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K. J. Hofstetter[a]; C. G. Hitz[a]
[a] Gpu Nuclear Corporation, Middletown, Pennsylvania

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The Use of the Submerged Demineralizer System at Three Mile Island

K. J. HOFSTETTER and C. G. HITZ

GPU NUCLEAR CORPORATION
P. O. BOX 480
MIDDLETOWN, PENNSYLVANIA 17057

ABSTRACT

The Submerged Demineralizer System (SDS) has been used at Three Mile Island-Unit 2 (TMI-2) to process more than 1.5 million gallons of water contaminated as a result of the March, 1979 accident. The SDS has processed approximately 315,000 gallons of water accumulated in tanks in the Auxiliary Building, approximately 650,000 gallons of water that existed in the Reactor Containment Building basement, approximately 90,000 gallons of primary reactor coolant (processed in a bleed and feed mode) and approximately 169,000 gallons of water used in the large scale decontamination of the Reactor Building. During its operation, the SDS has immobilized approximately 340,000 curies of the principal fission products ^{137}Cs, ^{134}Cs and ^{90}Sr on inorganic media (zeolite). Processing summaries and performance evaluations are presented.

INTRODUCTION

The Submerged Demineralizer System (SDS) was designed to process the large quantity of water contaminated as a result of the accident at Three Mile Island. GPU Nuclear Corporation (GPUNC) developed the SDS in consultation with a group of technical experts assembled by the US Department of Energy. This Technical Advisory Group (TAG)

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provided technical direction for the development of the SDS; Chem-Nuclear Systems and Allied-General Nuclear Services were employed as subcontractors for design of the system, and the Oak Ridge National Laboratory and the Savannah River Laboratory were engaged to develop and test the processing flow sheet.

The SDS uses inorganic sorbents (zeolites) to immobilize the principal fission product radionuclides ^{137}Cs, ^{134}Cs and ^{90}Sr. Zeolites were chosen because (1) they are inorganic and thus stable to ionizing radiation, (2) they are selective for the sorption of radionuclides from solutions containing competing cations, and (3) they are compatible with the vitrification process.

Table I shows the major constituents in the contaminated water processed by means of the SDS at TMI-2. Water used to decontaminate the Reactor Building is not included in the table since it was principally recycled, previously processed water. It is obvious from the data in Table I that highly radioactive solutions were

TABLE I

Major Constituents in Contaminated Waters at TMI Processed by Means of SDS

Analysis	Bleed Tanks	Reactor Building*	Reactor Coolant**
pH	7.5	8.4	7.6
Na (ppm)	160	1200	1000
B (ppm)	1200	2000	3700
^{3}H (μCi/mL)	0.03	0.8	0.05
^{137}Cs (μCi/mL)	2.3	140	15
^{134}Cs (μCi/mL)	0.3	18	1.5
^{90}Sr (μCi/mL)	1.5	5.5	18

*Results of sample taken May, 1981
**Results of sample taken September, 1981

processed through the SDS. Good waste management practices required maximizing the radionuclide concentrations and therefore produced media which had high specific radionuclide loading. Under such high loadings, organic ion exchangers would suffer radiation damage. The instability of organic ion exchange resins at radiation exposures above 10^8 rads has been documented.(1) However, zeolite sorbents exposed to radiation levels up to 10^{11} rads show few changes. The proposed activity loadings for the zeolites used in SDS were up to 8000 Ci/ft^3 (60,000 Ci ^{137}Cs per vessel) resulting in integrated doses of up to 10^{11} rads. A US-DOE study(2) evaluated the effects of these high activity loadings on the SDS zeolites and determined that even higher loadings could probably be tolerated.

The radioactive contaminants in the TMI-2 waters were accompanied by high concentrations of sodium and boron making selective clean up difficult. The choice of sorbents, flow rates, and throughput volumes and the resulting anticipated decontamination factors were determined as a result of laboratory tests and calculations at ORNL(3,4) and SRL.(5) Experiments were performed using synthetic and actual reactor building water at ORNL to determine the operational perameters. These tests confirmed the ability of the zeolites to selectively remove cesium and strontium while passing sodium and boron. The selection of the zeolites, Linde Ionsiv IE-96 and Linde A-51 in a 3:2 ratio provided the best decontamination for reactor building basement water. The IE-96 is the naturally occurring chabazite zeolite converted to the sodium form supplied by Union Carbide. Tests demonstrated its high selectivity for cesium. Linde A-51 is a synthetic Type A zeolite which is also supplied by Union Carbide.

