |
| Regeneration | 2-6BV/h<br>0.25-0.75gpm/ft³ | HCl (Normal) | 30-60 | 1.0 | 100-150g/l (RT)<br>6.25-9.5 lb/ft³ |
| Rinse | 2-4BV/h<br>0.25-0.5gpm/ft³ | Soft water | 30-60 | 1.0 | 2BV(RT)<br>1 5gal/ft³ |
| Sodium Conversion | 2-4BV/h<br>0.25-0.5 gpm/ft³ | NaOH (Normal)<br>(Upflow) | 15-60 | 1.45 | 20-80g/l (RT)<br>1.25-5 lb/ft³ |
| Rinse | 2-4BV/h<br>0.25-0.5 gpm/ft³ | Soft water | 30-60 | 1.45 | 2BV (RT)<br>15 gal/ft³ |

* Exhaustion time and volume of treated brine depend upon the operating conditions (see Figures 1-4) "gallons" refer to US gallons =3.785 litres

**Purolite S-940** may also be used in the hydrogen form for heavy metals removal. The above operating conditions may be adapted as follows. The regeneration is carried out using HCl, as above (or 2N $H_2SO_4$ may also be used at 200-300g/l; 12.5-19lb/ft³). The objective of the sodium conversion is to optimise the pH of solution to maximise capacity and reduce leakage. The aim should be to achieve the same pH as that of the incoming solution. Operation flow rates of 8-16 BV/h (1-2 gpm/ft³) may be used, and displacement prior to backwash eliminated or modified.

## PRINCIPLES OF OPERATION

The capacity of this resin is dependent upon pH; it is able to operate in neutral, acidic or alkaline media, however the relative affinities for metals vary as a function of pH and ionic concentration, hence it is recommended that laboratory trials (column tests) are carried out to prove the process. The list of relative affinities will help serve as guide in such trials.

- Acidic pH
$Pb^{2+} > Cu^{2+} > U^{4+}, Zn^{2+}, Al^{3+} > Mg^{2+} > Sr^{2+}, Ca^{2+}, Na^{+}, Ba^{2+}$

-Alkaline pH
$Cd^{2+}\ Mg^{2+} > Ca^{2+} > Sr^{2+}\ Al^{3+} > Ba^{2+} \geq\ , Na^{+}\ K^{+}$

In the particular case of brine purification by softening the feed solution of chloralkali electrolysis cells, the characteristic reactions are described as follows:—

-Service
$2RCH_2NH\ CH_2PO_3\ Na_2 + Ca^{2}+ \rightarrow (RCH_2NH\ CH_2PO_3\ )2\ CaNa_2$ .

- Regeneration to H+ form
$(RCH_2NH\ CH_2PO_3)2\ CaNa_2 + 4HCl \rightarrow 2RCH_2NH\ CH_2PO_3\ H_2 + CaCl_2 + 2NaCl$

-Conversion to sodium form
$RCH_2NH\ CH_2PO_3H_2 + 2Na\ OH \rightarrow RCH_2NH\ CH_2PO_3Na_2 + 2H_20$



efficient exhaustion and regeneration.
Recovery of heavy metals from effluents from the plating industry is achieved by concentration and is particularly useful where full demineralisation and recycling of the rinse water is not practised. The simplest case is where only one heavy metal is present, when volumes of rinse water are low, waste water fees may be low, and raw water has a low salt content.
**Purolite S-930** can be used to reduce residual toxic heavy metals to below the maximum admissible concentration levels which are often far below those obtainable after precipitation reactions. It may also be used to remove similar residuals from demineralised rinse water circuits.
**Purolite S-930** is also used to separate and concentrate heavy metals in hydro-metallurgical processes (ore dressing and scrap recovery). It is particularly suitable where metals are present in low concentrations. Separation techniques may be carried out according to the order of selectivity given above. However changes in the sequence occur with change in pH and in the presence of certain anions (including higher concentrations of chloride and sulphate). The sequence given above is applicable for neutral and weakly acidic solutions.

## OPERATING PERFORMANCE

The information below may be taken as a general guide. However, before any plant design is contemplated, the user should ascertain the exact operating performance under the proposed conditions of use, by way of column testing of the feed solution to be treated.
The operating capacity is a function of *p*H, and inlet concentration solution for each metal. Fig. 1 gives the exchange capacity obtainable when using the operating conditions given above, as a function of pH. This capacity is a function of ionic concentration, hence the multiplication factor given in fig. 2 should be applied.

