THE RATIONALE OF CONDENSATE TREATMENT

Uninterrupted flow of impurity-free feedwater is basic to the efficient operation of high pressure boilers, nuclear reactors and steam generators.

Under equili-brium conditions, impurities in the feedwater are very low and consist of salts, silica and metal oxides in trace concentrations.

These are introduced into the cycle by make-up, corrosion, erosion and very small condenser leaks. Impurity levels in feedwater are particularly high at initial plant start-up, after forced or planned outages or during periods of condenser water inleakage caused by tube ruptures.

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Condensate polishing demonstrates cost effectiveness

1) Much faster initial plant start-up.

2) Rapid restart to full load after outages.

3) Continued on-line operation during small conden-ser leak episodes.

4) Increased turbine efficiency because of diminished silica deposition.

5) Prolonged turbine life due to elimination of sodium, chloride and sulfate stress corrosion and cracking.*

6) Improved quality of spray desuperheater water.

7) Reduction in waterside failures from suspended solids erosion.

8) Substantial Btu savings due to blowdown reduc-tion.

TABLE A Recommended feedwater quality for high pressure fossil-fired boilers under steady state conditions.

Cation conductivity (25°C) micromhos	0.15
Sodium (Na) ppb	3
Total iron (Fe) ppb	10
Copper (Cu) ppb	1
Chloride and sulphate (total as Cl and S04)	2 ppb
Carbon dioxide (CO2) ppb	20
Silica. (SiO2) ppb	2
pH (25°)	8.8-9.3

TABLE B Recommended feed water quality for Boiling Water Reactors under steady state conditions.

Specific conductivity (25°C) micromhos	0.15
Chloride (Cl) ppb	0.2
Silica (SiO2) ppb	2
Total iron (Fe) ppb	10
Total Copper (Cu) ppb	2
pH (25°C)	7

TABLE C Recommended feed water quality for Pressurized Water Reactors under steady state conditions.

Cation conductivity (25°C) micromhos	0.15
Sodium (Na) ppb	0.5
Oxygen (O2) ppb	20
Total iron (Fe) ppb	10
Total Copper (Cu) ppb	2
pH (25°C)	9-9.4

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9) *Lower chemical, neutralization and waste treat-ment costs because of lower feedwater make-up demand.*

