REMOVAL OF TOXIC ELEMENTS IN MINE EFFLUENTS BY CCIX

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Introduction

Most manufacturing facilities and mining enterprises have abatement programmes to treat the effluents produced by their operations.

Recent changes to regulations, which have resulted from a greater knowledge of the detrimental effects of prolonged exposure to low concentrations of toxic ions have further lowered the concentration of some constituents like Uranium, Radium, Cyanide and most heavy metals permissible in the final discharge of the plants.

Because of the varied nature of these waste streams equipment designs have evolved to permit the varying feed concentrations of the specific ions to be removed as well as the high concentration of suspended solids contained in many waste waters.

Since 1969 Himsley Engineering of Canada has developed continuous ion exchange systems for the treatment of waste water and mine water effluents.

Continuous Ion Exchange has become a state of the art technology for the treatment of waste streams and Himsley Engineering has developed three primary designs:

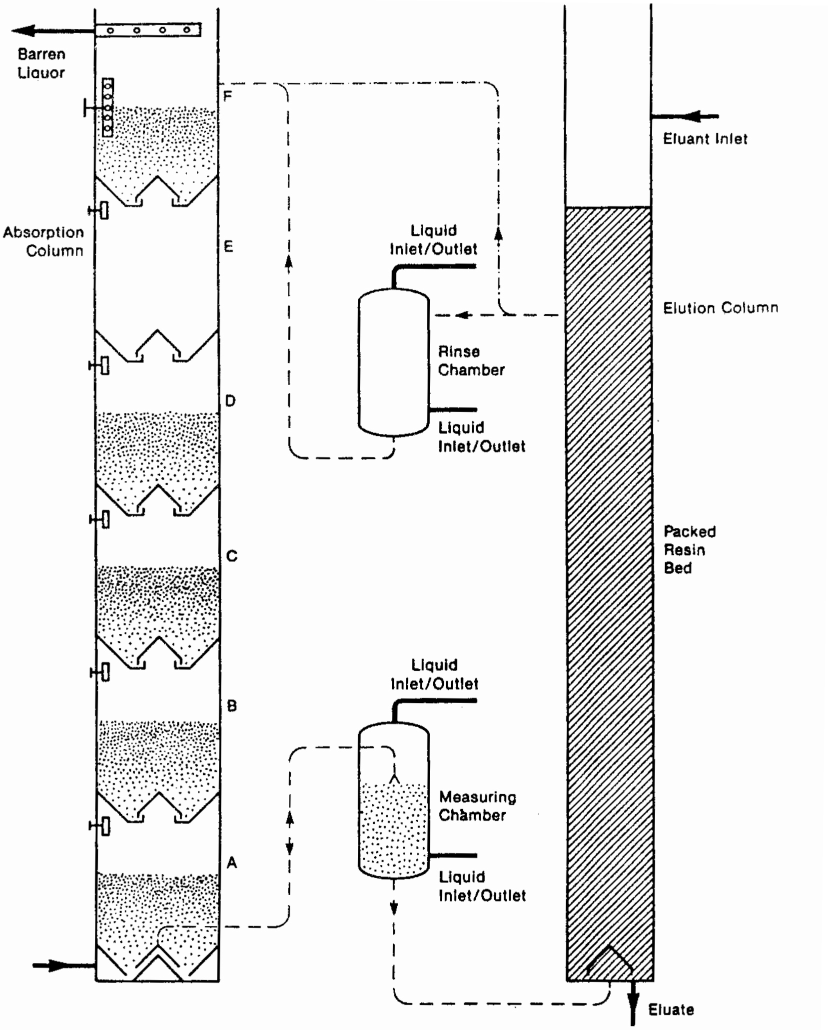
1. Continuous Upflow with Multi Chamber Adsorption Column.
2. Continuous Downflow Moving Packed Bed Adsorption Column.
3. Continuous Upflow Open Tank Adsorption Column.

