ION EXCHANGE
Refreshing the Planet

INDION® FF-IP

Description

INDION FFIP is a Type 1 strong base, unifunctional anion exchange resin in bead form, containing trimethyl benzyl ammonium groups. It is based on cross-linked polystyrene and has an isoporous structure.

INDION FFIP has a very high basicity. It is effective in removing weak acids such as silica and carbon dioxide and recommended in two stage/multiple stage or mixed bed de-ionising, where high quality de-ionized water and lowest silica residuals are desired.

In addition INDION FFIP demonstrates stability to high temperature regeneration required for minimum silica leakage. It has a high reversible capacity for the natural organic matter present in some surface waters, with excellent resistance to fouling by this organic matter.

Characteristics

Appearance	:	Translucent red brown beads
Matrix	:	Styrene -EDMA copolymer
Functional Group	:	Benzyl trimethyl amine
Ionic form as supplied	:	Chloride
Total exchange capacity	:	1.2 meq/ml, minimum
Moisture holding capacity	:	47-55%
Shipping weight *	:	680 kg/m^3, approximately
Particle size range	:	0.3 to 1.2 mm
> 1.2 mm	:	5.0%, maximum
< 0.3 mm	:	1.0%, maximum
Uniformity co-efficient	:	1.7, maximum
Effective size	:	0.45 to 0.55 mm
Maximum operating temperature	:	60 °C in OH form 90 °C in Cl and other forms
Operating pH range	:	0 to 14
Volume change	:	Cl to OH, 10-15 %
Resistance to reducing agents	:	Good
Resistance to oxidizing agents	:	Generally good, chlorine should be absent

* Weight of resin, as supplied, occupying 1 m^3 in a unit after backwashing and draining

Applications

De-ionising

Two stage de-ionising

INDION FFIP is used as the anion exchanger in the second stage of a de-ionising pair with INDION 225 cation exchange resin in the first stage.

When used in a two stage de-ionising plant, upstream of a mixed bed unit, INDION FFIP will protect the strong base anion exchanger in the latter unit against organic fouling. At the same time it will assist in the production of final treated water with a low residual of organic matter and silica.

Multiple stage de-ionising

INDION FFIP is recommended as the anion exchanger in a multiple stage de-ionising train with strong acid cation exchange resin and weak base anion exchange resin in the preceding stages to keep operating costs low.

Regeneration and silica removal efficiency are enhanced if a warm regenerant solution is used. Where plant operating conditions allow, INDION FFIP can be regenerated in this manner.

Mixed bed de-ionising

If treated water with the lowest possible level of silica residual is required, two stage/multiple stage treatment should be followed by mixed bed de-ionsing using INDION FFIP.

Typical operating data

Two stage/multiple stage de-ionising	Co-flow regeneration	Countercurrent regeneration
Minimum Bed depth	0.75 m, minimum	1.0 m, minimum
Treatment flowrate	60 $m^3/h\ m^2$, maximum	60 $m^3/h\ m^2$, maximum
Pressure loss	Refer Figure 19	Refer Figure19
Bed expansion	Refer Figure 20	Refer Figure 20
Backwash.....................................	3 $m^3/h\ m^2$ for 5 minutes or till effluent is clear	3 $m^3/h\ m^2$ till effluent is clear *
Regenerant	Sodium Hydroxide (2-4% w/v)	Sodium Hydroxide (2-4% w/v)
Regenerant flowrate	4.5-18 $m^3/h\ m^2$	4.5- 18 $m^3/h\ m^2$
Regenerant injection time	30 minutes minimum	30 minutes minimum
Slow rinse	2.5 to 3 bv at regenerant flowrate	2 to 3 bv at regenerant flowrate
Final rinse.....................................	7.5 bv at service flowrate	5 bv at service flowrate

* After a set number of regenerations
1 bv (bed volume) = 1 m^3 fluid/m^3 resin.

Operating Exchange capacity

Co-flow regeneration

Two stage de-ionising

The operating exchange capacity of INDION FFIP when used as the anion exchanger in a two stage de-ionising system is dependent upon:

- The regeneration level employed
- The composition of water to be treated, specifically the concentration of mineral acid anions (SO_4/EMA)
- Silica content (SiO_2/TA)
- Exhaustion rate

Figure 1 shows typical capacities obtained with a de-ionising system using INDION 225 strong acid cation exchange resin in the first stage followed by degasser and INDION FFIP anion exchange resin in the second stage and employing co-flow regeneration.