10) *Reduced consumption of internal treatment chemicals.*

11) *Longer time between turnarounds for boiler acid cleaning.*

12) *Orderly power reduction or shutdown during large condenser leakages.*

** Now recommended by all turbine manufacturers.*

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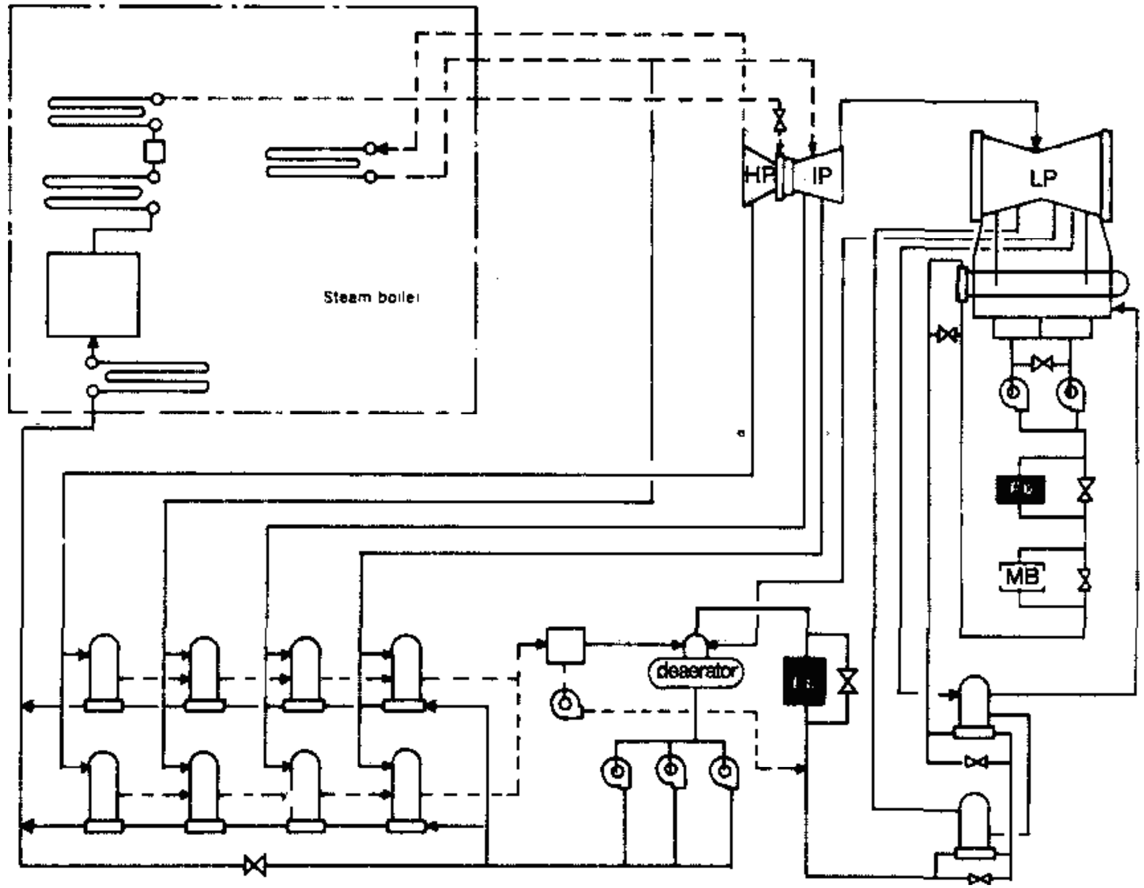
TYPES OF CONDENSATE TREATMENT SYSTEMS



Location of condensate polishing system in a fossil-fired high pressure power station.

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The design of condensate polishing systems will be influenced by steam cycle, site conditions, space considerations, availability and temperature of cooling water, materials of construction used in condenser, pumps, ancillary equipment and piping, and lastly by particular preferences of the engineer and client based on past experience.

The most widely used designs, all of which have been designed and manufactured by Idreco, are:

- *Precoat filter/demineralizers of the Decorex® type using powdered ion exchange resins for simulta-neous removal of dissolved and suspended solids.*
- *High rate bead type cation units followed by high rate bead type mixed bed demineralizers.*
- *High rate mixed beds alone or in combination with Decorex type precoat filter/demineralizers.*
- *Cation units operating in the sodium cycle to remove hardness and suspended solids applicable to mode-rate pressure steam cycles treating hot condensate.*

The Decorex filter/demineralizer is a proprietary Idreco design.

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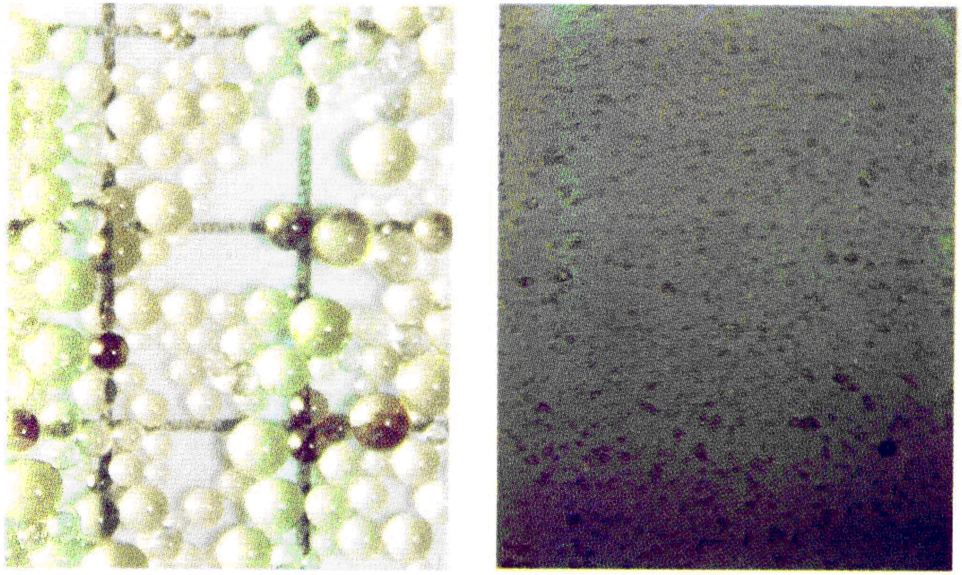
THE DECOREX PROCESS