Continuous Upflow with Multi Chamber Adsorption Column

The original Himsley CCIX design, Patent No. 4,279,755, which has been described in previous papers and is illustrated in fig. 1 (1,2) is representative of this type of equipment.

This type of plant is best suited for medium throughput capacities of up to 1200 US gpm with a adsorption column having a maximum diameter of thirteen feet.

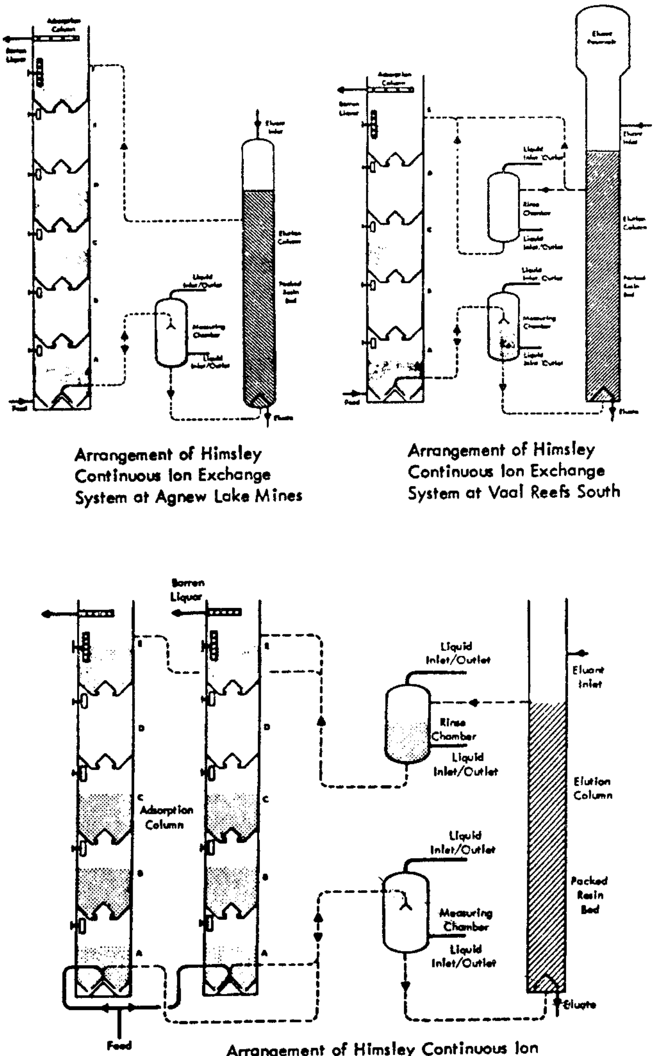
It is designed to handle turbid feeds with a solid concentration in the order of 2000 to 3000 ppm having a 100% minus 250 mesh particle size.



Typical arrangement of Himsley Continuous Ion Exchange System
Fig. 1

The system's capacity depends upon many factors such as solution pH and ionic concentration in the pregnant feed as well as resin saturation capacity. Typically this design can handle feed solutions of pH ranging from 1 to 11 and ionic concentrations ranging from few ppm to several g/l depending of course upon the specification or ions to be removed.

Several plants of this design have been installed in the Republic of South Africa, the USA and Canada (3). A summary of the configuration of three of these plants is seen in Table 1 and the Flow Sheets in fig. 2.



