LIQUID RADWASTE VOLUME REDUCTION USING DISPOSABLE DEMINERALIZERS - A CASE STUDY AT JOSEPH M. FARLEY NUCLEAR PLANT

Robert M. Lugar
Hittman Nuclear and Development Corporation
A Westinghouse Electric Corporation Subsidiary
Columbia, Maryland 21045

Joseph M. Walden
Alabama Power Company
Joseph M. Farley Nuclear Plant
Columbia, Alabama 36319

ABSTRACT

This paper presents a case study of the disposable demineralizer system supplied and operated by the Hittman Nuclear and Development Corporation at Alabama Power Company's Joseph M. Farley Nuclear Plant. The demineralizer system was installed to supplement the existing 15 gpm Waste Evaporators and installed solidification system for treating liquid radwaste. Nineteen months of operating data and performance evaluation has demonstrated that the demineralizer system provides a reduction in liquid radwaste volume that is fifteen times the volume reduction provided by the evaporators. The demineralizer system also provides better effluent quality, and higher reliability at a significantly lower cost than the previously used evaporators.

SYSTEM DESCRIPTION

Joseph M. Farley Nuclear Plant consists of two 829 megawatt pressurized water reactors. Unit 1 has been in commercial service since December 1977 and Unit 2 since July 1981.

In May 1981, HITTMAN's disposable demineralizer system was purchased to supplement the existing evaporators for treating and concentrating the liquid waste streams from both units.

The demineralizer system consists of three separate processing vessels operating unpressurized and in a series (See Fig. 1). The system is installed in a seismic structure modified with a special mezzanine which supports the demineralizers and provides access via an overhead crane. Four concrete cubicles (3 for processing and 1 for dewatering) house the vessels. Liquid radwaste is drawn through an underdrain system in each tank by means of a pump which discharges into the following tank. The third pump in the processing train discharges back to the plant. Flow control is automatically maintained by appropriate valves, level control probes and pump speeds. This allows balanced flow through the system and precludes overfilling of any vessel.

Farley Plant utilizes a 15 micron cartridge prefilter upstream of the demineralizer system to provide for initial solids removal.

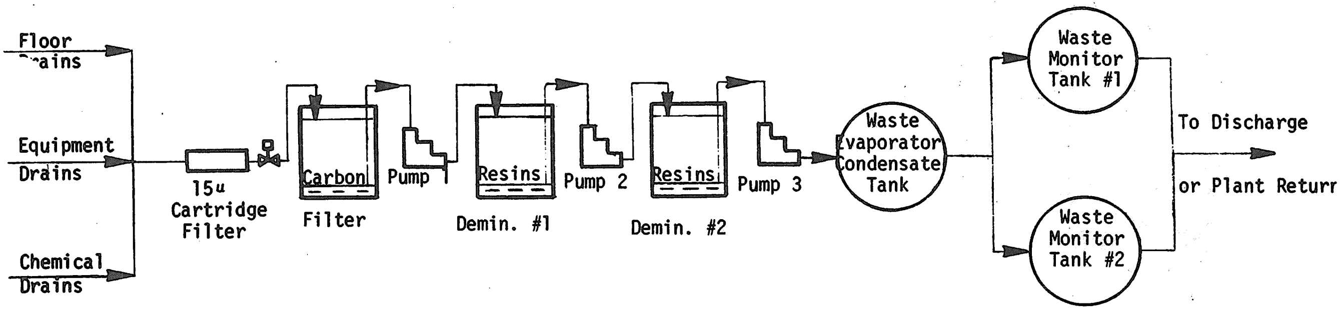

Fig. 1. HITTMAN Disposable Demineralizer System at Joseph M. Farley Nuclear Plant

The first unit in the HITTMAN system is a carbon-steel vessel containing granular activated carbon filter media. This filter removes solids (>8 microns), Cobalt isotopes existing as suspended colloids, as well as cleaning agents, and other chemicals that can be removed by adsorption on the activated carbon, thus conditioning the waste stream for treatment in the ion exchange vessels. The second and third units are carbon-steel vessels filled with layered ion exchange resins selected for specific radionuclide removal. Operating experience indicates that the first of the two ion exchange vessels removes nearly all of the radionuclides, with the other ion exchange vessel acting as a polisher unit.