Granular (left) and powdered (right) ion exchange resins

In the Decorex process, finely powdered Suprex® ion exchange resins are used as the precoat media to exchange dissolved ionic species, remove suspended particulates, organics, non-reactive silica and colloidal matter. The process is being increasingly used to remove such contaminants in the production of ultrapure condensate for feed water to high pressure fossil-fired and nuclear boilers.

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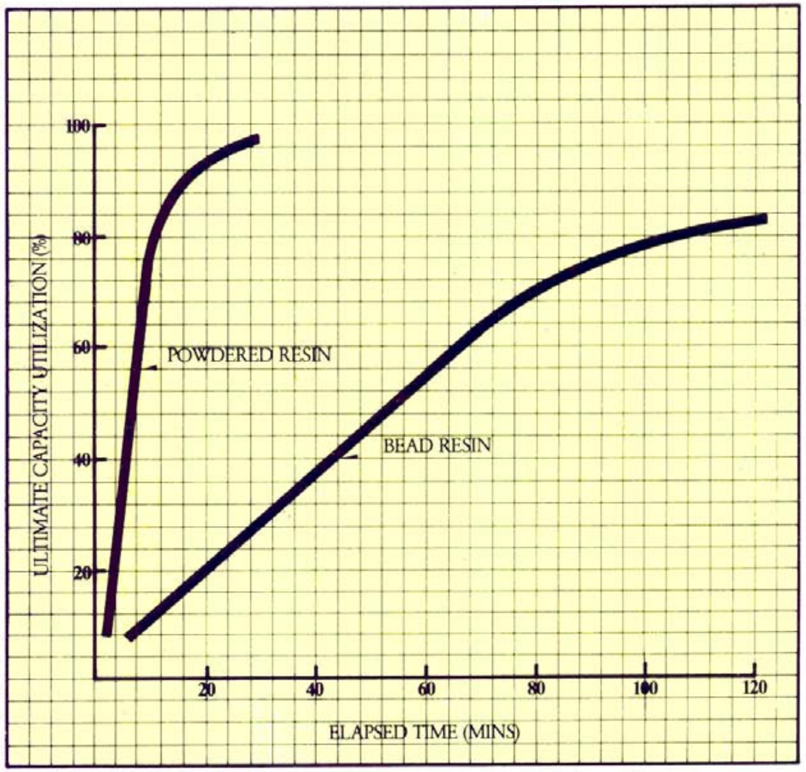

Comparison of reaction rates of powdered and bead resins. Type I strong base anionic resin.

Upon wetting Suprex formulations, electrostatic forces cause the mixed cationic and anionic resins to agglomerate.

Agglomeration leads to a very large in-crease in volume and the thin precoat layer becomes bulky and easily permeable to liquid, distinct from granular matted precoats obtained with ordinary materials.

