ORP/EERF 73-2

CONSTRUCTION AND OPERATION OF AN ION EXCHANGE CARTRIDGE FOR MONITORING RADIONUCLIDES IN THE ENVIRONMENT

U.S. ENVIRONMENTAL PROTECTION AGENCY

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CONSTRUCTION AND OPERATION OF AN ION EXCHANGE CARTRIDGE FOR MONITORING RADIONUCLIDES IN THE ENVIRONMENT

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FOREWORD

The Eastern Environmental Radiation Facility participates in the identification of solutions to problem areas as defined by the Office of Radiation Programs. The Facility provides laboratory capability for evaluation and assessment of radiation sources through environmental studies and surveillance and analysis. The EERF provides technical assistance to the State and local health departments in their radiological health programs and provides special laboratory support for EPA Regional Offices and other federal government agencies as requested.

Charles R. Porter
Acting Director
Eastern Environmental Radiation Facility

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CONSTRUCTION AND OPERATION OF AN ION EXCHANGE CARTRIDGE FOR MONITORING RADIONUCLIDES IN THE ENVIRONMENT

J. K. Hasuike and S. T. Windham

SUMMARY

The increased emphasis on measuring environmental levels of radioactivity requires a maximum of sensitivity in the collection and analysis of samples. Described below is an ion exchange sampler developed by this Facility that has proved very useful in monitoring for low-level radioactive effluents in the environment. The sampler consists of a compartmentalized ion exchange column containing a particulate prefilter and cation and anion resins. After use the prefilter and resin are gamma analyzed directly and/or processed via chemical analysis. The column is easy to construct and use, is inexpensive, and is reusable.

INTRODUCTION

The Atomic Energy Commission (AEC) has the responsibility of regulating radioactive discharges from nuclear power plants. It is the reactor operators, State health departments, private contractors, and other groups who are actually charged with monitoring the environs of nuclear facilities to ascertain the actual radioactive contents discharged. In 1970 the AEC published in the Federal Register amendments which specified that operators of light-water cooled reactors keep levels of radioactive effluents released to unrestricted areas as low as practicable. The AEC's quantitative definition of "as low as practicable" recommends that for population groups in uncontrolled areas their maximum exposures resulting from these effluents be less than approximately one percent of natural background.

Thus there is an increased need to identify and quantify low levels of environmental radioactivity with a minimum commitment of equipment, time and expense. The Environmental Studies Branch of the Eastern Environmental Radiation Facility designed and developed a sectional ion exchange sampler which when used with the technique described by Krieger[1], is very effective in monitoring for low-level radioactive liquid effluents in the environment.

The sampler has been used extensively in a study of the long-term buildup of radionuclides in an impounded lake supplying cooling water to a nuclear power plant[†]. Preliminary data to be published later verifies that the columns are operating successfully. The ion exchange field method has been employed by others[1], but it is felt that the columns described here far surpass any others for simplicity, reliability, and efficiency.

Ion Exchange Method of Sampling

Ion exchange techniques have received rather widespread acceptance as a method of selectively removing radionuclides from solutions; e.g., separation of iodine from milk[2,3] and the radioactive decontamination of water supplies.[4-7]

Samuelson has described ion exchange separation techniques[8], and Krieger[1] has developed a technique for selectively collecting and analyzing environmental levels of radioactive effluents. The equipment discussed here implements Krieger's technique.

Routine environmental sample analysis involves the collection and return to the laboratory of large sample volumes to obtain adequately low detection capabilities. By using the field ion exchange method, it is possible

[†]Study of the Long-Term Buildup of Radioactivity in an Impounded Cooling Lake. Being conducted by Nuclear Facilities Research Branch, Eastern Environmental Radiation Facility. Results not yet published.

