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4410-85-L-0157
Document ID 0293A

August 16, 1985

TMI Program Office
Attn: Dr. B. J. Snyder
Program Director
US Nuclear Regulatory Commission
Washington, DC 20555

Dear Dr. Snyder:

Three Mile Island Nuclear Station, Unit 2 (TMI-2)
Operating License No. DPR-73
Docket No. 50-320

Technical Evaluation Report for the Submerged Demineralizer System

In accordance with your letter dated February 4, 1982, attached is the annual update to the Technical Evaluation Report for the Submerged Demineralizer System. This update contains new appendices for the Fuel Transfer Canal Draining System, the Fuel Transfer Canal Shallow End Drainage System, and the Early Defueling Water Cleanup Reactor Vessel Filtration System.

Sincerely,



F. R. Standerfer
Vice President/Director, TMI-2

FRS/RDW/eml

Attachment

cc: Deputy Program Director - TMI Program Office, Dr. W. D. Travers

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DIVISION
TECHNICAL EVALUATION REPORT
FOR

Submerged Demineralizer System

COG ENG SD P. Delisle DATE 8/1/85

RTR R. G. H. Hille DATE 8/5/85

COG ENG MGR. RP Warren DATE 8/5/85

Rev.	SUMMARY OF CHANGE	Approval	Date
0	Initial issue per GPUNC Letter 4400-82-L-0066		4/82
1	Reissue per GPUNC Letter 4410-83-L-0122		6/83
2	Reissue per GPUNC Letter 4410-84-0109 Incorporates changes required by ECM's S-1151 (Revisions 0 through 3), S-1163 (Revisions 0 through 3) 1110 Revision 0, 1140 Revision 0, 1159 Revision 0, and 1141 Revision 0.		7/84
3	Annual update Incorporates changes made by S-ECM-1110 Revisions 0 and 1, ECA's 072, 042, 047, 041, and 102.		8/85

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7/85

TECHNICAL EVALUATION REPORT
SUBMERGED DEMINERALIZATION SYSTEM

JULY 1985

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Chapter 1

Summary of Treatment Plan

1.1 Project Scope

To date the SDS system has processed in excess of 2 million gallons of contaminated water, including; 650,000 gallons of Reactor Building sump water, 366,000 gallons from RB decon and 760,000 gallons of RCS water. The continued decontamination of TMI-2 includes the repeated processing of the IIF/RCS using the IIF Processing System or the Reactor Vessel Filtration System (DWCS). The activity level of this water is given in Table 1.1. In addition, Reactor Building Decon water or water from other sources may be processed through SDS as necessary.

This report describes the Submerged Demineralizer System (SDS) and the work associated with the development of the system for the expeditious clean-up and disposition of the contaminated water mentioned above. Specific design features of the system include:

1. Placement of the operating system in the spent fuel pool to take advantage of shielding provided by the water in the pool.
2. Radioactive gas collection and treatment prior to release.
3. Liquid leak-off collection and treatment.

4. Underwater placement of ion-exchange vessels into a shipping cask without removal from the spent fuel pool.
5. Use of existing EPICOR-II equipment for polishing of SDS effluent, as required.

1.2 Identification of Radionuclides and Radioactivity Levels

Water samples were taken from the reactor coolant system and the containment sump, and were analyzed to identify specific radionuclides and concentrations. Typical results are listed in Table 1.1. The Reactor Coolant System (RCS) and containment sump specific radionuclides and concentrations are based upon actual sample data taken. The RCS activity decreases due to radioactive decay and leakage from the RCS. However, RCS activity may increase during processing shutdown due to leaching.

1.3 Alternatives Considered

During the early phases of developing a system for the control, clean-up, and disposition of the contaminated water located in the containment building of TMI-2, several methods or alternatives were evaluated. These alternatives were grouped into two categories:

- (1) those with no volume reduction, and
- (2) those with volume reduction.

Presented below, are the alternatives considered with a discussion and conclusion about each.

Alternative I: Leave Contaminated Water in Containment Indefinitely
(No Volume Reduction)

Discussion

A. Containment Sump Water

1. The sump water contains radionuclide concentrations as depicted in Table 1.1. The existence of this may cause some increase in radiological exposure problems during the recovery program, i.e., increased exposure to recovery program personnel, increased contamination levels, and increased possibility of airborne radioactivity.
2. The presence of the contaminated sump water would prevent decontamination of the lower levels of the containment building.

B. Reactor Coolant System Water

The presence of the contaminated water in the reactor coolant system would inhibit disassembly of the reactor and impede defueling operations.

Conclusion: Alternative I is not deemed feasible for the following reasons:

1. The potential for increased personnel exposure exists. Therefore, compliance with the principles of ALARA is not possible.
2. Facility decontamination and defueling operations are seriously inhibited or perhaps prevented.
3. Continued storage of the contaminated water in the containment sump for increased periods of time increases the probability that leakage from the building may occur. Leakage of contaminated water from the reactor building sump may threaten the public health and safety.
4. Continued storage of the water in the containment building for an extended period of time is undesirable. The primary isotopes of concern (Cs-137 and Sr-90) exhibit decay half-lives of approximately 30 year. Storage in the containment sump for approximately 300 years would be required for 10 half-life decay. Maintenance of containment integrity for this interval of time cannot be assured.

Alternative II: Transfer Water to On-site Storage Facility (No Volume Reduction)

Discussion:

1. To safely contain the contaminated water, the construction of an on-site liquid radwaste storage facility would be required.
2. Additional radiation areas on the plant site would be created if a liquid radwaste storage facility were built.
3. Estimates indicate the construction of a liquid radwaste storage facility would require two to three years, at a minimum.
4. A liquid radioactive waste transfer system for the transfer of the contaminated water from the various locations to the waste storage complex would be required.
5. Handling and pumping operations may involve leakage and the spread of contamination.
6. Disposal of the water prior to natural decay is required because of the long radioactive decay half-lives. This alternative is not representative of an acceptable long-term solution.

Conclusion: Based on the above discussion, Alternative II is not a feasible method.

Alternative III: Solidification and Disposal (No Volume Reduction)

Discussion:

1. The construction of an on-site solidification facility would be required.
2. Based on 1,000,000 gallons of contaminated water originally to be processed, a 30-gallon availability of water volume in a 55-gallon drum, 70% availability, 24-hour/day operation, and a 45 minute cycle time, the processing time may exceed four years.
3. Based on 1,000,000 gallons of contaminated water originally to be processed and a 30-gallon availability of water volume in a 55-gallon drum. The number of drums of solidified waste that would be generated would exceed 33,000. Handling, transportation and disposal of this extremely large quantity of solidified waste would be prohibitively expensive and violate basic principles of minimizing radioactive waste volumes.
4. The handling evolution required to solidify the contaminated water may involve substantial radiation exposure to personnel.
5. The potential for leakage and contamination problems may be substantial in operating a solidification facility for processing this contaminated water in this manner.

Conclusion: Based on the above considerations, Alternative III is not considered to be feasible.

Alternative IV: Submerged Demineralizer System (SDS) in the "B" Spent Fuel Pool and EPICOR-II System (Volume Reduction)

Discussion:

1. The system would be capable of concentrating fission products on a medium to effectively remove those products from the water.
2. Processing contaminated water would result in concentrated waste requiring additional shielding.
3. The system incorporates remote operability features.
4. Design, construction and operation would allow for relatively short lead times.
5. The system would require minimal maintenance.
6. The SDS is amenable to location within the Spent Fuel Pool which would utilize the shielding capability of the pool water.
7. Containers of highly loaded ion exchange media arising from operation of the SDS would not be acceptable at shallow land disposal sites. The SDS design and selection of ion exchange media allows volumes of such highly loaded media to be minimized to permit interim storage and probable ultimate disposal in a geological repository. It is believed that the EPICOR-II liners, generated as a result of polishing the SDS effluent, will be suitable for shallow land disposal because of their low curie content.

8. The EPICOR-II system, used in conjunction with SDS, will provide the capability to remove trace quantities of radionuclides from the SDS effluent.

Conclusion: Based on the above considerations, Alternative IV is an acceptable method for decontamination.

Alternative V: Evaporation (Volume Reduction)

Discussion:

1. Evaporation would require the design and construction of a new facility.
2. Due to the nature of the contaminated water to be processed the design of the facility would be complex to allow for maintenance of the processing system and personnel radiological protection. The construction of the facility may require at least four years.
3. Evaporation provides the ability to process a wide range of chemical contaminants.

Conclusion: Evaporation is an acceptable alternative for processing the contaminated waste waters. Based on the long construction time of the facility and inherent potential for higher occupational exposure due to increased maintenance requirements, this alternative is less desirable than Alternative IV, Submerged Demineralizer System (SDS) coupled with the EPICOR II system.

1.4 Description of the Decontamination Process

1.4.1 General

Analysis of the alternatives previously presented has resulted in the determination that, of the two alternative categories considered, volume reduction is appropriate for the disposition of contaminated water. This conclusion was reached based on the considerations that volume reduction:

1. fixes the contaminants
2. concentrates the activity
3. minimizes storage and disposal space

Of the volume reduction category, the Submerged Demineralizer system (SDS) in conjunction with EPICOR II for final polishing, or Alternative IV, was chosen as the most appropriate process for the following reasons:

1. Basic design simplicity.
2. High performance for decontaminating liquids, i.e., decontamination factors up to 10^7 , or higher.
3. Amenable to placement under water to take advantage of shielding properties of the water

4. Ability to implement water processing in a timely fashion for support of the overall objective of fuel removal.
5. Ability to use existing proven plant structures, equipment and technology for containment of the processed water and final process polishing (EPICOR-II)

The SDS with EPICOR II is an ion-exchange process expected to provide decontamination factors of up to 10^7 for cesium and 10^5 for strontium (see Table 3.1), thus removing the majority of the activity from the water prior to placement in the Processed Water Storage Tanks, or usage for continued decontamination or makeup to the RCS.

1.4.2 SDS Operating Description

Figure 1.1 shows a block diagram of the process flow of the Submerged Demineralizer System (SDS) with the EPICOR II System. Radioactive water enters the SDS via the RCS manifold. This source of water can pass through two cartridge or sand type filters for removal of particulate matter.

Sample connections are provided on the influent and effluent of the filters, and influent to the ion-exchange system to determine radionuclide content and concentrations of the water to be processed.

The first part of the SDS ion-exchange system consists of up to six underwater vessels (24 1/2 in. x 54 1/2 in.). Each vessel contains approximately 8 cubic feet of homogeneously mixed IE-96 and LINDE-A zeolite ion exchange media. Zeolite media volumes and mixtures may be changed to reflect different processing scenarios (The resin mix is specified by Radiochemical Engineering on the form included in OP 4215-OPS-3527.16). Inlet, outlet, and vent connections are made with remotely operated couplings. The vessels are arranged in two parallel trains with three columns in each train. Flow may be directed through one train of three vessels or through both trains in parallel. Loading of the vessels will be controlled by feed batch size, residence time, influent and effluent sample analysis, and continuous monitoring.

The second part of the SDS ion exchange system consists of two parallel sand filter vessels located underwater and immediately downstream of the zeolite beds. These sand filters will contain a mixture of sand and are intended to remove system effluent particulates, primarily zeolite fines. The columns are intended to be operated singly.

Present SDS operations are envisioned to provide for radionuclide loading of the zeolite media to a maximum of 60,000 Ci of ¹³⁴Cs and ¹³⁷Cs at the time of shipping.

This loading level is based on restrictions imposed based on the shielding provided by the Chem-Nuclear 1-13C II shipping cask. From the point of view of minimizing waste volume generation it is desirable to load the zeolites to these higher levels.

When the desired bed loading is achieved on the first bed of the train, the feed flow to the train will be stopped, the bed will be flushed with clean water, and the first bed will be disconnected and moved to the storage rack in the spent fuel pool using the pool area crane. The second and third beds will be disconnected, moved to the first and second positions, respectively. A new ion exchanger vessel is then installed in the third position. Following installation of the new ion-exchanger, the treatment of the contaminated water will recommence. This operational concept, which is the currently intended mode of operation, has eliminated the potential for valving errors and also minimizes the possibility of an unexpected radionuclide "breakthrough" which could recontaminate the water already processed. This mode of operation may change if the processing scenario changes.

Additionally some processing operations will require fewer than three (3) ion exchange units per train to achieve desired decontamination factors. In these cases jumpers will be installed to bypass the unused positions.

When the SDS is processing contaminated sump water, the effluent from the "cation" sand filters can be sent to EPICOR-II for polishing. When processing reactor coolant the effluent may be routed to installed tankage for injection back into the Reactor Coolant System as a source of makeup or to EPICOR for polishing. The spent ion-exchangers and filters of SDS will be retained under water in the spent fuel pool until removed. To transport spent ion-exchangers, they will be bulk dewatered, vacuum dewatered, and catalyst recombiner added, and loaded into shielded casks while under water and removed from the spent fuel pool. Following decontamination of the cask surface, the cask can then be loaded onto a trailer for transportation.

TABLE 1.1

Typical Results of Analysis from
the Reactor Coolant System Water and
the Containment Sump Water

Radionuclide Concentrations
($\mu\text{Ci/ml}$)

Isotope	Reactor Coolant System	RB Sump Decon
Sampling Date	(6/85)	(7/83)
H3	0.07	0.12
Sr-90	2.3	1.6
Sb-125	0.055	0.023
Cs-134	0.0058	0.14
Cs-137	0.14	2.1
pH	7.55	7
Boron	5230 ppm	3193 ppm
Na	1420 ppm	240 ppm

Chapter 2

Summary of Health and Environmental Effects

2.1 Occupational Radiation Exposure During Routine Operation

The SDS has been designed to maintain radiation exposures to operating personnel as low as reasonably achievable. To implement the ALARA concept, the following features have been incorporated into the SDS design.

- o Shielding has been designed to limit whole body dose rates in operating areas to less than 1 mRem/hr. The filters and ion-exchangers are located approximately 16 feet underwater for shielding. Components and piping carrying high activity water not contained underwater in the fuel pool have been provided with shielding to maintain external dose rates to acceptable levels.
- o Controls and instrumentation are located in low radiation areas.
- o Components containing high activity water have been designed for venting exhaust gases to the SDS Off Gas System. The Off-Gas System will minimize the potential for excessive airborne radioactivity releases in the work areas and to the environment.

Additional design and operational ALARA features are given in Section 6.

The occupational exposure for the EPICOR-II system was assessed in NUREG-0591. The occupational radiation exposure for the EPICOR-II system will be lower for the processing of the effluent from the SDS than previously processed by EPICOR-II since the influent activity to the EPICOR-II from the SDS has been substantially reduced by processing the radioactively contaminated water through the SDS.

2.1.1 Exposure Planning

Several activities will be implemented prior to and shortly after, the SDS start up to assure occupational exposures are minimized. These activities include:

- o Review of operating, maintenance and surveillance procedures to assure precautions and prerequisites are adequate.
- o Review of the installed system to identify potential problems during operation and the implementation of corrective actions.
- o Operational evaluations during preoperational testing and system training will be performed to update exposure estimates.
- o Determination of radiation dose rates during normal operations and maintenance evolutions will be performed.

As these reviews are completed, operating and surveillance frequencies can be established; total occupational exposures can be updated for the various activities during SDS operation. This exercise will permit review of those activities estimated to yield the highest man-rem expenditure. Pre-examination to assure that every reasonable effort is expended to minimize personnel exposure may include the following considerations:

- o Reduction of the frequency of operation
- o Temporary or additional shielding
- o Tool modifications
- o Procedure modification
- o Personnel training to reduce work time
- o Component modifications

2.2 Exposures to the Public During Routine Operation of the SDS and EPICOR-II

Refer to Chapter 6 for information on exposures to the public from routine operation of the SDS and EPICOR-II processing.

2.3 Evaluation of Unexpected Occurrences

The radiological assessment of unexpected occurrences includes the analysis of five hypothetical accidents that are postulated to occur during operation of the system.