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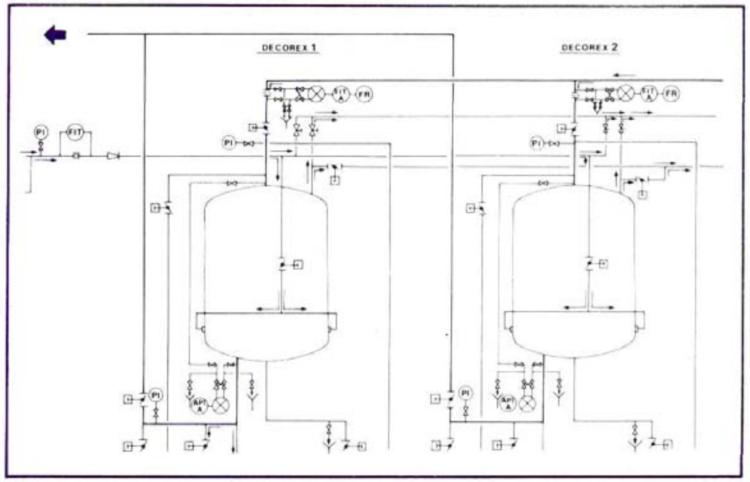
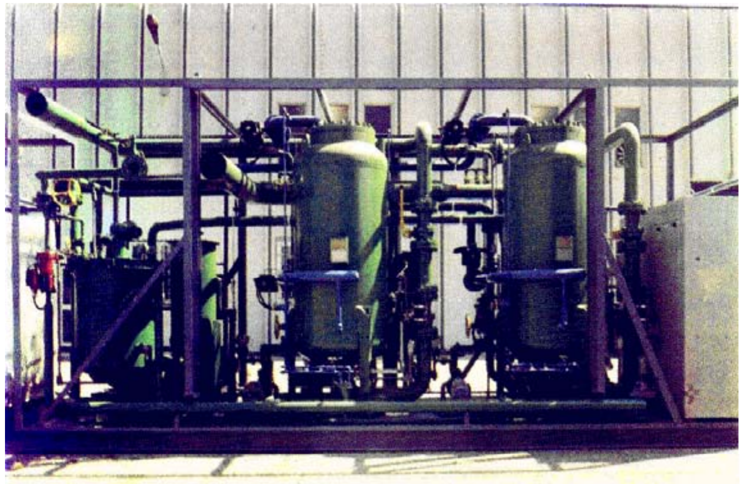


Typical P&ID for a Decorex condensate polishing system



Package skid mounted Decorex condensate polishin system installed at Korba, Farakka and Ramagundam power station India, Nine units at 200MV.

Filtration takes place in depth throughout the entire mass of the precoat and not simply by the thin surface layer. Crud retention and ion exchange capacity are thus increased, run lengths are greatly extended. Very important, this all takes place at very low pressure drop. Differential Pressure of less than 2 psi is seen at design flow across freshly precoated elements.

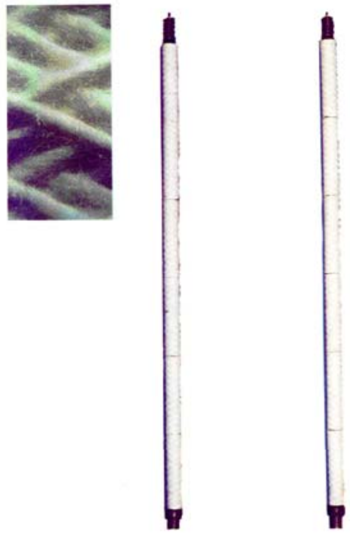
It is important to remember that ion exchange takes place both on the surface of and within resin particles. With very fine Suprex resins, diffusion effects are minimized.

Furthermore, surface is vastly multiplied. Suprex powdered resins thus react about 100 times as fast as bead resins.

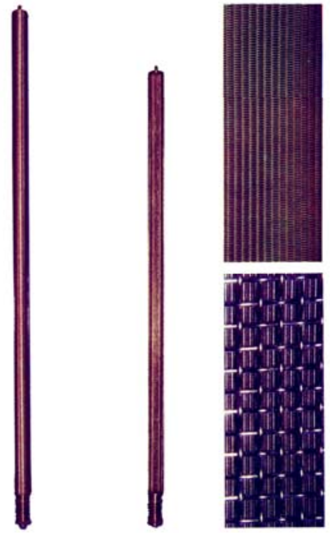
Actual utilization of ultimate exchange capacity is also increased significantly. Normal operating capacities of conventional bead resins run to a designated endpoint are usually 20-50% of analyzed capacity. Because of low driving force (due to low dissolved solids concentration) and stringency of endpoint specifications, actual capacities are often even lower. With Suprex resins, rapid reaction rates due to reduced diffusion effects and increased surface area result in stoichiometric utilization of 60-95% of analyzed exchange capacity.

For all these reasons, the Decorex process has become the preferred technology for condensate polishing.

THE DECOREX ELEMENTS



Decorex wound yarn filtering elements.