Effect of sulphate and EMA

The operating exchange capacities (Figure 1) are shown as a function of regeneration level for various percentages of SO_4 /EMA and at EMA values around 100-200 ppm $CaCO_3$.

Effect of silica

Capacity deduction data (Figure 2) is shown as a function of SO_4/EMA ratio for various percentages of SiO_2 upto 50%.

Effect of exhaustion rate

The capacity data is related to exhaustion times greater than nine hours. Figure 3 shows the variation in capacity with exhaustion time.

In selecting operating conditions of INDION FFIP consideration should be given to the expected treated water quality. Figures 9-13 show average treated water quality that can be expected from this resin. These are related to the regeneration level, the temperature of the regenerant and the ratio of silica to total anions in the feed.

Multiple stage de-ionising

In a multiple stage de-ionising system, where a strong acid cation exchanger such as INDION 225 is used in the first stage, followed by a weak base anion exchanger such as INDION 850, preceded or followed by a degasser and a strong base anion exchanger such as INDION FFIP in series, INDION FFIP treats an influent water containing predominantly weak acids like silica and carbon dioxide. Figure 4 gives operating exchange capacity of INDION FFIP, when used in co-flow regeneration mode.

Countercurrent regeneration (CCR)

Two stage de-ionising

The operating exchange capacity of INDION FFIP when used as the anion exchanger in a two stage De-ionising system is dependent upon:

- The regeneration level employed
- Silica content (SiO_2/TA)
- Exhaustion rate

Figure 5 shows typical capacities obtained with a de-ionising system using INDION 225 strong acid cation exchange resin in the first stage followed by a degasser and INDION FFIP anion exchange resin in the second stage and employing countercurrent regeneration.

The operating exchange capacities (Figure 5) are shown as a function of regeneration level and refer to an end point silica of 150 ppb over the average silica residual obtained during the run. The capacities are determined with a feed containing zero sodium slip and ratio of silica to total anion of 20%.

Figure 6 gives the correction factor for operating exchange capacity as a function of end-point silica.

The capacity data apply to exhaustion times greater than 9 hours. Refer Figure 3 for the variation of capacity with exhaustion time.

In selecting operating conditions of INDION FFIP, consideration should be given to the expected treated water quality. Figure 14 shows average treated water quality that can be expected from the resin. These are related to the regeneration level and the ratio of silica to total anions in the feed with the temperature of regenerant at 25 °C.

Multiple stage de-ionising

In a multiple stage de-ionising system, where a strong acid cation exchanger such as INDION 225 is used in the first stage, followed by a weak base anion exchanger such as INDION 850, preceded or followed by a degasser and a strong base anion exchanger such as INDION FFIP in series, INDION FFIP treats an influent water containing predominantly weak acids like silica and carbon dioxide.

Figure 7 gives operating exchange capacity of INDION FFIP, when used in countercurrent mode at various regeneration levels with alkali injected at 25°C. The capacities refer to end point silica of 0.2 ppm SiO_2.

Figure 8 gives the operating exchange capacity of INDION FFIP, when used in countercurrent regeneration mode at various regeneration levels with alkali injected at 25° C. The capacities refer to an end-point silica of 0.1 ppm SiO_2

Mixed bed de-ionising

When used as the anion exchanger in mixed bed de-ionising systems the capacity of INDION FFIP is independent of the feed water composition and therefore corresponds to the zero curve in Figure 1.

No correction for silica content of the feed water need be made, although the amount loaded on the resin and hence the volume of water treated between regenerations may need to be adjusted in order to obtain satisfactory silica residual in the treated water (Figures 15-18).

Regeneration

Coflow and counter current regeneration

The use of sodium hydroxide solution at the recommended flowrate and concentration, results in contact time that is favorable for achieving optimum capacity and leakage characteristics.