All three processing units are carbon-steel vessels approximately six feet in diameter, six feet high, and contain about 125 cubic feet of resins or activated carbon. Each vessel contains an underdrain system extending over the entire bottom of the unit and connects to a dewatering outlet at the top of the vessel.

A fill flange bolts to the liner neck and forms a liquid-tight gasketed closure. Incorporated into this fill flange is a three element level detector to provide monitoring for flow control into the demineralizer unit. An overflow vent connection is provided to accomodate unanticipated overflow conditions and is connected to the plant drains (See Fig. 2). Level signals are generated for low water level, operating level, and high level alarm. These signals are monitored at the remote control panel.

1 MOUNTING BOLTS (3)
2 LINER FLANGE
3 FILL CONNECTION
4 OUTLET AND DRAIN CONNECTION
5 LEVEL INSTRUMENTATION DETECTORS
6 GASKETED CLOSURE

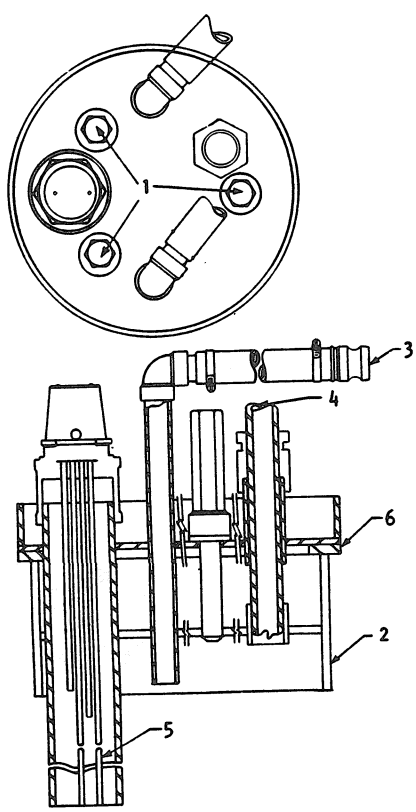

Fig. 2. Disposable Demineralizer Fill Flange

Quick coupling connectors are used to terminate fill, vent, and dewatering penetrations. This facilitates connection of the hoses between the demineralizer units, the pumping skids and plant drains and minimizes personnel exposure during changeout.

The system operates unpressurized and uses separate pump and level control modules for each process vessel. An automated monitoring/control panel located inside the auxiliary building provides for balanced operation of the three vessels and ensures safe operation. Logic components which control the valves and pumps are located inside the control panel. Panel readouts are provided for influent and effluent conductivity, conductivity between vessels and flowrate. Indication lamps, operating controls, and an audible alarm are provided. Sampling capability is provided by sampling lines which run to a remotely located common sampling sink.

SYSTEM OPERATION AND PERFORMANCE

Since May 1981, HITTMAN's disposable demineralizer system has been used in lieu of the waste evaporators for treating the liquid waste streams from both units. From May 1981 through December 1982 (19 months) the system processed over 4,200,000 gallons of liquid radwaste. In December 1982, the system was using its fourth and fifth demineralizer vessels, and the fourth filter unit since start-up.

The disposable demineralizer system at Joseph M. Farley Plant treats liquid radwaste from both units. The three major liquid radwaste sources are: floor drains, equipment drains, and chemical drains. The waste volume treated in 1982 was 2.6 million gallons (216,000 gal/month) at an average flow rate through the demineralizer system of 28 gpm. Actual liquid waste characteristics are variable, depending on the source, and the current mode of plant operation. Table I provides the typical range for select parameters of the influent waste stream treated at the Farley Plant.

Table I
Influent Characteristics

Typical Activity	1×10^{-4} to 5×10^{-5} μci/ml
pH	5.4 to 8.2
Conductivity	4.3 to 280 μmhos/cm

Major isotopes requiring removal from the liquid radwaste include: iodine, cesium, cobalt, manganese, strontium, and others in smaller quantities depending on plant operations and waste source.