Decorex stainless steel filtering element

The Decorex filter consists of a pressure vessel equipped with tubular filter elements installed vertical-ly on a support plate.Influent condensate enters the filter from the top, passes through the precoated elements and collects under the support plate. Effluent exits through a bottom connection.A separate bottom drain is provided for backwashing spent precoat material.

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Two types of filter elements are available:

Fiber type:

wound polypropylene or nylon yarns -filtration to remove suspended solids.Temperature 140° max.

Removal/exchange capacities:

Cellulose fibers/Solka-Floc / inert material precoat. Effective oil removal - 100 ppb max. With powdered ion exchange resin added for simultaneous removal of dissolved/suspen-ded solids and colloidal material, temperature 240°F max.

Metal type:

stainless steel septum-polishing condensa-te for low to medium pressure industrial boilers, and for high pressure, high temperature fossil-fired boilers, nuclear reactors and steam generators, fuel pool, radwaste and reactor water cleanup. Same precoat media, 0.2-0.3 Ib/sq ft dry weight basis. No temperature limitation.

Removal/exchange capacities:

Cellulose precoat media will remove only 50-70% of suspended solids and no dissolved solids.Powdered ion exchange resins will remove virtually all suspended and dissolved solids at an efficiency of 0.1 to 0.2 pounds per pound of dry resin.

DECOREX SYSTEMS FLEXIBLE AND VERSATILE

Condensate polishing systems must produce high purity effluent satisfying the following requirements:

1) TDS less than 10 ppb, with influent in the 20-200 ppb range.

2) With influent pH of 8.8-9.6 and 300-2000 ppb ammonia.

3) Maximum sodium removal at high pH, all volatile treatment (AVT) water chemistry.

4) Maximum removal of suspended or colloidal metal oxides and other contaminants under all operating conditions.

5) Operation at minimum pressure drop.

6) Optimum use of ion exchange resins for maximum impurities removal at lowest operating cost.

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How Decorex systems accomplish this:

- *Powdered resins are changed after every run. The polishing system always operates with new, fully regenerated resins.*
- *Powdered resin purity is higher than most bead resins. Powdered resins meet nuclear grade specs.*
- *Powdered resin kinetics are extremely rapid. Finer mesh means more reactive surface available.*
- *Powdered resins are regenerated to 90-95% of capaci-ty - virtually impossible with deep beds except for the first run.*
- *Powdered resins are regenerated to 90-95% crud removal capacity - levels unreachable with deep beds except with new resins.*
- *Powdered resins can be varied sharply into different cationic and anionic ratios - difficult to do with deep beds.*

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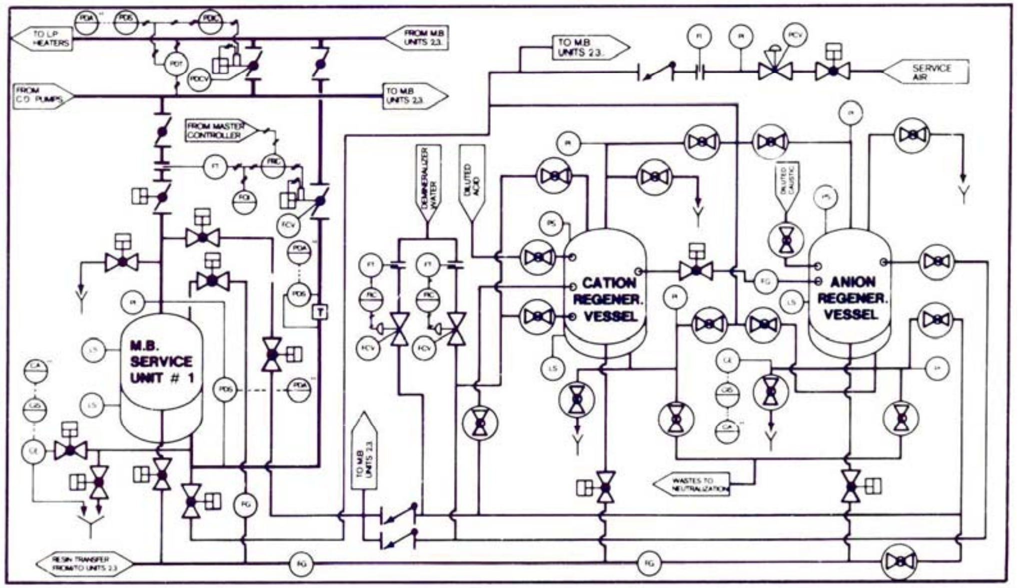
HIGH RATE MIXED BED PROCESS