Thoroughfare regeneration

If the strong base anion exchanger is operating with weak base anion resin in the preceding stage, the regeneration process can be conducted in series in the direction of strong base towards weak base anion exchanger to improve the overall regeneration efficiency. The useful capacity will be high and silica leakage will be low as the strong base resin receives all the sodium hydroxide required for both columns. The injection is followed by a slow rinse with water to transfer the residual caustic present in the strong base anion exchanger to the weak base anion exchanger. This method is commonly referred to as thoroughfare regeneration.

Treated Water Quality

Two stage/Multiple stage de-ionising

The quality of the treated water from a two stage de-ionising plant using INDION FFIP as the anion exchanger is determined by:

- The regeneration level employed
- The temperature of the regenerant used for the anion exchanger
- The level of sodium ion leakage from the cation (hydrogen) exchanger
- The silica to total anions ratio of the water fed to anion exchanger

Sodium ions leaking from the cation exchanger are converted to NaOH, as the water passes through the anion exchange stage.

Each mg/1 of sodium leakage, expressed as $CaCO_3$, increases the electrical conductivity of the water leaving the anion exchange stage by approximately 5 microsiemens/cm at 20°C.

The values for silica residual in the treated water at various regeneration levels and temperatures can be obtained from Figures 9-13 for coflow mode of regeneration.

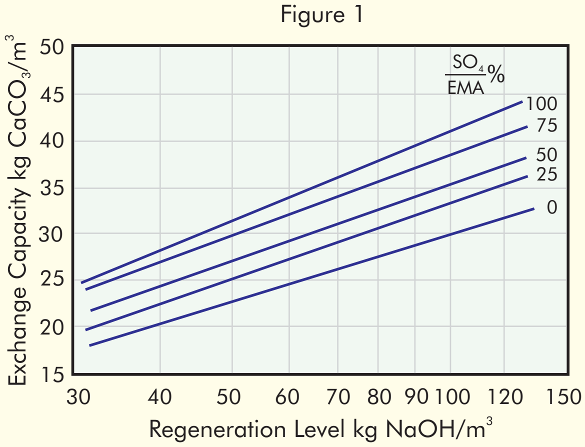
The values for silica residual in the treated water at various regeneration levels can be obtained from Figure 14, for countercurrent regeneration at a temperature of 25°C.

These values assume zero sodium slip and for every mg/l of sodium leakage as $CaCO_3$, the residual silica will increase by 15%.