Effluent characteristics are shown in Table II

Table II
Effluent Characteristics

Typical Activity	5×10^{-6} to 1×10^{-7} μci/ml
pH	4.7 to 6.4
Conductivity	1.9 to 76 μmhos/cm

During the initial start-up phase of the system, sampling was performed on a regular schedule to insure proper treatment and system optimization. Once the system proved itself, sampling frequency was reduced.

Presently, sampling is routinely performed on the effluent in the waste evaporator condensate tank prior to its release to one of two waste monitor tanks and eventual discharge or recycle (see Fig. 1). Bed performance is normally monitored as required by sampling each of the four sample points.

Resin column tests performed on chemical drain liquids showed that as long as the ratio of chemical drains to other wastes was low (approximately 1:50), the chemical drain water could be processed through the demineralizers without excessive resin depletion. The plant carefully rations the amount of chemical drain wastes that are processed by the demineralizer system or processes larger batch quantities of chemical drains when the resin bed is nearly depleted. Effluent quality was maintained even during the processing of certain batches of chemical drain wastes.

Throughputs for demineralizers and filter units are shown in Table III. Throughputs for the first demineralizer vessels in the series averaged 1,198,000 gallons before breakthrough occurred. This high throughput was achieved even after the vessel had served as the second position polisher demineralizer. Total throughputs of the demineralizer vessels when disposed (throughput as polisher plus throughput as first demineralizer unit) were about 2,400,000 gallons. The carbon filter units which are changed out in conjunction with the first *demineralizer* changeout, had corresponding throughputs of 1,198,000 gallons.

Table III
Disposable Demineralizer/Filtration System Throughput History

<u>Demineralizer Unit #1</u>	
in service:	05-20-81 (first position only)
removed from service:	12-20-81
throughput:	1,365,974 gal.
<u>Filter Unit #1</u>	
in service:	05-20-81
removed from service:	12-20-81
throughput:	1,365,974 gal.
<u>Filter Unit #2</u>	
in service	12-20-81
removed from service:	5-10-82
throughput:	1,192,755 gal.
<u>Demineralizer Unit #2</u>	
in service:	05-20-81 @ polisher, 12-20-81 @ first position
removed from service:	05-17-82
throughput:	1,365,974 @ polisher 1,247,102 @ first position 2,613,076 TOTAL
<u>Demineralizer Unit #3</u>	
in service:	12-20-81 @ polisher 5/17/82 @ first position
removed from service:	10-8-82
throughput:	1,247,102 @ polisher 980,611 @ first position 2,227,713 TOTAL
<u>Filter Unit #3</u>	
in service:	5-10-82
removed from service:	10-15-82
throughput:	1,133,595 gal.

A 15 micron cartridge prefilter used upstream of the demineralizer system removes a considerable amount of solids. Under normal conditions this filter is changed out about once per week (approximately 50,000 to 60,000 gallons throughput).

Changeout of the first demineralizer unit is determined by monitoring the effluent for isotopic breakthrough. The carbon filter unit is replaced in conjunction with the changeout of the expended first demineralizer unit. When the first demineralizer vessel is expended, the second demineralizer unit is moved into the first position, and the replacement unit put on line as the "polisher" unit.

Depending on the specific activity of the spent demineralizer and/or filter unit, it will be either shipped dewatered to the burial site, or solidified with cement prior to burial. Vessels with greater than 1 μci/ml require solidification. Operating experience at Farley Plant has demonstrated that the spent vessels consistently contain 0.8 μci/ml, thus permitting dewatering of the vessels prior to disposal.

The spent vessel (filter or demineralizer) is moved into a fourth shielded cubicle where the dewatering operation is performed prior to shipping. Once the spent vessel is dewatered, and capped, it is loaded into a shipping cask for transport to the burial site. Dose rates for the dewatered liners range from 150 millirem/hour on the top surface of the liner to a maximum value of 750 millirem/hour about one third of the way down the liner sidewall surface.