The use of A-51 provided the SDS with high ^{90}Sr removal capability. A computer model of the SDS system was developed[5] which predicted column loadings and breakthrough curves; this model also provided the basis for vessel changeout criteria and methodology.

The basic water processing strategy at TMI-2 is to utilize the SDS followed by water polishing using deionization techniques suggested by ORNL. The SDS captures the majority of the cesium and strontium while the polishing system, EPICOR, further reduces the SDS effluent radionuclide concentrations to acceptable on-site storage and decontamination specifications. Polishing of the SDS effluent in the EPICOR system is accomplished using organic ion exchange resins. A survey of resins to find the best candidates for water polishing was performed by laboratory scale experiments at TMI-2. The overall desire to minimize the quantity of immobilizing media and remain within commercial waste disposal guidelines led to the use of layered resins for water polishing. Nearly all the water processed through the SDS has been polished through the EPICOR system.

System Description

The SDS is a water processing system consisting of two parallel trains of four 75-gallon vessels each containing approximately 60 gallons of zeolite sorbent. All demineralizer vessels are located approximately 25 feet underwater in the B-Spent Fuel Pool for shielding. Water is forced through two submerged 75-gallon filter vessels (sand beds) and into four 15,000-gallon shielded feed tanks located in the A-Spent Fuel Pool. From the feed tanks, the filtered water is pumped through one of the two trains containing the zeolite-loaded vessels, then through a post filter to remove zeolite fines and finally into one of two 12,000-gallon monitor tanks. These monitor tanks serve as a staging and surge capacity for influent to the EPICOR system. The SDS flowsheet for water processing is shown in Figure 1. A detailed description of the SDS and its components is given in Reference 6. A summary of SDS operation for processing each major source of water is described below, with processing data given in Table II.

Reactor Coolant Bleed Tank Water Processing

Decontamination of the Auxiliary and Fuel Handling Building (AB/FHB) and normal plant inleakage resulted in water contaminated to intermediate levels of activity. The chemical content of this water is given in Table I Column 1. This water was accumulated in the Reactor Coolant Bleed Tanks (RCBT) located on the lowest elevation in the AB/FHB. These tanks have a useable capacity of ∿75,000 gallons per tank. Water was transferred from the RCBTs (using the waste transfer pumps for motive force) through the filter vessels and into the SDS feed tanks.

Processing of the RCBT water was chosen as the first batch of water to pass through the SDS to demonstrate its processing capability. Three 50,000 gallon batches of RCBT water were processed through the SDS. The results of these processing batches (1-3) are given in Table II. This RCBT water was processed through Train 1 which contained two vessels loaded with a 1:1 mix of IE-96 and A-51. As can be computed from the data given in Table II, the average decontamination factor for ^{137}Cs and ^{90}Sr was greater than 100. The