The first accident is an inadvertent pumping of RCS water into the fuel storage pool until a total of 225 gallons of radioactive water is released to the pool. No exposures occur to the public since the contaminated water is contained in the pool. The maximum exposure rate at a distance of six feet above the pool surface is estimated to be 4.2 mR/hour. Since the release of water occurs underwater, no significant internal exposures are expected for workers. The primary impact of the accident is the contamination of water in the Spent Fuel Pool (233,000 gallons). (Refer to Section 7.1)

The second hypothetical accident assumes a pipe is ruptured and RCS water is sprayed into the building and fuel storage pool. It is possible that workers could be contaminated, however, prompt implementation of emergency procedures would minimize radiation exposures. The radioactive materials would be contained within the building except small amounts of radionuclides that would become airborne and subsequently be released through the monitored station discharge. This airborne radionuclide release would not result in significant exposures to the public. (Refer to Section 7.2)

The third hypothetical accident evaluated considers the inadvertent raising of a loaded prefilter above the pool surface. The dose rate at a distance of 15 feet from the source is estimated to be 21 Rem/hour and could result in a dose of approximately 1.8 rem to workers who remain in the area for a five minute period. (Refer to Section 7.3)

The fourth hypothetical accident evaluated considers the inadvertent raising of a loaded zeolite ion exchanger above the pool surface. The dose rate at a distance of 20 feet from the source is estimated to be approximately 340 Rem/hr. (Refer to Section 7.4)

The final hypothetical accident considers the inadvertent drop of the SDS shipping cask containing a loaded zeolite ion exchanger. The SDS shipping cask is assumed to be dropped from the maximum height of the Fuel Handling Building crane to the EL 305' floor. The dose rate resulting from a complete rupture of the SDS shipping cask at a distance of 20 feet is approximately 340 Rem/hr and assumes rupture of both the cask and the vessel. The small amounts of radionuclides assumed to become airborne would not result in significant exposures to the public. Also there would not be a significant effect from direct radiation exposure to the public. (Refer to Section 7.5) Evaluation of additional unexpected occurrences is covered in Appendix 2 to this TER.

The evaluation of unexpected occurrences for the EPICOR-II system was analyzed in NUREG-0591. The potential releases from processing SDS effluent water will be significantly lower because of the lower concentration of water being processed through EPICOR-II from the SDS. (See Table 3.1)

2.4 Industrial Health and Safety

2.4.1 Public Safety

Operation of the Submerged Demineralizer System poses no risk from an industrial safety standpoint to the general public for the following reasons:

1. Lifting and handling activities described take place within the TMI complex.
2. Hazardous chemical species, flammable or explosive substances, heavy industrial processes, and concentrated manufacturing activities are not involved in the installation or operation of the SDS.
3. No toxic substances are used in the SDS.

2.4.2 Occupational Safety

During the operation of the SDS, operating personnel will adhere to station requirements for occupational safety. Structural equipment and operating equipment used shall meet Occupational Safety and Health Administration requirements as applicable. Personnel protective equipment that would be required for the operation of the SDS will be utilized in accordance with standard station procedures.

2.5 Non-Radiological Environmental Effects

Adverse environmental effects from the construction and operation of the SDS are not anticipated. The system will be installed and operated in an existing, on-site facility and thus will not require any change in land-use. Additionally, the system is designed in such a manner as to allow zero discharge of liquid effluents to receiving waters. The final disposition of the processed water will be determined at a later date. Solid wastes (spent ion-exchangers, etc.) generated by the SDS will be stored and held until final disposal is accomplished.

2.6 Ultimate Waste Disposition

Radioactive material generated as a result of the accident at TMI is currently restricted to disposal at the commercial disposal site operated by U.S. Ecology at Hanford, Washington. SDS vessels meeting the criteria for disposal at this site will be disposed of by shallow land burial at this location. SDS vessels not meeting the Hanford Site criteria will be classified as abnormal waste and disposed of by the Department of Energy in accordance with the Memorandum of Understanding dated July 15, 1981, between the Nuclear Regulatory Commission and the Department of Energy dealing with the disposition of solid nuclear waste from the cleanup of TMI Unit 2.

Process Description

3.1 Introduction

A combined filtration-ion exchange process has been selected as the method for treating radioactive water contained in the reactor coolant system and containment building. The filter ion-exchange method has been used successfully to reduce quantities of radionuclides in the process effluent to levels that are in compliance with 10 CFR 20 and 10 CFR 50.

Furthermore, experiments conducted at ORNL, documented in ORNL report TM-7448, provide evidence that SDS processing, followed by EPICOR-II polishing, should provide an effective method for water decontamination.

The initial processing of the waste water is filtration for the removal of solids to optimize the subsequent ion-exchange process. Filtration is believed to be necessary to protect the zeolite beds from particulates in the sump and RCS water.

After filtration, radioactive ion removal from the waste water involves the use of ion-exchange materials. The two or three ion-exchange columns (per train) contain homogeneously mixed inorganic zeolite material which effectively removes essentially all of the cesium and

much of the strontium. Other trace levels of radionuclides are also partially removed by the zeolite media. The radioactivity content in the effluent stream of each bed is used to determine when the bed is expended and replaced.

Final demineralization of the contaminated sump water and selected batches of RCS water is intended to be by the EPICOR-II system. Essentially, all remaining radionuclides excluding tritium are expected to be removed from the water during this process step.

3.2 Ion-Exchange Concepts

Ion-exchangers are solid inorganic and organic materials containing exchangeable cations or anions. When solutions containing ionic species are in contact with the resin, a stoichiometrically equivalent amount of ions are exchanged. As an example, an ion-exchanger in the sodium (Na^+) form will "soften" water by an ion-exchange process. Hard water containing CaCl_2 is "softened" by this exchange mechanism which removes the Ca^{++} ions from solution and replaces them with Na^+ ions. In a similar manner, Sr^{++} and Cs^+ ions are exchanged with the Na^+ ions from the solid zeolite material.

Characteristic properties of ion exchangers involve micro-structural features contained in a framework held together by chemical bonds and/or lattice energy. Either a positive or negative electric surplus charge is carried within this framework which must be compensated for by ions of opposite sign. Because the exchange of ions is a diffusion process

within the structural framework, it does not conform to normal chemical reaction kinetics. The preference of ion-exchangers for a particular specie is due to electrostatic interactions between the charged framework and the exchanging ions which vary in size and charge number.

The decontamination factor (DF) is the ratio of the concentration in the influent stream to that in the effluent stream and is used for determining the efficiency of a purification process for radionuclide removal.

The following equation is a qualitative expression for the removal of a single ionic specie from solution.

$$DF = \frac{1}{1 - \frac{KnQE_w}{C_r V}}$$

where: Q = Total exchange capacity (meq/ml wet resin)

n = Fraction of Q used

E_w = Equivalent weight of the nuclide under consideration

C_r = Nuclide concentration (weight/volume)

V = Feed throughput (number of ion-exchange bed volumes)

K = Unit conversion constant

Important variables which are considered as part of the evaluation of ion-exchangers for decontamination are ion exchange media type, selectivity and capacity, concentration of the species to be removed, total composition of the feed stream, and the presence of contaminants. Operating parameters such as resin bed size, flow rate, flow distribution, pH, and temperatures are specified for the ion-exchange beds in order to maximize removal of the contaminating ions.

Specifications which have been defined for this purification process include:

- (1) The flow rate to provide an acceptable residence time for ion diffusion and exchange to occur.
- (2) The cross-sectional area of the ion-exchange media to provide an acceptable linear velocity through the bed.
- (3) The bed depth to result in an acceptable pressure drop.
- (4) A uniform flow distribution and a uniform media distribution to reduce the potential for channeling.
- (5) The ion-exchange media bead size to minimize attrition and large pressure drops.
- (6) The curie loading to satisfy personnel exposure, radiation damage, transportation, and storage regulations.
- (7) The cation form and the amount of ion-exchange media impurities to maximize removal of specific nuclides.

3.3 Ion-Exchange Materials

The ion-exchanger media selected for use in this processing system are an inorganic zeolite material that is commercially available and known as Ion Siv IE-96 (Na⁺ form of IE-95), and LINDE-A, to be used for SDS and cation and anion resins to be used in EPICOR II.

Zeolites are aluminosilicates with framework structures enclosing large and uniform cavities. Because of their narrow, rigid, and uniform pore size, they can also act as "molecular sieves" to sorb small molecules, but to exclude molecules that are larger than the opening in the crystal framework.

Other media are also being evaluated. Should our plans change with regard to ion exchange media to be employed, the NRC will be notified.

Organic ion exchange resins are typically gels and are classified as cross-linked polyelectrolytes. Their framework, or matrix, consists of an irregular, macromolecular, three-dimensional network of hydrocarbon chains. In cation exchangers, the matrix carries ionic groups such as SO_3^- , COO^- , $(\text{PO}_2)^-$, and in anion exchangers groups such as NH_4^+ , Na^+ , H^+ are carried. The framework of the organic resins, in contrast to that of the zeolites, is a flexible random network which is elastic, can be expanded, and is made insoluble by introduction of cross-links which interconnect the various hydrocarbon chains. The extent of crosslinking establishes the mesh width of the matrix and, thus, the degree of swelling and the ion mobilities within the resin. This, in turn, determines the ion exchange rates and electric conductivity of the resin.

Since the mechanism of the ion exchange process involves the stoichiometric exchange of ions between the exchanger and the solution while electrical neutrality is maintained, the rate determining step is controlled by the interdiffusion of ions within the framework of the

ion-exchanger. Since the rate of ion exchange is determined by diffusion processes, rate laws are derived by applying well-known diffusion equations to ion-exchange systems. However, complications arise from diffusion-induced electric forces, from selectively specific interactions, and changes in swelling such that rate laws are applicable for only a few limited cases. Experimental efforts have been conducted at the Savannah River Laboratory to investigate the kinetics of cesium and strontium ion-exchange with the zeolite exchanger. Cesium was absorbed so rapidly that only rough estimates of the diffusion parameter could be obtained. The resulting equation, used to calculate column performance, did not involve kinetic parameters but was suitable to describe the equilibrium column behavior.

3.4 Resin Selection Criteria

Technical information obtained from previous use of various ion-exchange materials and the results of recent experimental work with simulated and actual water samples from Three Mile Island were used to support the selection of specific ion exchange materials for this processing system. The performance of an ion exchange system is controlled by the physical and chemical properties of the exchange material as well as by the operating conditions specified in Section 3.2. The important criteria which were used in the ion exchanger selection process included:

- (1) Exchange capacity
- (2) Swelling equilibrium
- (3) Degree of crosslinking
- (4) Resin particle size

- (5) Ionic selectivity
- (6) Ion-exchange kinetics
- (7) Chemical, radiolytic and physical stability
- (8) Previous demonstrated performance (EPICOR-II)

Experimental studies with reactor coolant water have been conducted to support and verify the selection of these ion-exchangers; refer to ORNL TM-7448. Further, onsite studies have been performed to support and verify selection of the ion-exchange media. The decontamination factors for the major contaminants were measured using a number of candidate ion exchangers including the organic resins, HCR-5 and SBR-OH, and the zeolite ION SIV IE-96 and LINDE-A. The results indicated the most favorable type of ion exchange media to be used in the cleanup process were the available cation-anion resins in combination with the zeolite exchanger.

Furthermore, as a result of processing in excess of 2,000,000 gallons of radioactively contaminated water from the Auxiliary Building, Reactor Building and RCS, we are confident that the SDS, with EPICOR-II used as a polishing system for treatment of SDS effluent, will continue to provide an effective means to decontaminate the contaminated waters. EPICOR-II resin loadings may be altered to improve polishing effectiveness, if required.

3.5 Predicted Performance of Ion-Exchangers

The concentrations of radionuclides in samples of water from the Reactor Coolant System have been measured. Those radionuclides still detectable in June, 1984 include Sr-90, Cs-134, Cs-137, and Sb-125. The expected performance of the SDS ion-exchangers, and the EPICOR-II ion exchangers is shown in Table 3.2. The concentrations of strontium and cesium are expected to be significantly reduced by processing through the SDS and EPICOR-II system. Table 3.1 is included to provide historical data on Reactor Building Sump water processing.

Antimony is expected to pass through the SDS ion exchangers and will end up as the predominant gamma emitter in the solution entering the EPICOR-II system. The Concentration of Sb-125 in the containment building sump sample is approximately 0.011 microcuries per milliliter.

3.6 Monitoring of Ion Exchangers

Methods which may be used to monitor the effectiveness of the ion exchangers include liquid sampling and in-line radiation detectors. Liquid samples of feed and effluent streams can also be used to establish the approximate curie loadings in the loaded beds.

TABLE 3.1
Actual activity concentrations* in SDS process streams
after 200 bed volumes through each zeolite bed
(Based on continuous flow through four zeolite columns)

Historical - RB Sump Processing

Nuclide	Effluent concentrations, * uCi/ml.						Effluent EPICOR-II
	Feed	Filter	Zeolite columns				
			First	Second	Third	Fourth	
^3H	0.83	0.88	0.88	0.88	0.88	0.88	0.83
^{60}Co	b	b	2E-5	2E-5	2E-5	2E-5	2.3E-6
^{90}Sr	5.02	5.02	2.5	1.0E-1	8.5E-3	5E-3	<1.0E-5
^{106}Ru	b	b	4.0E-4	4.0E-4	4.0E-4	4.0E-4	1E-6
^{125}Sb	b	b	1.1E-2	1.1E-2	1.1E-2	1.1E-2	3.4E-7
^{134}Cs	1.39E+1	1.39E+1	1.7E+0	1.1E-4	1.1E-4	1.1E-4	2E-8
^{137}Cs	1.23E+2	1.23E+2	1.5E+1	1.0E-3	1.0E-3	1.0E-3	2E-7
^{144}Ce	b	b	4.0E-4	4.0E-4	4.0E-4	4.0E-4	1E-6

* In $\mu\text{Ci/ml}$ as of February 1982 based on actual samples

^a Not quantifiable by gamma spectroscopy due to overall sample activities.

TABLE 3.2
Actual activity concentrations* in SDS process streams
after 200 bed volumes through each zeolite bed
(Based on continuous flow through two zeolite columns)

RCS Processing

Nuclide	Feed	Filter	Effluent concentrations, * $\mu\text{Ci/ml}$.		
			Zeolite columns		
			First	Second	Sand Filter
^{60}Co	$<2.0\text{E-}3$	$2.2\text{E-}3$	$1.2\text{E-}3$	$<1.6\text{E-}4$	$<2\text{E-}4$
^{90}Sr	3.4	3.1	0.084	$2.8\text{E-}3$	$3.0\text{E-}3$
^{106}Ru	$2.3\text{E-}2$	$<2\text{E-}2$	$<5.2\text{E-}3$	$<1.5\text{E-}3$	$<1.7\text{E-}3$
^{125}Sb	0.16	0.15	0.15	0.14	0.15
^{134}Cs	0.025	0.023	$1.2\text{E-}3$	$<1.1\text{E-}4$	$<1.2\text{E-}4$
^{137}Cs	0.56	0.51	$3.0\text{E-}2$	$<1.7\text{E-}4$	$<1.6\text{E-}4$
^{144}Ce	$<1.2\text{E-}2$	$<1.2\text{E-}2$	$<4.5\text{E-}3$	$<1.8\text{E-}3$	$<2.0\text{E-}3$

* In $\mu\text{Ci/ml}$ as of June 1984 based on actual samples

" Not quantifiable by gamma spectroscopy due to overall sample activities.

Submerged Demineralizer System Design Basis

4.1 Introduction

The Submerged Demineralization System (SDS) is an underwater ion-exchange system which has been specifically designed to process higher-level waste waters*, with inherent system features for reduction of occupational and environmental exposures. The SDS is submerged in the spent fuel pool (1) to provide shielding during operation, (2) to permit access to the system during demineralizer changeout, (3) to minimize the hazard from potential accidents, and (4) to utilize an existing Seismic Category I facility. In conjunction with the SDS, the EPICOR-II system may be used to provide final polishing of the SDS effluent water for removal of trace quantities of radionuclides.

Design features for SDS include:

1. A prefilter and final filter in series, followed by two parallel trains of 2 or 3 zeolite ion-exchangers in series. These ion-exchangers are followed by two "cation" sand filters in parallel followed by the EPICOR-II equipment. This combination of filters and ion-exchangers achieves the desired process flow rates and decontamination factors (DF's).

*Higher-level waste waters are those contaminated waters having gross activity concentrations in excess of 100 $\mu\text{Ci/ml}$.

2. Series operation logic that allows for sequencing the demineralization units to prevent activity breakthrough in the final zeolite bed and maximize activity loading on spent beds to accomplish the best possible activity concentration.

The design objectives are as follows:

- a. A totally integrated system that is as independent as possible from existing waste systems at the Three Mile Island plant. The SDS is a temporary system for the recovery of TMI-2.
- b. A system that has the capability to reduce the fission product concentration in the contaminated water and has optional capabilities for removing chemical contaminants to permit future disposition of the concentrated waste form.
- c. A system that could be operated with a minimum of exposure to personnel and a negligible risk to the public.
- d. A system that could accomplish the objective listed above in a timely and cost effective manner.
- e. A system that incorporates known and demonstrated processing equipment, materials and techniques. (EPICOR-II)

4.2 Components of the SDS Waste Processing System

The SDS is comprised of the following components, all of which will be located in the Unit 2 B fuel pool, or in the near vicinity of the B fuel pool. (See Figure 5.6, General Layout Plan.)