PROCESSING ECONOMICS

Prior to the startup of the HITTMAN disposable demineralizer system in May 1981, the Farley Plant used liquid waste evaporators for treatment and concentration of their liquid radwaste. When the evaporator was being used, solidified liquids and resins (wet waste) accounted for approximately 57 percent of all waste shipped from the plant (average of 1978, 1979, and 1980). Upon conversion to the disposable demineralizer system, the 1981 wet waste fraction decreased to 25 percent. In 1982, full-scale use of the disposable demineralizers resulted in a wet waste fraction of only 7.6 percent of the total waste shipped from Farley Plant (See Fig. 3).

Evaporator operation had a low reliability. Operation was complicated and resulted in a poor quality effluent. Approximately 50 percent of the effluent had to be reprocessed. In addition, the evaporator required a significant amount of expensive steam and maintenance. Processing costs for evaporator operation typically were 44 cents-per-gallon of liquid radwaste (See Table IV). The evaporator concentrates were solidified with cement prior to disposal with an overall volume reduction factor of 34.8.

In comparison, the disposable demineralizer system has proven to be very reliable. It has operated for 19 months with only thirty-six hours of downtime. It produces an effluent of excellent quality, and its operation and monitoring require minimal manpower. Experience at Farley has demonstrated that the demineralizer operator spends about 50% of his time with demineralizer operations monitoring and maintenance, while the remainder of his time is spent performing other radwaste-related activities (e.g., cask scheduling, etc.). Operator exposure is minimal,

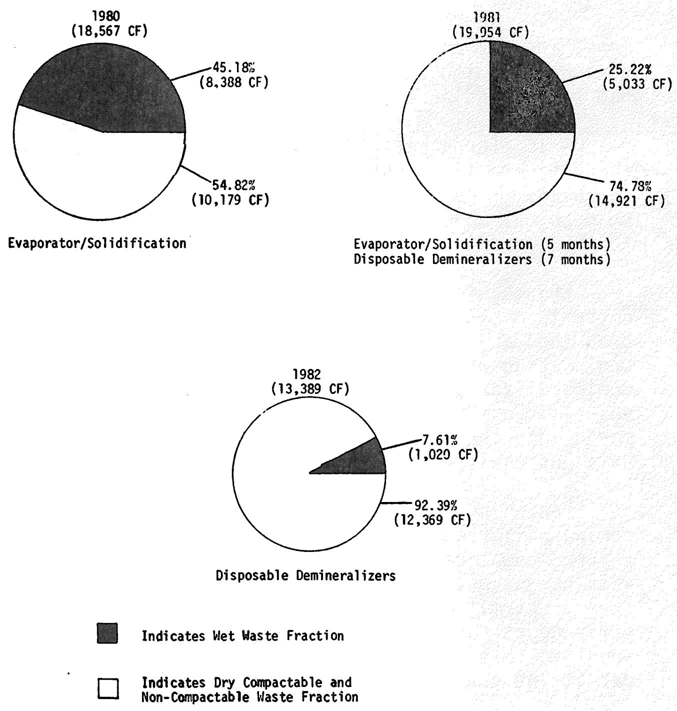

Fig. 3 Radwaste Volumes Shipped

Table IV
Evaporator Costs
(1/81 to 5/81) (5 months, Unit 1 Only)

	Price
Labor and Maintenance	$150,000
(6) Operators	
(3) Chemists	
(1) Radiochemist (part-time)	
(3) Maintenance	
Solidification Liners, and Solidification Services	$140,010
(22) 170 CF Liners	
(22) Evaporator Bottoms Solidifiction	
Transportation and Burial	$104,300
(22) Shielded Shipments to Barnwell, S.C. Burial Volume = 170 Cf/liner	
Evaporator Steam Requirements	$ 30,820
(10,700 lbs. steam/hr x 720 hrs/month x 50% availability x 5 months) x $0.0016/lb	
Total	$425,130

195,200 gallons/month/unit x 5 months x 1 unit = 976,000 gallons

Cost per gallon = 44¢/gallon

Volume reduction factor (volume of liquid influent/ volume of waste buried) = 34.8

Table V
HITTMAN Disposable Demineralizer Costs*
(5/81 to 12/82) (7 months, Units 1 and 2)