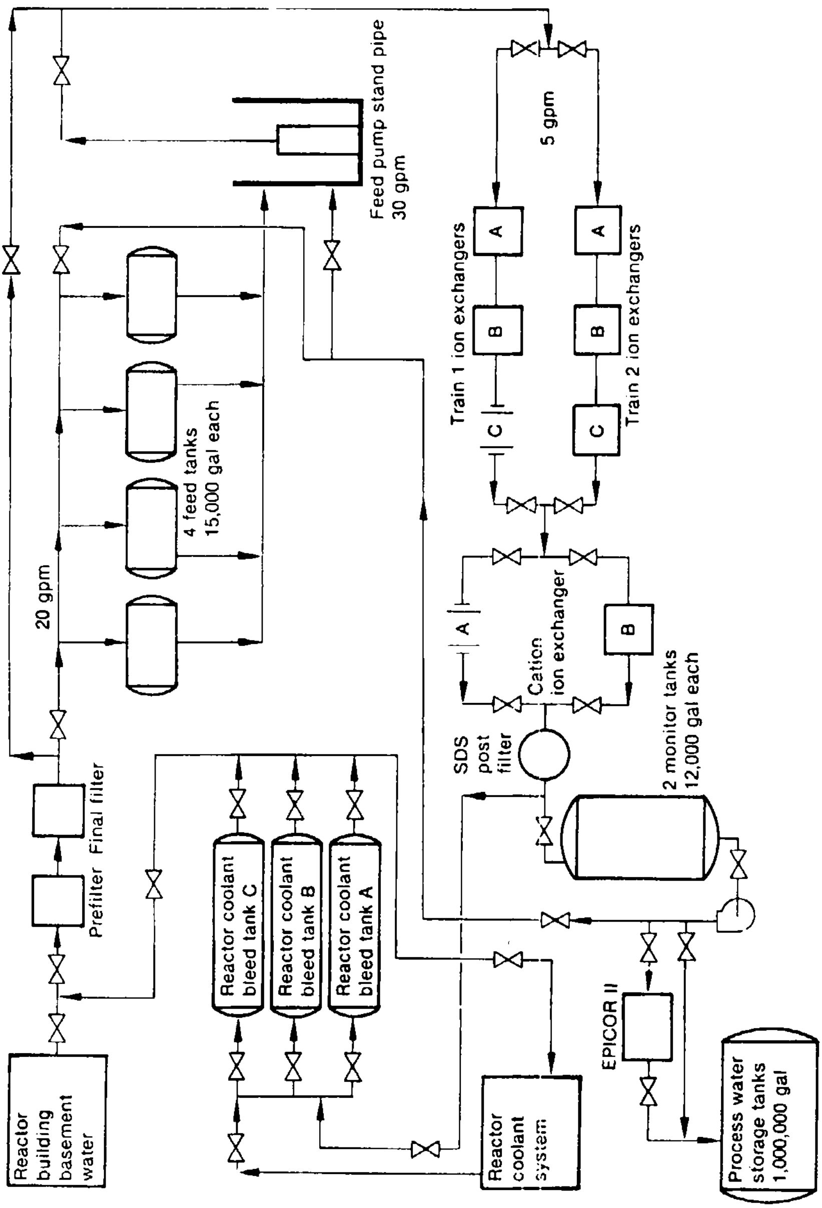

Figure 1. Flowsheet for Water Processing Through the SDS

RCBT water was then processed through the EPICOR system to further reduce the radionuclide content and then stored in one of two 500,000 gallon Processed Water Storage Tanks (PWST).

Batch 4 was a small batch of RCBT water processed through Train 2 as a test of the installed piping prior to the commencement of Reactor Building Sump (RBS) water processing. After processing this batch of RCBT water, the SDS was used principally for RBS water removal and Reactor Coolant System (RCS) water processing. From time to time, processing normal plant inleakage to the RCBT was performed using two zeolite vessels in Train 1 (for example, Batches 12, 13, 23, 24 and 26).

Reactor Building Sump Water Processing

During the accident, a large quantity of water was accumulated in the Reactor Building Sump and overflowed to the basement. Since this water was contaminated as a result of a direct release of reactor fuel, it contained high concentrations of ^{137}Cs, ^{134}Cs and ^{90}Sr, as well as high concentrations of boron and sodium. The sodium was present because it was injected as sodium hydroxide by the building spray system during the accident. The concentrations are given in column 2 of Table I. The water reached a depth of ∿8.5 feet above the containment building floor.

Prior to processing of this water, successful manned entry into the Reactor Containment Building (RCB) was accomplished. During one of the early entries, a submersible pump equipped with styrofoam floatation was dropped into the sump at an accessible location. This pump took suction from the surface of the water and developed

TABLE II

SDS Batch Processing History (As of March 1, 1983)

