RADIONUCLIDE SEPARATION PROCESS (RASEP)

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ABSTRACT

Liquid radwaste generated from nuclear power plants or other nuclear facilities consists of a small amount of radioactive nuclides and a large amount of non-radioactive matter. By separating radioactive and non-radioactive matter, original liquid radwaste can be further reduced in volume and a large portion of it can be released as non-radioactive waste. In addition, by fixing the separated radionuclides according to their nature, it will be possible to effectively and efficiently meet the waste disposal requirements. With this approach, JGC developed a radionuclide separation process called RASEP in which radionuclides are selectively separated from liquid waste and fixed in an inorganic adsorbent. As a result, maximum reduction of waste via a simple and economical method, plus safe discharge of the treated (decontamination) liquid waste to the environment can be achieved.

INTRODUCTION

Liquid radwaste generated at nuclear power plants and other nuclear facilities usually contains insoluble CP nuclides, soluble CP/FP nuclides and non-radioactive substances. The CP and FP are contained in the waste with a considerable amount of non-radioactive substances, which occupy substantial volumes in waste packages produced by conventional immobilization processes.

By separating and fixing only the trace amounts of radioactive nuclides from the large amount of non-radioactive substances present in liquid radwaste, the quantity of final waste packages can be greatly reduced since the resulting decontaminated effluent may be discharged to the environment. By using inorganic material and metal as long term and radioactivity-fixing media, JGC developed a process which solely and selectively separates radioactive nuclides from liquid radwaste. This process fixes separated nuclides in the form of stable packages for safe, long-term storage and disposal.

In cooperation with Tokyo Electric Power Inc., and other five Japanese utility companies, JGC has established this radionuclide separation (RASEP) process which mainly consists of filtration, adsorption and electro-deposition.

RASEP PROCESS

Figure 1 shows these major steps.

1. Filtration: The filtration step separates suspended solids including insoluble CP nuclides, such as Co-60, Mn-54, Fe-59 and Zn-65, from liquid radwaste.
2. Adsorption I: The soluble CP nuclides such as of Co-60, Mn-54, and Zn-65 are then selectively adsorbed and removed by chelating resin from the liquid radwaste.
3. Adsorption step II: Here, Sr nuclides are adsorbed by chelating resin from the liquid waste in which soluble FP nuclides remain.
4. Adsorption step III: Zeolite, an inorganic material with a high adsorption selectivity for Cs nuclides, is next used to separate the Cs nuclides.
5. Electro-deposition step: The CP nuclides adsorbed in adsorption step I are now eluted from the chelating resin and fixed on a metal cathode, such as a stainless steel plate, by electro-deposition.
6. Auxiliary adsorption step: Sr nuclides concentrated in adsorption step II are eluted from the chelating resin and fixed by synthetic zeolite which has a high selective adsorption performance with regard to Sr.

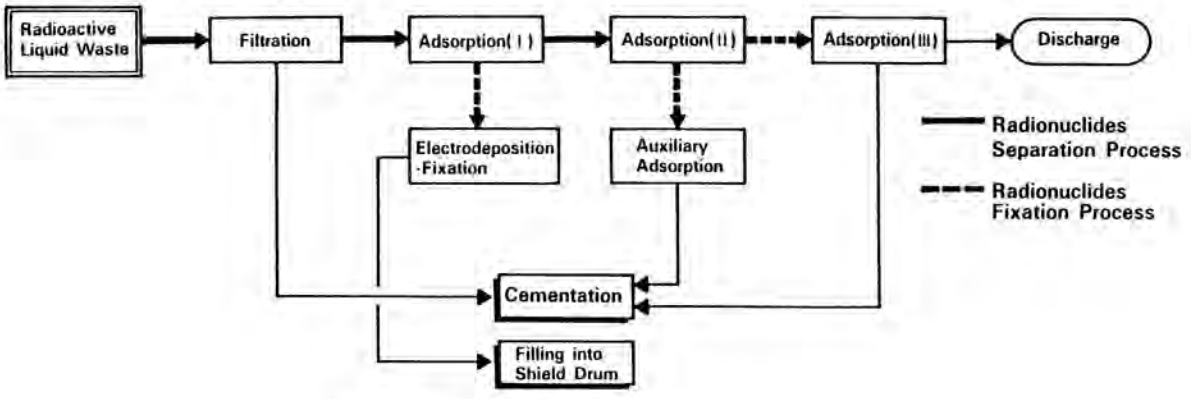

Fig. 1. Major Steps of RASEP System.

BASIC PROCESS FLOW

Figure 2 shows the basic process flow. Principal specifications of the filter materials and adsorbents are summerized in Table I.

