PUROLITE
ION EXCHANGE RESINS

GUIDELINES FOR SELECTING

RESIN ION EXCHANGE OR REVERSE OSMOSIS

FOR FEED WATER DEMINERALISATION

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Date: November 2003

Operating Puropack Plant

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1. INTRODUCTION

The two major options for water treatment to produce demineralised water suitable for boiler water feed are Reverse Osmosis (RO) and Resin Ion Exchange (IX). Both RO and IX technologies are well established and have reached advanced levels of development. Comparison of the two processes for water demineralisation can therefore be reliably made and cost comparisons can be carried out on a case by case basis. This document examines the significant factors which should be taken into account in the comparison and gives guidelines for decision making.

2. FACTORS TO BE CONSIDERED

a) Reliability

Both RO and IX are well established reliable technologies with a good track of performance world wide. Future technical developments are not expected to have a major influence on plant and process costs.

b) Feed Water Pre-treatment Required

Both processes require pre-treatment to remove suspended solids to a low level to avoid fouling. However IX is more tolerant of suspended solids and RO requires additional pre-treatment by micro-filtration. Membranes are also subject to scaling by hardness present in the feed water and require either a softening plant as part of the feed water pre-treatment or the addition of anti-scaling chemicals.

c) Quality of Treated Water

IX can produce demineralised water with a conductivity of less than 0.5uS/cm from a simple SAC→SBA combination and less than 0.1µS/cm with the addition of a mixed bed SAC/SBA unit. Even the best performing RO plants cannot meet the treated water quality of a simple IX plant and a subsequent IX unit is required to achieve boiler feed water quality. (SAC is strong acid cation resin, SBA is strong base anion resin).

d) Flexibility

Ion exchange plants tend to be more flexible than RO, for example in terms of performance over a wider range of temperature variations and the ability to recover from high suspended solids in the feed.

e) Fouling by Organics

Both RO membranes and IX resins can be fouled by organics present in the feed water. IX resins are much more easily cleaned than RO membranes without long plant shut down and use cheap cleaning chemicals; salt and sodium hydroxide.

However RO has a place in producing demineralised water and when used in combination with IX can produce the highest quality boiler feed water. The role of RO is in treating high TDS waters and in order to establish guidelines for selection of RO versus IX it is necessary to carry out detailed cost comparisons.

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3. COMPARISON OF NEW PLANT COSTS OF RO AND IX.

3.1 RANGE OF OPERATING CONDITIONS CONSIDERED

Economic evaluations of the cost advantages of R.O and IX in new water treatment plants over a range of feed water compositions, scale of operation and input costs have been carried out at various times (e.g. Ref 1for West European operation). The parameters considered for a comparison of new plant producing boiler feed water in this document are:

Feed Water TDS: Range 1.6eq/m^3 to 9.4 eq/m^3 (80 to 470ppm as $CaCO_3$)
Hardness 35%
Sodium 15%
Alkalinity 25%
SMA 25%
Silica 10ppm
Flow-rates: 50m^3/hour and 200m^3/hour
Pre-treatment: Flocculation / Clarifier → Sand Filter (common to both systems)
IX Plant: Layout: SAC → DG → Layered Bed WBA/SBA → MB SAC/SBA
Vessel Design: Packed bed SAC and WBA/SBA
Number of lines: 2x100%, one on line and one on regeneration/standby.
Regenerant: Counter-flow Sulphuric acid and Counter-flow Sodium Hydroxide
Recovery: >90 to 95%
RO Plant: Layout: Chemical addition/Cartridge Filter → 2 Stage RO → DG → Storage → MB IX SAC/SBA → Storage
Recovery: 80%
Number of lines: 1x100% for 50m^3/h and 2x50% for 200m^3/h flowrate.
Treated Water Specification: Conductivity: <0.1 µS/cm
Na: <10ppb
SiO_2: <10PPB
Chemicals, Power and Labour Costs: Western European mean values.

