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RECYCLING AND RESOURCE RECOVERY AT OAK RIDGE NATIONAL LABORATORY

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RECYCLING AND RESOURCE RECOVERY AT OAK RIDGE NATIONAL LABORATORY

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1. INTRODUCTION

Oak Ridge National Laboratory (ORNL) is a multipurpose research and development facility operated by Martin Marietta Energy Systems, Inc. for the United States Department of Energy (DOE). A wide variety of liquid wastewater streams are generated from the operations of these research facilities. The major chemical constituents—bicarbonates of calcium, magnesium, and sodium—are introduced by local river water and shallow drainage wells. Liquid low-level waste (LLLW), generated in support of DOE's nuclear energy technology programs over the past 40 years, are highly contaminated with fission products and transuranic (TRU) elements. These wastes are routinely collected in centralized collection tanks, concentrated by evaporation, and stored for future processing and disposal. The Resource Conservation and Recovery Act (RCRA) of 1976 mandated a nationwide system for the safe management of wastes that have been determined hazardous from their creation to their ultimate disposal (i.e., cradle-to-grave control).[1] The Hazardous and Solid Waste Amendments of 1984 (HWSA) prohibited the continued placement of RCRA regulated hazardous wastes in or on the land without following Environmental Protection Agency (EPA) treatment standards. The EPA promulgated RCRA-LDR (land-disposal-restricted) regulations, minimizing short- and long-term threats arising from land disposal, will not allow facilities to store mixed LLLW after 1994 (55 FR 42730, August 29, 1991). Tank storage volume capacities are approaching maximum limits while treatment facilities to process and dispose these type wastes have been delayed indefinitely. As a result, these regulations and additional challenges have increased emphasis on recycling and resource recovery.

This paper discusses recycling and resource recovery strategies being developed to maintain continued operations at the Oak Ridge National Laboratory (ORNL). Several industrial decontamination techniques for minimization, segregation, and recycling of wastes volumes are presented.

2. BACKGROUND

The process waste system at ORNL is used to collect waste streams that are slightly contaminated with radioactivity, such as process wastewater from research laboratories, condensate from evaporators, and surface groundwater. The process waste system uses a chemical water softening process to remove chemical constituents, as shown in Table 1, followed by treatment with an organic ion-exchange resin for removal of ^{90}Sr and ^{137}Cs at typical concentrations of 750 Bq/L and 70 Bq/L, respectively.[2] The LLLW system currently treats over 400,000 gal of waste per year, reducing the volume by evaporation to approximately 12,500 gal of waste concentrate.[3] The concentrated wastes have been accumulating in eight 50,000-gal vaulted underground storage tanks since 1984. Combining wastes from various facilities is an "end-of-pipe" type treatment philosophy that has created a legacy of mixed wastes (combination of TRU, RCRA, and hazardous contaminants) that are difficult to separate and treat for disposal. Storage space for these type wastes are very limited, and treatment facilities to process the wastes are currently not available. Therefore, recycling efforts to minimize volumes of LLLW that will need to be treated are being explored.

3. STRATEGY

Recycling and resource recovery strategies are being developed to reduce, at conception, volumes of waste generation. Waste management plans are written at start of all industrial and laboratory programs to characterize wastes, identify potential waste recycle benefit, and to evaluate

Table 1. Chemical Composition of ORNL Process Wastewater (pH = 7.7)

Cation	Concentration (mg/L)	Anion	Concentration (mg/L)
Ca	40	HCO_3	60
Mg	10	SO_4	18
Na	20	Cl	6
Si	2	NO_3	4
K	2	F	1
Sr	0.2	PO_4	0.2
Al	0.1		
Fe	0.05		
Zr	0.05		
Cu	0.02		
Ni	<0.02		
Cr	<0.02		
U	<0.001		