Batch Number	Date	Process Flow (gal)	Water Type	Prefilter	Final Filter	Vessel Positions 1A	1B	2A	2B	2C	Cat B	Average Influent Conc. (μCi/mL) ^{90}Sr	^{134}Cs	^{137}Cs	Average Effluent Conc. (μCi/mL) ^{90}Sr	^{134}Cs	^{137}Cs
1	6/30-7/19/81	49,451	RCBT	F10002	F20001	D10015	D10018	-	-	-	-	1.10	2.16(-1)	1.74	9.98(-3)	6.36(-4)	5.84(-3)
2	7/22-7/31	48,519	RCBT	F10002	F20001	D10015	D10018	-	-	-	-	9.88(-1)	2.06(-1)	1.78	3.44(-3)	1.09(-3)	9.78(-3)
3	7/31-8/9	49,301	RCBT	F10002	F20001	D10015	D10018	-	-	-	-	4.18(-1)	6.62(-2)	5.60(-1)	6.91(-3)	7.91(-4)	7.40(-3)
4	9/7-9/17	5,489	RCBT	D00005	D00007	-	-	D10017	D10012	D10013	D10016	3.20(-1)	7.30(-2)	6.70(-1)	1.15(-2)	7.05(-5)	1.15(-3)
5	9/22-9/25	15,559	RBS	F10001	D00007	-	-	D10017	D10012	D10013	D10016	3.23	12.30	106.00	1.50(-2)	8.02(-5)	8.72(-4)
6	9/26-10/4	45,311	RBS	F10001	D00007	-	-	D10017	D10012	D10013	D10016	3.78	12.00	110.60	1.26(-2)	2.15(-4)	6.55(-4)
7	10/4-10/18	50,168	RBS	F10001	D00007	-	-	D10012	D10011	D10013	D10016	3.91	9.92	94.80	1.56(-2)	1.27(-4)	9.09(-4)
8	10/18-10/31	44,237	RBS	F10001	D00007	-	-	D10012	D10011	D10013	D10016	4.19	12.80	115.40	8.71(-3)	6.21(-5)	5.89(-4)
9	10/31-11/9	7,070	RCBT	F10001	D00007	-	-	D10012	D10011	D10013	D10016	2.85	1.46(-2)	2.74(-1)	7.36(-3)	8.30(-5)	7.61(-4)
		40,646	RBS										11.20	104.50			
10	11/10-11/19	44,213	RBS	F10001	D00007	-	-	D10011	D10013	D20028	D10016	5.13	12.70	122.50	8.78(-3)	1.10(-5)	9.17(-4)
11	11/20-11/28	43,448	RBS	F10001	D00007	-	-	D10011	D10013	D20028	D10016	5.30	10.70	101.80	9.17(-3)	7.18(-5)	7.18(-4)
12	11/28-12/9	43,247	RCBT	F10001	D00007	D10015	D10018	-	-	-	-	9.19(-1)	5.60(-2)	5.34(-1)	2.25(-2)	3.19(-4)	3.30(-3)
13	12/9-12/18	44,331	RCBT	F10001	D00007	D10018	D20026	-	-	-	-	5.91(-1)	7.04(-2)	6.84(-1)	2.09(-2)	5.34(-4)	5.23(-3)
14	12/19-12/27	44,699	RBS	D00002	D00009	-	-	D10013	D20028	D10016	D10014	2.66	9.82	93.80	8.33(-3)	1.23(-4)	1.29(-3)
15	12/28/81-1/4/82	43,269	RBS	D00002	D00009	-	-	D10013	D20028	D10016	D10014	2.96	9.33	93.00	7.65(-3)	8.57(-5)	8.32(-4)
16	1/6-1/10	21,367	RBS	D00002	D00009	-	-	D10013	D20028	D10016	D10014	2.49	9.25	96.50	7.38(-3)	9.37(-5)	9.43(-4)
17	1/10-1/29	44,764	RBS	D00002	D00009	-	-	D20028	D10016	D10014	D20027	3.02	10.00	100.00	7.57(-3)	7.81(-5)	9.08(-4)
18	1/30-2/6	43,789	RBS	D00002	D00009	-	-	D20028	D10016	D10014	D20027	4.18	11.70	113.30	6.68(-3)	6.50(-5)	6.16(-4)
19	2/7-2/9	10,985	RBS	D00002	D00009	-	-	D20028	D10016	D10014	D20027	4.80	11.50	110.00	6.38(-3)	6.13(-5)	5.43(-4)
20	2/10-2/16	33,498	RBS	D00002	D00009	-	-	D10016	D10014	D20027	D20029	4.36	11.70	113.30	6.15(-3)	6.85(-5)	7.19(-4)
21	2/17-2/27	43,844	RBS	D00002	D00009	-	-	D10016	D10014	D20027	D20029	4.43	13.00	130.00	5.97(-3)	6.31(-5)	6.64(-4)
22	2/27-3/5	33,149	RBS	D00002	D00009	-	-	D10016	D10014	D20027	D20029	4.71	13.00	123.30	5.67(-3)	5.57(-5)	5.40(-4)