INDION FF-IP Operating Exchange Capacity Co-flow

TWO STAGE DE-IONISING

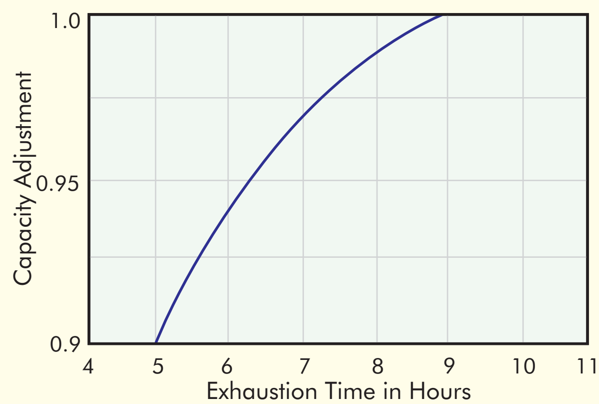
Figure 1



EMA = Equivalent Mineral Acidity

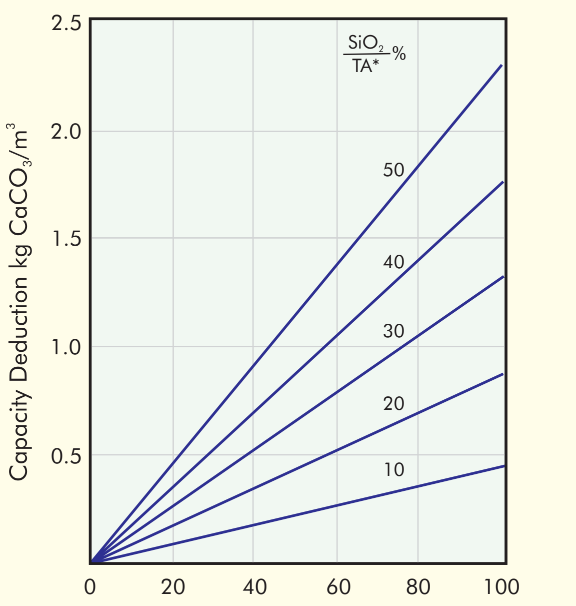
CAPACITY ADJUSTMENT FOR EXHAUSTION TIME

Figure 3



CAPACITY ADJUSTMENT FOR $\frac{SiO_2}{TA^*}$ %

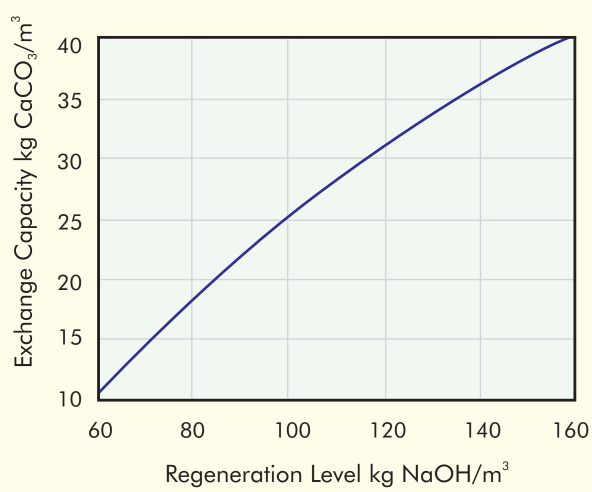
Figure 2



So_4/ EMA % TA* = Total Anions

MULTIPLE STAGE DE-IONISING

Figure 4

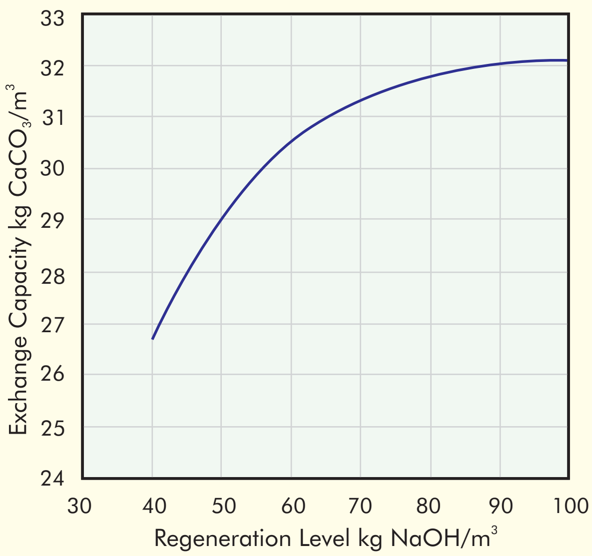


$SiO_2/TA \geq 80\%$

INDION® FF-IP Operating Exchange Capacity - CCR

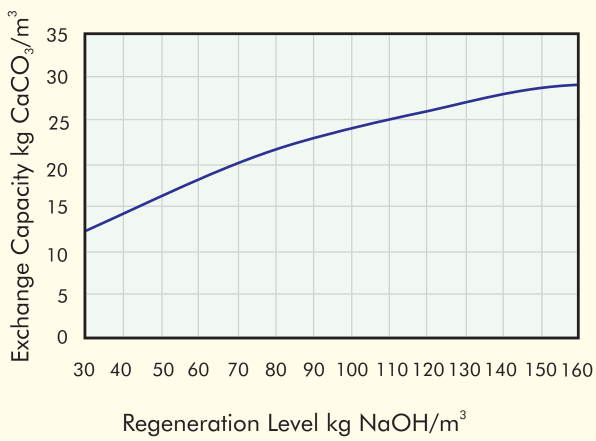
TWO STAGE DE-IONISING