Fig. 1. Exchange capacity for metals as a function of *p*H.

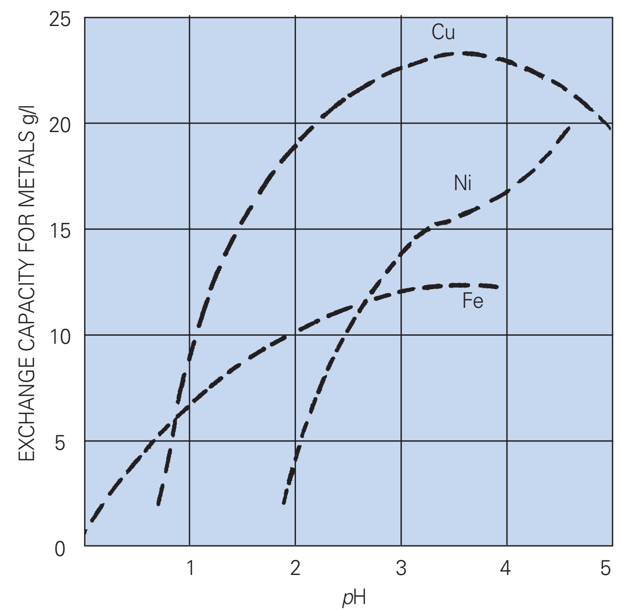
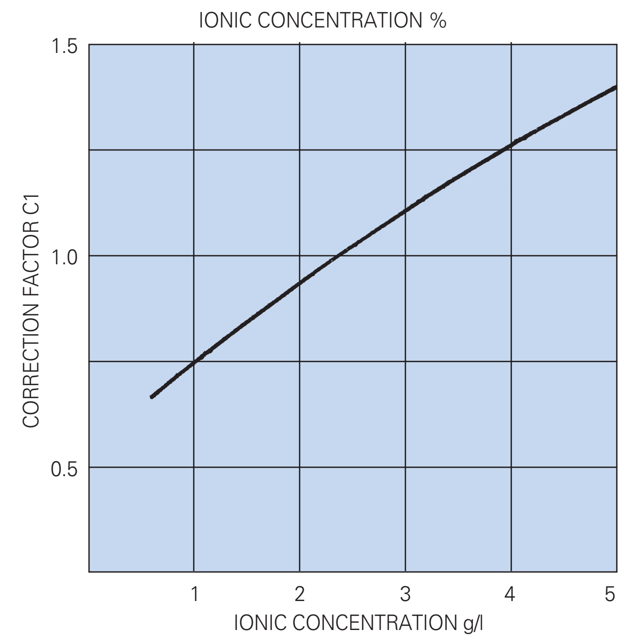



Fig. 2. Correction factor for ionic concentration




## HYDRAULIC CHARACTERISTICS (General Applications)

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, and on the flow rate 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 bed will have an adverse effect, and result in an increased headloss. Service flow rates from 8-16 bed volumes per hour, 1-2gpm/ft³, depending on the application, may be regarded as the normal range used on this resin.

Typical pressure drop figures to be expected for ordinary aqueous solutions, are given in fig. 3., below. This is applicable to the freshly regenerated $H^+$ Form. As the resin is converted to the metal form the pressure drop will decrease slightly.

Fig. 3 PRESSURE DROP VS. FLOWRATE

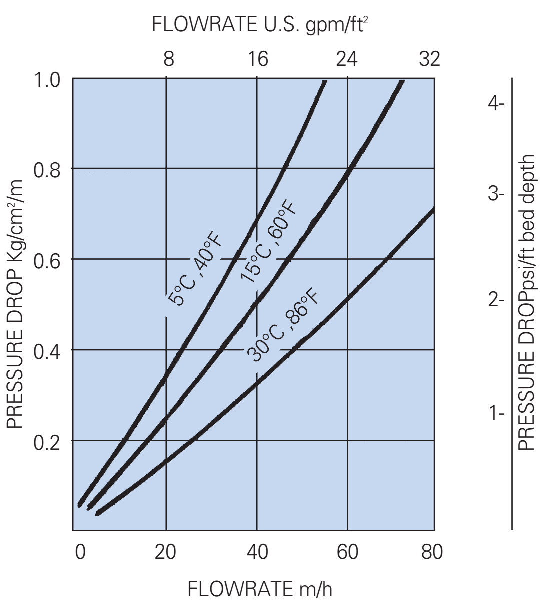
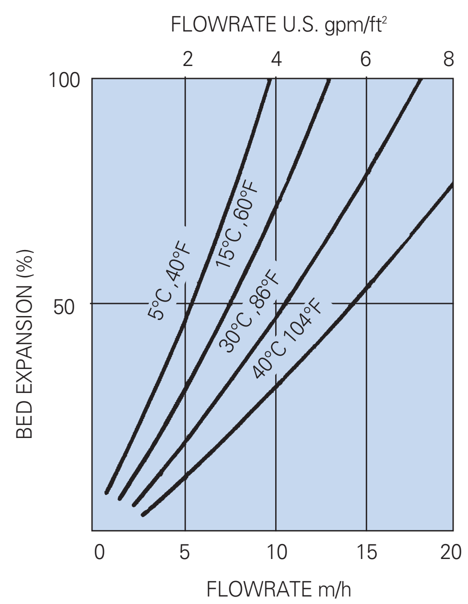