Arrangement of Himsley Continuous Ion Exchange System at Agnew Lake Mines

Arrangement of Himsley Continuous Ion Exchange System at Vaal Reefs South

Arrangement of Himsley Continuous Ion Exchange System at Anamax Mining Company

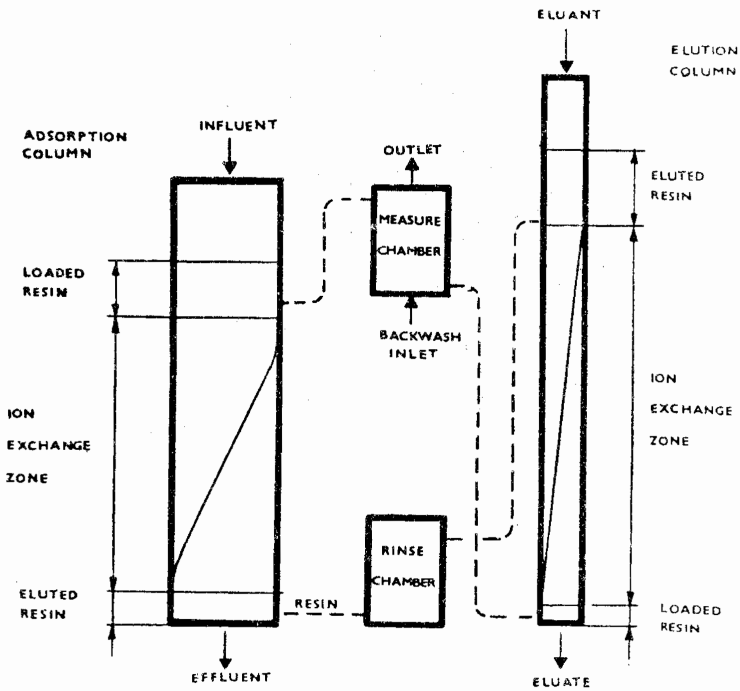
FIG. 2

All of these plants employ counter currently eluted fixed bed multi-batch elution columns. This provides the maximum eluate strength possible, by eluting many small batches of resin in series, however, with this system the recycle storage tanks, valves and pumps normally associated with conventional designs are eliminated.

Adsorption Column Details	Agnew Lake Total Flow 162 m^3/hr.	Vaal Reefs South Total Flow 1050 m^3/hr.	Anamax Total Flow 1590 m^3/hr.
Number of adsorption columns	3	5	6
Diameter - m	1.83 to 2.0	4	3.7
Height - m	7.3	19.85	16
Total number of chambers per column	9	6	5
Resin per chamber - m^3	1	6	5.7
Flow/column - m^3/hr.	54	210	245
Superficial velocity - m/hr.	20.5 to 17.2	16.7	24.6
Resin type	Duolite ES131	Duolite A101DU	Dowex 21K
Resin particle size - U.S. stnd. mesh	16 to 30	16 to 40	16 to 30
Resin loading - g/l. U_3O_8	13	21	6
Resin residence time - hours	13.3	30	40
Cycle time - hours	1.7	6	10
Elution Column Details			
Number of elution columns	3	5	3
Diameter - m	1.4	1.5	1.8
Height - m	6.25	20.5	15.4
Volume of resin to outlet nozzle - m^3	6.4	30	21.2
Eluant	125 g/l. H_2SO_4	120 g/l. H_2SO_4	110 g/l. H_2SO_4
Bed volumes eluant/cycle	2.6	4	5
Temperature of eluant - $^{\circ}$ C.	Ambient	Ambient	Ambient
Average eluate flow/elution column - m^3/hr.	1.95	1.05	2.86
Eluate grade - g/l. U_3O_8	5	5	1.2
Stripped resin - g/l. U_3O_8	0.1	0.5	0.4

TABLE 1

The elution column employed by this type of system has recently been used for the carbon strip circuit at Cullaton Lake Gold Mines in the North West Territories of Canada. Because of the multi batch design the long stripping times of 40 to 60 hours are achieved without the increase in carbon inventory and additional storage tanks usually required with conventional Carbon Strip Circuits.



PACKED MOVING BED SYSTEM

FIG. 3

Continuous Downflow Moving Packed Bed Adsorption Column

The most efficient design of equipment using a ion exchanger is one which contains sufficient resin to accommodate only the ion exchange zone.