Figure 5



MULTIPLE STAGE DE-IONISING

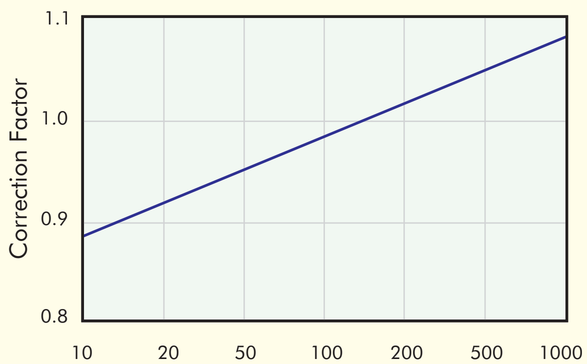
Figure 7



End-point Silica 0.20 mg/l SiO_2/TA* ≥ 80%

CORRECTION FACTOR

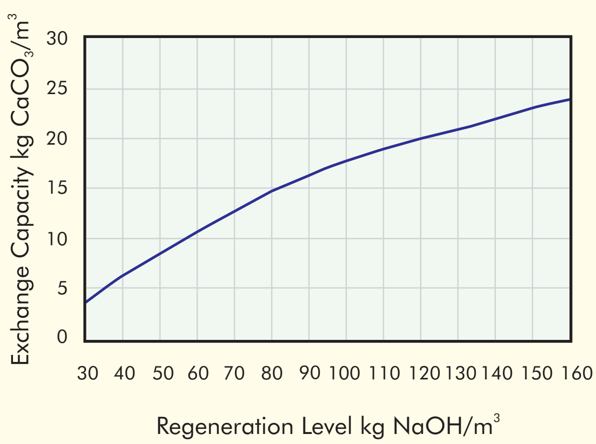
Figure 6



Silica End-point (above average leakage) ppb SiO_2

MULTIPLE STAGE DE-IONISING

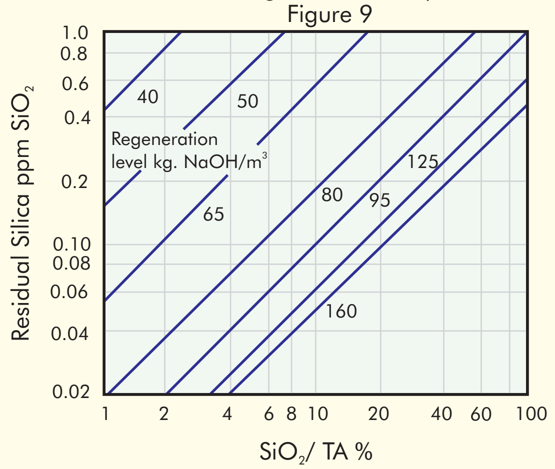
Figure 8



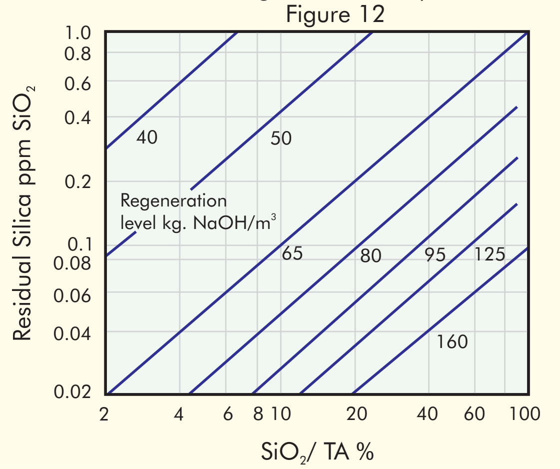
End-point Silica 0.10 mg/l SiO_2/TA* ≥ 80%

FF-IP Treated Water Quality

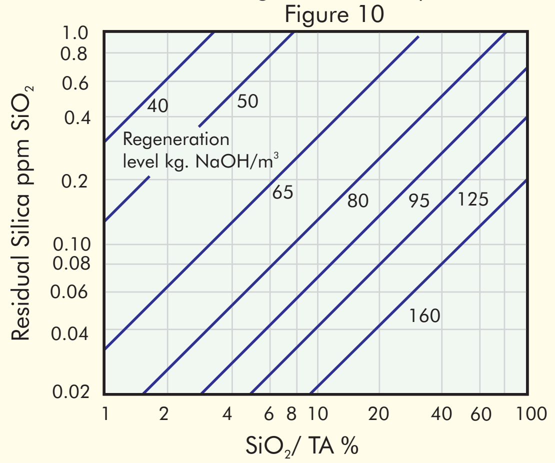
TREATED WATER QUALITY - CO-FLOW
Residual Silica -Regeneration Temperature 5°C
Figure 9