Fig. 4 BACKWASH EXPANSION
(Exhausted Form)




During upflow backwash, the resin bed should be expanded in volume by between 50 and 75%, in order to free it from any particulate matter from the influent solution, to clear the bed of bubbles and voids, and to reclassify the resin particles as much as possible, ensuring minimum resistance to flow. Bed expansion increases with flow rate and decreases with temperature, as shown in fig. 4, for a typical exhausted form of the resin. Care should always be taken to avoid resin loss by over-expansion of the bed.

### CONVERSION OF UNITS

| | | |
|---|---|---|
| 1 m/h (cubic metres per square metre per hour) | = | 0.341 gpm./ft². |
| | = | 0.409 U.S. gpm./ft². |
| 1Kg/cm² /m (Kilograms per square cm. per metre of bed) | = | 4.33 psi/ft. |
| | = | 1.03 atm./m/ |
| | = | 10 ft. $H_2O$/ft |



PUROLITE®
ION EXCHANGE RESINS

# S-940
## Macroporous Aminophosphonic Chelating Resin
(Especially for decalcification of brine solutions)

## Technical Data

Section V. **PRODUCT DESCRIPTION**

**Purolite S-940** is a chelating resin of macroporous structure, with a polystyrene matrix crosslinked with divinylbenzene (DVB) substituted with weakly acidic aminophosphonic active groups. This chemical structure facilitates the formation of complexes with metallic ions. The aminophosphonic chelating resins have a greater affinity for certain cations, and form more stable complexes with cations of low atomic mass metals than their iminodiacetic resin counterparts. Hence **Purolite S-940** is capable of fixing one or more specific cations from a larger range even from solutions which are highly concentrated.

### Typical Chemical & Physical Characteristics

| | |
|---|---|
| Polymer Matrix Structure | Macroporous Styrene-divinylbenzene |
| Physical form & Appearance | Opaque Cream Spheres |
| Whole Bead Count | >95% |
| Functional Groups | $-CH_2NHCH_2PO_3$ |
| Ionic Form (as shipped) | Na+ |
| Shipping Weight | 710 - 745 g/l (44.5 - 46.5 lb/ft³) |
| Screen Size Range | |
| (British Standard Screen) | 18-36 mesh |
| (U.S. Standard Screen) | 20-40 mesh |
| Particle Size range | + 0.85mm <2%, -0.425mm <2% |
| Moisture Retention, $Na^+$ Form | 55-65% |
| Reversible Swelling, ($H^+ \rightarrow Na^+$) Max | <50% |
| ($H^+ \rightarrow Ca^{++}$) Max | <20% |
| Specific Gravity. Moist $Na^+$ Form | 1.11 |
| Total Exchange Capacity, ($Na^+$ Form) | 20 g Ca/L (1.24 lb/ft³) min at *p*H 9,5 |
| Max, Operating Temperature, °C (°F) | 90°C (195°F) |
| Solubility | Insoluble in water, acids and bases, common solvents |

NOTE: **Purolite S-940** is susceptible to oxidation. Hence direct treatment of brine solutions containing free chlorine should be avoided, for instance by preliminary reaction with sulphur dioxide, sulphite or, by use of a treatment with activated carbon. Brine solution can often contain significant concentrations of chlorates. In this case it is necessary to ensure that the displacement rinse prior to the acid regeneration is efficient, so as to avoid the formation of free chlorine from contact of chlorates in the brine solution with the regenerant acid.