CRYSTAL QUEST®
Water Filters

Nitrate I
PRODUCT DATA SHEET

Product Description

Eaglesorb-Nitrate I is a macroporous strong base anion resin which is specially designed for the removal of nitrates from water for potable processes. The macroporous matrix and special ion exchange group functionality imparts ideal nitrate selectivity to Eaglesorb-Nitrate I making this resin particularly suitable for nitrate removal even when moderate to high concentrations of sulphate are present. Hence this resin gives superior performance in nitrate removal applications when compared with standard exchange resins. A requirement of the nitrate removal process is to produce potable water meeting the quality standard defined by the European Economic Community in the Directive No. 80/778 of July 1980. This directive limits the nitrates to a maximum admissible concentration (M.A.C.) of 50 mg NO_3/l. The U.S.A. drinking water regulations limit nitrates to 45 mg NO_3/l.

Typical Physical & Chemical Characteristics	
Polymer Matrix Structure	Macroporous Styrene-Divinylbenzene
Physical Form and Appearance	Opaque Cream Spherical Beads
Whole Bead Count	95% min.
Functional Groups	Quaternary Ammonium
Ionic Form, as shipped	Cl^-
Shipping Weight (approx.)	680 g/l (42.5 lb/ft^3)
Screen Size Range: - US. Standard Screen	16 - 50 mesh, wet
Particle Size Range	+1200 mm <5%, -300 mm <1%
Moisture Retention, Cl^- form	50 - 56%
Reversible Swelling $Cl^- \rightarrow SO_4 / NO_3$	negligible
Total Exchange Capacity, Cl^- form, wet, volumetric dry, weight	 0.9 meq/ml min. 2.8 meq/g min.
Operating Temperature, Cl^- Form	100°C (212°F) max.
pH Range, Stability	0 - 14
pH Range, operating	4.5 - 8.5

Standard Operating Conditions Nitrate Removal				
Operation	Rate	Solution	Minutes	Amount
Service	8 - 32 BV/h 1 - 4 gpm/ft^3	Influent water to be treated	per design	per design
Backwash	Refer to Fig. 2	Influent water 10 - 20°C (50 - 68°F)	5 - 20	1.5 - 4 BV 10 - 25 gal/ft^3
Regeneration	2 - 5 BV/h 0.25 - 0.6 gpm/ft^3	3 - 10% NaCl	20 - 60	90 - 250 g/l 7.8 - 15.6 lb/ft^3
Rinse, (slow)	2 - 5 BV/h 0.5 - 0.6 gpm/ft^3	Influent water	20 - 60	2 - 5 BV 15 - 40 gal/ft^3
Rinse, (fast)	8 - 32 BV/h l - 4 gpm/ft^3	Influent water	-	-
Backwash Expansion 50% to 75% Design Rising Space 100% "Gallons" refer to U.S. Gallon = 3,785 liters				

Regeneration

Sodium chloride is generally preferred for regeneration for reasons of cost and efficiency. When available, sea water can be used quite effectively. The use of softened water for makeup of brine and rinse is often recommended to avoid the precipitation of calcium carbonate in and around the Eaglesorb~Nitrate I (or any other resin used in this application). Although the precipitation is not particularly detrimental in the short term, the long term effects may include increased resin attrition and leakage of nitrates.

Preconditioning Procedure

Eaglesorb~Nitrate I is processed to insure that it meets the requirements for use in the treatment of potable water. On installation it is recommended that the resin be regenerated with two bed volumes of 6% NaCl followed by a rinse of four bed volumes of potable water, prior to use.

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 void volume of the exchange material as well as on the viscosity (and hence on the temperature) of the influent solution. Factors affecting any of these parameters, for example the presence of particulate matter filtered out by the bed, abnormal compressibility of the resin, or the incomplete classification of the bed will have an adverse effect and result in an increased headloss. Depending on the quality of the influent water, the application and the design of the plant, service flow rates may vary from 10 ~ 40 bed volumes/ hour (1 ~ 5 gpm/ft3). Typical pressure drop data is given in Fig. 1.