	Price
Labor and Maintenance	$41,981
(1) Operator (full-time)	
(1) Radiochemist (part-time) Dewatering Assistance (for 2 units)	
Processing Units and Spare Parts	$33,305
(1) Carbon Filter Vessel	
(1) Demineralizer Vessel Spare Parts	
Transportation and Burial	$ 9,755
(2) Shielded Shipments to Barnwell, S.C. Burial Volume = 170 CF/vessel	
Total	$85,041

97,570 gallons/month/unit x 7 months x 2 units = 1,365,974 gallons

Cost per gallon = 6¢/gallon

Volume reduction factor (volume of liquid influent/ volume of waste buried) = 537:1

*Excludes any equipment lease charges or equipment purchase payments, and any supplemental engineering and support services.

as the remote units operate automatically. The only exposure received is during vessel changeout or maintenance.

The disposable demineralizer system achieves a volume reduction factor of 400 to 500, significantly better than the previous evaporator/solidification method. This translates into major savings in radwaste packaging, transportation, and burial. Processing costs for the first seven months of disposable demineralizer operation are shown in Table V. Table VI provides a comparison of the liquid radwaste processing factors and costs at the Farley Plant using evaporators and disposable demineralizers. This comparison is based on 5 months of evaporator operation and the initial 7 months of demineralizer operation. Table VII provides a summary of the 1982 operating costs for the demineralizer system, which was used exclusively in 1982 to process liquid radwaste

Table VI
Liquid Waste Processing - A Comparison of Evaporator versus Disposable Demineralizers

Item	Evaporator	Deminerlizers
Labor	6 operators 3 chemists 1 radiochemist (4 hr/day) 3 maintenance techs.	1 operator 1 radiochemist (4 hrs/day)
Effluent quality	Poor $\approx 10^{-5}$ µc/ml (50% must be reprocessed)	Excellent 1×10^{-6} to < 5×10^{-7} µci/ml
Reliability	Poor	Excellent
Predictability	Poor	Excellent
Operability	Complicated	Simple
Energy Required	Extensive Steam	Negligible
Pretreatment	Excessive	Negligible
Maintenance	Continuous	Very little
Waste Handling	12 wt % concentrates must be solidified	insitu resin dewatering
Volume Reduction Factor	34.7	400-500
Gallons of Liquid Waste per CF buried	260 gal/CF	4,018 gal/CF
Cost Per Gallon Processed	44¢/gal	8¢/gal

Table VII
Approximate Annual Costs* for HITTMAN Disposable Demineralizer System

(5/20/81 to 5/17/82, Units 1 and 2)

Alabama Power Company
Joseph M. Farley Nuclear Plant

	Price
Labor and Maintenance	$ 75,800
(1) Demineralizer Operator (full-time)	
(1) Radiochemist (part-time)	
Dewatering Assistance (for 5 units)	
Processing Units and Spare Parts	$109,000
(2) Carbon Filter Vessels	
(3) Demineralizer Vessels Spare Parts	
Transportation and Burial	$ 27,880
(5) Shielded Shipments to Barnwell, S.C.	
Burial Volume - 170 CF/vessel	
Total	$212,680

108,878 gallons/month/unit x 12 months x 2 units = 2,613,076 gallons

Cost per gallon = 8¢/gallon

Volume reduction factor (volume of influent waste/ volume of waste buried, including container) = 411:1

*Excludes any equipment lease charges or equipment purchase payments, and any supplemental engineering and support services.

from both units at the Farley Plant. Processing costs for 1982, using the disposable demineralizer system were 8¢/gallon. Note that a total of 5 liners were required to treat the 2.6 million gallons of liquid radwaste in 1982. (The third demineralizer unit went into service into 1983.) This amounted to only 850 cf of waste requiring disposal. A sixth liner from 1981 processing was disposed of in 1982, and is included in the volumes shipped (See Figure 3).

CONCLUSION

After nineteen months of actual operating experience, the processing of over 4.2 million gallons of liquid radwaste has shown that the HITTMAN disposable demineralizer system at Farley Plant is a highly reliable and low cost method for treating the Plant's liquid radwaste. The system has resulted in a major reduction in the wet waste fraction of the Plant's radwaste.