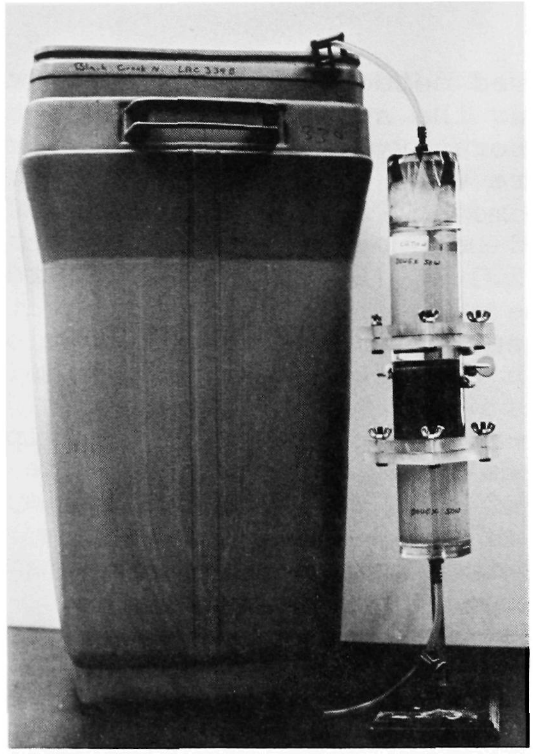
to achieve improved detection sensitivity while at the same time reducing the size of the sample to be transported to the laboratory. As a routine field ion exchange procedure used at the EERF radionuclides are quantitatively removed from 200 liters (438 pounds) of water on site and returned to the laboratory on a resin column weighing 2.3 kg (5 pounds). This reduction in weight and volume plus increased sensitivity makes it possible to collect samples at more locations and to provide data with greater statistical significance.

These ion exchange columns were developed through laboratory studies and field testing. The column was designed to satisfy the following criteria:

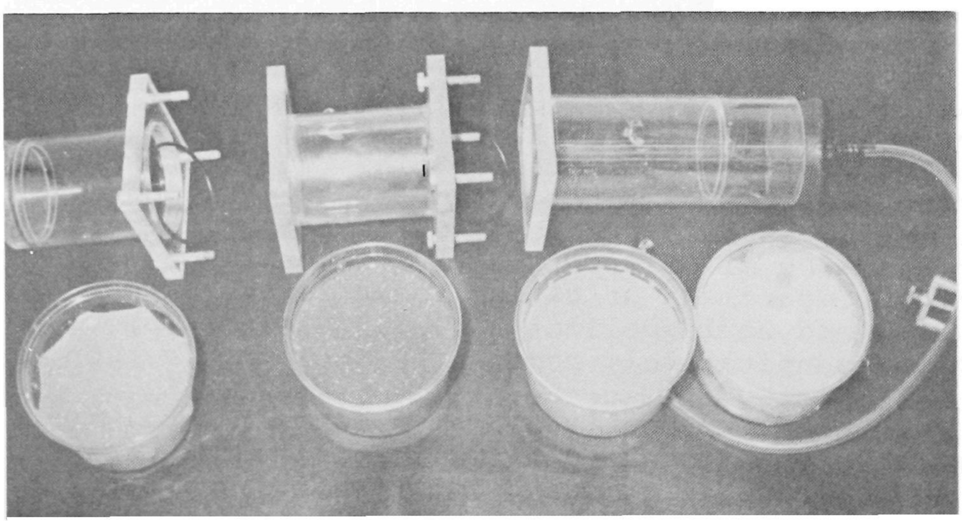
1. Easy and inexpensive to construct using ordinary shop tools;
2. Easy to set up and use in the field;
3. Easy to process in the laboratory;
4. Provide an efficient means of collecting radionuclides from water.

The column shown in figure 1 consists of several separate compartments. The number and size of the compartments are determined by the requirements of the particular situation. The one shown has three compartments for resin plus a glass wool prefilter. The prefilter removes coarse suspended materials which would clog the resin. The top resin compartment contains 300 ml of Dowex 50W-X8 cation resin; the center resin compartment contains 300 ml of Dowex 2-X8 anion resin; and the bottom compartment contains 300 ml of Dowex 50W-X8 cation resin. The bottom compartment of cation resin is a backup or safety section and would collect the radionuclides should they not be quantitatively removed by the upper cation resin.