subsequent waste disposal options. Obtaining this information at the earliest stages of process development provides baseline data to target hazardous contaminants for potential removal, minimize waste volumes, identify recycle treatment schemes for optimum removal/recycle, and provide a waste segregation plan. Primarily, segregation of hazardous waste streams at the source is the most cost-effective step toward effective recycling. At ORNL, small portable recycle systems are being designed and developed using lessons learned from proven treatment technologies to allow source treatment, segregation, and waste disposal. Additionally, new technology developments with private industries are also being sought in terms of Cooperative Research and Development Agreements (CRADAs) that allow federal and private industries to combine expertise and share in the development of solutions to the worldwide waste minimization and treatment efforts. Since many of the treatment technologies and waste streams are similar, although federal facilities generally have a wider spectrum of contaminants, there are many areas where technologies can be combined to benefit both industries.

4. TREATMENT METHODS

Various methods of treating wastes can be identified after the waste characterization is performed. A generic treatment system, as shown in Fig. 1, would consist of a combination of basic pretreatment systems such as filtration for solid/liquid separations, oil/water separators, centrifuges, and carbon adsorption or ion exchange for dissolved contaminants. These processes typically produce secondary byproduct wastes (Fig. 2) for which waste disposal options must be identified. Subsequent treatment systems for large volume applications may employ evaporators or reverse osmosis units. Both evaporator and reverse osmosis systems produce two byproduct streams— concentrate and condensate streams or a concentrate and permeate stream, respectively. Evaluation of optimum treatment systems is best performed on a case-by-case basis. Advantages can be realized when combining treatment systems such as reverse osmosis systems for metals recovery and an evaporator

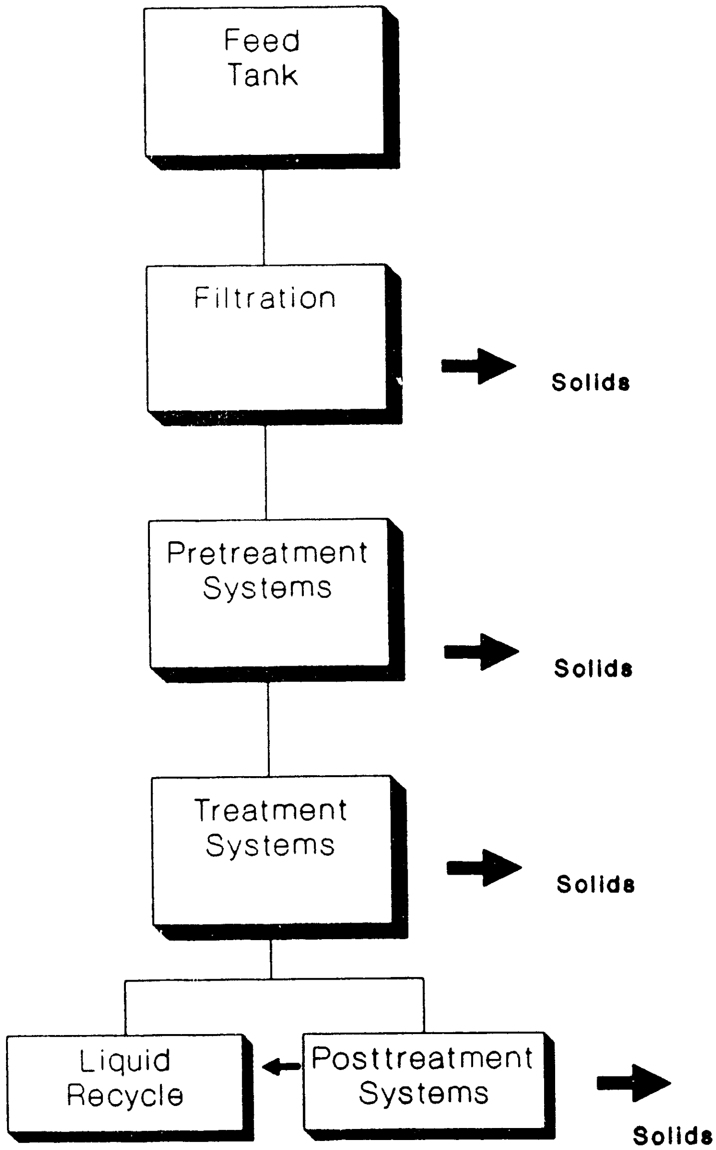

Fig. 1. Flowchart for generic recycle systems.