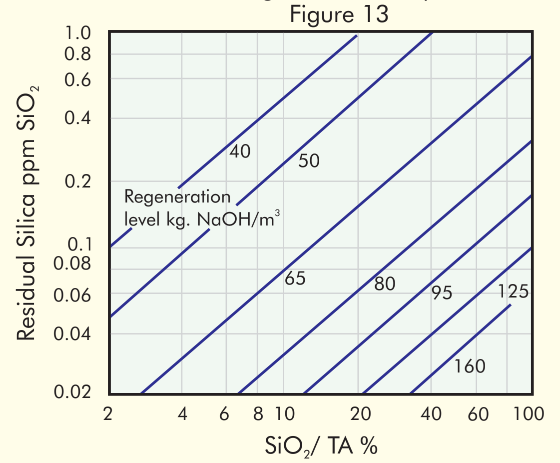
TREATED WATER QUALITY - CO-FLOW
Residual Silica -Regeneration Temperature 40°C
Figure 12



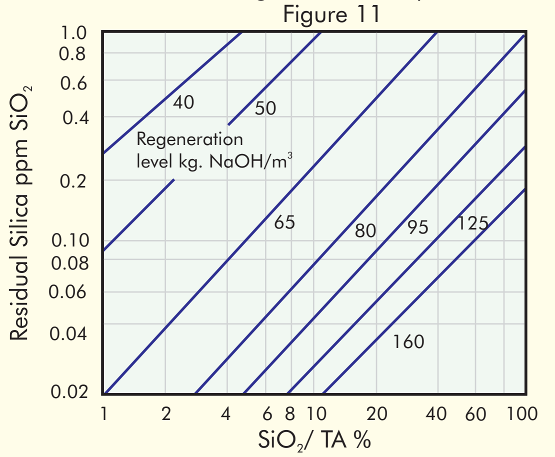
TREATED WATER QUALITY - CO-FLOW
Residual Silica -Regeneration Temperature 15°C
Figure 10



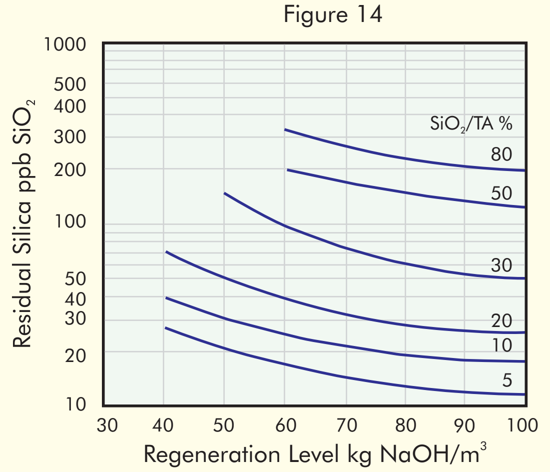
TREATED WATER QUALITY - CO-FLOW
Residual Silica -Regeneration Temperature 60°C
Figure 13



TREATED WATER QUALITY - CO-FLOW
Residual Silica -Regeneration Temperature 25°C
Figure 11



TREATED WATER QUALITY - CCR
Figure 14



Mixed Bed De-ionising

A correctly designed and operated mixed bed unit using INDION FFIP with INDION 225 strong acid cation exchange resin will produce treated water with a conductivity of 0.5 microsiemens/cm or less. When the mixed bed units preceded by two-stage de-ionising, conductivity of 0.1 mircosiemens/cm is easily achieved.

The silica content of the treated water from a mixed bed unit depends upon the level and temperature of the regenerant used for INDION FFIP and the silica loading during the treatment run. This loading can be calculated from the silica content of the feed water and the volume of water treated per run.

To maintain any desired silica residual level in the treated water, reference should be made to Figures 15-18. These graphs give the maximum silica loading that INDION FFIP will tolerate at various regeneration levels and temperatures to maintain the required silica residuals.