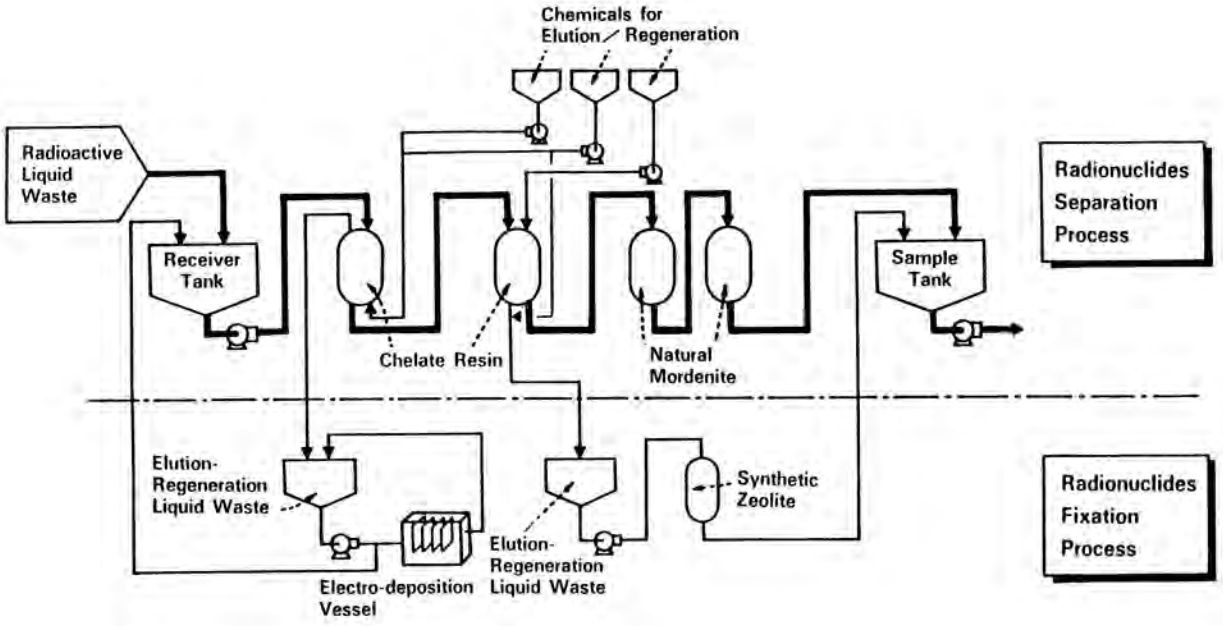

Fig. 2. Basic Flow Diagram of RASEP System.

TABLE I

Principal Specifications of the Filter Materials and Adsorbents.

Unit Operation	Material
Filtration	Hollow fiber filter
Adsorption I	Chelate resin (Unicellex UR-10)
Adsorption II	ditto
Adsorption III	Natural mordenite
Auxiliary adsorption	Synthetic zeolite (A-4)

Major steps for the treatment of liquid waste and filtration, and three adsorption steps from (I) to (III).

Liquid radwaste is fed to the RASEP process by a pump under slight pressure. Radioactivity level of the treated liquid radwaste is below the detectable limit of conventional monitoring method. The adsorbed radioactive nuclides in the chelating resin at the adsorption step I are eluted by sulfuric acid,then electro-deposited under certain electrochemical conditions and the nuclides are finally fixed on the metal cathode.

Moreover, Sr nuclides adsorbed in the chelating resin during adsorption step III are eluted by hydrochloric acid for re-adsorption onto inorganic adsorbents which are suitable for disposal.

RADIOACTIVE NUCLIDE SEPARATION PERFORMANCE TEST

1. Simulated liquid radwaste solutions: Radwaste solutions simulating the high conductivity liquid waste generated at a BWR power plant were used to test the RASEP process performance.

2. Filtration step: A High Efficiency (HE) filter, capable of removing particles larger than 0.04 microns, thoroughly separated suspended solids consisting mainly of Fe, and most Co-60, Mn-54, Zn-65.

3. Adsorption step I: Chelating resin, Unicellex UR-10, was adopted in the test. All soluble CP nuclides present in a simulated solution were removed to the extent that the radioactivity level of the treated solution was below the detectable limits. The bed volume defined as a ratio of volume of treated liquid waste to resin volume, was found to be extremely large. Figures 3 and 4 show adsorption curves and the bed volume of the resin respectively.