1. Feed filtering system;
2. Two parallel ion exchange trains, each comprised of two or three 10-cubic-foot vessels loaded with 8 cubic-feet (nominal) of homogeneously mixed IE-96 and LINDE-A zeolite exchange media;
3. Two parallel "cation" sand filters containing graded sand filter media;
4. A monitoring and sampling system for control of demineralizer unit loading;
5. A secondary containment system for the filters and zeolite beds and radiation shielding for piping, valves, sampling, and monitoring systems;
6. Two monitoring tanks for collecting treated water.
7. An off-gas system for treating and filtering gases and vent air from the system;

8. A Liner Recombiner and Vacuum Outgassing System (LRVOS) designed to eliminate the potential of a combustible hydrogen and oxygen mixture existing in the SDS liners.
9. Associated piping, valving, and structural supports required for placement of system components;
10. Auxiliary systems including underwater ion-exchange column storage, a dewatering system, and analytical equipment;
11. Vent system to allow for venting of stored vessels.

The EPICOR-II system is downstream of the SDS process flow stream for removal of trace fission products that are not removed in the ion exchange media of the SDS.

4.3 Submerged Demineralizer System Design Criteria

4.3.1 Design Basis

Regulatory guidance followed during the design of the Submerged Demineralization System was extracted from the following documents:

- o U.S. Nuclear Regulatory Guide 1.140 dated March, 1978
- o U.S. Nuclear Regulatory Guide 1.143 dated July, 1978

- o U.S. Nuclear Regulatory Guide 8.8, dated June, 1978
- o U.S. Nuclear Regulatory Guide 8.10, dated May, 1977
- o U.S. Nuclear Regulatory Guide 1.21 Revision 1, June 1974
- o Code of Federal Regulations, 10 CFR 20, Standard for Protection Against Radiation
- o Code of Federal Regulations, 10 CFR 50, Licensing of Production and Utilization Facilities.

4.3.2 Process

The design shall provide for operations and maintenance in such a manner as to maintain exposures to plant personnel to levels which are "as low as is reasonably achievable", in accordance with Regulatory Guide 8.8.

4.3.3 Performance

The isotopic inventory for the water to be processed is summarized in Table 1.1. The SDS followed by the EPICOR-II systems is designed and operated such as to reduce the average isotopic specific activity of the treated waste streams. The expected performance of these systems is given in Table 3.2.

4.3.4 Capacity

Flow Rate - 5 to 30 GPM (up to 15 GPM per train). The system will have the ability to operate continuously, (subject to periodic maintenance shutdown).

4.3.5 Performance and Design Requirements

The following system requirements have been incorporated into the design of the SDS.

- o Leak Protection and Containment
- o Shielding (Beta, Gamma)
- o Ventilation
- o Functional Design and Maintainability
- o Criticality Concerns
- o Decontamination - Decommissioning

4.3.6 Piping System (piping, valves and pumps)

1. The mechanical and structural design criteria and fabrication of piping systems and piping components are specified in ANSI B31.1, 1977 Edition with Addendum through Winter 1978 or ANSI B31.1, 1980 for components added after 1980, and Table 1 of Regulatory Guide 1.143.
2. Piping system design shall be based on a maximum of 150 psi at 100°F.

3. Piping runs are generally designed to permit water flushing.
4. Instrument connections to piping systems are located to provide clearance for attachment, operation and maintenance.

4.3.7 Vessels and Tanks

1. The mechanical and structural design criteria and fabrication of vessels and tanks will be in accordance with the requirements of the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1, 1977, Addendum through Winter 78.
2. The vessels shall be of two types:
 - a. Primary ion-exchangers shall contain approximately eight (8) cubic feet of zeolite ion exchange media for the purpose of removing cesium and strontium from the waste water. Should our processing scenario be changed it may be necessary to alter the volume of the zeolite media. Should changes occur, the NRC will be informed.

- b. Influent and "cation" sand filter units are planned to contain cartridge type filter assemblies or sand capable of removing particles greater than approximately 10 microns. SDS effluent filter capability has been provided to incorporate the capability to filter out ion-exchange media fines from the process stream should fines carryover occur.
- 3. The SDS ion-exchangers and filters shall be capable of functioning submerged under approximately 16 feet of water within the spent fuel pool.
- 4. The ion-exchangers shall be designed for 15 GPM nominal process rate, filters shall be designed for 50 GPM nominal; volume velocity through the loaded ion-exchangers shall be limited to prevent channeling or breakthrough.
- 5. Pressure loss through the ion-exchangers should not exceed 15 psi when operating at 5 GPM with clean resins.
- 6. The ion-exchangers shall be equipped with a lifting arrangement compatible with the spent fuel pool crane to permit movement of the vessels in the pool.
- 7. The 10-cubic-foot vessels will be equipped with all required nozzles, including inlet, outlet, vent connections, and fill and sluicing connections.

8. Each ion-exchanger shall be equipped with all internals required for media distribution, dewatering, and venting.

9. Design Condition

- a. The 10-cubic-foot vessels will be compatible with the piping design conditions of 150 psig at 100°F. The vessel design conditions for continuous operation will be, at least, equivalent to the piping design conditions.
- b. The following additional design conditions have been imposed:
- o Overall Height 54 1/2 inches
 - o Overall Diameter 24 1/2 inches
 - o Materials Stainless Steel
 - o Weight will have negative buoyancy
 (loaded with ion-exchange media)

10. Testing

The vessels shall be hydrostatically tested at 1.5 times the design pressure per ASME Section VIII.

4.3.8 Shielding Design

The shielding shall be designed to reduce levels resulting from the SDS to less than 1mR/hr, general area. The shielding for the EPICOR-II equipment is adequate for the processing of the SDS effluent because the SDS effluent water activity will be lower than the activity level of the water for which EPICOR-II shielding was originally designed.

4.3.9 Leakage

To minimize the operational impact of activity that can potentially leak from bad process connections to Fuel Pool B, SDS vessels are contained in secondary containment enclosures. Pool water is continuously drawn through these enclosures and passed through separate ion exchangers (Leakage containment). This design prevents the pool water from eventually attaining high level concentrations of radionuclides. Monitoring of potential leakage is accomplished through the established SDS Sampling System.

4.3.10 Building and Auxiliary Service Interfaces

The SDS has been designed to meet the following building interface requirements.

1. All components of the SDS located in the Fuel Handling Building do not exceed the normal load capacities of the cranes in this area. The Fuel Handling Building auxiliary and main cranes have capacities of 15 tons and 110 tons, respectively.
2. The SDS will operate in the ambient conditions of the Fuel Handling Building as supplied by the building heating, ventilating and air conditioning system, and lighting system.
3. Auxiliary services supplied to the SDS are from the Demineralizer Water, Electrical Distribution, Instrument Air and Service Air Systems.
4. During installation of the system, no equipment was permanently attached to the fuel pool liner and no penetrations were made in the fuel pool liner.
5. Structural support for the system will be designed to take the dynamic and static loads associated with the normal operation of the system.

4.3.11. Controls and Instrumentation

4.3.11.1 General System Description

1. The control and instrumentation systems shall be designed to control and monitor the various normal process functions throughout the system and will permit a safe, orderly shutdown of the system.
2. The controls and instrumentation systems will enable the operators to perform the designated functions efficiently and safely.
3. Where portions of the process must be operated remotely, sufficient instrumentation shall be included to assure safe operation and permit analysis of a process upset or remote detection of equipment malfunction.
4. Control and instrumentation systems shall be categorized as: (1) controls and instrumentation systems essential for the maintenance of process fluid confinement, and (2) process controls instrumentation systems essential for the determination of process operating parameters.

5. Radiation monitoring and surveillance instrumentation essential for the protection of operating personnel, the public and the environment is provided.

4.3.11.2 Performance and Design Requirements

1. Remote controls and instrumentation shall have provisions for remote connection of electrical leads.
2. Alarms and/or indicators are provided for adequate surveillance of process operation.
3. Process-connected instrumentation shall be constructed of material compatible with that used for the construction of the process equipment.
4. Electrical wiring shall be designed in such a manner as to minimize noise and spurious signals.
5. Instrumentation identification and numbering should follow the standards and practices of the Instrument Society of America (ISA).
6. Radiation monitors shall be provided for the detection of gamma radiation. In-line radiation monitors were installed to monitor beta radiation, however to date have not been used or maintained, nor are they planned to be.

7. Specific instruments shall be designated to function in a fail-safe mode and will alert to a failure condition.

4.4 System Operational Concepts

The following is a summary operation description. This operating sequence depicts the processing scenario as currently planned and could be changed based on operating experience.

The SDS process logic as currently planned, is based on the following steps:

1. Ion-exchanger units will be preloaded with new ion exchange media prior to placement in the system. The ion exchanger units will utilize a homogeneous mixture of zeolite media.
2. Water will be introduced to fill and vent the ion-exchange units.
3. These preloaded SDS ion-exchange units will be lowered into the Unit 2 spent fuel pool and placed in the containment enclosures.
4. Inlet and outlet header connections will be made to the ion-exchange units.
5. The ion-exchange system isolation valves will be opened and treatment of the contaminated waste stream will begin at low flow rates until system integrity and acceptable out water quality are verified.

6. The flow rate to the ion-exchange units will be increased on a gradual basis until the desired operational flow rate is achieved.
7. When the first ion-exchange bed becomes depleted, the unit will be flushed with processed water to ensure that radioactive waste water in the system piping is purged prior to disconnecting the quick disconnects on the demineralizer unit.
8. The ion-exchange unit will be decoupled remotely via the use of quick disconnects and will be stored in the spent fuel pool. However, loading directly into a cask prior to shipment is possible.
9. After the first ion-exchange unit has been removed, the second ion exchange unit will be placed into the position of the first unit, and the third ion exchange unit will be moved to the second position. A new ion-exchange unit will be installed in the third position. In some instances fewer than three (3) ion-exchange units will be required to achieve the desired decontamination factors. In these cases, jumpers will be installed to bypass the unused positions.

System Description and Arrangement

5.1 Demineralizer System

5.1.1 Influent Water Filtration

A flow diagram of the waste water influent system is shown in Fig. 5.1. Contaminated water is pumped into the SDS from the containment sump, the RCS, the fuel transfer canal, or liquidwaste (WDL) tanks. The containment sump will employ the presently installed SWS-P-1 pump (jet pump).

Two filters have been installed to filter out solids in the untreated contaminated water before the water is processed by the ion-exchangers. These filters will be either cartridge or sand type. The cartridge filter elements are protected by 3/16 inch perforated metal plate serving as a roughing screen. The prefilter has 125 micron filter cartridges to remove debris and suspended solids from the contaminated water. The design of the final filter is similar to the prefilter except that the filter cartridge is designed for removal of suspended solids of greater than 10 microns in size from the contaminated water. The two sand filters are loaded in layers. The first layer is 200 pounds of 0.35 mm sand and the second layer is 700 pounds of 0.45 mm sand. Borosilicate

glass with a normal Boron content of 22% is added uniformly through the sand to prevent potential criticality. The flow capacity through each filter is 50 gpm. Reverse flow through filters is prevented by a check valve in the supply line to each filter.

Each filter is housed in a containment enclosure to enable leakage detection and confinement of potential leakage. The filters are submerged in the spent fuel pool for shielding considerations.

Influent waste water may be sampled from a shielded sample box located above the water level to determine the activity of contaminated water prior to and following filtration.

Inlet, outlet, and vent connections on the filters are made with quick disconnect valved couplings which are remotely operated from the top of the pool. Inlet-outlet pressure gauges are provided to monitor and control solids loading. Load limits for the filters are based on filter differential pressure, filter influent and effluent sampling, and/or the surface dose limit for the filter vessel. A flush line is attached to the filter inlet to provide a source of water for flushing the filters prior to removal.

5.1.2 Ion Exchanger Units

A flow diagram of the ion exchange manifold and primary ion-exchange columns is shown in Fig. 5.2. This system consists of six underwater columns (24 1/2 in. x 54 1/2 in.), each containing eight cubic feet of homogeneously mixed Ion Siv IE-96 and LINDE-A zeolite media and two underwater columns containing sand filter media. The six zeolite beds are divided into two trains each containing three beds (A, B, C.) with piping and valves provided to operate either train individually or both trains in parallel.

The effluent from the first parallel train of three zeolite beds flows through either of the "cation" sand filters. Jumpers are provided to permit fewer than four (4) vessel per train operation. An in-line radiation monitor measures the activity level of the water exiting the cation exchanger. The valve manifold for controlling the operation of the primary ion exchange columns is located above the pool, inside a shielded enclosure that contains a built-in sump to collect leakage that might occur. Any such leakage is routed back to the RCS manifold. A line connects to the inlet of each primary exchanger to provide water for flushing the exchangers when they are loaded. Radionuclide loading of ion exchange vessels is determined by analyzing the influent and effluent from each exchanger. Process water flow is measured by instruments placed in the line to each ion-exchange train.

When processing containment sump water, effluent from the SDS is directed to the EPICOR-II polishing unit, if desired. When the SDS is to be utilized to process reactor coolant, the effluent can be valved into the RCS clean-up manifold then back into the Reactor Coolant System via installed tankage, bypassing EPICOR-II.

5.1.3 Leakage Detection and Processing

Each submerged vessel is located inside a secondary containment box that contains spent fuel pool water. During operation the secondary containment lid is closed. This lid is slotted to permit a calculated quantity of pool water to flow past the vessels and connectors. Pool water from the containment boxes is continuously monitored to detect leakage and is circulated by a pump through one of the two leakage containment ion-exchangers (See Figure 5.2). Any leakage which occurs during routine connection and disconnection of the quick-disconnects will be captured by the containment boxes, diluted by pool water, and treated by ion-exchange before being returned to the pool.

5.1.4 EPICOR-II

EPICOR-II (Figure 5.3) can provide final treatment of water after the water is processed through the SDS. When processing containment sump water, the processing plan is to polish with EPICOR-II. When processing RCS water, EPICOR II may be used

as necessary to remove Antimony 125 before being returned to RCS (prior chemical adjustment will be required). EPICOR-II consists of filters, ion-exchangers and receiver tanks. The purpose of EPICOR-II is to remove trace fission products they may be present in the water. The EPICOR-II safety assessment is provided in NUREG-C591.

5.1.5 Monitoring Tank System

Effluent from the SDS ion-exchanger can flow into one of two monitoring tanks (Figure 5.4) or in the case of RCS processing, directly to one of three RCBT's. The purpose of the monitoring tank system is to collect treated water. Each monitor tank is equipped with a sparger and tank level indicators that will automatically shut the inlet to the tank should a high level condition exist. Water in the monitoring tanks can be transferred back for reprocessing by SDS or used as flush water in the SDS, or directed to existing tankage.

5.1.6 Off-Gas and Liquid Separation System

An off-gas and liquid separation system collects gaseous and liquid wastes resulting from the operation of the water treatment system. The off-gas system is illustrated in Figure 5.5. Gaseous effluent lines from the ion exchange vessels, sampling glove boxes and shielded valving manifolds are connected to the off-gas system. Gaseous effluent is passed through a mist eliminator in the off-gas separator tank before being treated by an electric off-gas heater to reduce the

off-gas relative humidity to 70%. A roughing filter and two HEPA filters are provided for further treatment. Air is moved through the system by a centrifugal blower rated at 1000 cfm. The discharge of this blower will be monitored and routed to the existing Fuel Handling Building HVAC system. Moisture collected by the off-gas system and waste returned from the continuous radiation monitoring system is directed into a separator tank. At the top of the tank a mist eliminator separates moisture from effluent gas prior to the gas entering the off-gas treatment system. The tank is located in the surge pit and is covered with a concrete and lead shield. The level in the tank will be indicated and controlled manually to return collected water to the RCS manifold for reprocessing. Offgassing of the RCBT's during processing of the RCS to the RCBT's is handled by established station procedures involving the Waste Gas Decay Tanks. Discharge from these tanks is filtered through HEPA filters before being released through the station vent.

5.2 Sampling and Process Radiation Monitoring System

The sampling glove boxes are shielded enclosures which allow water samples to be taken for analysis of radionuclides and other contaminants. The piping entering the glove boxes contains cylinders that permit draining a predetermined amount of sample into a collection bottle. Cylinders are purged by positioning valves to permit the water to flow through them and return to a waste drain header and into the off-gas separator tank. A water line connects to the inlet of the sample cylinders to allow the line to be flushed after a sample has been taken.

5.2.1 Sampling System

Sampling of the SDS process to monitor performance is accomplished from three shielded sampling glove boxes. One glove box is for sampling the filtration system, the second is for sampling the feed and effluent for the first zeolite bed if there is significant breakthrough of the first zeolite bed and the third for sampling the effluents of the remaining zeolites beds.

The entire sampling sequence is performed in shielded glove boxes to minimize the possibility of inadvertent leakage and spread of contamination during routine operation.

5.2.2 Process Radiation Monitoring System

The SDS is equipped with a process radiation monitoring system which provides indication of the radioactivity concentration in the process flow stream at the effluent point from each ion exchanger vessel. The purpose of this monitoring system is to provide indication and alarm of radionuclide breakthrough of the ion exchange media.