Batch Number	Date	Process Flow (gal)	Water Type	Prefilter	Final Filter	Vessel Positions 1A	1B	2A	2B	2C	Cat B	Average Influent Conc. (μCi/mL) ^{90}Sr	^{134}Cs	^{137}Cs	Average Effluent Conc. (μCi/mL) ^{90}Sr	^{134}Cs	^{137}Cs
23	3/9-3/12	20,120	RCBT	D00002	D00009	D10018	D20026	-	-	-	D20029	8.78(-1)	1.17(-1)	1.08	1.37(-2)	1.23(-3)	1.30(-2)
24	4/29	10,901	RCBT	D00002	D00009	D20027	D20029	-	-	-	-	5.70(-2)	6.80(-2)	7.50(-1)	7.53(-3)	7.67(-5)	8.33(-4)
25	4/30-5/2	36,960	RBS	D00002	D00009	-	-	-	-	-	-	N/A	11.00	110.00	-	-	-
26	5/5-5/8	18,009	RCBT	U00001	U00002	D20027	D20029	-	-	-	-	N/A	8.17(-2)	7.67(-1)	9.80(-3)	1.58(-4)	1.55(-3)
27	5/21-5/29	50,152	RCS	U00001	U00002	D20027	D20029	-	-	-	-	9.15	9.02(-1)	9.50	4.67(-2)	1.05(-4)	8.37(-4)
28	6/5-6/12	50,240	RCS	U00001 U00004	U00002	D20027	D20029	-	-	-	-	8.43	6.15(-1)	6.79	4.25(-2)	8.82(-5)	7.95(-4)
29	6/14	4,718	RBS	U00004	U00002	-	-	-	-	-	-	N/A	8.00	87.00	-	-	-
30	6/19-6/25	50,124	RCS	D20030	D20034	D20027	D20029	-	-	-	-	9.71	3.27(-1)	3.66	2.68(-2)	8.59(-5)	5.27(-4)
31	7/1-7/9	51,284	RCS	D20030	D20034	D20029	D20031	-	-	-	-	8.03	4.02(-1)	4.49	4.18(-2)	1.06(-4)	4.02(-4)
32	7/19-7/26	48,052	RCS	D20030	D20034	D20029	D20031	-	-	-	-	10.30	2.65(-1)	3.01	3.29(-2)	1.04(-4)	3.61(-4)
33	8/19-8/24	32,774	RBS	-	-	-	-	D10014	D10018	D20026	-	7.00	9.31	106.70	2.41(-2)	2.35(-4)	3.02(-3)
34	8/27-8/30	18,945	RBS	-	-	-	-	D10014	D20026	D20022	-	5.32	6.64	76.20	7.32(-3)	2.24(-4)	2.82(-3)
35	8/30-8/31	3,584	Flush	D20030	D20034	-	-	D10014	D20026	D20022	-	9.80	2.60(-1)	2.90	9.30(-3)	5.00(-5)	5.20(-4)
36	9/25-10/3	31,734	RBD	D20030	D20034	-	-	D10014	D20026	D20022	-	2.88	1.77	20.70	7.19(-4)	2.84(-5)	1.01(-4)
37	10/6-10/7	5,122	Flush	D20030	D20034	D20029	D20031	-	-	-	-	9.30	2.10(-1)	2.70	2.85(-2)	9.30(-5)	4.85(-4)
38	11/2-11/14	44,177	RBD	D20030	D20034	-	-	D20026	D20022	D20037	-	5.37	1.36	16.70	2.59(-4)	2.09(-5)	3.75(-5)
39	12/18	1,932	Flush	D20030	D20034	D20029	D20031	-	-	-	-	9.40	3.00(-1)	3.70	2.20(-2)	8.90(-5)	4.50(-4)
40	12/21-12/27	39,407	RCS	D20030	D20034	D20029	D20031	-	-	-	-	10.30	2.24(-1)	2.86	2.75(-2)	1.04(-4)	4.12(-4)
41	12/31/82-1/22/83	49,343	RBD	D20030	D20034	-	-	D20026	D20022	D20037	-	3.35	7.35(-1)	9.70	9.41(-3)	3.32(-5)	3.21(-5)
42	1/22-1/23	2,000	RCS	D20030	D20034	D20031	D20023	-	-	-	- }	6.93	1.08(-1)	1.41	1.94(-2)	9.09(-5)	3.06(-4)
43	1/23-1/29	46,201	RCS	D20030	D20034	D20031	D20023	-	-	-	- }						
44	2/2-2/8	40,364	RCS	D20030	D20034	D20031	D20023	-	-	-	-	5.91	5.04(-2)	7.24(-1)	1.50(-2)	9.10(-5)	3.38(-4)
45	2/10-2/22	43,514	RBD	D20030	D20034	-	-	D20022	D20037	D20024	-	2.41	8.40(-1)	11.10	9.14(-4)	2.72(-5)	6.61(-5)