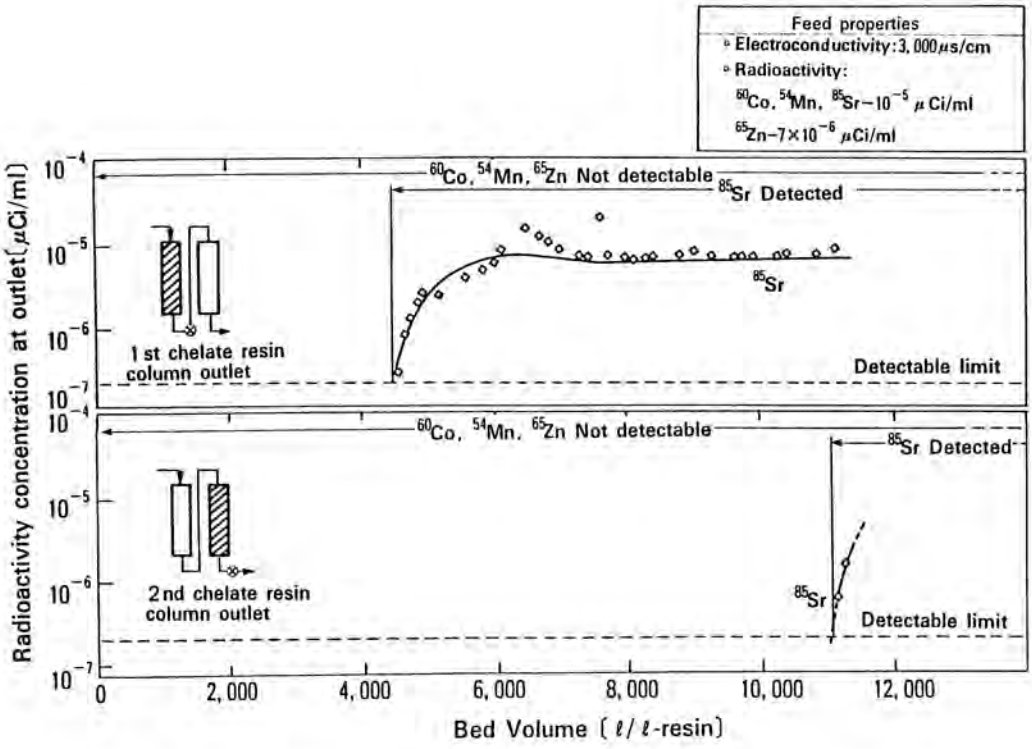

Fig. 3. Radionuclide Adsorption Performance of UR-10 Chelating Resin.

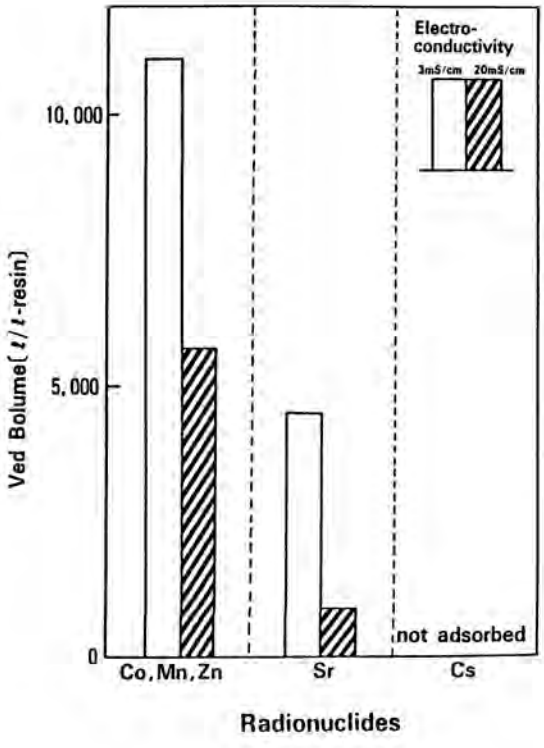

Fig. 4. Bed Volume of UR-10 Chelating Resin for Radionuclides.

4. Adsorption step II: As shown in Fig. 3, Sr nuclides passing through adsorption step I were efficiently removed by this additional UR-10 column.

5. Adsorption step III: Natural mordenite selected from various inorganic adsorbents was used to selectively remove Cs nuclide from the waste. Radioactivity level of the treated effluent was below the detectable limit.

   Adsorption steps II and III are auxiliary steps when soluble FP nuclides coexist in the liquid radwaste.

6. Electrodeposition step: The eluted solution was obtained by treating spent UR-10 by sulfuric acid. Co-60 and Mn-54 as major CP nuclides were tested in the presence of a small amount of Ni ion with the application of DC voltage. The Ni deposition on a metal cathode was observed with simultaneous incorporation of these nuclides.

   Figure 5 shows the removal ratio of CP nuclides vs time under Ni deposition conditions. Figure 5 indicates that more than 90% of the CP nuclides was removed and the metal cathode could be repeatedly used.