5.3 Ion-Exchanger and Filter Vessel Transfer in the Fuel Storage Pool

Prior to system operation, ion exchanger and filter vessels are placed inside the containment boxes and connected with quick-disconnect couplings. When it is determined that a vessel is loaded with

radioactive contaminants to predetermined limits as specified in the Process Control Program, the system will be flushed with low-activity processed water. This procedure flushes away waterborne radioactivity, thus minimizing the potential for loss of contaminants into the pool water while decoupling vessels. Vessel decoupling is accomplished remotely. Vessels are transferred using the existing fuel handling crane utilizing a yoke attached to a long shaft. The purpose of this yoke-arm assembly is to prevent inadvertent lifting of the ion exchange bed or filter vessel to a height greater than eight feet below the surface of the water in the pool. This device is a safety tool that will mechanically prevent lifting a loaded vessel out of the water shielding and preclude the possibility of accidental exposure of operating personnel.

The ion-exchange vessels are arranged to provide series processing through each of the beds; the influent waste water is treated by the bed in position "A", then by the bed in position "B", then by the bed in position "C" and finally either of the "cation" sand filters "A" or "B". The first vessel in each train (position A) will load with radioactive contaminants first. The loaded vessel will then be stored until transfer to a shielded cask. At no time during the operation of the system will a loaded vessel be taken out of the pool before it has been placed in a shielded cask. The loaded cask will be transferred from the pool with the overhead crane.

5.4 Arrangement of the Water Treatment System in the Fuel Storage Pool

Figure 5.6 illustrates the arrangement of the SDS in the fuel storage pool (viewed from above). The filters, and zeolite ion exchanger vessels, are located underwater in containment enclosures in the "B" spent fuel pool. These enclosures and the exchangers are supported along one side of the pool on a structural steel rack that is attached to the pool curb. The racks act as a support for the system and also provides an operating platform from which the remote connections can be made. The off-gas system is mounted on the curb near the surge tank area.

A dewatering station is located in the "B" SFP cask pit below the water level and is used for displacing the water from expended columns and filters and dewatering them prior to placement in the cask. An underwater storage rack, designed to handle 60 expended vessels is located in the pool. This storage capacity allows processing to continue without interruption due to handling operations or vessel disposal or shipping. Stored IX vessels will be vented via a common header connecting to the liquid separation module to continually vent gas byproducts that may be generated in the vessels during storage.

5.5 Liner Recombiner and Vacuum Outgassing System (LRVOS)

The Liner Recombiners and Vacuum Outgassing System (LRVOS) is designed to eliminate the potential of a combustible Hydrogen and Oxygen mixture existing in the SDS Liners. This will facilitate the ultimate shipment and burial of the SDS Liners.

The LRVOS will perform the following operations while maintaining the normal operating depth of water between the operators and the SDS liner.

1. Reduce water in the SDS liner using vacuum outgassing to ensure enhanced operation of the recombiner catalyst.
2. Allow sampling of the liner gas at atmospheric pressures.
3. Provide capability to inert the SDS Liner with Argon or N_2 to approximately 10 psig prior to tool removal. This will prevent any water intrusion during tool decoupling.
4. Provide a means to remotely insert the recombiner catalyst into the SDS liner vent port. The catalyst is retained inside the liner by the internal vent port screen.
5. Provide sufficient recombiner catalyst to recombine the hydrogen and oxygen produced by radiolysis of the water remaining in the liner.

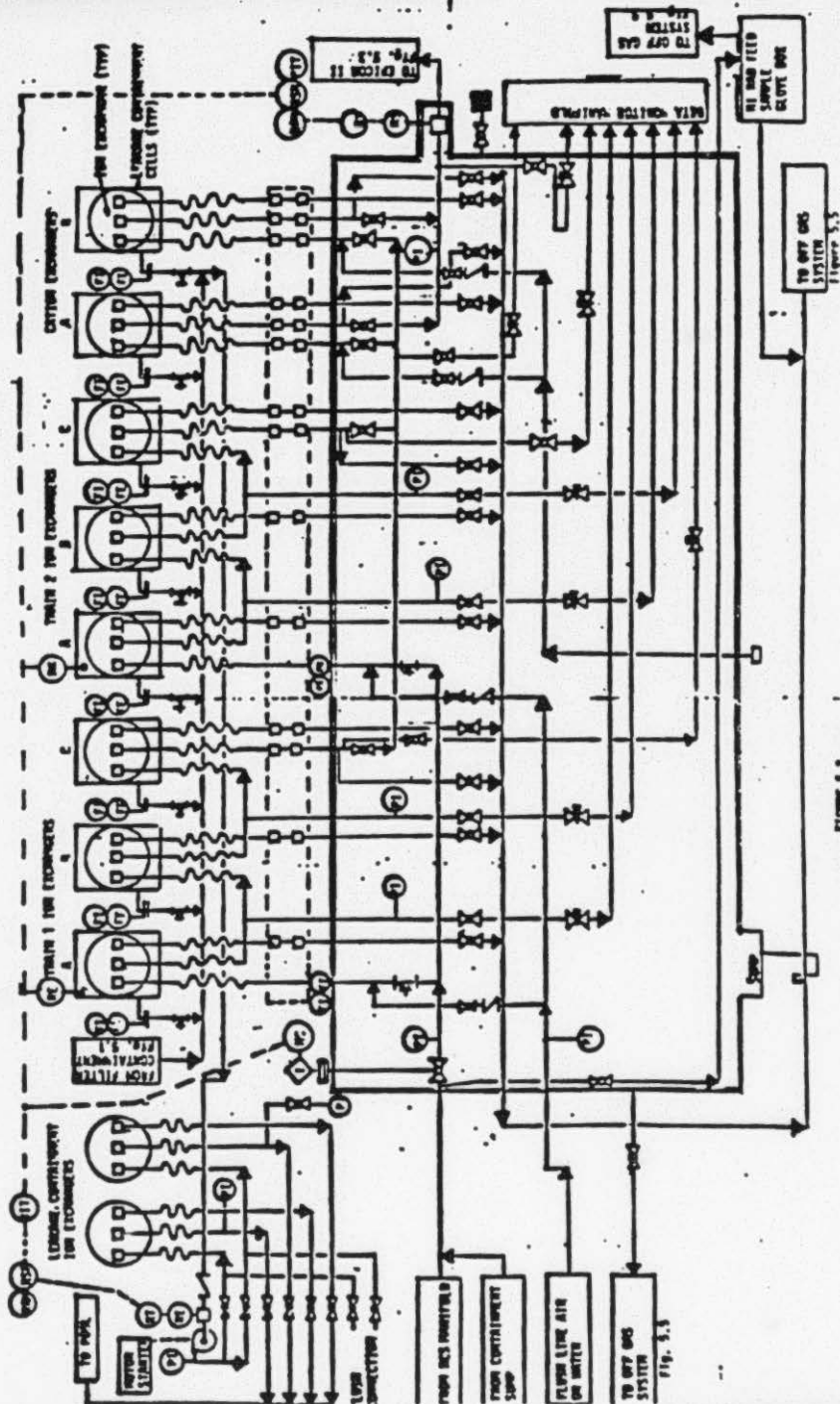
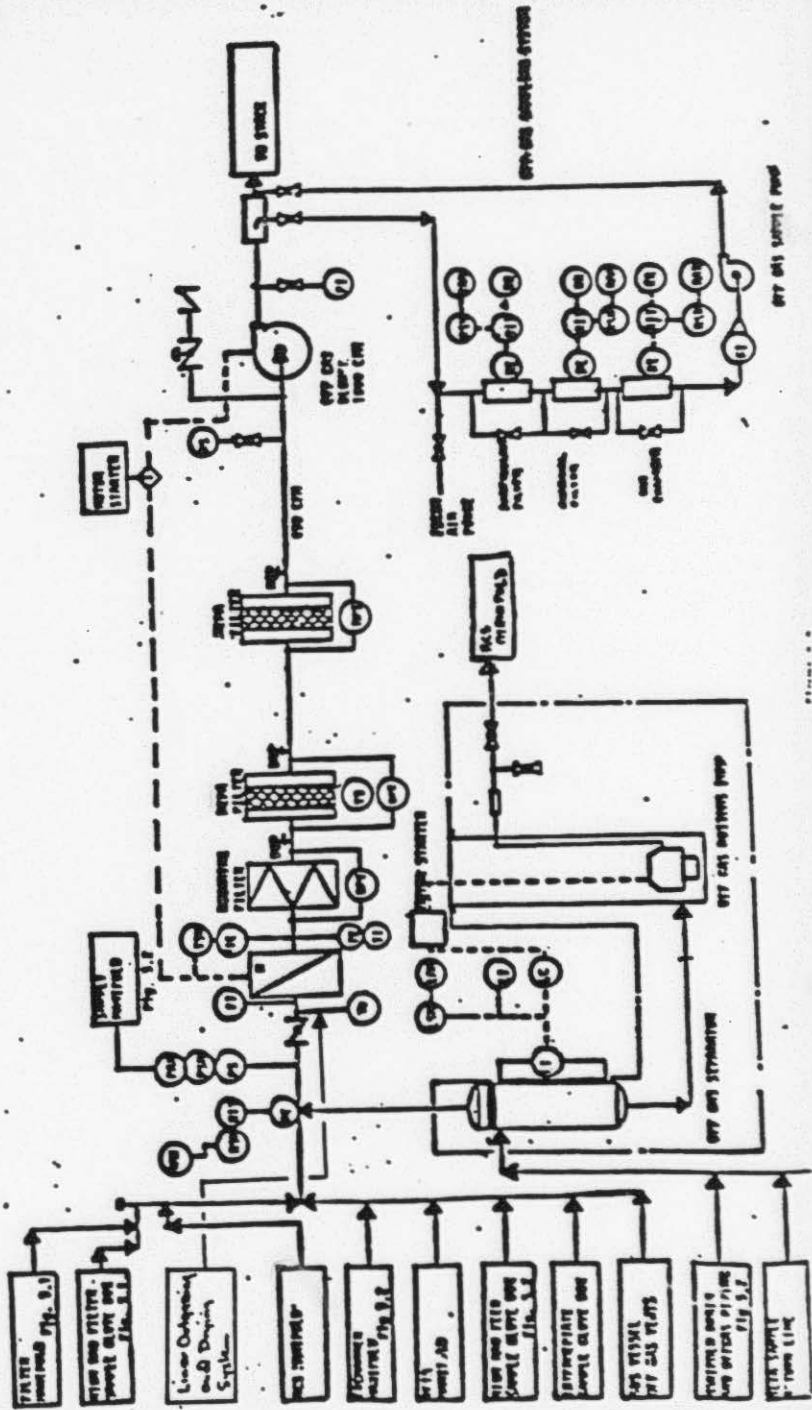


FIGURE 5.2
GAS CHROMATOGRAPH



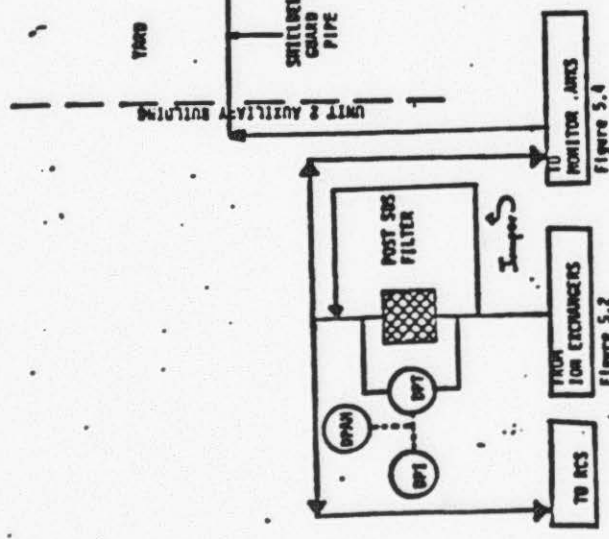


Figure 5.2

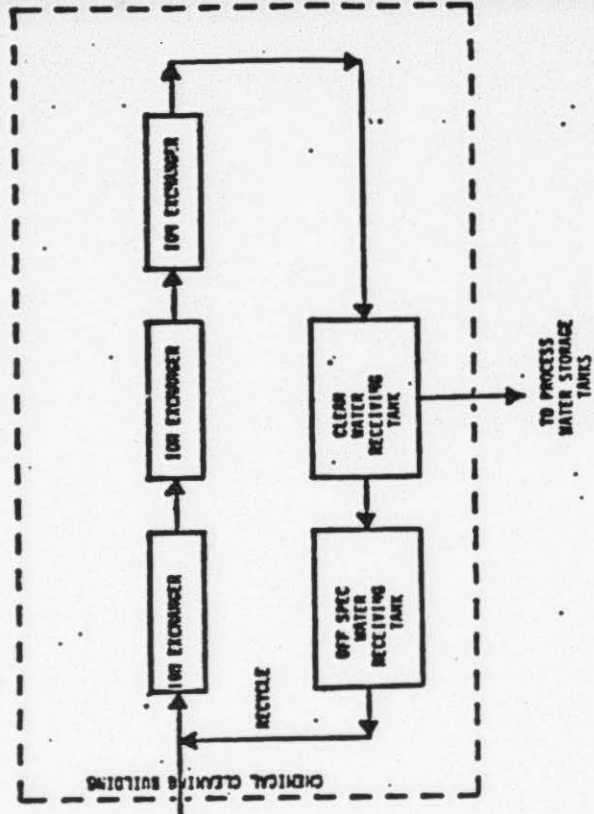


Figure 5.4

Chapter 6

Radiation Protection

6.1 Ensuring Occupational Radiation Exposures are ALARA

6.1.1 Policy Considerations

The objectives with respect to SDS operations are to ensure that operations conducted in support of the on-going demineralization program are conducted in a radiologically safe manner, and further, that operations associated with radiation exposure will be approached from the standpoint of maintaining radiation exposure to levels that are as low as reasonably achievable.

During the operational period of the system, the effective control of radiation exposure will be based on the following considerations:

1. Sound engineering design of the facilities and equipment.
2. The use of proper radiation protection practices, including work task planning for the proper use of the appropriate equipment by qualified personnel.

3. Strict adherence to the radiological controls procedures as developed for TMI-2.

6.1.2 Design Considerations

The SDS was specifically designed to maintain exposure to operating personnel to as low as reasonably achievable. To implement this concept the components carrying high level activity water will be provided with additional shielding or are submerged in the spent fuel pool. Shielding has been designed to limit whole body exposure rates in operating areas to approximately 1 mR/hr. In addition, components carrying high level process fluids have been designed for exhaust to the SDS off-gas system. This method of off-gas treatment will minimize the potential for airborne releases in the work areas.

The specific design features utilized in meeting this requirement are discussed in detail in Section 6.2.1.

6.1.3 Operational Considerations

The system design reflects the following operational ALARA considerations:

1. Exposure of personnel servicing a specific component on the SDS will be reduced by providing shielding between the individual components that constitute substantial radiation sources to the receptor.
2. The exposure of personnel who operate valves on the SDS will be reduced through the use of reach rods through lead and steel shield boxes.
3. Controls for the SDS will be located in low radiation zones.
4. Airborne radioactive material concentrations will be minimized by routing the off-gas effluent from the SDS to the IMI ventilation system for further treatment.
5. The sampling stations for the feedstream and filters that contain high levels of radioactive materials will be exhausted through the SDS ventilation system.
6. All sampling is performed in shielded glove boxes to minimize the possibility of inadvertent leakage and spread of contamination during routine operation.

6.2 Radiation Protection Design Features

6.2.1 Facility Design Features

The system is designed to take maximum advantage of station features already in place and operational in terms of protection of the public. In addition, design features provided by the system are intended for the reduction of releases of radioactive material to the environment. The following features provide for protection of individuals from radiological hazards during normal operations from external exposure and unanticipated operational occurrences, such as spills.

1. The SDS primary demineralization units are housed under approximately 16 feet of shielding water in the TMI-2 spent fuel pool.
2. The entire process and all equipment is housed in the Auxiliary and Fuel Handling Buildings which are Seismic Category I structures with air handling and ventilation systems designed to mitigate the consequences of radiological accidents.
3. The system is designed in such a manner as to allow zero discharge of liquid effluents. The effluent processed water will be stored on the TMI site until final disposition has been determined.

4. The off-gas system effluent will be filtered and monitored before input to existing ventilation exhaust systems.
5. Filters, primary ion-exchange beds, "cation" sand filters, and their associated couplings are operated in containment devices. Each containment device is connected to a pump manifold and a continuous flow of approximately 10 GPM is maintained through each containment. The combined flow from the containment enclosures is then processed through a separate ion exchange column and then discharged back to the spent fuel pool.
6. Loaded vessels will be placed in a shielded cask underwater.
7. To the extent possible all-welded stainless steel construction is specified to minimize the potential for leakage.
8. Lead or equivalent shielding is provided for pipes, valves, and vessels (except those located under water) where necessary for personnel protection.
9. Design of a sequenced multi-bed process - three (3) beds in series to preclude breakthrough and contamination of the outlet stream.