The compartmentalized design makes the column very versatile to fit varied field requirements. For example, in waters containing large amounts of suspended materials, it is essential that these materials be removed prior to entering the resin beds. A settling chamber was incorporated on top of the column which solved this problem. (figure 2)

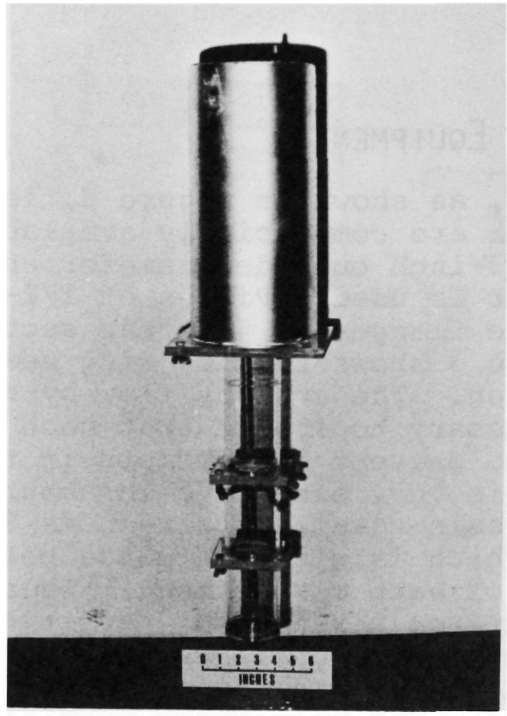


Column assembled for use

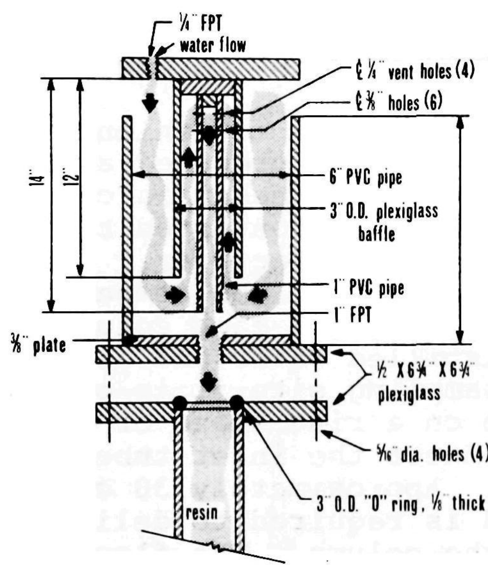


Components of disassembled column

Figure 1. Assembled and disassembled column



Column with settling chamber attached



Construction diagram of settling chamber

Figure 2. Details of column with settling chamber.

Description of Equipment

The column, as shown in figure 3, is constructed of materials which are commercially available. Plexiglas tubing with a 3-inch outside diameter and 2 3/4-inch inside diameter is used. Pieces of 1/2-inch Plexiglas are used as the flanges to join the sections of the column. Figure 3 shows the "O" ring seal and the resin-retaining screen. The columns flow by syphon action and it is necessary to insure that each compartment is leakproof to prevent air pockets in the resin. The "O" ring seal is very effective in assuring a leak-free system. The resin-retaining screen is 80 mesh stainless steel screen which is glued in place between rings in the lower end of each compartment. These screens prevent the resin from mixing, but permit the water to flow through unimpeded. All Plexiglas to Plexiglas joints in the columns are made using ethylene dichloride as the adhesive. The only tools required for construction are a band saw, a disc sander, and a 1/2-inch drill press with circle cutting and regular bits.

Preparation and Use of the Column

To allow for maximum convenience in the field, each cartridge is completely prepared and sealed in the laboratory. The cation resin is converted to the H^+ form, and the anion resin is converted to the OH^- form as recommended by the manufacturer.[9] The resin is then measured and loaded into the compartments, the compartments are assembled, and each column is backwashed gently with distilled water and sealed with hose clamps. At the field sampling site it is only necessary to set the column on a ring stand or other convenient support and connect the inlet tube to the water source to be sampled. Approximately 30 centimeters (12 inches) of syphon head is required to deliver a suitable flow rate through the column. The flow rate is set between 300 to 400 ml/minute, and at this flow rate approximately 10 to 11 hours is required to process 200 liters. Once started, the column is allowed to run overnight with the outlet hose from the column secured at a position above the top resin level. This allows for continuous flow, at the same time preventing the resin from drying out. After processing the entire sample, the column is sealed at the inlet and outlet using hose clamps and returned to the laboratory for analysis.

