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USE OF SAND AS A PREFILTER FOR ION EXCHANGE COLUMNS

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Engineering and Equipment
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USE OF SAND AS A PREFILTER FOR ION EXCHANGE COLUMNS

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ABSTRACT

In laboratory tests, a sand prefilter minimized pluggage in an ion exchange resin column when used to purify water from a Savannah River Plant storage basin for fuel elements.

CONTENTS

	Page
List of Figures	4
Introduction	5
Summary	5
Experimental	6
Apparatus	6
Source and Characteristics of Water Used . . .	7
Procedure	7
Results and Discussion	8
References	11

LIST OF FIGURES

Figure		Page
1	Sand Filter and Ion Exchange Resin Columns	6
2	Hydrostatic Head Required to Maintain Flow Through Resin Columns	9
3	Removal of ^{137}Cs from Water by Ion Exchange Resin	9

INTRODUCTION

Ion exchange is a well established and effective means of removing radionuclides from waste streams.[1] Its use is expected to increase with the growing concern about water pollution.

As water flows through a column of ion exchange resin, suspended solids, as well as exchangeable ions, are retained by the resin. Accumulated solids restrict flow and increase the pressure drop across the column at a given flow. This may necessitate expensive backwashing before exchange capacity is exhausted.[2]

No single type of prefilter is satisfactory for all radioactive waste streams flowing into ion exchange resin columns. Filtration theory provides some guidance, but final evaluation of a prefilter must be based on performance.

The use of filters composed of granular materials ahead of ion exchange resin columns is not new. The Tokai Research Establishment, JAERI, Tokai-Mura, Japan, has recently reported[1] the use of sand filters preceding ion exchange membranes. The Los Alamos Scientific Laboratory uses granular anthracite filters preceding ion exchange resin columns.[1] The Western Electric Company produces ultrapure water at its Laureldale, Pennsylvania Plant by filtering city water through anthracite particles preceding ion exchange.[3] Sand filters are very efficient in removing small particles and have long been used by municipal water works.[4] Their simplicity of construction and operation is well known, and these characteristics are quite important when filtering water containing radioactive waste, because remote operation is often necessary. However, more complex and costly filtration systems are sometimes used where sand filters would be satisfactory.

This report describes a laboratory study in which a sand prefilter prevented excessive pressure drop across an ion exchange resin column.

SUMMARY

The pressure drop was measured across two laboratory columns of ion exchange resin, one of which received sand-filtered water from a fuel element storage basin, and the other received unfiltered water from the same source. The pressure drop across the column receiving filtered water did not increase significantly

during the passage of more than 50,000 gallons of sand-filtered water per square foot of resin. This volume exceeds the capacity of the resin to remove ^{137}Cs from the fuel element storage basin water used. A high pressure drop (>100 inches of water) developed repeatedly across the column receiving unfiltered water. The pressure drop was relieved each time by interrupting flow and removing accumulated solids from the top of the resin.

EXPERIMENTAL

Apparatus

The test apparatus is shown in Figure 1. "Amberlite"* IR 120 cation exchange resin was used; resin particles ranged from 0.45 to 0.66 mm in diameter.