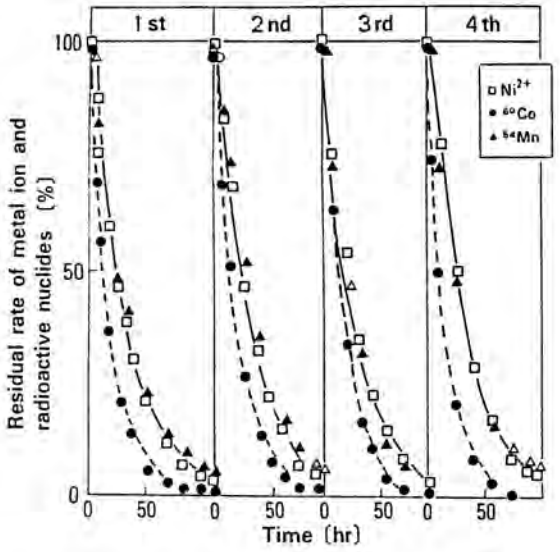

Fig. 5. Metallic Ion and Radionuclide Removal Characteristics by Electro-deposition Unit.

7. Auxiliary adsorption step: For the purpose of concentrating Sr nuclide from original liquid waste, chelating resin is superior to zeolite because of higher bed volume even for high conductivity liquid waste. However, zeolite is a more stable long term matrix material for fixing Sr nuclides.

VOLUME REDUCTION

High conductivity liquid waste is conventionally concentrated by evaporation, then solidified using cement, asphalt or plastic.

In the RASEP, however, liquid radwaste can be treated to obtain almost non-radioactive liquid effluent which renders the solidification of such liquid unnecessary as a rule. As a result, a very high volume reduction is achieved. Figure 6 compares volume reductions achievable with the RASEP process and with conventional processes at BWR plants.

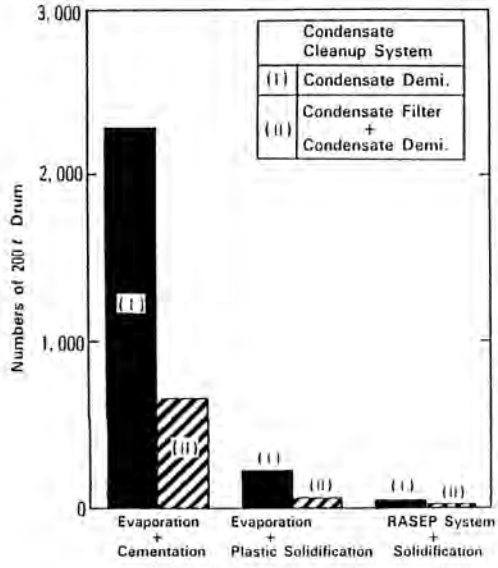

Fig. 6. Comparison of Amounts of Waste Packages between Three Systems.

COST-EFFECTIVENESS OF THE RASEP SYSTEM

The RASEP consumes minimal energy since it can be operated at normal temperatures and pressures. Cost can also be reduced since its simple construction eliminates the need for any special, expensive components or equipment.

Compared with an evaporation concentration system (without a solidification process), the RASEP facility and utility costs are below one-sixth of those of the evaporation system, as shown in Fig. 7. Since a costly solidification unit is usually installed for conventional evaporation systems, the RASEP process can be expected to be far more economically advantageous than conventional processes.

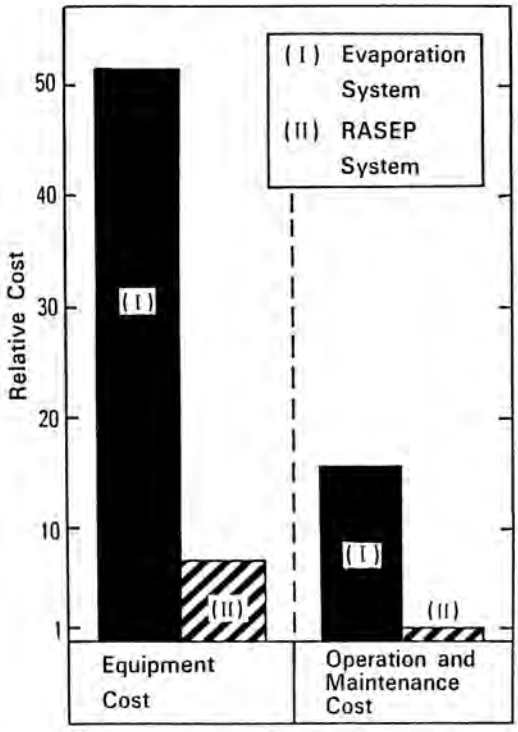

Fig. 7. Cost-Benefit Comparison between the RASEP and Evaporation Systems.

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