sufficient hydraulic pressure to force the water out of the RCB using an existing penetration, through the filter vessels, and into the SDS feed tanks. Typically, 44,000-gallon batches were staged out of the RCB to the tank farm using the surface suction pump. The RCB sump water was then processed through Train 2 containing four zeolite vessels loaded with a 3:2 mixture of IE-96 and A-51. The 44,000 gallon batch size was chosen because four full monitor tanks could then be conveniently processed through the EPICOR system. After processing ∿110,000 gallons of RCB water, the modular zeolite vessels were moved countercurrent to water flow, removing the first vessel, advancing the remaining vessels and placing a new vessel in the last position. This method of vessel changeout was done to achieve maximum loading of ^{137}Cs and yet remain below the shipping cask limit of 60,000 Ci. The vessel in the 2A position was discharged and placed in a storage location in the pool. Samples of each bed influent and effluent were taken during the processing of each batch at a frequency designed to monitor bed loading and minimize breakthrough. The details of the sampling system and analyses performed are given in Reference 7. A summary of sample results and a description of the chemistry support facilities are also given in this reference.

Processing of sump water began in late September, 1981, by staging a small batch (∿15,000 gallons) of water from the RBS (Batch 5 in Table II). This small batch served as a full system test with highly radioactive water. Following successful completion of this small batch, a full batch (Batch 6) was processed through the same train. At the completion of this batch, the first zeolite vessel D10017 (see Reference 6 for a discussion of nomenclature) was removed and the second vessel in Train 2 (D10012) moved to the 2A position and a new liner (D10011) moved into the 2B position. The original 2A vessel had accumulated 28,800 Ci of ^{137}Cs, far below the 60,000 Ci limit. The decision to take this vessel out of service prior to reaching the recommended loading limit was based on the desire to test the existing vessel handling procedures with a half-loaded vessel and to confirm anticipated vessel dose rates. Radiation profiles confirmed the predictions. Because of the low loadings, the abnormal vessel changeout was performed rather than the originally planned sequence.

Sump water Batches 7, 8 and 9 were processed through Train 2 of the SDS with vessel D10012 in the 2A position resulting in the deposition of approximately 55,000 Ci of ^{137}Cs on the zeolites. All subsequent vessel loadings were less than this amount. After Batch 9, vessel D10011 was moved to the 2A position where Batches 10 and 11 resulted in the deposition of 41,800 Ci of ^{137}Cs. Sump water processing continued through the SDS until early March, 1982 (Batch 22) when the surface suction pump lost suction with less than one foot of water remaining in the RCB basement. A jet pump was then installed in the basement and the remaining water was staged to the SDS feed tanks (Batches 25 and 29). These batches were subsequently processed through the zeolites at a later date (Batches 33 and 34).

In early March, 1982 the large-scale Reactor Building decontamination tests were begun with the introduction of ∿13,000 gallons of water into the RBS by the hydrolasing decontamination operations. This additional water diluted the radionuclide concentrations in the remaining RBS water.