Designs such as the Higgins Column (fig. 4) attempted to achieve this maximum efficiency, however, the treatment of the ion exchange resin in this system while moving around the circuit causes excessive attrition which results in high pressure drops across the working bed. This is turn aggravates the attrition problem.

The Chem-Seps design also demostrates the potential problems which can occur as a result of incomplete elution, excessive flowrates and suspended solids in the influent solution.

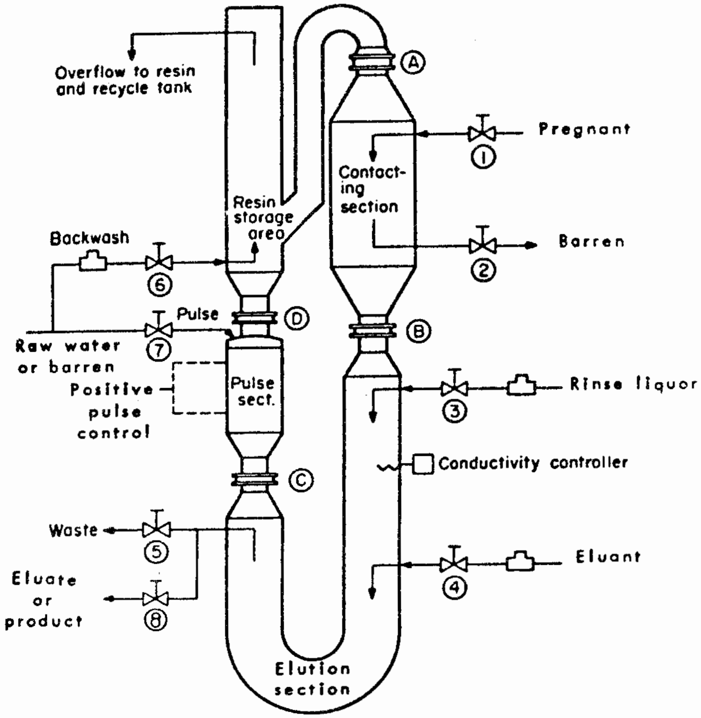


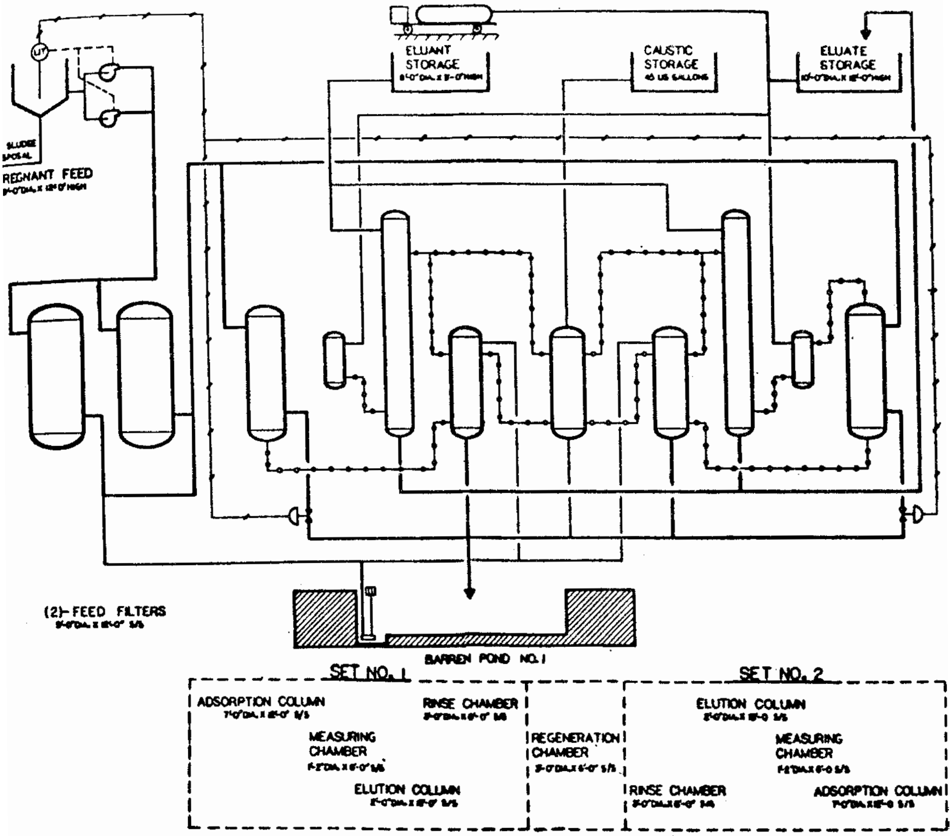
FIG. 4 HIGGINS COLUMN

The Continuous Moving Packed Bed system "CMPB" was designed to overcome these problems by using the solids transports technology acquired in the development of the original CCIX equipment.

The operation of this plant described in earlier papers (4) employs a counter currently operated packed bed of ion exchange resin for both the adsorption and elution process. This provides the lowest possible barren effluent as well as the maximum eluate strength which minimizes the volumetric capacity required for downstream processes like solvent extraction or precipitacion.

The first commercial installation of a plant of this design was at Cotter Corporation's Schwartzwalder Mine in Golden, Colorado in 1982. A flow sheet of this plant is seen in fig. 5.

The selection of the Minsley Continuous Moving Packed Bed desigh came after several months of pilot plant testing which compared three alternate designs supplied by Chem-Seps with a Higgins Column, Bateman with a NIMCIX column, and Himsley Engineering Ltd. with the CMPB column (5).



PROCESS FLOW SHEET FIG. 5

The Himsley design showed the lowest capital and operating cost of the three systems proposed and a contract was awarded to build a 900 US gpm plant in March 1982.

The plant was commission in December 1982 and since that time Cotter Corporation has reported 100% equipment availability while continuously maintaining an effluent concentration below the design maximum of 10 parts per billion U308.