High rate mixed beds use bead type ion exchange resins to polish condensate. In a typical unit, beds are 3-4 ft deep and flow velocity around 50 gpm/sq ft. High rate mixed beds can be used alone, in combina-tion with precoat filters, or downstream of a cation unit.

In naked beds, one must depend on bead resin alone to remove both dissolved and suspended solids. Due to the large mass of resin present, exchange capacity is high.

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They are thus often used for sea water- or brackish water-cooled condensers where a leak could cause hea-vy condensate contamination. Crud removal capacity is low, however, generally running 0.1-0.2 lb/lb dry resin.

Removal efficiency for both dissolved and suspended solids is lower than for Decorex filter/demineralizer systems using powdered ion exchange resins. Crud removal for mixed beds is 70-80% for black oxides, 30-50% for yellow or other metal oxides, and pratically zero for colloidal material. In most cases this performance is not sufficient to guarantee efficient power station operation.

External cleaning and regeneration.

When the exchange capacity is exhausted or when high pressure drop indicates maximum suspended solids removal, bead resins are generally cleaned and regenerated outside the service unit itself.

Mixed resin is transferred to the cation regeneration unit. Backwashing then separates the anion resin and it is tranferred to the anion regeneration unit. Both resins are then regenerated and thoroughly rinsed. The two resins are next mixed in a holding tank and held until required to recharge the service vessel

Resin contamination and degradation.

During operation of a mixed bed polishing system, suspended solids penetrate resin pores, and colloidal metal oxides deposit and coagulate within the pores and on the surface of the beads. Both effects are harmful: metallic oxides catalyze oxidation of functio-nal groups, degrading resin capacity - and oxides occlu-de reactive sites, slowing kinetics and lowering capacity.

To maintain the polishing system at maximum efficien-cy, it is imperative to clean and regenerate the resin perfectly in every cycle. To maintain sodium level at 1 ppb as required for operation of high pressure boi-lers and reactors, for example, no more than 0.1% of active functional cation groups can be in Na form.

This can be achieved only by high efficiency of cation regenerating system, and preventing traces of cation resin from contaminating the anion resin.

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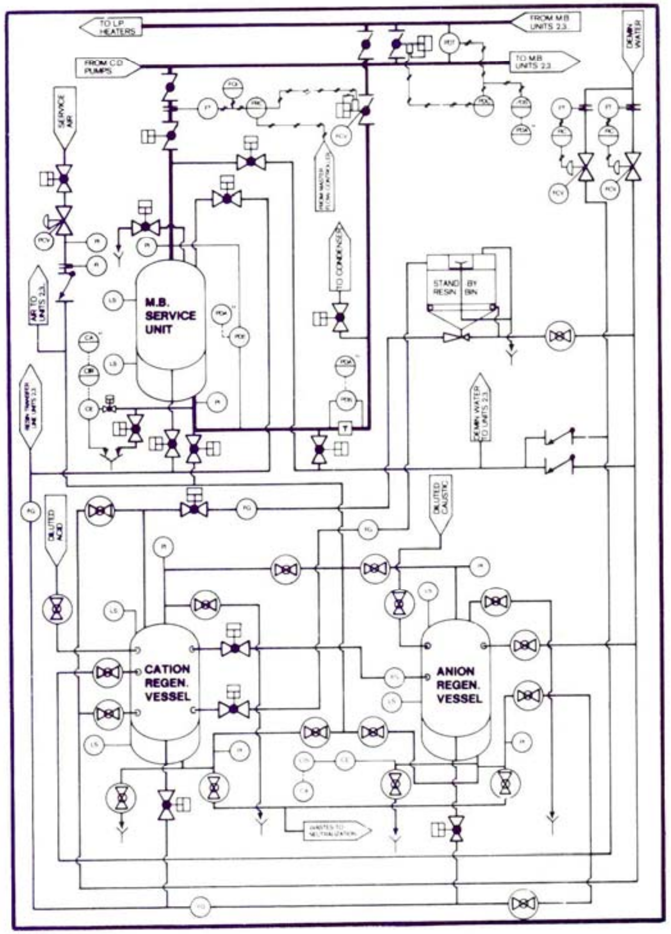
COMREC MIXED BED REGENERATION PROCESS