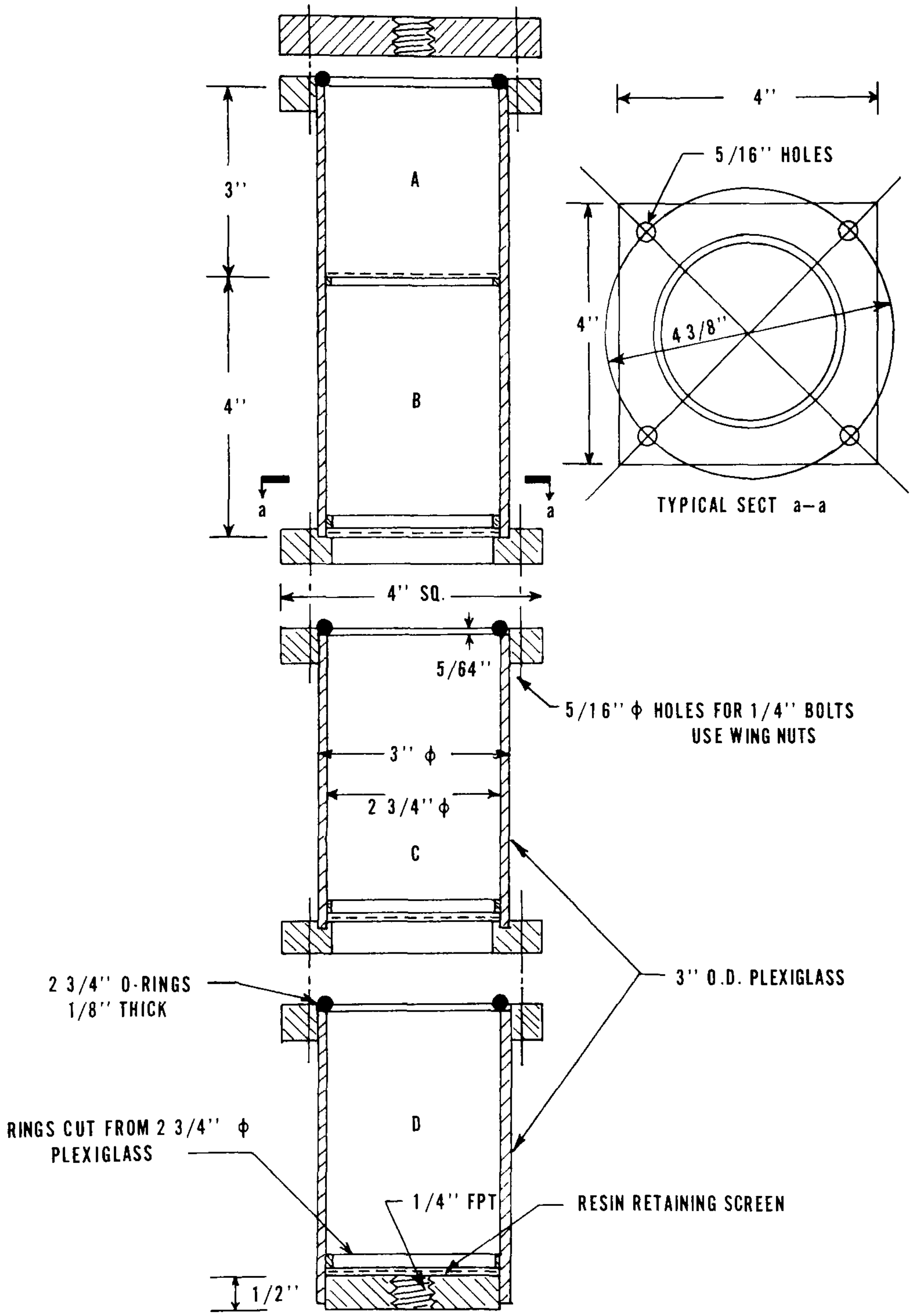


Figure 3. Construction details of ion exchange column.