3.2 RESULTS OF THE COST STUDIES

a) Break Even Cost/m3 of Treated Water
Under the conditions summarised above the break-even point for feed water TDS below which it is more economic to use IX rather than RO-IX is 6.3 to 7.9 eq/m^3 (315 to 395 ppm as $CaCO_3$). The range represents range of the input capital and operating cost variables. However this break-even TDS is based on a set of assumptions on the components of the capital and operating costs and these will vary from region to region as discussed below. Other studies based on other input data have shown that under certain operating conditions the break-even point can be 500ppm $CaCO_3$.

b) Plant Size/ Feed Flow-rate
The capital cost of an RO plant is generally higher than that of an IX plant and is relatively insensitive to scale. If investment cost is the major consideration in selecting RO or IX plants then IX will be selected. It is also pointed out that the high capital cost of RO plants is a very strong disincentive to replacing existing IX plants by a new RO plant.

c) Operating Costs

Operating costs represent 70 to 80% of the total cost of both cases. Chemical costs for IX and power costs for RO are the most significant contributors to operating costs. Variation in power and chemicals costs from region to region can significantly influence the operating costs of both the RO-IX and the IX plants and should be carefully considered when selecting a water treatment system. High power cost could increase the break even TDS by 1.5 eq/m^3 (75ppm $CaCO_3$).

d) Membrane and Resin Replacement Costs

The cost of membrane plus resin replacement in the RO-IX system is significantly higher than the cost of resin replacement in the IX system and this is very little affected by the ionic load and scale of operation.

e) Plant Maintenance

RO plants have higher maintenance costs than IX plants owing to the more complex nature of RO plants.

f) Variations in the IX Plant Flowsheet.

When the feed water has high temporary hardness (high hardness associated with alkalinity) the size and chemicals cost of the cation exchange unit can be significantly reduced by using counter-flow WAC/SAC layered bed. The high capacity WAC (weak acid cation) resin removes most of the temporary hardness and can be regenerated with near stoichiometric quantity of acid from the SAC bed which is now removing only the alkali metals sodium and potassium thus reducing the quantity of regenerant acid used.

g) Manpower

Manpower costs are similar in both cases

h) Costs of Feed water and Waste Treatment.

In all cases the sum of water costs and waste treatment is greater for RO-IX than for IX plants The lower water recovery of the RO-IX system results in a higher cost contribution of feed water to treated water cost for this system This costs can be even greater in regions where the cost of water is high. The high rejection rate of RO plants also results in the production of large volumes of low concentration waste whereas IX plants produce small volumes of concentrated waste which is more easily disposed of. These factors can results in high treatment costs of RO-IX and could increase the break-even TDS below which IX produces lower cost water than RO-IX to 10eq/m3 (500ppm CaCO3).

In considering the cost of water and waste treatment it is important to remember that as water becomes a scarcer and higher cost commodity, especially in countries with limited water resources, the cost contribution of water and waste treatment will increase with time. This will in all cases favour the use of IX. RO costs which may seem attractive now may not seem so in 10 years time.

4. PUROLITE PUROPACK PACKED BED SYSTEM.

The comparison of the RO-IX and IX water treatment options assumes the most modern packed bed ion exchange technology for the main IX units. Purolite International has developed advanced packed bed technology called Puropack. Information on Puropack is summarised in the Purolite Brochure, Ref 2.

Puropack is a maximum performance packed bed system which provides a combination of superior engineering principles and improved resins that together optimise water treatment plant performance. The design philosophy is based on up-flow service and down-flow regeneration.

Detailed design and operating information on Puropack is given in the Puropack Engineering Design Manual (Ref 3) which covers:

- Choice of Puropack resin system and layout
- Guidance on suspended solids
- Capacity and Leakage
- Regeneration procedures
- Vessel sizing and bed depth
- Compaction flows Pressure loss
- Resin filling and transfer Backwash graphs
- Engineering drawings
- Regenerant chemical quality
- General information relating to demineralisation systems.

All the data was generated from a Purolite pilot plant that operated for two years. The Puropack system is now operated in many plants in Europe and elsewhere and has an excellent track record of performance, producing treated water of the highest quality in an economic plant.

Both the Puropack Summary Bulletin and the Engineering Manual are available from Purolite Offices and Agents on request.

5. PUROLITE PUREDESIGN SOFTWARE

Design assistance is available from Purolite to design the Puropack and conventional water treatment plants and to provide operating information which can be used to carry out an economic assessment of competing RO-IX and IX systems. The design is carried out using the Purolite Puredesign software.

The Puredesign software is available on the Purolite websites www.purolite.com and www.puroliteusa.com. Assistance in downloading and using Puredesign can be obtained from Purolite Offices and Agents.

6. ADDITIONAL INFORMATION AND ASSISTANCE

See Purolite websites (Ref 4)

7. REFERENCES

1) "An Economic Comparison of reverse Osmosis and Ion Exchange in Europe" by P.A. Newell, S.P. Wrigley, P. Sehn, S.S. Whipple. Proceedings of SCI Conference IEX 96.
2) "PUROPACK from Purolite" Puropack Summary Bulletin
3) "PUROPACK Packed Bed Technology", Puropack Engineering Manual
4) Purolite websites: www.purolite.com and www.puroliteusa.com.