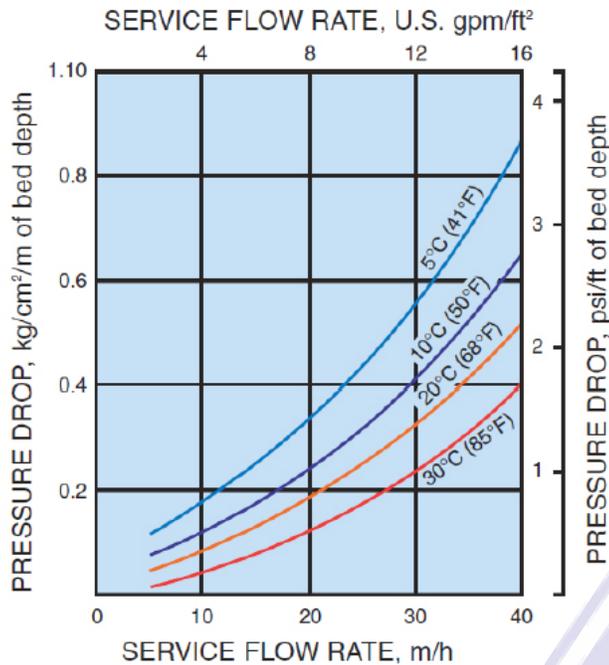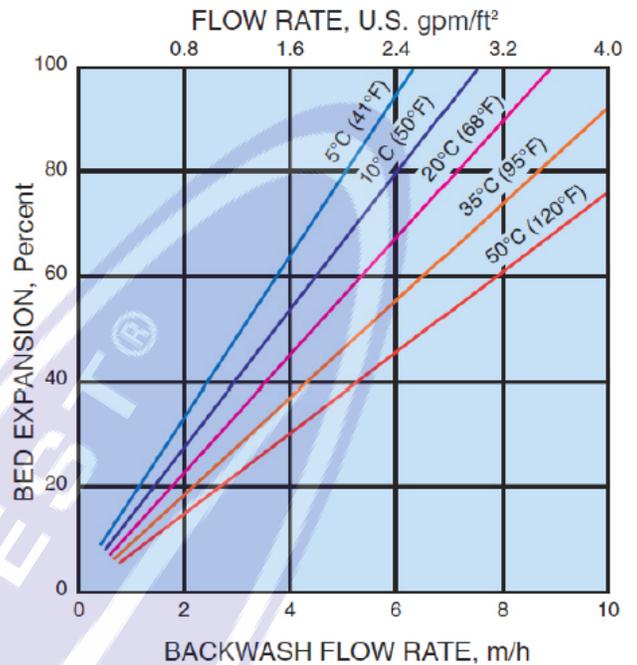## Fig. 1 PRESSURE DROP CHARACTERISTICS

Fig.2 BACKWASH EXPANSION

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

Conversion of Units	
1 m/h (cubic meters per square meter per hour)	= 0.341 gpm/fl² = 0.409 U.S. gpm/ft²
1 kg/cm²/m (kilograms per square cm per meter of bed)	= 4.33 psi/ft = 1.03 atmos/m = 10 ft H$_2$O/ft

Operating Performance

The high selectivity of Eaglesorb~Nitrate I for nitrate over sulphate ensures that any necessary reduction in nitrate levels can be achieved even in the presence of high influent sulphate concentration. Hence it so offers the advantage over standard strong base resins that its exchange capacity for nitrates is less affected by a high influent concentration of sulphate. For this reason, although Eaglesorb~Nitrate I has a lower total exchange capacity than standard strong base anion resin, its use can produce advantageously higher throughputs for the following reasons.