Cross-contamination of mixed bed resins always re-sults in the presence of some sodium and chloride (or sulphate), ions in treated condensate. A prime task facing the efficiently run power station is to reduce these concentrations to the minimum. Towards this end, Idreco has introduced the Comrec process.

This patented process separates anion and cation resins to a degree not possible even when using inert beads of intermediate specific gravity to make separation by backwashing more effective.



Typical Comrec process P&ID for ultrahigh quality regeneration of mixed bed resin.

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The Comrec process depends on two key operations:
first, hydraulic classification of mixed resin into lighter anion and heavier cation fractions within a single vessel, and second, mechanical isolation of the narrow interface zone in which anion and cation resins are inextricably mixed.

The process operates as follows:

1) *Exhausted mixed bed resin from the service vessel is transferred to the cation regeneration vessel and separated by backwashing.*

2) *After separation, the most of the lighter anion resin is trasferred to the anion regeneration vessel.*

3) *An adequate interface layer containing unseparable mixed resin is completely transferred to a standby hopper, thus leasing back the uncontaminated lower portion of cation resin.*

4) *Cation and anion resins are regenerated individually in separate vessels. Since their separation is total and complete, no regenerant cross-contamination takes place.*

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5) *After regenerations are complete, the heavier cation resin is transferred back to the anion holding vessel where the resins are thoroughly remixed, washed and rinsed.*

6) *The interface layer is transferred from the standby hopper to the empty cation regeneration vessel whe-re it remains until a new batch of exhausted mixed resin arrives for processing.*

By this simple yet ingenious step of isolating the interface layer and never permitting it to contact condensate, the Comrec process maintains all service resin in appropriate H or OH form. Cross-contamina-tion is eliminated, low conductivity effluent quality assured. No other process can offer such high quality at such low costs.

TABLE D Removal of crud with Decorex and high rate mixed bed condensate polishing system. Actual operating data units in ppb.

Polisher Type	Boiler Type	Iron (total)		Copper (total)	
		Inlet	Outlet	Inlet	Outlet
DB	BWR	36	9.7	10	2.6
DB	O.Th.	60	25	5.0	2.2
DB	Drum	40	6.0	4.3	0.3
PRF	BWR	14	0.6	1.3	0.2
PRF	O.Th.	17	0.6	0.2	Trace
PRF	PWR	57	1.0	1.1	0.2

DB = deep bed demineralizer – PRF = powdered resin filter/ demineralizer – O.Th. = Once through boiler – Drum = Drum type boiler – PWR = Pressurized Water Reactor – BWR = Boiling Water Reactor.

TABLE E Removal of TDS with Decorex and high rate mixed bed condensate polishing system. Actual operating data. Units in ppb.

Polisher Type	Boiler Type	Sodium		Sulfate		Chloride	
		Inlet	Outlet	Inlet	Outlet	Inlet	Outlet
DB	O.Th.	1.0	0.1	0.4	0.05	0.6	0.3
DB	Drum	0.7	0.2	2.2	1.0	0.3	0.3
DB	PWR	0.06	0.04	0.8	0.4	0.12	0.06
PRF	Drum	0.5	0.2	1.5	0.7	0.04	Trace
DB	BWR	2.1	0.4	1.8	1.7	1.5	1.2
PRF	O.Th.	0.8	0.5	0.4	0.1	0.3	0.1

DB = deep bed demineralizer – PRF = powdered resin filter/ demineralizer – O.Th. = Once through boiler – Drum = Drum type boiler – PWR = Pressurized Water Reactor – BWR = Boiling Water Reactor.

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