10. The entire process stream is designed with appropriate pressure indicators.
11. Inlet, outlet and vent connection are made with remote operated-valved quick release couplings.

6.2.2 Shielding

The minimum shielding thickness required for radiological protection has been designed to reduce levels in occupied areas to less than 1 mR/hr. Operating panels and instrumentation racks are located away from potential sources of radiation or adequate shielding is provided to meet radiological exposure design limits.

All movements of the vessels out of the fuel pool will be performed utilizing a shielded transfer cask.

6.2.3 Ventilation

The ventilation and off-gas system provided to service the SDS is designed to minimize airborne radiological releases to the environment. Among these design features are:

1. Manual level controlled off-gas separator tank with mist eliminator to receive vent connections from the ion exchange and filter vessels, sample glove boxes, piping manifolds, and the dewatering station.

2. Roughing filter with differential pressure indication.
3. Two HEPA filters with differential pressure indication.
4. A centrifugal off-gas blower with flow indication.
5. Sample ports for monitoring the system and DOP test ports for HEPA testing.
6. The effluent of the SDS off-gas system is routed to the existing TMI-2 ventilation system exhaust, which is filtered again through the Fuel Handling Building exhaust HEPA filters prior to discharge from the plant.

6.2.4 Area Radiation Monitoring Instrumentation

General area radiation monitors have been provided which will be utilized to alert personnel of increasing radiation levels during normal operations or maintenance activities.

6.3 Dose Assessment

6.3.1 On-site Occupational Exposures

Normal Operation

During the operation of the Submerged Demineralization System, there are operations that involve occupational exposures, but precautions have been taken in the design stage to minimize personnel exposures. Major operational activities involving such exposures are as follows:

- A. Sampling operations
- B. System start-up valve alignment
- C. Spent vessel changeout
- D. Cask removal, decontamination and survey operations
- E. System maintenance
- F. Vessel dewatering

Decommissioning

The SDS detailed decommissioning plan is being developed in conjunction with the operating procedures for the system. However, the modular design of the system is conducive to disassembly while minimizing exposure to personnel.

6.3.2 Off-site Radiological Exposures

Source Terms for Liquid Effluents

Liquid effluent from the system will be returned to station tankage for further disposition, therefore, no liquid source term is required for this report.

Radiological source terms for potential environmental releases are dependent on the processing schedule proposed for SDS and/or EPICOR-2. Review of this schedule shows that from the present (4/84) until the end of defueling, SDS, and possibly also EPICOR-2, will be dedicated to processing of RCS. Up to this time EPICOR-2 has not been used for RCS processing, but recent elevations in the Sb-125 concentration in the RCS may necessitate the use of EPICOR-2 to remove this contaminant. The assumption made here for potential source term generation purposes is that both SDS and EPICOR-2 will be dedicated to processing RCS. Miscellaneous small batches of liquid waste may be processed by EPICOR-2, but would be infrequent since liners dedicated for RCS more than likely could not be used for other waste streams.

Experience with previous operations within the RCS show that minor disturbances within the reactor vessel give rise to increased concentrations of a select number of isotopes which become candidates for potential releases to systems involved

In RCS decontamination and therefore, potentially to the environment. A history of concentrations of the major radiologically significant isotopes with time is shown in Figure 6-1. Not reflected in this figure are the increases in Ce-144 and alpha concentrations that accompany disturbances within the RCS. Sample analysis results, tabulated below, show typical concentrations resulting from RCS disturbances.

Radiochemistry Analysis Results

for RCS Sample of 4/9/84

(Sample #84-04966)

<u>Isotope</u>	<u>Concentration</u>	
	<u>($\mu\text{Ci/ml}$)</u>	<u>Uncertainty</u>
Ag-110m	$<1.5\text{E}-2$	
Ce-144	$1.1\text{E}+0$	$4.0\text{E}-2$
Co-60	$1.7\text{E}-1$	$1.0\text{E}-2$
Cs-134	$2.3\text{E}-1$	$1.0\text{E}-2$
Cs-137	$4.9\text{E}+0$	$4.2\text{E}-2$
Ru-106	$3.2\text{E}-1$	$5.8\text{E}-2$
Sb-125	$5.5\text{E}-1$	$3.1\text{E}-2$
gross α	$1.2\text{E}-3$	$6.1\text{E}-4$
gross β	$1.9\text{E}+1$	$2.6\text{E}-1$
H-3	$3.5\text{E}-2$	2.2%
Sr-90	$9.9\text{E}+0$	35%

The increased concentration of Ce-144 and associated alpha activity is expected for RCS disturbances and is due to a colloidal suspension of finely divided fuel fines resulting from the accident. Concentration elevations of alpha bearing activity, and Ce-144, are projected to be much more significant than reflected in the table above. Short term concentration spikes may increase a factor of 10^1 or more depending on operations in the R.V.. However, for purpose of

potential source term generation, these time averaged concentrations are assumed to be as tabulated above except for tritium which remains fairly stable at 0.04 $\mu\text{Ci/ml}$, neglecting radioactive decay.

Source Terms for Gaseous Effluents

When the SDS Technical Evaluation Report was originally written a methodology was conceived for the definition of gaseous effluent source terms resulting from SDS/EPICOR-2 processes. This methodology used defendable, but highly conservative assumptions for defining gaseous effluent source terms. Since the beginning of SDS operation in August 1981, a significant amount of operating experience has yielded effluent data that allows more reasonable gaseous effluent source terms. The effluent data applicable to the EPICOR-2 and SDS operations is reviewed in the following section for purposes of arriving at gaseous source terms appropriate to the proposed future operations of these two systems.

A review of the 6/83 version of the SDS TER shows that, according to Table 6.2, the following quantities of the applicable isotopes would have been released to the environment over the previous 27.5 months of SDS operation through the off-gas system had the release values been correct.

<u>Isotope</u>	<u>Quantity (μCi)</u>
H-3	5.20 x 10 ⁴ μCi
Sr-90	11.5 μCi
I-129	4,125 μCi
Cs-134	31.6 μCi
Cs-137	280 μCi

Review of these values against airborne effluent release reports, shows the projected releases from the SDS off-gas system to be highly conservative. Because the data applicable to the SDS Off-Gas system has been reduced so that the amount attributable to this system can be separated from other sources, the following sources attributable to the future SDS/Epicor-2 operations are based on previous operations of these systems. Processed water concentrations, the ultimate source of airborne effluent concentrations, for previous operations will differ from water concentrations to be processed in the future. This initial water concentration difference has been factored into the projected release values considered for this evaluation.

SDS Off-Gas System Releases for the Period 09/15/81 to 12/31/83

SDS Off-Gas Particulate & Tritium Releases

Particulate and tritium data as measured by the Off-Gas PING-1A & H-3 bubblers was assembled for the period 9/14/81 to 12/31/83. The total amount of Tritium released through the off-gas system for this period was $7.18\text{E-}1$ Curies.

The total particulates attributed to sampling through the PING-1A at the off-gas system was $3.15\text{E-}7$ curies of Cs-137 and $2.52\text{E-}8$ curies of Cs-134. Cs-134 appeared > LLD on one instance between 12-14-81 and 12-21-81.

The SDS Off-gas system feeds to the exhaust ventilation of the Fuel Handling Building at 1000 cfm. The point of insertion into the Fuel Handling Building exhaust is before the HEPA filters, therefore, no increase in particulate is seen at the station vent. In addition, the Fuel Handling Building exhaust is diluted by a factor of 3 by the time it reaches the station vent.

Table 6.1 lists the dates of positive particulate samples identified as Cs-137.

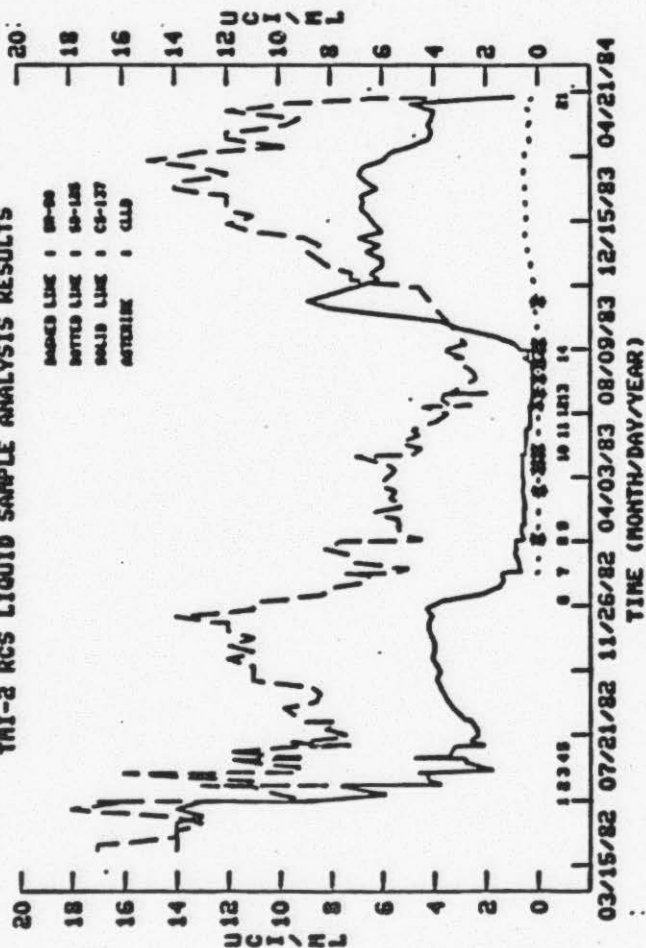
As a condition to startup of SDS, a tritium sampler in the off-gas system was required. A sampling unit which consists of two Fisker-Milligan bubblers in series was installed downstream of the pump of the PING-1A in the SDS off-gas system. The total cumulative curies released through the off-gas system was integrated for the time period 09/14/81 to 12/31/83 and is $7.18\text{E-}1$ curies of tritium. Table 6.2 lists the H-3 curies by month and compares amounts released from the station vent, the SDS amount as a fraction of the Station Vent Release and the curies of H-3 released through EPICOR-2.

Table 6.3 shows environmental release calculations for the proposed RCS processing through SDS and EPICOR-2. The values of column 3 of the table 6.3 are about a factor of 100 lower than would have been estimated by the method of the original SER but are considered to still be conservative. The values in column 3 are the assumed values for the release rate to the environment. The values in column 4 are the concentrations at a downwind distance of 0.5 miles from the station vent, assuming atmosphere dispersion is calculated by the most restrictive data published in NUREG-0683, (Table W-3). The highest value of X/Q from this table is $3.996 \text{ E-6 sec/M}^3$. Using this factor and the dose conversion factor for tritium from Reg. Guide 1.109, an inhalation dose was calculated for the most restrictive recipient, an adolescent. This dose was calculated to be $1.5 \times 10^{-5} \text{ mrem/yr}$.

As shown by the value of summation of the Cx/MPCx at the bottom of column 6, the total maximum yearly average concentration for all the isotopes is 16.5 million times more restrictive than allowable under the guidelines of 10 CFR 20 using the more restrictive of the "soluble"/"insoluble" form of each isotope.

DATE: April 14, 1984

TNI-2 RCS LIQUID SAMPLE ANALYSIS RESULTS



[Each RCS Cleanup Batch "TIER 1" series is marked above the appropriate point on the time axis.

NOTE: BETWEEN 08/01/83 AND 04/11/84, RCS WAS SAMPLED VIA CEN H-8 ORIFICE IN THE REACTOR HEAD, BEFORE AND AFTER, VIA THE THERMAL SECTION SAMPLING LINE.

Table 6.1

Positive Particulate Samples Identified as Cs-137

<u>Dates</u>	<u>Curies of Cs-137</u>	<u>Curies of Cs-134</u>
9-28-81 to 10-5-81	3.17E-9	-
12-7-81 to 12-14-81	1.64E-8	-
12-14-81 to 12-21-81	2.49E-7	2.52E-8
12-21-81 to 12-28-81	2.88E-9	-
1-18-82 to 1-25-82	4.53E-9	-
6-14-82 to 6-27-82	4.46E-9	-
9-20-82 to 9-27-82	6.16E-9	-
9-25-83 to 10-2-83	1.73E-8	-
11-20-83 to 11-27-83	1.09E-8	-
Total	3.15E-7 Curies of Cs-137;	2.52E-8 Curies of Cs-134

Table 6.2
Station Tritium Release Values

Dates	SDS Ping 1A H-3, Ci	Station Vent H-3, Ci	SDS Ping 1A H-3, fraction of Station Vent	EPICOR-II H-3, Ci
9-14-81 to				
9-30-81	2.99E-2	5.24E-1	0.0367	2.91E-1
Oct. 81	5.71E-2	3.25E0	0.0176	1.03E-2
Nov. 81	1.17E-1	1.30E1	0.0090	1.20E-2
Dec. 81	6.64E-2	1.14E0	0.0582	3.10E-2
Jan. 82	5.70E-2	5.77E0	0.0099	3.06E-2
Feb. 82	2.12E-2	1.68E-1	0.1262	5.77E-3
Mar. 82	3.54E-2	3.97E1	0.0009	7.71E-1
Apr. 82	2.72E-2	1.80E0	0.0151	2.30E-3
May 82	1.02E-2	6.31E0	0.0016	1.26E-3
Jun. 82	9.80E-3	3.06E0	0.0032	6.39E-3
Jul. 82	8.50E-3	1.42E0	0.0060	6.58E-3
Aug. 82	2.17E-2	1.40E1	0.0016	1.11E-2
Sep. 82	8.80E-3	1.48E1	0.0006	1.30E-2
Oct. 82	1.38E-2	1.17E1	0.0012	1.33E-1
Nov. 82	2.84E-2	1.88E0	0.0151	6.50E-2
Dec. 82	2.05E-2	1.02E1	0.0020	2.02E-2
Jan. 83	1.44E-2	3.83E0	0.0038	3.00E-2
Feb. 83	1.08E-2	8.04E0	0.0013	1.01E-2
Mar. 83	1.05E-2	3.58E0	0.0029	6.20E-3
Apr. 83	3.00E-2	3.03E0	0.0099	1.02E-3
May 83	7.80E-3	1.61E0	0.0048	3.71E-3
Jun. 83	2.13E-2	1.33E1	0.0016	4.82E-3
Jul. 83	9.50E-3	2.13E0	0.0045	3.56E-3
Aug. 83	7.00E-3	3.15E0	0.0022	1.04E-2
Sep. 83	1.33E-3	2.60E0	0.0005	9.10E-3
Oct. 83	2.34E-2	2.15E0	0.0109	4.24E-3
Nov. 83	3.48E-2	2.41E0	0.0144	< LLD
Dec. 83	1.38E-2	2.83E0	0.0049	< LLD
Total	7.175E-1	177.4	-----	1.44
Ci/month	2.61E-2	6.45	-----	5.22E-2

Environmental Release Calculations for the Proposed
RCS Processing Through SDS and EPICOR-2

The amount of RCS to be processed over a years time is projected to be 1.3×10^6 gallons. Concentrations of the various radionuclides in this volume are assumed to be as tabulated below.

Table 6.3

RCS Processing Release Parameters

Isotope	Conc. ($\mu\text{Ci/ml}$)	CI/sec.	Conc. at 0.5 units (CI/m5)	10 CFR 20 Table II Col. 1	Cx MPCx
Ag-110m	$<1.5\text{E}-2$	$<4.7\text{E}-18$	$<1.9\text{E}-23$	3E-10	$<6.3\text{E}-14$
Ce-144	$1.1\text{E}+0$	$3.4\text{E}-16$	$1.4\text{E}-21$	2E-10	$7.0\text{E}-12$
Co-60	$1.7\text{E}-1$	$5.3\text{E}-17$	$2.1\text{E}-22$	3E-10	$7.0\text{E}-13$
Cs-134	$2.3\text{E}-1$	$7.0\text{E}-17$	$2.8\text{E}-22$	4E-10	$7.0\text{E}-13$
Cs-137	$4.9\text{E}+0$	$1.5\text{E}-15$	$6.0\text{E}-21$	5E-10	$1.2\text{E}-11$
Ru-106	$3.2\text{E}-1$	$9.9\text{E}-17$	$3.9\text{E}-22$	2E-12	$2.0\text{E}-12$
Sb-125	$5.0\text{E}-1$	$1.6\text{E}-16$	$6.4\text{E}-22$	9E-10	$7.1\text{E}-13$
Sr-90	$9.9\text{E}+0$	$3.2\text{E}-15$	$1.3\text{E}-20$	3E-11	$4.3\text{E}-10$
H-3	$3.5\text{E}-2$	$2.9\text{E}-9$	$1.2\text{E}-14$	2E-7	$6.0\text{E}-8$
U-235*	$3.8\text{E}-7$	$1.2\text{E}-22$	$4.8\text{E}-28$	4E-12	$1.2\text{E}-16$
U-238*	$2.4\text{E}-6$	$7.4\text{E}-22$	$3.0\text{E}-27$	3E-12	$1.0\text{E}-15$
Pu-238*	$4.7\text{E}-7$	$1.5\text{E}-22$	$6.0\text{E}-28$	7E-14	$8.6\text{E}-15$
Pu-239*	$8.4\text{E}-4$	$2.6\text{E}-19$	$1.0\text{E}-24$	6E-14	$1.7\text{E}-11$
Pu-240*	$2.1\text{E}-4$	$6.5\text{E}-20$	$2.6\text{E}-25$	6E-14	$4.3\text{E}-12$
Pu-241*	$1.4\text{E}-2$	$4.3\text{E}-18$	$1.7\text{E}-23$	3E-12	$5.7\text{E}-12$
Am-241*	$1.4\text{E}-4$	$4.3\text{E}-20$	$1.7\text{E}-25$	2E-13	$8.5\text{E}-13$
Np-237*	$1.1\text{E}-7$	$3.4\text{E}-23$	$1.4\text{E}-28$	1E-13	$1.4\text{E}-15$
Np-239*	$1.7\text{E}-8$	$5.3\text{E}-24$	$2.1\text{E}-29$	2E-8	$1.1\text{E}-21$
(Gross α)	$(1.2\text{E}-3)$	$(3.7\text{E}-19)$	$(1.5\text{E}-24)$	$(2\text{E}-14)$	-----

Cx
TOTAL MPCx = $6.05\text{E}-8$

- * Values calculated according to the Ce-144/fuel ratio value is calculated by the ORIGEN Computer code as programmed for the TMI-2 Operational history and a decay time of 5.5 years.