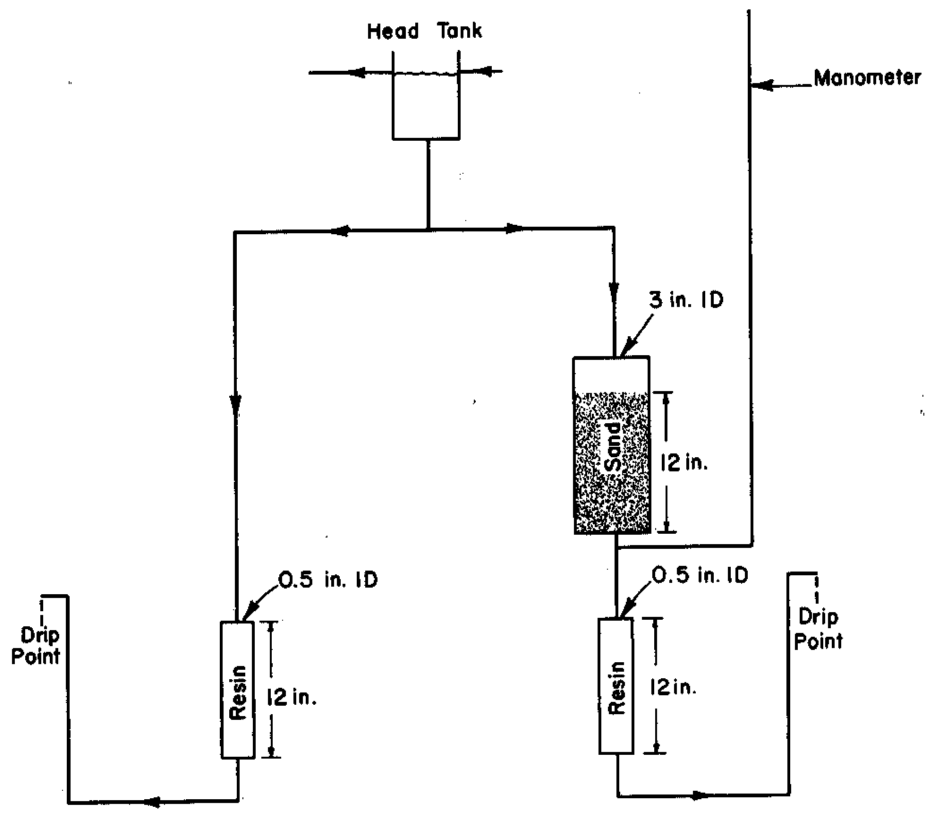

FIG. 1 SAND FILTER AND ION EXCHANGE RESIN COLUMNS

* Trademark of Rohm and Haas Company.

Adequate specifications for sand filters for use under various operating conditions have been published.[5-8] Sand filtration of SRP fuel element storage basin water has been studied exhaustively for the purpose of improving visual clarity in the basins. Those studies revealed that with a flow rate of 5 gallons per minute per square foot (5 gpm/ft^2), 20,000 to 130 gallons of water from these basins could be filtered, per square foot of filter, to produce a high degree of visual clarity. Filters consisted of 18 inches of crushed anthracite over 18 inches of sand (0.35 to 0.55 mm diameter). The pressure drop across these filters did not exceed 60 inches of water, and 10 to 20 minutes of backwashing at 5 gpm/ft^2 effectively removed accumulated solids to a settling tank and restored the utility of the filter.

The large diameter of the filter in this study was selected as a convenience; its diameter in proportion to the diameter of the ion exchange resin columns does not indicate that this ratio is needed. The sand particles ranged from 0.35 to 0.55 millimeters in diameter with a uniformity coefficient of <1.7.

Source and Characteristics of Water Used

Irradiated fuel from Savannah River reactors is stored in water-filled basins until most of its short-lived radionuclides have decayed.[9] Cooling water for the stored fuel is normally circulated through the basin and released to surface streams. In the event of increased concentrations of radionuclides in the water, it can be recirculated to heat exchangers for cooling and through ion exchange resins for removal of radionuclides.

Water entering the basins comes from the Savannah River and has been alum-precipitated and filtered, as is done in the treatment commonly used for municipal water supplies. Total dissolved solids in the water range from 30 to 50 ppm, and suspended solids (retained on a 0.45-µ pore diameter "Millipore"*) range from 0.7 to 2.8 mg/gallon. During normal residence time in the basins the concentration of solids increases 2 to 3 times, largely due to corrosion products. Chemical analyses of filterable solids show the predominant cations to be iron, aluminum, and silicon.

Procedure

Water from the fuel element storage basin was maintained at a constant level in the head tank. From the head tank the stream divided, flowing in one direction to the sand filter and the

* Trademark of Millipore Filter Corporation.

resin column receiving filtered water, and in the other direction to the resin column receiving unfiltered water. Flow rates were adjusted to 5 gpm/ft^2 of resin by raising or lowering the drip point of each column effluent tube. Hydrostatic heads across each system were measured from the drip point to the water level in the head tank or in the manometer.

^{137}Cs was selected as the radionuclide to be used for ion exchange studies because it is monovalent and has a long half-life. Sufficient ^{137}Cs was added to the feed water to produce a concentration of 0.2 µCi/ml. Column effluent samples were analyzed by gamma ray spectrometry.

RESULTS AND DISCUSSION

The hydrostatic head required to maintain a flow of 5 gpm/ft^2 of resin through each column is shown in Figure 2. Initially a hydrostatic head of 10.5 inches produced the desired flow through each column. However, in the column that received unfiltered water, the hydrostatic head required to maintain flow rapidly increased to 103 inches, the maximum possible with our apparatus. At this point, the flow was interrupted and accumulated solids were removed from the top of the column. This was accomplished by siphoning the upper one inch of resin into a beaker where it was washed five times with a total of 500 ml of distilled water and returned to the column. This procedure was used rather than backwashing the resin because it affected only the upper one inch of the column and had a minimal effect on the ^{137}Cs breakthrough. Each time flow was resumed after removing solids, the hydrostatic head on this column was again 10.5 inches at 5 gpm/ft^2.

The hydrostatic head on the column receiving unfiltered water increased to 103 inches and was relieved as described five times during a total throughput of 56,000 gallons per square foot (gal/ft) of resin. In contrast, the hydrostatic head on the column receiving sand-filtered water increased less than 1.0 inch above its initial value of 10.5 inches during a throughput of 52,500 gal/ft^2 of resin, and increased only six inches during a throughput of 76,000 gal/ft^2 of resin.