Both standard gel type or macroporous strong base resins are quite capable of effective nitrate removal where sulphates to total anion ratios are low. However, on account of the high selectivity for sulphate in dilute solutions which follows the order, HCO3/ < Cl, < N03, < 504: selective displacement of nitrate by sulphate results in the effective nitrate removal capacity being reduced by sulphate loading. Apart from the obvious disadvantage of the reduction of treated water obtained on cycling, the exchange of both nitrate and sulphate by chloride will result in less palatable and sometimes less acceptable water than the influent supply, in that the treated water may be more corrosive and the limits for chloride concentration may be exceeded.
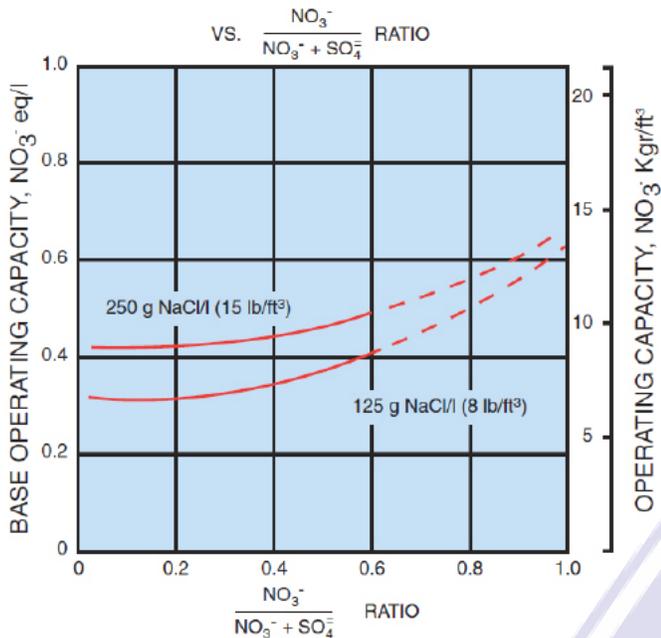
Fig. 3 OPERATING CAPACITY

$$\text{VS.} \quad \frac{NO_3^-}{NO_3^- + SO_4^=} \quad \text{RATIO}$$

Fig. 4 NITRATE LEAKAGE

$$\text{VS.} \quad \frac{NO_3^-}{NO_3^- + SO_4^=} \quad \text{RATIO}$$
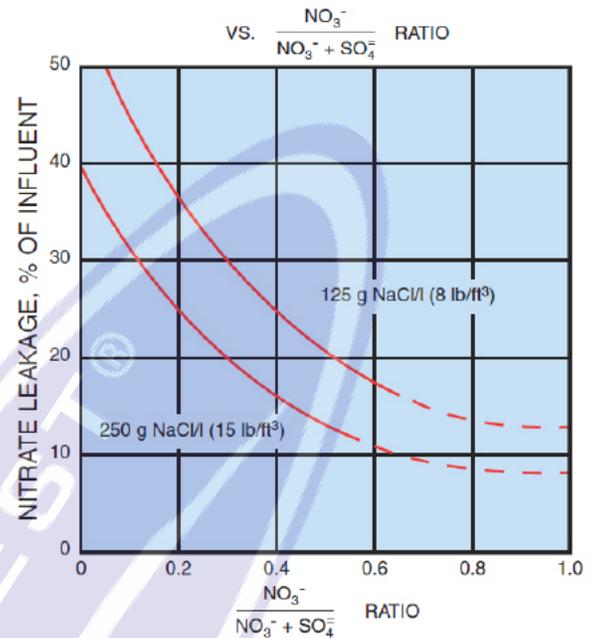

Fig. 3 and Fig. 4 give the operating capacity and nitrate leakage respectively Which may be obtained using concurrent regeneration at the given regeneration levels. Values obtained from Fig. 3 are expressed in terms of nitrate throughput, corrected for nitrate leakage, and hence may not be used directly to determine the throughput of Water. All ion concentration values are either on a ppm or a meq/l basis for ratio determination.