During normal RBS processing, the effluent of SDS was polished through the EPICOR system and sent to the PWST for storage. The performance of the SDS and the EPICOR system are illustrated in Table III which shows the average SDS/EPICOR system processing effectiveness. The decontamination factors (DF) for ^{137}Cs removal by means of the SDS and the EPICOR system were 1.4×10^5 and 2.7×10^3 respectively. A total of 278,000 Ci of ^{137}Cs and 11,600 Ci of ^{90}Sr were removed from the Reactor Building Sump and trapped on the SDS zeolites during RBS processing. Details of the processing of the 650,000 gallons of RBS water have been presented previously.[8]

TABLE III

Average SDS/EPICOR System Performance for Reactor Building Sump Water Processing

Radionuclide	Influent (μCi/mL)	SDS Effluent (μCi/mL)	EPICOR Effluent (μCi/mL)	System DF	Curies Removed	Curies Remaining*
^{134}Cs	13	1.0(-4)**	<2(-7)	>6.6(7)	29,800	4(-4)
^{137}Cs	123	8.6(-4)	3.2(-7)	3.8(8)	278,000	7(-4)
^{90}Sr	5.1	8.8(-3)	1.7(-5)	3(5)	11,600	4(-2)
^{125}Sb	1.1(-2)	1.1(-2)	<4(-7)	>2.7(4)	25	9(-4)
^{144}Ce	4(-4)	4(-4)	<1(-6)	>4(2)	1	3(-3)
^{60}Co	2(-5)	2(-5)	<2(-7)	>1(2)	.05	4(-4)
^{3}H	8.8(-1)	8.8(-1)	8.8(-1)	∿1	∿0	2150

*Remaining in the 650,000 gallon effluent.
**The number in parenthesis is the exponent (e.g., 1.0(-4) means 1.0×10^{-4}).

Reactor Coolant System Water Processing

The contaminated Reactor Coolant System (RCS) water has been processed through the SDS by utilizing two of the RCBT's for interim staging. Since the SDS removes only the cesium and strontium while slipping the sodium and boron, it provides an ideal system for processing the RCS while leaving the bulk chemicals for criticality and corrosion control undistrubed. The chemical content of the RCS is given in column 3 of Table I. Because of the requirement to keep the core flooded, the RCS was processed in a feed and bleed mode. A 50,000 gallon batch of RCS was letdown at ∿20 gpm to one of the bleed tanks (RCBT-C) while simultaneous make-up occurred from another bleed tank (RCBT-A). Using a specially designed RCS piping manifold and the waste transfer pumps, contaminated coolant in RCBT-C was processed through the filters and Train 1 zeolite vessels, by-passing the SDS feed tanks. The SDS effluent was collected in RCBT-A. The decontaminated coolant in RCBT-A was then used as make-up for the next letdown batch. Since the clean-up of the RCS is governed by bleed/feed dilution, even if infinite mixing occurs in the RCS, the clean-up requires multiple processing batches to reach the desired activity concentrations. Prior to the in-core camera inspection, five batches of RCS were processed through the SDS decreasing the ^{137}Cs concentration to about 2.5 μCi/mL.[9] As other parameters may affect the rate of decrease of RCS decontamination, a careful study[10] of letdown data resulted in several conclusions concerning leaching of radionuclides from the TMI-2 core debris, flow patterns within the RCS and anticipated decontamination factors for subsequent RCS processing campaigns. Subsequently, four additional RCS processing runs have been made and resulted in the present RCS ^{137}Cs concentration of 0.5 μCi/mL, an early target goal. Table VI summarizes SDS processing of the nine batches (376,000 gallons) of RCS required to reach the 0.5 μCi/mL level. The data presented in Table IV indicate that a significant appearance rate is occurring for ^{90}Sr in the RCS. The DF's for ^{137}Cs and ^{90}Sr removal from the RCS water were approximately 10^4 and 200 respectively.

Reactor Building Decontamination Water

As the draining of the RCB water neared completion, the next major work activity--that of decontaminating the large surfaces in the Reactor Building, began with hydrolasing operations using high