Typical operating data

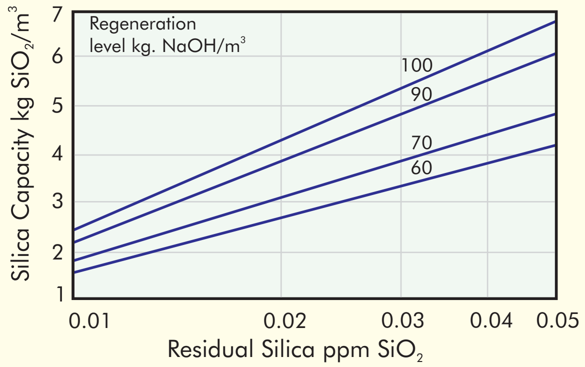
Mixed bed de-ionising

Total Bed depth	1.0 - 2.4 m using INDION FFIP and INDION 225 resin
Rising space	75% of bed depth
Treatment flowrate	60 $m^3/h\ m^2$,maximum
Pressure loss	1.2 kg/cm^2 ,maximum
Bed separation	9 $m^3/h\ m^2$ for 10 minutes
Bed settlement	Allow 5 minutes after separation before commencing injection of regenerants
Regenerant	Sodium hydroxide for INDION FFIP Hydrochloric acid/Sulphuric acid for INDION 225
Acid injection rate	4.5-18 $m^3/h\ m^2$ for 6-10 minutes with 2-5% w/v acid
Down flow	1.5 $m^3/h\ m^2$
Acid rinse	2 bv
Down flow	1.5 $m^3/h\ m^2$
Alkali Injection rate	4.5-18 $m^3/h\ m^2$ for 10-15 minutes with 2-5% w/v alkali
Upflow	4.5 $m^3/h\ m^2$
Alkali rinse	4 bv in 10-15 minutes
Upflow	4.5 $m^3/h\ m^2$
Unit drain down	Before re-mixing the resin, the water level should be lowered to approximately 0.4 m above the bed.
Bed remix	2m^3/minute m^2 oil free air at 0.4 kg/cm^2 pressure for 10 minutes
Settle bed, refill unit, final rinse..............	These operations should be carried out in such a way to avoid separation of the two resins. Final rinse to satisfactory water quality should be effected at the treatment flowrate, or at 24 $m^3/h\ m^2$, whichever is greater. Total time required is normally about 5-10 minutes depending upon end point conductivity required.