A review of the plant operation during the first year of operation showed that since its commissioning several tons of Uranium had been recovered that would have otherwise been lost to the environment.

A plant of similar design was subsequently installed at Key Lake Mine in Saskatchewan in the fall of 1984. This ion exchange plant was intended to remove Radium 226 from the excess plant effluent, estimated at 500,000 m^3, which had accumulated over several months of operation and which could not be processed with the existing treatment system capacity.

Once this solution had been processed the intention was to use the equipment to test various ion exchange materials like resins and natural and synthetic zeolites in full scale operation to establish a viable alternative to the conventional co-precipitacion of Radium and Barium Sulphate.

The plant was designed and built in sixteen weeks and commissioned in October 1984. Within a few days the plant was operating at full capacity and the Radium 226 concentration in the final discharge was well within effluent limits. The equipment continued in operation until all of the solution had been processed.

Continous Upflow Open Tank Adsorption Column

The development of this type of system came from a requirement of process streams having a low ionic concentration in the pregnant feed with high volumetric throughputs.

The first attempt at this type of design employed a modified multi compartment adsorption column fig. 6 and was operated at a feed solids concentration of 5-10% and 60%-250 mesh. The testwork was conducted at Pathfinder's Shirley Basin Mine in Wyoming.

The results obtain in this pilot plant operation (6) were quite encouraging, however, the system contained some screens which would blockup with slimes when the plant feed reached peak solids concentration. This adversely affect the plant operation.