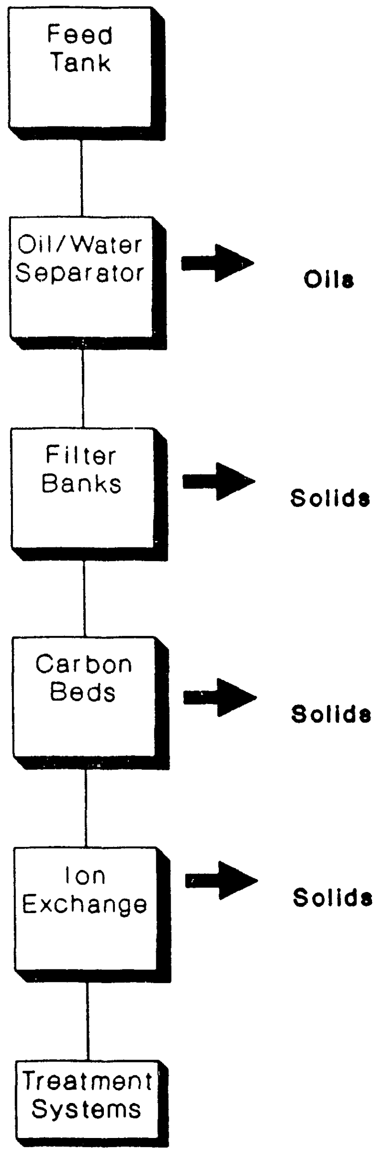

Fig. 2. Flowchart of the secondary products from pretreatment systems.

system for subsequent concentrate volume reduction as was demonstrated in the minimization and removal of chromium metals at a plating facility in the eastern United States.[4]

A schematic of a conceptual decontamination recycle system, currently under development to provide source treatment options, is shown in Fig. 3. The system is designed to treat a variety of wastes streams potentially containing RCRA, TRU, mixed wastes, and polychlorinated biphenyls (PCBs) using carbon adsorption. The basic pretreatment systems included are an optional oil/water separator followed by filtration and evaporation. An evaporator is used to allow processing of a wider range of feed compositions. Off-gases from the evaporator are condensed using a reflux condenser and condensate is collected. Collected condensate, which is expected to be decontaminated by a factor of 1000-2000 during evaporation, is treated using a series of mixed bed ion exchange and/or carbon columns. An in-line radiation detector is used to monitor and control the column effluent activity levels to ensure that only treated water meeting the preset recyclable water specifications are collected in the Solution Monitoring and Collection Tank. Rejected effluents are recycled to the front-end of the Decontamination Recycle System (DRS). Concentrate bottoms from the evaporator are stored in a holding tank that is temperature-controlled and monitored to prevent premature precipitation as a result of exceeding solubility limits. The bottoms are solidified using a Dryer and ultimately disposed as solid wastes. Finally, demineralized "contaminant-free" water is recycled minimizing secondary waste volume generation.

5. CONCLUSIONS

Wastewaters generated at ORNL's multipurpose research facilities are similarly produced throughout the world. There are increasing demands for federal facilities and private industries to combine expertise, resources, and lessons learned in waste minimization and recycling technologies. The past methods of "end-of-pipe" treatments have often been devastating to the economics of waste