The multi-compartment design of the column expedites laboratory processing. After the water is drained from the column it is physically disassembled and the resin from each compartment is transferred to separate counting containers. These are directly gamma counted for activity. If desired, the resin may then be eluted or stripped using appropriate techniques to permit chemical separations and analyses for specific isotopes.

Laboratory Results

Since the ion exchange concept for removing radionuclides from water is a proven method, little emphasis has been placed on extensive laboratory testing. Instead, this report deals with equipment development and not ion exchange procedure. Tests were run with flow rates of 500 ml/minute to determine if any radioisotope breakthrough would occur in the top section of the column. Table 1 shows results of 3 runs made using water spiked with strontium-85 and cesium-137. No breakthrough was observed.

Conclusion

The ion exchange sampler described is simple, reliable, efficient, and inexpensive. It can be easily constructed and used by most groups conducting environmental radiological surveillance programs.

In addition to sampling for radioactivity, applications of these columns could be made in marine research, water pollution studies, and pesticide studies.

TABLE I

LABORATORY TESTS OF CARTRIDGES

	Run 1 500 ml/min ^{85}Sr cpm	Run 2 500 ml/min ^{85}Sr cpm	 ^{137}Cs cpm	Run 3 500 ml/min ^{85}Sr cpm	 ^{137}Cs cpm
Total original activity in 200 liters[1]	41,215	22,435	13,518	14,950	13,518
Glass Wool[2]	168	NA	NA	NA	NA
Top Cation Resin[3]	35,228	22,977	13,725	15,750	13,725
Anion Resin[3]	0	0	0	0	0
Bottom Cation[3]	30	31	6	0	0

NA - not available

[1] Samples were counted in 300 ml solution before addition to 200 L of tap water

[2] Counted in cottage cheese containers, amount not available

[3] Transferred all 300 ml of resin into a container for counting

REFERENCES

(1) H. L. Krieger, G. W. Frishkorn, Evaluation of Ion Exchange Surveillance Sampler for Analyzing Radioactive Liquid Effluents. Health Phys: 21: No. 4, 591-5 (Oct 1971).

(2) D. G. Easterly, I. B. Brooks, J. K. Hasuike, Development of Ion Exchange Processes for the Removal of Radionuclides from Milk. Eastern Environmental Radiation Laboratory Report RD/EERL 71-1 (Jan 1971).

(3) G. K. Murthy, J. E. Gilchrist, J. E. Campbell; Method for Removing Iodine-131 from Milk. J. Dairy Sci., 45:1066-74 (Sept 1962).

(4) D. C. Lindsten, J. K. Hasuike, A. G. Friend; Removal of Radioactive Contaminants from a Seminatural Water Source with U. S. Army Water Purification Equipment. Health Phys., Vol. 11, pp 723-729 (Aug 1965).

(5) D. C. Lindsten et al., Removal of Radioactive Contaminants from Water with the Corps of Engineers Mobile Water Purification Unit, Office of Technical Services; Department of Commerce, Report PB 135996 (1955).

(6) D. C. Lindsten et al., Removal of Nuclear Bomb Debris, Strontium-90-Yttrium-90 and Cesium-137-Barium-137 from Water with Corps of Engineers Mobile Water Treating Equipment, Office of Technical Services, Department of Commerce, Report PBAD 265585 (1961).

(7) D. C. Lindsten,and R. P. Schmitt, Removal of Chemical, Biological, and Radiological Contaminants from Water with Corps of Engineers Field Water Supply Equipment, Office of Technical Services, Department of Commerce, Report PBAD 274300 (1961).

(8) O. Samuelson, Ion Exchanges in Analytical Chemistry John Wiley, New York (1953).

(9) Dowex: Ion Exchange, The Dow Chemical Company, Midland, Michigan.

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