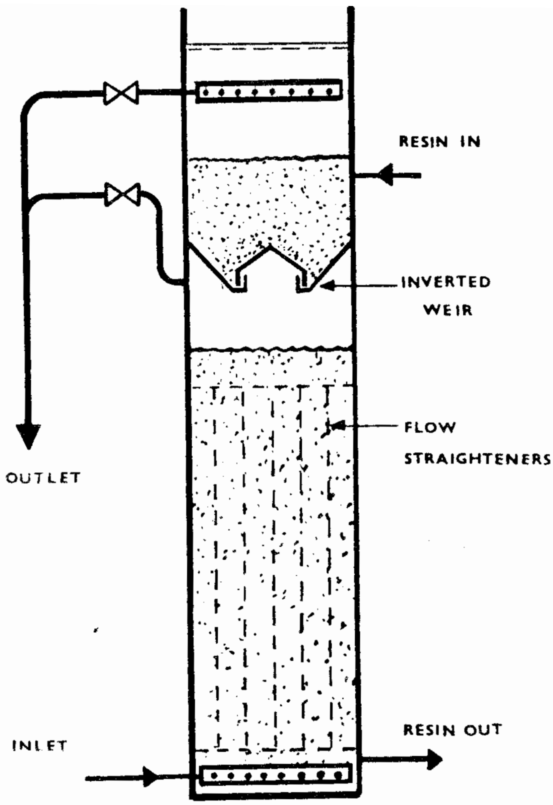
The final design eliminated the use of any internal screens for resin transfer and employed an air lift transfer mechanism for resin movement.

The system comprises a series of vertical tanks, usually 5 to 7 in number, through which the liquid passes in series from one tank to the next.

In each tank the flow enters at the bottom through a distributor and rises upwards fluidizing the batch of resin in the tank.

The flow continues for a period of time until the resin is approaching equilibrium with the solution entering the tank. When the resin in the first tank which receives the feed liquor is saturated it is then transferred to a vessel for elution employing air which is discharged through a perforated pipe to create an air-lift.

When that tank is empty the resin from the next tank is transferred to the first tank and so on down the line until the last tank is empty and ready to receive a batch of freshly eluted resin.



SIMPLIFIED ADSORPTION COLUMN

FIG. 6

A system of valves is arranged so that there is no interruption in the flow through the system during resin transfers and therefore no opportunity for frequent settling of resin with slimes which are difficult to re-fluidize.

No valves close on the resin and since the resin is always moved in a fluidized manner the attrition is minimal. The transfer of resin from one tank to the next takes just a few minutes depending upon the design conditions.

To eliminate back-mixing the solution used to transport the resin is that which the resin is to contact in the tank to which it is being transferred. Consequently there is no need for any resin/liquid separating screens between stages to prevent back-mixing as required by other processes of this type.

Also no screens are needed on the outlet of each thank because the depth of tank and the degree of fluidization is arranged so that elutriation of resin from one tank to the next should not occur. However, to safeguard against any unforeseen flow surges the barren effluent from the last tank goes to a suitable device such as a DSM screen that will prevent any loss of resin from the system.

The loaded resin is eluted by whichever method is adopted for the circumstances and the stripped resin is then returned to the last tank in the series.

A brief list of advantages is given below and although these relate to the application of the system for ion exchange resin it can of course be used with polymeric adsorbents, carbon particles or other materials having suitable fluidizing properties.

1. Large flows of turbid solutions can be handled.

2. The system is truly continuous as there is no interruption of flow during resin transfer.

3. Complete transfer of resin from one tank to the next empty one maintains even quantities of resin in each tank.

4. Counter-current operation employing equal batches of resin ensures maximum operating efficiency.

5. Low pressure loss through system reduces energy costs.

6. No screens required between chambers reduces cost and maintenance.

7. No back-mixing during resin transfer.

8. No valves close on resin to cause attrition.

9. Gentle hadling of resin results in low resin attrition.

10. Vessels may be constructed simply from brick, concrete, steel, fibreglass or lined timber, whichever may be suited for application, location and cost.

The use of ion exchange for the removal of Toxic ions has become state of the art technology for waste water treatment. Research into new ways in which ion exchangers can be employed and the development of new equipment is very expensive, however, the protection of our environment and its biological stability must always remain of parament importance.

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