Accident Analysis

Because of the inherent safety features of the Submerged Demineralizer System and maximum utilization of existing site facilities, potential accidents which involve the release of radionuclides to the environment are minimized.

Hypothetical accidents during system operations are proposed and evaluated in the following assessment. The following accident analysis has been performed based on the assumption that zeolite beds are radiologically loaded to 60,000 Ci. Should higher radiological loadings be determined to be appropriate, the accident analysis will be reassessed using the higher radiological loadings.

7.1 Inadvertent pumping of RCS water into the spent fuel pool.

Assumptions:

The effluent line from the final filter develops a leak and is not detected immediately. Contaminated water is released into the pool at a rate of 15 gpm for a period of 15 minutes, (225 gallons or ~15 curies).

It is assumed that the total activity is made up of 0.2Ci of Cs-134 and 4.2 Ci of Cs-137, 0.94 Ci of Ce-144, 8.4 Ci of Sr-90, and 0.5 Ci of Sb-125 (based upon the measured concentrations as reported in Chapter 6). Analysis of the accident also assumes uniform mixing in 233,000 gallons of pool water and results in pool water contamination

levels of 0.017 $\mu\text{Ci}/\text{ml}$ of total activity or of 0.0075 $\mu\text{Ci}/\text{ml}$ of gamma emitters. This value is only about 3% of the value calculated for the same accident assuming RB "sump" water was inadvertently pumped into the fuel pool water.

Occupational Exposure Effects:

The dose rate is calculated to an individual on the walkway at a point three feet above the surface of the water using the ISOSHLD-II computer code. The depth of water in the pool is 38 feet. The calculated maximum exposure rate at three feet above the surface is 4.2 mR/hr.

After such an accidental leak the pool would contain ~1 millicurie of alpha activity. Such a leak would require that more stringent contamination control procedures would have to be installed to prevent alpha activity from leaving the pool. Cleanup of the pool would require passing the water through 2 specially prepared 4x4 liners: one similar to the SDS liners and one similar to the EPICOR.

Off-site Effects:

A review of previous SDS operation shows that this accident does not release measurable activity to the environment.

No significant increases in the site boundary direct gamma exposure level is expected as a result of this hypothetical accident due to the spent fuel pool configuration and inherent shielding properties of the pool side walls and the distance to the site boundary.

Conclusions:

This hypothetical accident is evaluated under conservative assumptions.

Although the analysis of this hypothetical accident provides results that indicate radiation field of 4.2 mR/hr at a level three feet above the pool surface, area radiation monitor alarms would indicate its presence. Personnel would be evacuated to ensure that occupational exposures are limited.

Off-site radiological consequences potentially resulting from this hypothetical accident are insignificant.

7.2 Pipe rupture on filter inlet line (above water level)

Assumptions:

A pipe rupture occurs in the inlet line to the filters above water level at the southeast corner of the pool. The leak proceeds for fifteen minutes before the pump is stopped. Contaminated water sprays from around the lead brick shielding. A total of 38 gallons of water is spread onto a surface area of 100 ft.² and 340 gallons of contaminated water are drained into the pool. It is further assumed that the contaminated water contains 0.065 Ci/gallon of activity in the same concentration ratios that were assumed for the previous hypothetical accident.

Occupational Exposure Effects:

As a result of this hypothetical accident, five significant effects are postulated:

1. The maximum gamma exposure rate at the surface of the contaminated floor area is calculated to be 100 mRem/hr.
2. The maximum beta exposure rate at a point three feet above the surface of the contaminated floor area is estimated to be 560 mRad/hr.
3. The exposure rate from the surface of the contaminated spent fuel pool waters, at a point three feet above the surface, would be approximately 6.3 mRem/hr gamma, and ~32 mRad/hr beta.
4. The pool water would contain about 1.5 millicuries of alpha activity, and
5. the floor surface would be contaminated with about 0.2 millicuries of alpha activity.

Offsite Effects:

To calculate off-site concentrations it is conservatively assumed that 0.1% of the activity sprayed from the pipe becomes airborne within the Fuel Handling Building. This airborne activity is evacuated from the

Fuel Handling Building by the FHB H&V system which is filtered through HEPA filters before the airborne effluent reaches the environment. The offsite concentration is maximized by assuming the activity is evacuated from the FHB in a 15 minute time period and, consequently, the hypothetical release to the environment occurs over a 15 minute period. Release parameters for this accident are as tabulated below. Credit has been taken for only 1 of the 2 HEPA filter banks of the FHB exhaust filter system.

Conclusions:

Analysis of this hypothetical accident, show that even under the conservative assumptions of the accident, the effluent concentrations, for a period of 15 minutes, are calculated to reach a level such that the summation of the individual, Ci/MPC, values is 79% of the allowable. Credit for the neglected HEPA filter and a less conservative X/Q would reduce this fraction to an even lower value.

Release Parameters for a RCS Pipe Spray Leak

Isotope	Release rate to FHB (ci/s)	Accident Station Vent Release Rate (ci/s)	EA Concentration (Ci/M ³) (at 610m with $X/Q=1.3 \times 10^{-11}$ S/M ³)*	Cx/MPC.
Ag-110m	<2.4E-8	<2.4E-11	<3.1E-14	<1.0E-4
Ce-144	1.8E-6	1.8E-9	2.3E-12	1.2E-2
Co-60	2.7E-7	2.7E-10	3.5E-13	1.2E-3
Cs-134	3.7E-7	3.7E-10	4.8E-13	1.2E-3
Cs-137	7.8E-6	7.8E-9	1.0E-11	2.0E-2
Ru-106	5.1E-7	5.1E-10	6.6E-13	3.3E-3
Sb-125	8.0E-7	8.0E-10	1.0E-12	1.1E-3
Sr-90	1.6E-5	1.6E-8	2.1E-11	7.0E-1
H-3	5.6E-8	5.6E-11	7.3E-11	3.7E-4
U-235	6.1E-13	6.1E-16	7.9E-19	2.0E-7
U-238	3.8E-12	3.8E-15	4.9E-18	1.6E-6
Pu-238	7.5E-13	7.5E-16	9.8E-19	1.4E-5
Pu-239	1.3E-9	1.3E-12	1.7E-15	2.8E-2
Pu-240	3.4E-10	3.4E-13	4.4E-16	7.3E-3
Pu-241	2.2E-8	2.2E-11	2.9E-14	9.7E-3
Am-241	2.2E-10	2.2E-13	2.9E-16	1.5E-3
NP-237	1.8E-13	1.8E-16	2.3E-19	2.3E-6
NP-239	2.7E-14	2.7E-17	3.5E-20	1.8E-12

C1 = 0.786
TOTAL MPC.

* The X/Q value chosen for this analysis (1.3×10^{-11} S/M³) was used because of the short duration of the release. This precluded the use of the annual average X/Q.

As shown at the bottom of column 5, the summation of the Cx is only 79% of the MPC.

specified 1.0 for this scenario.

Even though high surface contamination levels exist at the floor area and the spent fuel pool waters are contaminated such that the total body could be exposed to relatively high radiation levels, area radiation monitors would indicate the presence of high radiation. Personnel would be evacuated from the area to ensure that occupational exposures are limited.

7.3 Inadvertent lifting of prefilter above pool surface

Assumptions:

It is assumed that due to a failure in the crane control system, the over head crane moves toward the loading bay after pulling one expended filter to the maximum height of eight feet below the pool surface. As the crane moves toward the bay, the handling tool hits the end of the pool and the filter is dragged from the water exposing operating personnel.

Analysis of the accident is performed by using a point source approximation and calculating the dose rate at a distance of 15 feet from the filter. The calculated dose rate is 21 Rem/hr and is based on an assumed filter loading of 1000 curies.

Occupational Exposure Effects:

As the filter assembly nears the surface of the spent fuel pool water area, radiation monitor alarms will be sounded announcing the presence of high radiation fields. Personnel would be evacuated from the area to ensure that occupational exposures are limited.

Off-site Effects:

Airborne contamination as a result of this hypothetical accident would not occur since the particulate activity is fixed on the filter elements which are contained within the filter housing.

The increase in the radiation level at the site boundary would not be significant due to the shielding characteristics of the fuel building walls and the distance to the site boundary.

Conclusions:

The public health and safety is not compromised as a consequence of this hypothetical accident.

7.4 Inadvertent lifting of zeolite ion exchanger above pool surface

Assumptions:

It is assumed that due to multiple failures, a zeolite vessel is lifted from the pool resulting in the exposure of plant operating personnel.

Analysis of the accident is performed by modeling the zeolite ion exchanger bed in cylindrical geometry and calculating the dose rate at a distance of 20 feet from the surface of the zeolite ion exchanger. The calculated dose rate is approximately 340 Rem/hr based on an estimated zeolite ion exchange bed loading of approximately 2730 Curies of Cesium-134 and approximately 51,900 Curies of Cesium 137.

Occupational Exposure Effects:

As the zeolite vessel nears the surface of the spent fuel pool water, area radiation monitor alarms will automatically sound announcing the presence of high radiation fields. Personnel would be evacuated from the area to reduce occupational doses. Airborne contamination would not occur since the activity is fixed on the zeolites.

Offsite Effects:

Airborne contamination as a result of this hypothetical accident would not occur since the activity is contained on the zeolites which are contained in the ion exchanger vessel. The increase in the radiation level at the site boundary would not be significant due to the shielding provided by the Fuel Handling Building walls and the distance to the site boundary.

Conclusions:

The public health and safety is not endangered as a result of this hypothetical accident. Occupational exposures are minimized by evacuation of the area.

7.5 Inadvertent Drop of SDS Shipping Cask

Assumptions:

It is assumed that due to a failure in SDS shipping cask handling equipment an SDS cask containing a zeolite ion exchanger is dropped from the Fuel Handling Building (FHB) crane to the floor at EL 305'. The SDS shipping cask is assumed to drop from the maximum crane lift height. Upon impact with the floor at EL 305', the SDS shipping cask is assumed to experience rupture as well as rupture of the zeolite vessel, thus exposing the dewatered zeolite resins to the FHB atmosphere. The radiation source is approximately 2730 Curies of Cs-134 and approximately 51,900 Curies of Cs-137 on the zeolite ion exchange media. The contribution from other isotopes on the zeolite media and residual containment building sump water (Table 1.1) in the ion exchange media is negligible; it is assumed that a factor of 10^{-4} of the isotopes are instantaneously released to the FHB atmosphere. This assumption is conservative because the isotopes are absorbed onto the zeolite media. The Fuel Handling Building HEPA filters are assumed to have an efficiency of 99%.

Occupational Effects:

Assuming that the SDS shipping cask ruptures completely exposing the zeolite ion exchanger containing the activity mentioned above, the calculated dose rate is approximately 340 Rem/hr at a distance of 20 feet. Upon the rupture of the cask, radiation monitors will sound

announcing the presence of high radiation fields. Personnel would be evacuated from the area to reduce radiation exposures. Airborne contamination will not occur if the zeolite ion exchange vessels remains intact. With the assumption that the vessels rupture and radioactive material becomes airborne, the airborne activity will be reduced to acceptable levels by the Fuel Handling Building HVAC System prior to atmospheric release.

Operational Effects:

1. Impact on systems, structures and components has been considered which could possibly result in adversely affecting the ability to operate these Reactor Plants safely, transfer load or unload fuel safely, or maintain these Plants in a safe cold shutdown condition.
2. Analysis has been conducted which demonstrates that a postulated SDS Cask drop along the proposed travel path would not adversely affect either TMI Unit 1 or Unit 2.

Off-Site Effects:

The increase in radiation level at the site boundary would not be significant due to the shielding provided by the FHB walls and the distance to the site boundary, if the SDS cask ruptures exposing the zeolite ion exchanger. With the assumption that radioactive material escapes, the whole body dose due to the released activity at the site boundary will be less than 1 mrem for both beta and gamma radiation.

Conclusions:

The public health and safety are not compromised as a consequence of this hypothetical accident.

References

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Conduct of Operations

The SDS program for operations is divided into a phased approach. These phases are:

8.1 System Development

System development activities have been performed to assure that components are developed specifically to meet the conditions imposed at TMI and perform in the intended manner.

The ion-exchange process is a well understood process. Even though ion-exchange media have been in use for approximately 50 years or more, a development program was conducted at the Oak Ridge National Laboratory, the results of which are documented in ORNL TM-7448, to ensure that the media selected for use at TMI provided optimized performance characteristics of various media using samples of the waters to be processed at TMI. In some cases, SDS effluent will be polished by EPICOR-II.

Additional development effort has been expended to verify that media loading and dewatering can be accomplished in the intended manner and that the remote tools, necessary for the coupling and de-coupling of the vessels, operates in the intended manner.

8.2 System Preoperational Testing

Prior to use in the SDS each vessel will be hydrostatically tested in conformance with the requirements of applicable portions of the ASME Boiler and Pressure Vessel Code. Upon completion of construction, the entire system will be pneumatically tested to assure leak-free operations. The system will be tested to an internal pressure of no less than 1.5 times the design pressure.

Individual component operability will be assured during the preoperational testing. Motor/pump rotation and control schemes will be verified. The leakage collection sub-system, as well as the gas collection sub-system, will be tested to verify operability. Filters for the treatment of the collected gaseous waste will be tested prior to initial operation. System preoperational testing will be accomplished in accordance with approved procedures. SDS system testing will be approved by the GPUN Start-up and Test Manager.

8.3 System Operations

System operations will be conducted in accordance with written and approved procedures. These procedures will be applicable to normal system operations, emergency situations, and required maintenance evolutions.

Prior to SDS operation, formal classroom instruction will be provided to systems operations personnel to ensure that adequate knowledge is gained to enable safe and efficient operation. During system operations on-going operator evaluations will be conducted to ensure continuing safe and efficient system operation.

8.4 System Decommissioning

The decommissioning plan for SDS is being developed. An outline of the planned approach to decommissioning is shown below.

The basis for the decommissioning plan is that the Submerged Demineralization System is a temporary system; its installation and removal will cause no permanent plant changes.

- 1) Equipment and interconnecting piping will be decontaminated; the levels to which decontamination is accomplished will depend on the intended disposition of individual items, i.e., disposal or reuse.
- 2) The system will be disassembled, component by component.
- 3) Major system components can be stored for later use or disposed of at a licensed burial facility.
- 4) Small components, such as valves, piping, instruments, etc. can be disposed of as radioactive waste.

Appendix No. 1

to

Submerged Demineralizer System
Technical Evaluation Report

REACTOR COOLANT PROCESSING PLAN
WITH THE REACTOR COOLANT SYSTEM
IN A PARTIALLY DRAINED CONDITION

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Chapter 1

SUMMARY OF TREATMENT PLAN

1.1 Project Scope

The decontamination of the TMI-2 Reactor Coolant System (RCS) requires the processing of the radioactive contaminated water to reduce the activity therein. The present activity level of this water is given in Table 1.1. To date, in excess of 1,000,000 gallons of water have been processed from the RCS. The feed and bleed operation via the Submerged Demineralizer System (SDS) has reduced the radionuclide concentration of the RCS water; specifically the Cs-137 concentration has been reduced from 14.0 $\mu\text{Ci/cc}$ to the present value of approximately 0.3 $\mu\text{Ci/cc}$.