MIXED BED DE-IONISING

Residual Silica - Regeneration Temperature 10°C

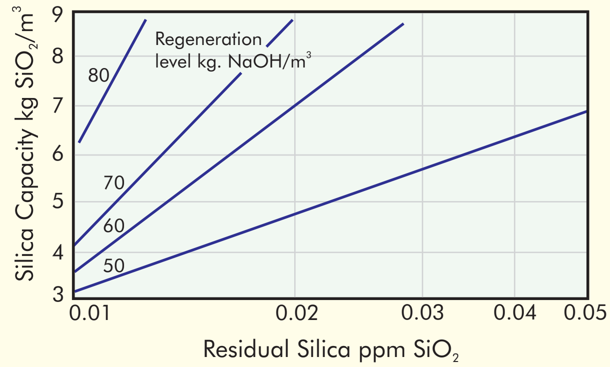
Figure 15



MIXED BED DE-IONISING

Residual Silica - Regeneration Temperature 60°C

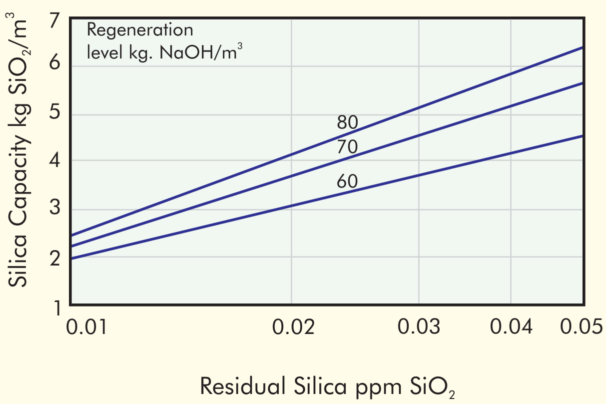
Figure 18



MIXED BED DE-IONISING

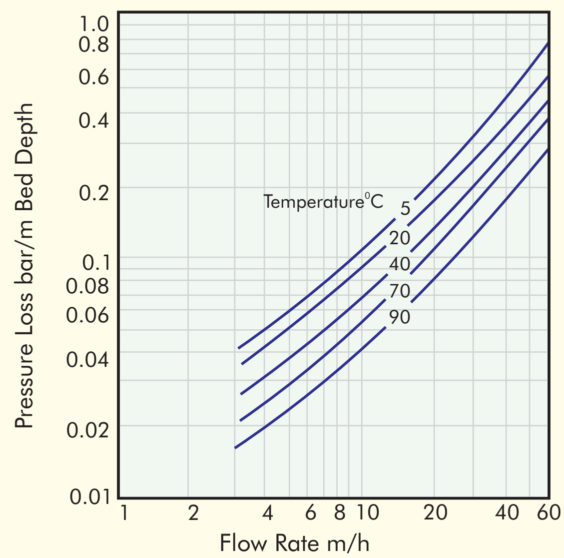
Residual Silica - Regeneration Temperature 25°C

Figure 16



PRESSURE LOSS

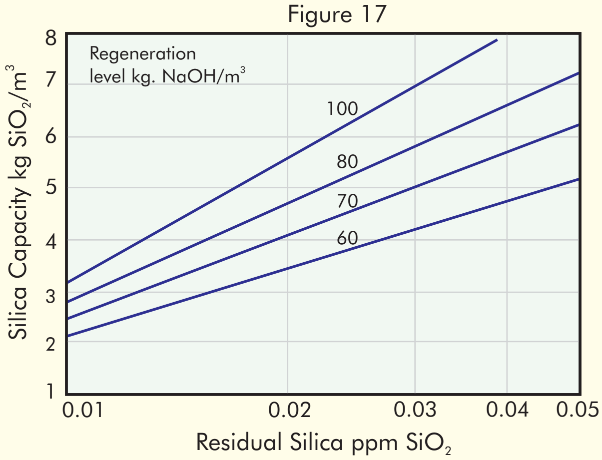
Figure 19



MIXED BED DE-IONISING

Residual Silica - Regeneration Temperature 40°C

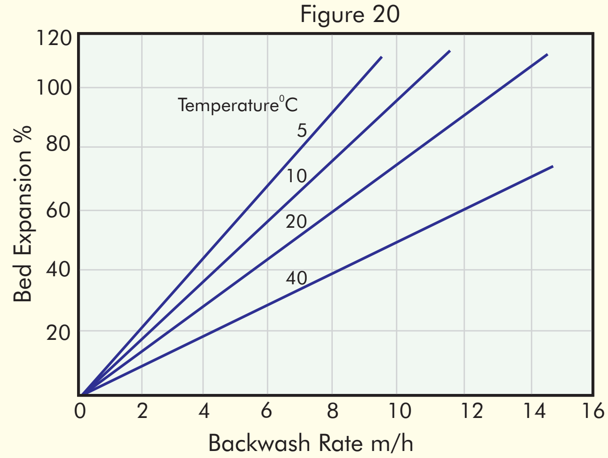
Figure 17



BED EXPANSION

Bed Expansion (Cl⁻ form)

Figure 20



Use of good quality regenerants

All ion exchange resins are subject to fouling and blockage of active groups by precipitated iron. Hence the iron content in the feed water should be low and the regenerant sodium hydroxide must be essentially free from iron and heavy metals. All resins, especially the anion exchangers are prone to oxidative attack resulting in problems such as loss of capacity, resin clumping, etc. Therefore sodium hydroxide should have as low a chlorate content as possible. Good quality regenerant of technical or chemically pure grade should be used to obtain best results.

Packing

HDPE lined bags	25/50 lts	LDPE bags	1cft/25 lts
Super sack	1000 lts	Super sack	35 cft
MS drums with liner bags	180 lts	Fiber drums with liner bags	7 cft

Storage

Ion exchange resins require proper care at all times. The resin must never be allowed to become dry.

Regularly open the plastic bags and check the condition of the resin when in storage. If not moist, add enough clean demineralised water and keep it in completely moist condition. Always keep the resin drum in the shade. Recommended storage temperature is between 20° C and 40° C.

Safety

Acid and alkali solutions are corrosive and should be handled in a manner that will prevent eye and skin contact. If any oxidising agents are used, necessary safety precautions should be observed to avoid accidents and damage to the resin.

INDION range of Ion Exchange resins are produced in a state-of-the-art ISO 9001 and ISO 14001 certified manufacturing facilities at Ankleshwar, in the state of Gujarat in India.

ION EXCHANGE

Refreshing the Planet

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