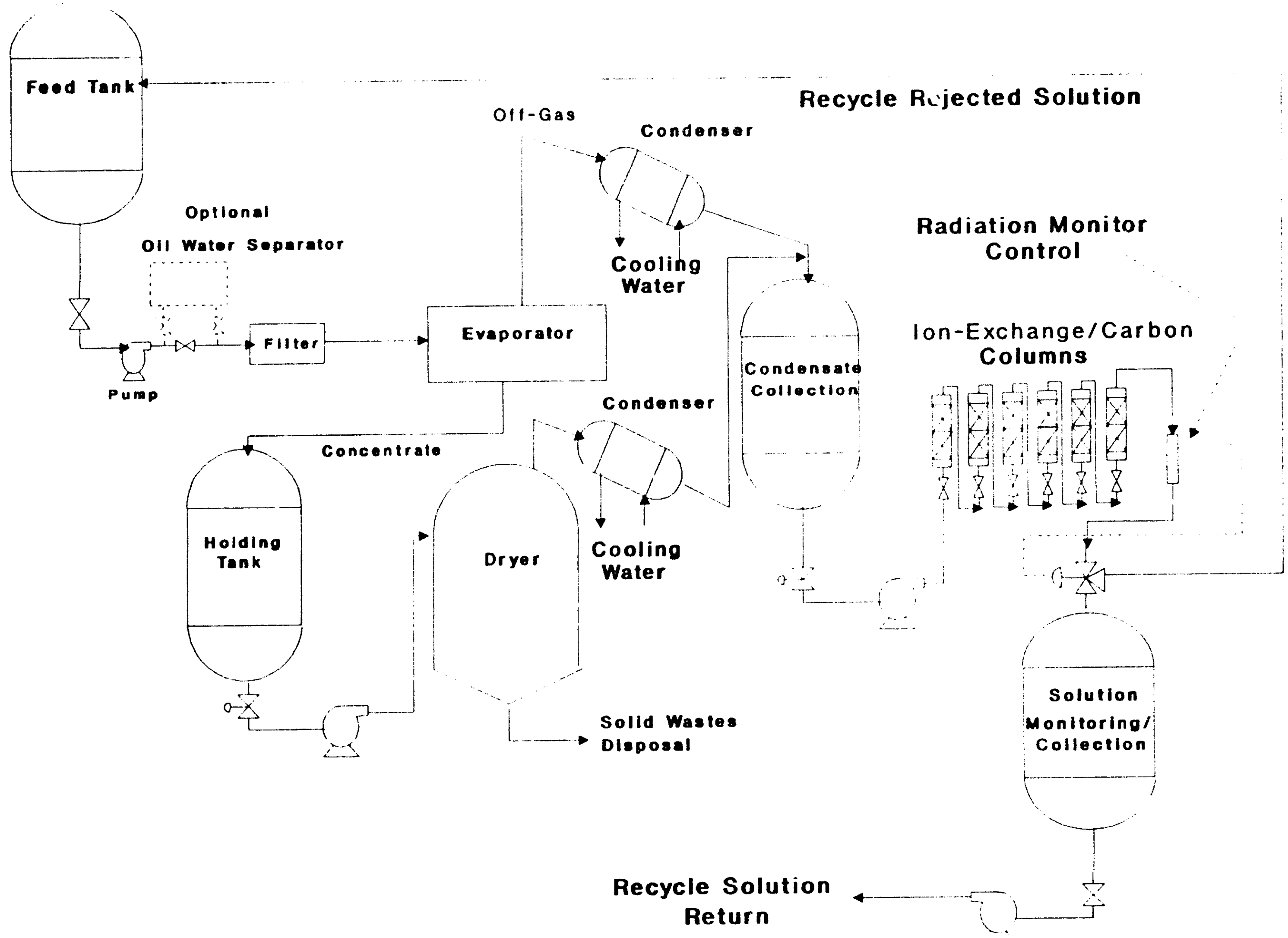

Fig. 3. Conceptual design of the Decontamination Recycle System (DRS).

recycling. Waste management techniques can be enhanced via source treatment and volume reduction. New innovative methods of source treating wastes, however, must allow for recycle, waste segregation, and volume reduction via waste minimization. Since land disposal areas are limited, the success of future operations is highly dependent upon the industries' ability to become waste minimizers and recyclers in all areas of process development.

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