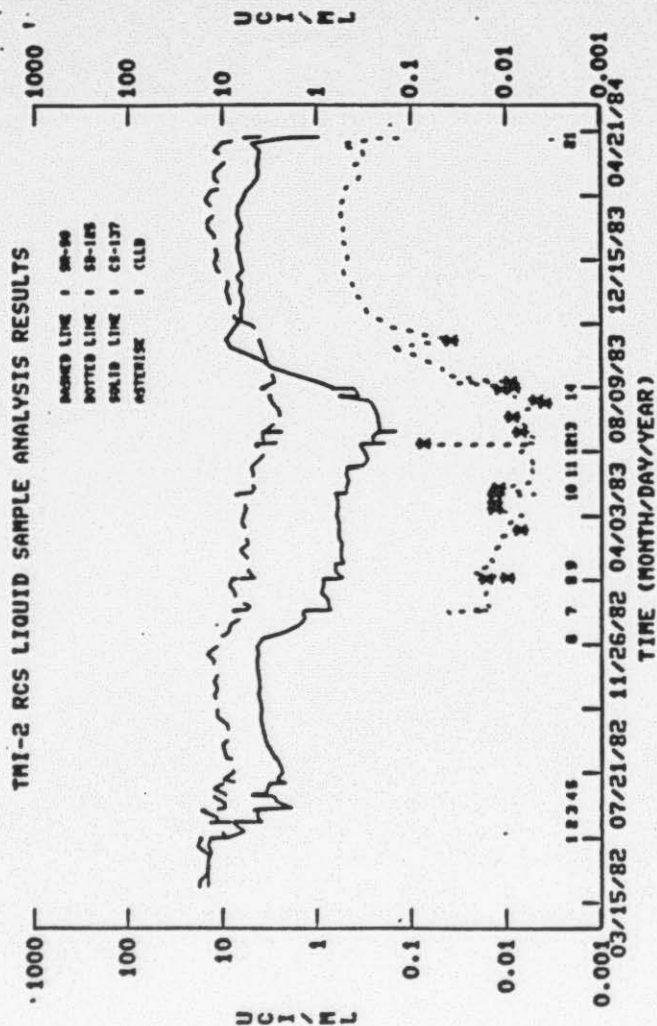
This report describes the processing of the RCS by the SDS while maintaining the RCS in the partially drained, open condition. The design features of this processing method will utilize:

1. proven processing capabilities of the SDS, and
2. Existing plant systems in support of the SDS.

1.2. Current RCS Radionuclide Inventory and Chemistry

Water samples have been taken continuously from the RCS to identify specific radionuclides and concentrations, and plant chemistry. Typical results are listed in Table 1.1. This data is based on actual samples taken. RCS activity is decreasing due to radioactive decay and leakage from the RCS which is being made up by injection of clean water into the RCS, and due to batches which have been removed for SDS processing. Figure 1.1 shows how activity for the major nuclides has decreased with respect to time. Currently Sb-125 concentrations have risen to radiologically significant levels due to changing RCS chemistry parameters. The Sb-125 will be removed by batching water from SDS through EPICOR using organic resins.

Figure 1.1



EACH RCS CLEANUP BATCH "TETS & FLITS" SERIES IS NUMBERED ABOVE THE APPROPRIATE POINT ON THE TIME AXIS.

BATCH NUMBERS REPRESENTING RCS SAMPLING BATCHES ARE NOT SHOWN.

NOTE: BETWEEN 06/01/83 AND 04/11/84, RCS WAS SAMPLED VIA CORN IN-S GRIFICE IN THE REACTOR HEAD, BEFORE AND AFTER, VIA THE TEMPORARY NUCLEAR SAMPLING LINE.

1.3 RCS Processing Description

On a batch basis, radioactive RCS water is letdown to Reactor Coolant Bleed Tank (RCBT) "C" while clean water is injected into the RCS from RCBT "A". RCS water is then pumped from RCBT "C" through the prefilter and final filter. RCS water then goes through the RCS manifold and the SDS ion exchangers. The effluent from the ion exchangers is routed through the cation sand filter to RCBT "A" for chemical adjustment, if necessary, and injection back into the RCS as makeup. The above process is repeated until the RCS water is decontaminated. EPICOR II may be used for processing selected batches of RCS water unless needed for chloride control.

The processing of the RCS will use the existing filter and ion exchangers of the SDS. Existing sampling connections will be used on the influent and effluent of the filters and ion exchangers to determine radionuclide and chemical composition of the RCS before and after processing.

As described in the SDS TER, the prefilters, final filters, and cation sand filters for the removal of particulate matter. The prefilter and final filter are followed by a series of ion exchange vessels containing about 8 cubic feet of zeolite ion exchange media. Location, operation, and handling of these vessels remains unchanged from the mode of operation used for processing of the Reactor Building sump water and the RCS water as described in the SDS TER.

TABLE 1.1
RCS RADIONUCLIDE AND CHEMISTRY DATA
(June 1985)

<u>ISOTOPE</u>	<u>RADIONUCLIDE CONCENTRATION</u> <u>μCi/cc</u>
H-3	0.07
Sr-90	2.3
Cs-134	0.0058
Cs-137	0.14
pH	7.55
Boron	5230 ppm
Na	1420 ppm

Chapter 2

RCS PROCESSING PLAN DESIGN CRITERIA

2.1 Introduction

This RCS Processing Plan is designed to use the Submerged Demineralizer System (SDS) and portions of existing plant liquid radwaste disposal systems to decontaminate the RCS water. This will reduce plant personnel and off site radiation exposures. The design objectives of this processing plan are to utilize:

1. A system that is as independent as possible from existing radioactive waste systems at TMI-2. The SDS portion of this plan is a temporary system for the recovery of TMI-2. Only small sections of existing TMI-2 plant systems will be used.
2. A system that has proven performance in processing radioactive waste. The SDS portion of this processing plan has successfully decontaminated the Reactor Building sump and the RCS water.

2.2 Design Basis

2.2.1 Submerged Demineralizer System

The Submerged Demineralizer System was designed in accordance with the following regulatory documents:

1. Code of Federal Regulations, 10CFR20, Standard for Protection against Radiation.
2. Code of Federal Regulations, 10CFR50, Licensing of Production and Utilization Facilities.
3. U.S. Regulatory Guide 1.21, dated June 1974.
4. U.S. Regulatory Guide 1.140, dated March 1978.
5. U.S. Regulatory Guide 1.143, dated July 1978.
6. U.S. Regulatory Guide 8.8, dated June 1978.
7. U.S. Regulatory Guide 8.10, dated May 1977.

The design basis for the SDS is presented in greater detail in Chapter 4 of the SDS Technical Evaluation Report.

2.2.2 Interfacing Systems

The interfacing systems with the SDS in the RCS Processing system are:

1. Radwaste Disposal (Reactor Coolant Liquid) System
2. Reactor Coolant Makeup and Purification System
3. Auxiliary and Fuel Handling Buildings Heating Ventilation and Air Conditioning Systems
4. Nitrogen Supply System
5. Decay Heat Removal System
6. Waste Gas System
7. Standby Pressure Control System
8. Spent Fuel Cooling System
9. Instrument Air System

The design criteria for these systems (except SPC) are presented in Chapter 3 of the TMI-2 FSAR. Conformance to these criteria is presented in the respective sections for these systems in the TMI-2 FSAR. Standby Pressure Control System data may be found in the TMI Recovery System Descriptions and TER's.

2.3 RCS Processing Plan Goal

The goal of the RCS Processing Plan is to reduce the total radionuclide concentration of Cs in the RCS to less than 1 $\mu\text{Ci/cc}$. The RCS Chemistry will be maintained as follows as a minimum:

Chlorides	< 5 ppm
pH	> 7.5 but < 8.4
Boron	> 4950 ppm

The processing of water through the SDS is not expected to have any undesirable effect on the chemical characteristics of the RCS water. Maintaining proper chemistry of the makeup water will ensure that there will be no adverse effects on the RCS with respect to corrosion. The boron concentration of the makeup will also ensure that sufficient boron is present to maintain the core in a non-critical safe condition. Sampling of the RCS water will be continued by taking samples via the CROM nozzle in accordance with approved operating procedure.

SYSTEM DESCRIPTION AND OPERATIONS

3.1 Introduction

This RCS Processing Plan is designed specifically for the controlled decontamination of the radioactive water in the RCS and the treatment of the radioactive gases and solid radioactive waste which are produced. This plan will use the SDS as the means of decontamination of the RCS with support from other existing plant systems.

3.1.1 Submerged Demineralizer System

The SDS consists of a liquid waste processing system, an off gas system, a monitoring and sampling system, and solid waste handling system. The liquid waste processing system decontaminates the RCS water by a process of filtration and demineralization. The off gas system collects, filters, and adsorbs radioactive gases produced during processing, sampling, dewatering, and spent SDS liner venting. The sampling system provides measurement of process performance. The solid waste handling system is provided for moving, dewatering, storage, and loading of filters and demineralizer vessels into the shipping cask. The SDS will be unchanged from that described in the SDS FER.

3.1.2 Interfacing Systems

Interfacing with the SDS are existing plant systems, as given in Section 2.2. The Reactor Coolant Liquid Waste Chain provides a staging location for the SDS for collecting and injection of RCS water from and to the RCS. The Fuel Handling Building and Auxiliary Building HVAC systems provide tempered ventilating air and controlled air movement to prevent spread of airborne contamination with the plant and to the outside environment. The Nitrogen Supply system provides N_2 for blanketing the Reactor Coolant Bleed Tanks. The Makeup and Purification and Spent Fuel Cooling Systems provide piping for the transfer of the waste water. The Waste Gas System processes the gases from the vents from the RCBF's. The Instrument Air System provides air pressure for air-operated valves in the Interfacing Systems. The Standby Pressure Control System, installed as a temporary IMI-2 recovery system, will be used as a backup system to ensure a source of additional makeup to the RCS.

3.2 RCS Water Processing Preparation

3.2.1 RCS Preparation

The RCS will be maintained in a partially drained condition vented to atmosphere. Its water level may vary from Elevation 347' to 323'6" depending on the needs for access to the reactor vessel.

The minimum water level is expected to be 323'6" (1' above the reactor vessel flange).

At this level and at all levels above this, the Waste Transfer pumps will be used to inject RCS makeup water into the RCS for the RCS cleanup process. The maximum discharge pressure of these pumps is 74 psig at a flow rate of 40 gpm. Flow to the RCS will be controlled by valve WDL-V-36A or 36B depending on which waste transfer pump is used for feed and, if necessary, MU-V-9. MU-V10 will also be open to permit makeup flow to the RCS. The flow rate to the RCS will be maintained at less than 5 gpm to match the letdown flow rate. Minor adjustments in flow rate will be made to maintain the RCS water level within the limits required.

The decay heat analysis as reported in Appendix B TMI-2 Decay Heat Removal Analysis, April 1982, submitted as a part of the Safety Evaluation for Insertion of a Camera into the Reactor Vessel Through a Leadscrew Opening Rev. 2 July 1982, is applicable for the RCS processing described herein. The average incore coolant temperature will be limited to less than 170°F. This criterion was adopted as a conservative value for the recovery program to maintain a positive margin to boiling.

3.2.2 SPC Operation

The Standby Pressure Control System (SPC) will serve as a backup system to ensure that the RCS level is maintained during RCS processing.

3.2.3 Reactor Coolant Liquid Waste Chain

Prior to starting RCS water processing, the RCBT "A" will be filled with more than 50,000 gallons of borated, suitable, processed water. The radionuclide and chemistry data for this water will be similar to that used for RCS makeup during the previous RCS processing period. Chemicals will be added to this water if required to ensure that this water complies with the plant chemistry specified in Section 2.3.

3.3 RCS Water Letdown and Injection

RCS letdown will be performed by a bleed and feed process of simultaneously removing the radioactive RCS water and injecting borated processed water at the same flow rate to maintain RCS water volume constant. The bleed and feed process will be controlled from the Control Room in coordination with the Radwaste Control Panel. The RCS water is letdown through the normal letdown line on the loop cold leg before Reactor Coolant Pump RC-P-1A. The letdown rate is 5 gallons per minute if the waste transfer pumps are used.

or 10 gpm if a newly installed sandpiper pump (fig. 3.4), which is normally disconnected, is used. The RCS water is letdown through the letdown coolers to RCBT "C". The plugged block orifice and Isolated Makeup Demineralizers and Filters are bypassed. As the RCS water is letdown, simultaneously the borated processed water located in RCBT "A" is injected to the RCS. After RCBT "C" has been filled to more than 50,000 gallons, the letdown and injection of water from and to the RCS will be secured. RCBT "C" will be recirculated prior to processing. After recirculating, decontamination of the RCS radioactive water by the SDS will commence.

3.4. RCS Processing By SDS

3.4.1 RCS Water Filtration

Two filters have been installed to filter out solids in the untreated contaminated water before the water is processed by the ion exchangers. Both filters are sand type. The two sand filters are loaded in layers. The first layer is 0.85 mm sand and the second layer is 0.45 mm sand. Mixed uniformly with the sand is approximately 6 pounds borosilicate glass which is at least 22 weight percent boron. The loading of these filters may be changed if applicable. The purpose of the borosilicate is to prevent the possibility of criticality should any fuel fines be transported in the let down. The flow capacity through each filter is 50 gpm. Reverse flow through filters is prevented by a check valve in the supply line to each filter.

Each filter is housed in a containment enclosure to enable leakage detection and confinement of potential leakage. The filters are submerged in the spent fuel for shielding considerations. Contaminated water can be pumped through the filters and the RCS manifold to the ion exchangers.

Influent waste water may be sampled from a shielded sample box located above the water level to determine the activity of contaminated water prior to and following filtration.

Inlet, outlet, and vent connections on the filters are made with quick disconnect valved couplings which are remotely operated from the top of the pool. Inlet/outlet pressure gauges are provided to monitor and control solids loading. Load limits for the filters are based on filter differential pressure, filter influent and effluent sampling, and/or the surface dose limit for the filter vessel. A flush line is attached to the filter inlet to provide a source of water for flushing the filters prior to removal.

3.4.2 RCS Water Demineralization

This system consists of eight underwater columns (24 1/2" x 54 1/2"), each capable of containing eight cubic feet inorganic zeolite sorbent. Homogeneously mixed Ion Siv IE-95 and LINDE-A

zeolite are the medias of choice to efficiently immobilize the Cesium and Strontium in the RCS. Six zeolite beds are divided into two trains each containing two or three beds (A, B, C) with piping and valves provided to operate either train individually or both trains in parallel.

3.4.2 RCS Water Demineralization (cont'd)

The effluent from the zeolite trains flows through the remaining "cation" sand vessel. Jumpers are provided to permit 2, 3, or 4 vessels per train operation. An in-line radiation monitor measures the activity level of the water exiting the last ion exchanger vessel. The valve manifold for controlling the operation of the primary ion exchange columns is located above the pool, inside a shielded enclosure that contains a built-in sump to collect leakage that might occur. Any such leakage is routed to the off gas bottoms separator tank and pump. A line connects to the inlet of each ion exchanger to provide water for flushing the ion exchangers when they are loaded. Radionuclide loading of ion exchange vessels is determined by analyzing the influent and effluent from each exchanger.

Process water flow is measured by instruments placed in the line to each ion-exchange train. The effluent from the "cation" sand vessel is routed back to the RCBI "A", as shown in Figure 3.3. The remaining SDS equipment and EPICOR II are not used for RCS water processing.

3.4.2 RCS Water Demineralization (cont'd)

Periodic sampling of the process stream will occur during the processing of a batch of water. At the completion of processing a batch, the contents of RCBT "A" will be sampled to determine acceptability for injections of this water into the RCS. If the water is within specification, it is injected into the RCS.

The types of samples to be taken at RCBT after letdown and prior to reinjection are shown in Table 3.1.

3.4.3 Leakage Detection and Processing

Each submerged vessel is located inside a secondary containment box that contains spent fuel pool water. During operation the secondary containment lid is closed. This lid is slotted to permit a calculated quantity of pool water to flow past the vessels and connectors. Pool water from the containment boxes is continuously monitored to detect leakage and is circulated by a pump through one of the two leakage containment ion exchangers. Any leakage which occurs during routine connection and disconnection of the quick-disconnects will be captured by the containment boxes, diluted by pool water, and treated by ion exchange before being returned to the pool.

3.4.4 Off Gas and Liquid Separation System

An off gas and liquid separation system collects gaseous and liquid wastes resulting from the operation of the water treatment system.

3.4.5 Sampling and Process Radiation Monitoring System

The sampling glove boxes are shielded enclosures which allow water samples to be taken for analysis of radionuclides and other contaminants. The piping entering the glove boxes permits the withdrawal of a volume limited amount of sample into a collection bottle. Cylinders are purged by positioning valves to permit the water to flow through them and return to a waste drain header and into the off gas separator tank. A water line connects to the sample line to allow the line to be flushed after a sample has been taken.