Comparing the hydrostatic head results with the ^{137}Cs adsorption results shown in Figure 3 demonstrates that sand filtration is more than adequate to maintain low pressure drops across the resin. After 25,000 gallons per square foot, the concentration of ^{137}Cs in the effluent from the resin had reached 1% of the feed concentration. Generally a resin column would be regenerated at that stage of operation, and our results show that several times

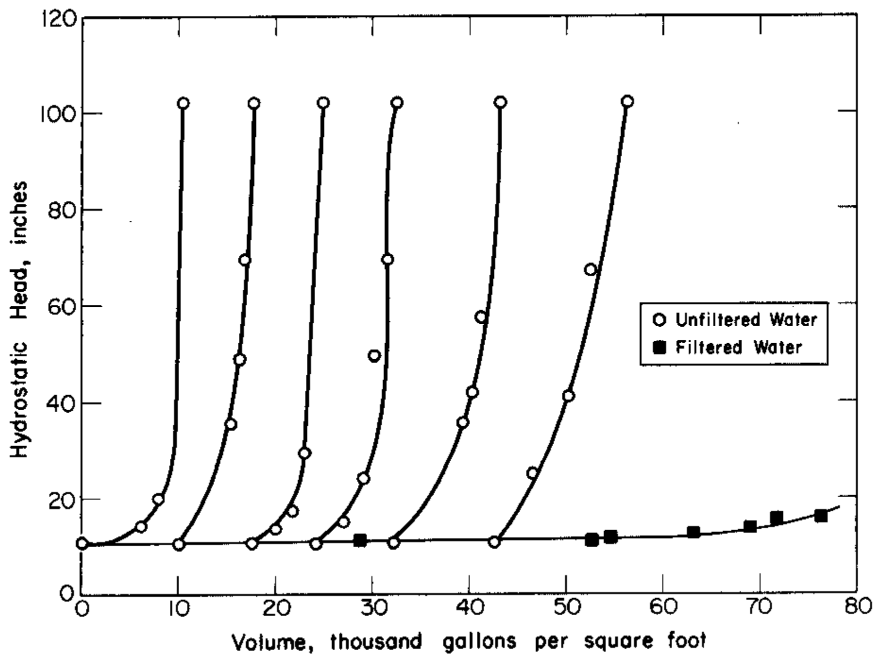

FIG. 2 HYDROSTATIC HEAD REQUIRED TO MAINTAIN FLOW THROUGH RESIN COLUMNS

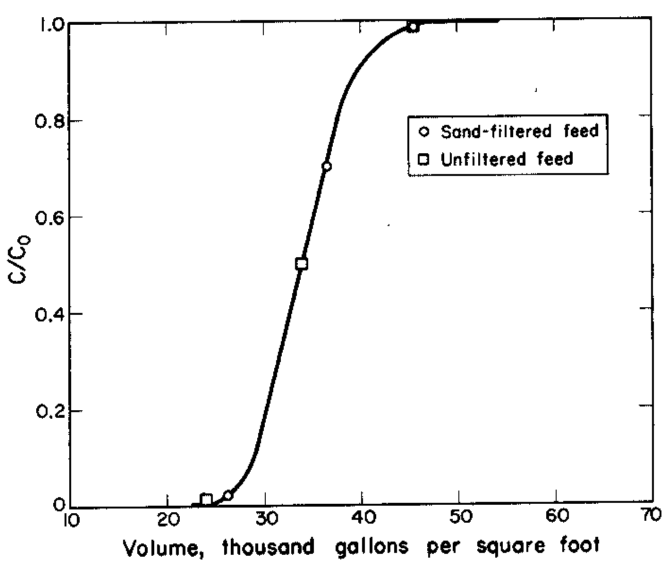

FIG. 3 REMOVAL OF ^{137}Cs FROM WATER BY ION EXCHANGE RESIN

that volume of sand-filtered water could flow through the resin column without an appreciable increase in the hydrostatic head required to maintain flow. In fact, when the resin column effluent concentration of ^{137}Cs equalled the feed concentration ($C/C_o = 1.00$), the hydrostatic head had increased less than 1.0 inch.

Although an ion exchange resin column can be operated without a prefilter if the resin is occasionally backwashed to remove the solids filtered from the feed,[2] there would be several disadvantages. Mixing of the resin during fluidized backwashing would reduce the throughput before regeneration was required. In addition, resin columns are more difficult to backwash than sand filters because the density of resin is considerably less than the density of sand. Consequently, the resin can be more easily washed from the column, and any resin lost in this manner is apt to contain high concentrations of radionuclides. Also, sludge is more difficult to wash from the smooth resin particles than from the sharp-edged sand grains which scour each other.

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