TABLE IV

SDS Processing of Reactor Coolant System Water

Batch Number	Radionuclide	Influent (μCi/mL)	Effluent (μCi/mL)	Curies Removed
27	^{137}Cs	9.7	8.4(-4)	1990
	^{90}Sr	9.5	4.7(-2)	1940
28	^{137}Cs	6.7	8.0(-4)	1280
	^{90}Sr	8.9	4.3(-2)	1690
30	^{137}Cs	3.6	5.3(-4)	712
	^{90}Sr	9.9	2.7(-2)	1950
31	^{137}Cs	4.4	4.0(-4)	840
	^{90}Sr	7.9	4.4(-2)	1500
32	^{137}Cs	2.9	3.7(-4)	550
	^{90}Sr	10	3.5(-2)	1890
40	^{137}Cs	2.9	4.1(-4)	410
	^{90}Sr	10.3	2.7(-2)	1530
42&43	^{137}Cs	1.4	3.0(-4)	260
	^{90}Sr	6.9	1.9(-2)	2160
44	^{137}Cs	0.72	3.4(-4)	110
	^{90}Sr	5.9	1.5(-2)	900

pressure water. Because of the uncertainty in the quantity of fuel debris that might have escaped the pressure vessel to the RCB sump, it was decided to use water containing at least 1700 ppm B for the flushing operations. The water used for hydrolasing was previously decontaminated water. The reuse of processed water is good waste management practice and minimizes the contamination of clean water inventory. When polishing the SDS effluent in the EPICOR system, the removal of sodium is required to permit the removal of all remaining radioactive species (cations). This practice results in low pH water which is then used for hydrolasing. Therefore, changes in general chemistry of the sump water occurs. After the decontamination water accumulates in the RCB sump, it is periodically staged through the filters to the SDS feed tanks and then processed through Train 2 of the SDS for repurification. Because of the continued decrease in Na^+ concentration and radioactivity content, it has been necessary to use only three SDS vessels for Reactor Building Decontamination (RBD) water processing. Table II summarizes the processing data to date. Thus far, approximately 260,000 gallons of processed water have been used for decontamination operations and 169,000 gallons have been processed through SDS and the EPICOR system for repurification. The balance of the water has been evaporated or lost due to aerosol formation during the hydrolasing operations.

Table V summarises the four batches of RBD water processed through SDS to date. As these batches were recycled through the SDS and the EPICOR system, with removal of sodium, the decontamination of this water in the SDS improved. This has occurred because the

TABLE V

SDS Processing of Water Used for Reactor Building Decontamination

Batch	^{137}Cs Influent (μCi/mL)	^{137}Cs Effluent (μCi/mL)	Average DF	Curies Removed
36	20.7	1.0(-4)	2.1(5)	2490
38	16.7	3.7(-5)	4.5(5)	2790
41	9.7	3.2(-5)	3.0(5)	1810
45	11.1	6.6(-5)	1.7(5)	1830
	^{90}Sr	^{90}Sr		^{90}Sr
36	2.9	7.2(-4)	4.0(3)	350
38	5.4	2.6(-4)	2.1(4)	900
41	3.3	9.4(-3)	3.5(2)	610
45	2.4	9.1(-4)	2.7(3)	395

distribution coefficients for cesium and strontium in the SDS zeolites are strongly dependent on Na^+ concentration. Continued use of the SDS to clean up the water used in the decontamination of the Reactor Building is anticipated.

Summary

A water processing system has been designed for decontaminating the highly radioactive water at TMI-2. The system has been utilized to process in excess of 1.5 million gallons of water and has removed ∿340,000 curies of fission product radionuclides which were present in these waters. These radionuclides have been sorbed on a relatively small volume (less than 150 cubic feet) of zeolites. A summary of the processing data up to March, 1983 is given in Table VI. Some of the SDS zeolites are presently being converted to an inert waste

TABLE VI

SDS Water Processing Summary Through March, 1983

	^{137}Cs (Curies)	^{90}Sr (Curies)	Volume Processed (Gallons)	SDS Vessels Discharged
Reactor Building Water Processing	278,000	11,600	650,000	9
Reactor Coolant Processing	6,370	12,100	376,000	3
Reactor Coolant Bleed Tank Processing Since 1980	6,050	940	315,000	3
Water Used for Decon	10,600	2,000	169,000	2
TOTALS	301,020	26,640	1,510,000	17

form at Richland, Washington as part of a waste vitrification demonstration program.[11, 12]

The SDS will be modified to support future water processing requirements in support of the reactor head list and fuel removal operations, in addition to processing routine inleakage and decontamination solutions. Modifications will include (1) the elimination of the feed tanks for interim staging, (2) provisions for direct processing from the RBS, and (3) installation of a pump in the fuel indexing fixture to permit processing the RCS after head lift.

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