Calculation for throughput of treated water	
cyclic output (liters) $= \dfrac{V \times OC}{L - 1_n} \times 10^3$	where V = resin volume (liters) OC = operating capacity (eq/l) L = nitrate load (meq/l) I_n = nitrate leakage (meq/l)
or cyclic output (U.S. gal) $= \dfrac{V_f \times OC_k \times 10^3}{0.058\,(L_p - 1_{np})}$	where V_f = resin volume (ft^3) OC_k = operating capacity (kgr/ft^3) L_p = nitrate load (ppm as CaCO$_3$) np= nitrate leakage (ppm as CaCO$_3$)

Similarly Fig. 5 and Fig. 6 give the values for countercurrent regeneration. It should be noted that in this case the nitrate leakage is lower for a given regeneration level. Hence the possibility to blend treated With untreated Water on a 50% basis is a useful option Which can make counter~current regeneration attractive. On the other hand the choice of co/current regeneration can result in the production of higher volumes of treated Water of satisfactory quality for direct use. The higher leakage (ln, lnp, in the equations above) so reduces the load on the ion exchange bed that for a given operating capacity greater throughputs per cycle are obtained. This latter effect can influence the throughput more than differences in basic operating capacity. It therefore follows that both capacity and leakage for alternative modes of regeneration should be evaluated before recommending specific design conditions.
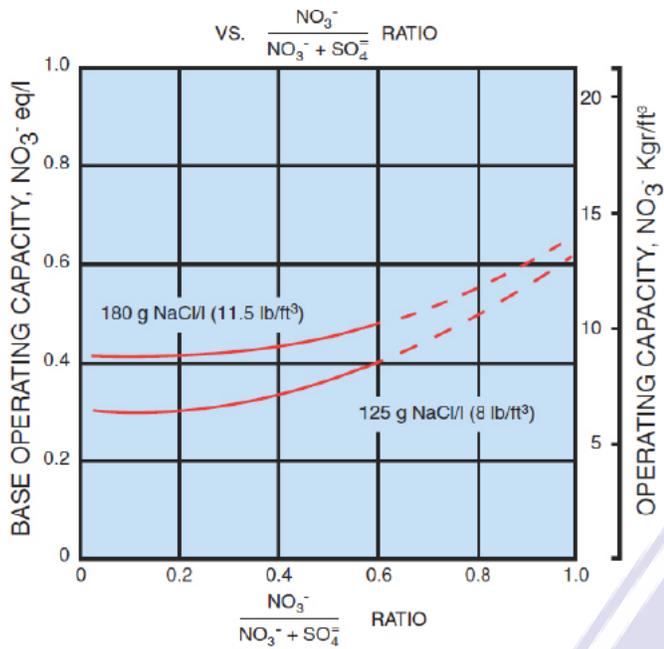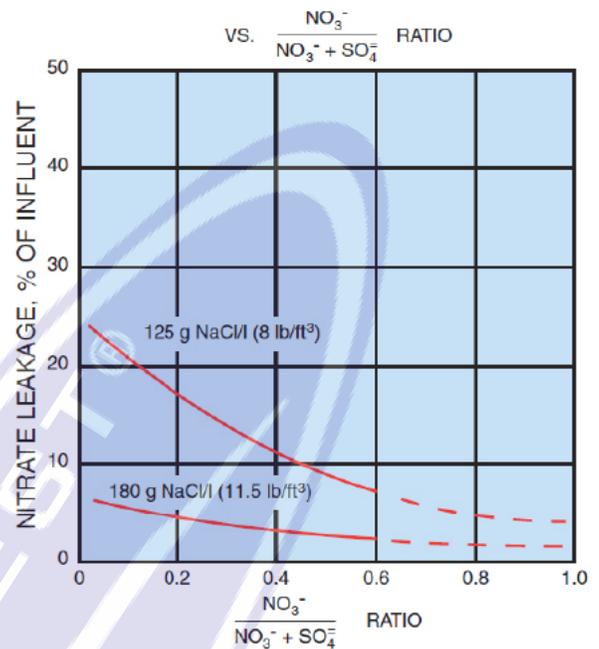
Fig. 5 OPERATING CAPACITY

VS. $\dfrac{NO_3^-}{NO_3^- + SO_4^=}$ **RATIO**

180 g NaCl/l (11.5 lb/ft³)

125 g NaCl/l (8 lb/ft³)

BASE OPERATING CAPACITY, NO_3^- eq/l

OPERATING CAPACITY, NO_3^- Kgr/ft³

$\dfrac{NO_3^-}{NO_3^- + SO_4^=}$ RATIO

Fig.6 NITRATE LEAKAGE

VS. $\dfrac{NO_3^-}{NO_3^- + SO_4^=}$ **RATIO**

125 g NaCl/l (8 lb/ft³)

180 g NaCl/l (11.5 lb/ft³)

NITRATE LEAKAGE, % OF INFLUENT

$\dfrac{NO_3^-}{NO_3^- + SO_4^=}$ RATIO

Presupposing that the objective of the nitrate removal treatment is to obtain potable Water of a quality Which meets the World Health Organization (WHO) limit, Where the nitrate/(nitrate + sulphate) ratio is higher than 0.6, a nitrate selective resin is not necessary. A standard strong base resin can give higher throughputs as a result of its higher total capacity. It Will be seen that up to the ratio of 0.6 the curves in Figs. 3 , 6 are continuous to show Where Eaglesorb~Nitrate I is the recommended resin. The discontinuous curves are given so that comparisons may be made With alternative resins. Where lower leakages than the WHO limit are required, for example in the processing of certain foods, Eaglesorb~Nitrate I Will often give a superior performance to the standard resins even Where nitrate/(nitrate + sulphate) ratios are higher than 0.6. One particular advantage here is that there is no slug of highly concentrated nitrate at breakthrough as is found With standard resins; hence the possibility to excessively contaminate the food product by overrunning the bed is avoided.

How to use Figs. 3 through 6.

It is assumed that it is required to treat a well water of the following analysis to produce a nitrate concentration of less than 50 mg/l.

WATER ANALYSIS

Anions	ppm	meq/l	ppm as CaCO3	Cations	ppm	meq/l
Nitrate	93	1.5(L)	76(L$_p$)	Calcium	90	4.5
Sulphate	98	2.0	100	Magnesium	18	1.5
Chloride	71	2.0	100	Sodium	30	1.3
[HCO$_3$*	122	2.0	100]	Potassium	8	0.2
Total Anions		7.5		Total Cations		7.5
Equivalent Mineral Acidity (EMA)		5.5				

$$\frac{\text{Nitrate}}{\text{Nitrate} + \text{Sulphate}} = \frac{NO_3}{NO_3 + SO_4} = \frac{76}{76+100} = 0.43$$

*Note: Unless concentration of bicarbonates is well above average it does not affect me performance to a significant extent.

A regeneration level of 125 g NaCl/l has first been chosen, using co-current regeneration,
To calculate the cyclic throughput from the equations given above:

From Fig. 3, Base Capacity at 0.43 for $\dfrac{NO_3}{NO_3 + SO_4} = 0.36$ eq/l

From Fig 4, Leakage at 0.43 $\dfrac{NO_3}{NO_3 + SO_4} = 23\%$

Hence for each litre of resin, throughput = (0.36/1.15) x 10³ liters
= 313 liters
And for each cubic foot of resin. = [7.9/(0.058 x 57.7)] x 10³
= 2360 U.S. gal.

Depending upon the throughput requirement the resin volume is chosen so as to operate within the flow rate stipulations given in the standard operating conditions above. A design factor of 0.9 is also recommended as is customary. Hence throughput/liter of resin for design purposes will be 313 X 0.9 : 281.7 liters (2124 US. gal/ft3). In this example the leakage is 17.3 ppm as CaCO3 (21.4 ppm as NO3), hence the useful option to blend treated water with raw water on a 50% basis could be applied. It would be of no advantage to move to counter~current regeneration in this case. Reference to Fig. 5 will show that the basic capacity curve is very similar. However the throughput will be lower, because the reduced leakage increases the ion exchange load for a given throughput. When on the other hand nitrate concentrations or ratios are higher, it may be advantageous to operate counter/current rather than increase the regeneration level while operating co~current. In this way a suitable blend may be obtained with lower regenerant costs (and costs of disposal).