The entire sampling sequence is performed in shielded glove boxes to minimize the possibility of inadvertent leakage and spread of contamination during routine operation.

3.4.5.1 Sampling System

Sampling of the SDS process to monitor performance is accomplished from three shielded sampling glove boxes. One glove box is for sampling the filtration system, the second is

for sampling the feed and effluent for the first zeolite bed, and the third from sampling the effluents of the remaining zeolite beds and the "cation" sand filter.

3.4.5.2 Process Radiation Monitoring System

The SDS is equipped with a process radiation monitoring system which provides indication of the radioactivity concentration in the process flow stream at the effluent point from the last ion exchanger vessel. The purpose of this monitoring system is to provide indication and alarm of radionuclide breakthrough.

3.4.5.3 Transuranic Element Monitoring

Filter and process train samples are being analyzed for isotopes of Uranium and Plutonium.

3.4.6 Ion Exchanger and Filter Vessel Transfer in the Fuel Storage Pool

Prior to system operation, ion exchanger and filter vessels are placed inside the containment boxes and connected with quick-disconnect couplings. When it is determined that a vessel is loaded with radioactive contaminants to predetermined limits as specified in the Process Control Program, the system will be

flushed with low activity processed water. This procedure flushes away waterborne radioactivity, thus minimizing the potential for loss of contaminants into the pool water while decoupling vessels. Vessel decoupling is accomplished remotely. Vessels are transferred using the existing fuel handling crane utilizing a yoke attached to a long shaft. The purpose of this yoke-arm assembly is to prevent inadvertent lifting of the ion exchange bed or filter vessel to a height greater than eight feet below the surface of the water in the pool. This device is a safety tool that will mechanically prevent lifting a loaded vessel out of the water shielding and preclude the possibility of accidental exposure of operating personnel.

The ion exchange vessels are arranged to provide series processing through each of the beds; the influent waste water is treated by the bed in position "A", then by the bed in position "B", then by the bed in position "C", and finally by the bed in the "cation" sand filter "A" or "B" position.

3.5 Zeolite Mixtures

The SDS ion exchangers will contain a uniform mixture of IONSIV-96 and LINDE-A ion exchanger media. These two zeolites were selected for their proven capabilities while processing Reactor Building Sump water to remove radionuclides. IONSIV-96 primarily removes

the isotopes of Cesium and LINDE-A removes the isotopes of Strontium.

The ratio of loading the two types of ion exchanger media will be determined by experimental data to determine the optimum loading.

Periodic sampling of the process stream will be used to verify the performance of the ion exchange media. If necessary revisions will be made to the loading ratios if conditions warrant to achieve the proper decontamination factors. Verification of the performance of the ion exchange media will be made in accordance with the Process Control Plan.

3.6 Waste Produced

Based on operating experience processing the Reactor Building sump water, the useful life of a zeolite resin bed is in excess of 100,000 gallons of waste water processed. At this point the DF of the zeolite bed for Strontium goes to 1.

Table 3.1

RCBT WATER SAMPLING

RCBT LETDOWN SAMPLE

Gamma Scan
Gross Beta - Gamma
Sr-90
pH
Conductivity
Boron
Na
Cl
Sulfates
H-3

RCBT INJECTION SAMPLE

Gamma Scan
Gross Beta - Gamma
Sr-90
pH at 77°F
Conductivity
Boron
Na
Cl
Sulfates
H-3
Oxygen
Fluorides

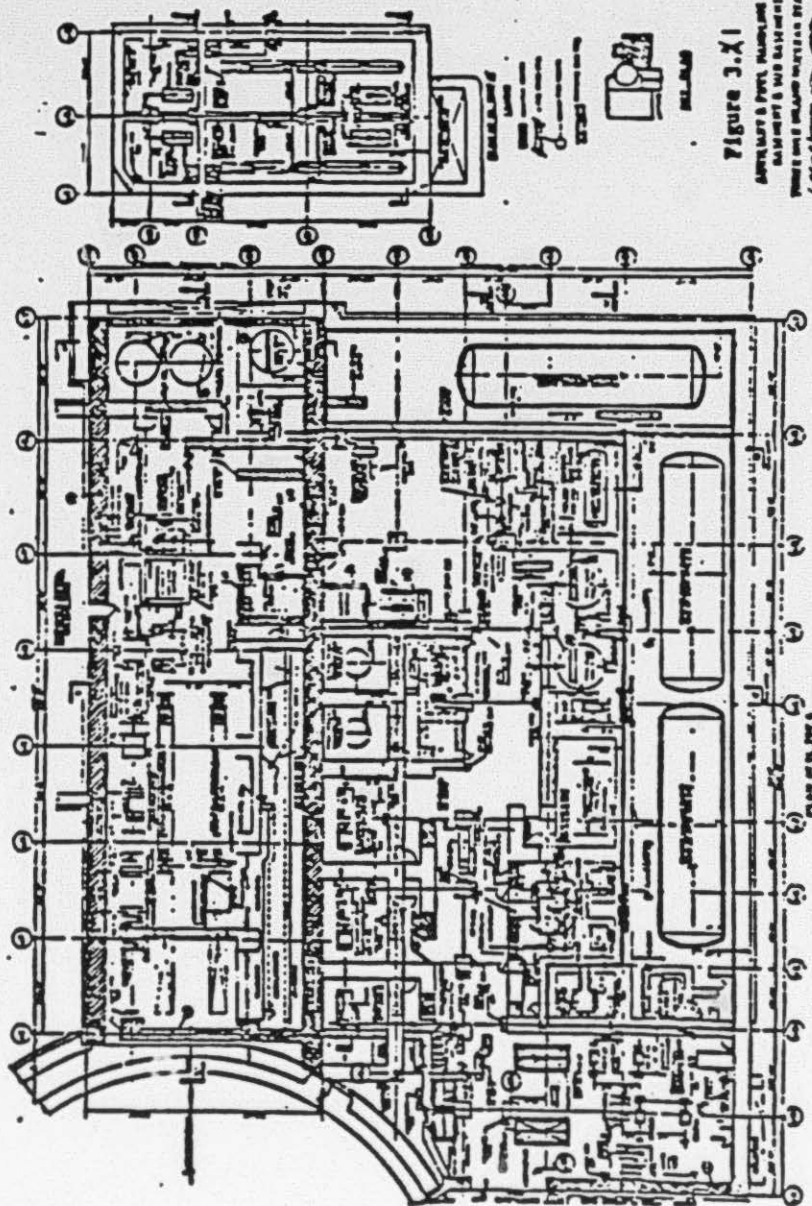
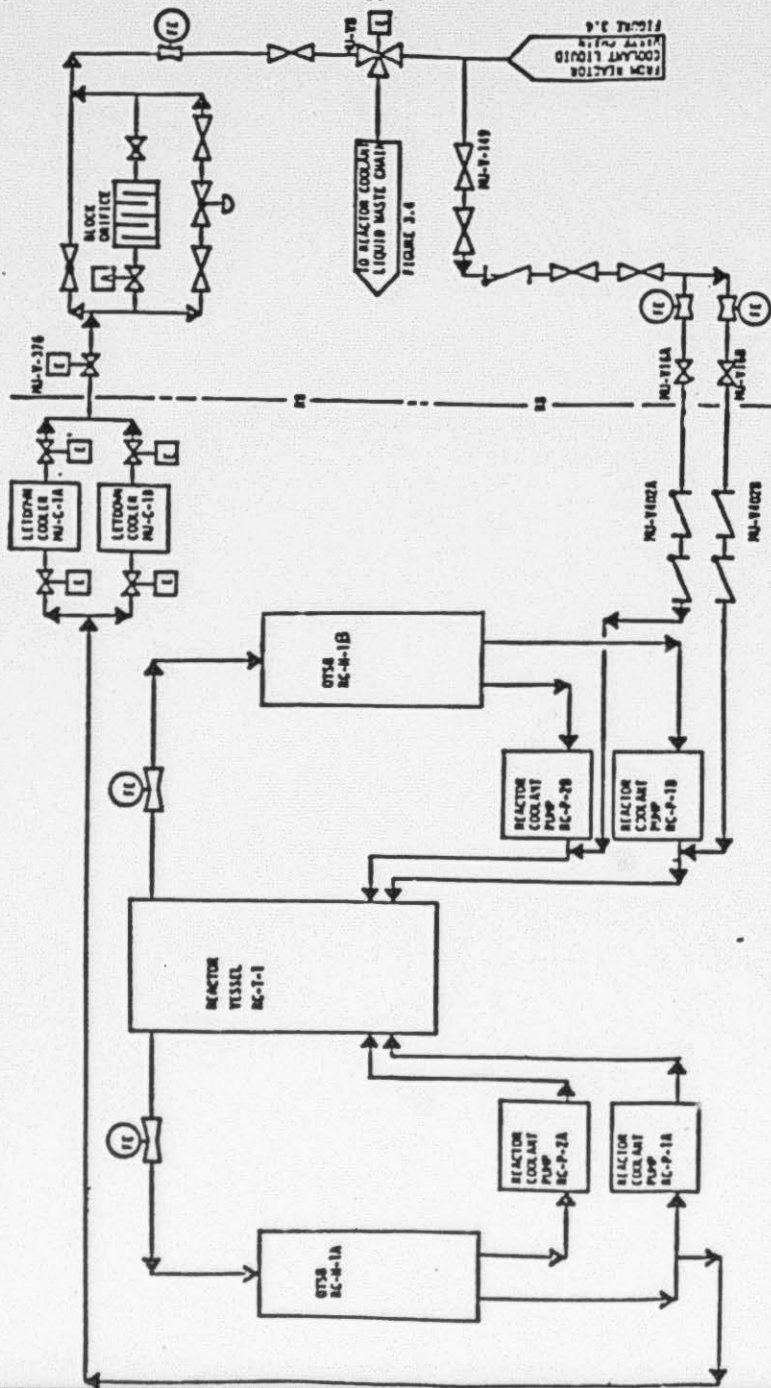


Figure 3.XI

[illegible]

FIGURE 3.2
REACTOR COOLANT SYSTEMFIGURE 3.4
TO REACTOR COOLANT
LIQUID WASTE OUTFALLFIGURE 3.6
FROM REACTOR
COOLANT LIQUID
WASTE OUTFALL

4.1 RCS Processing Safety Assessment

Processing of the RCS while in a partially drained condition does not present a unique safety concern. The actual processing of Reactor Coolant is adequately addressed in the SDS Technical Evaluation Report and the maintenance of the Reactor Coolant System in a partially drained condition is adequately addressed in the Quick Look Safety Evaluation. The only evolution not previously addressed is the simultaneous feed and bleed of the Reactor Coolant System in a partially drained configuration. During this evolution, RCS water level will be monitored and maintained by operating procedures. Such procedures will maintain the water level to within six (6) inches of the predetermined level set point. At the present RCS level, to permit incore inspections, this level is $210" \pm 6"$. This level is the same as that established for the Quick Look program and will be monitored in a similar fashion. Thus this evolution will not increase the probability of occurrence or consequences of an accident previously evaluated or create the possibility of a different type accident, nor will the margin of safety as defined in the basis for any Technical Specification be reduced.

Appendix No. 2
to
Submerged Demineralizer System
Technical Evaluation Report

Title
Internals Indexing Fixture
Processing System

June 1983

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Chapter 1

SUMMARY OF TREATMENT PLAN

1.1 Project Scope

Reactor Coolant System (RCS) processing via IIF capability must be continually available. The combined volume of water in the Rx Vessel & the Internals Indexing Fixture (IIF) is 50,000 gal. The current RCS activity is given in Table 1.1. The primary purpose for the system, is the control of dissolved radio nuclides however, improvement of water clarity is expected as a byproduct.

This report describes the post Rx vessel head removal processing of the Reactor Coolant System (RCS) by the Submerged Demineralizer System (SDS) and other interfacing plant system for the maintenance of RCS dissolved radionuclide concentrations. The design features of this processing method are:

1. Use of the proven processing capabilities of the SDS.
2. Use of existing plant systems in support of the SDS.

This report is presented as an addendum to the previously submitted SDS Technical Evaluation Report (TER) (Reference 1) to provide greater detail in those aspects of system design and operation which are unique to the processing of the RCS & IIF water using the IIF Processing System.

1.2 Current RCS Radionuclide Inventory and Chemistry

Water samples have been taken weekly from the RCS to identify specific radionuclides and concentrations, and plant chemistry. Current results are listed in Table 1.1. This data is based on actual samples taken. RCS activity decreases due to radioactive decay, leakage from the RCS, and RCS processing. However, RCS activity may increase during processing shutdown due to leaching. Radionuclides concentrations are expected to be less in the IIF due to the dilution of the Rx Vessel when the IIF is filled with RCS grade processed water.

1.3 IIF Processing Description

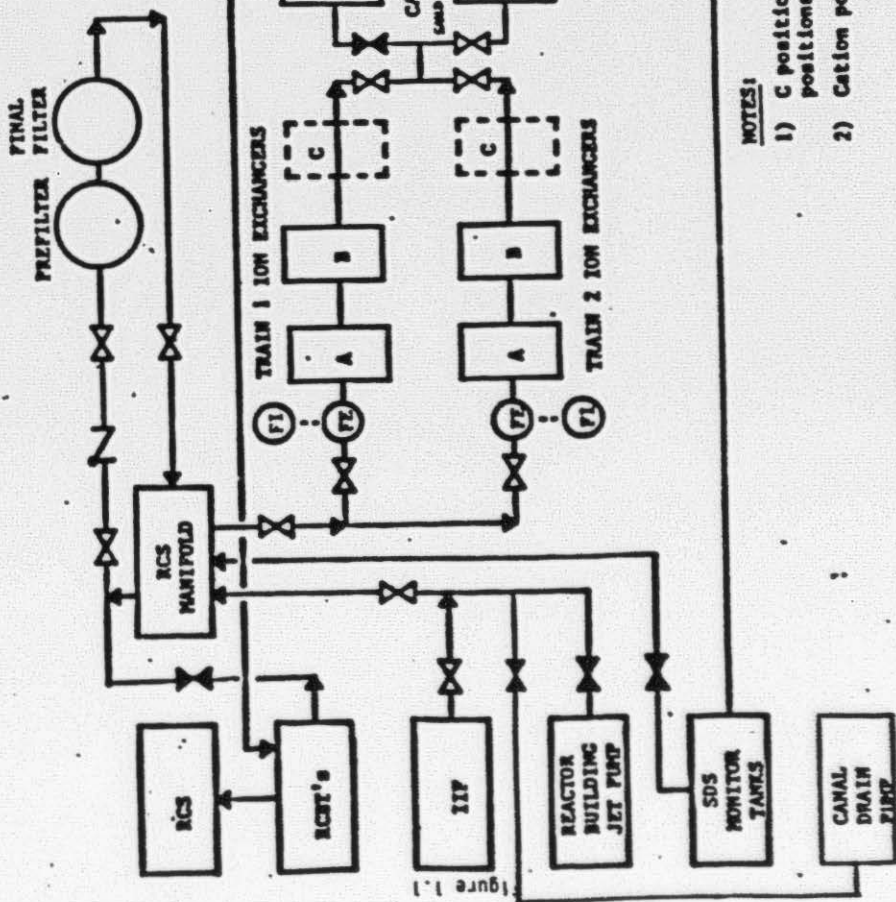
Figure 1.1 shows a block diagram of the IIF processing flow path. On a batch basis, radioactive RCS water is pumped directly to the SDS and processed through the prefilter and final filter. RCS water then goes through the RCS manifold and one or both trains of ion exchangers at a flow rate of up to 15 gpm. However, due to deboration concerns the flowrate will not exceed 6.5 gpm. The effluent from the ion exchangers is routed through a sand filter in the cation position to either the A or C RCBT for sampling. Concurrently, while water is being removed for processing, previously processed RCS grade water from the other bleed tank is being injected into the RCS to maintain water level. The return flow path is identical to that used during the prehead lift RCS processing.

The IIF processing of the RCS will use the existing filter and ion exchangers of the SDS. Existing sampling connections will be used on the influent and effluent of the filters and ion exchangers to determine radionuclide and chemical composition of the process steam before and after processing.

As described in the SDS IER, the prefilters and final filters consist of sand filters for the removal of particulate matter. These filters are followed by a series of ion exchange vessels containing about 8 cubic feet of zeolite ion exchange media. Location, operation, and handling of these vessels remains unchanged from the mode of operation used for the prehead lift RCS processing. However both trains may be used. A sand filter in the cation position will replace the existing post filter in order to lower system differential pressure and improve effluent turbidity.

TABLE 1.1
RCS RADIONUCLIDE AND CHEMISTRY DATA
 (06/03/85)

<u>ISOTOPE</u>	<u>RADIONUCLIDE CONCENTRATION</u> μCi/cc
H-3	0.07
Sr-90	2.3
Sb-125	0.055
Cs-134	0.0058
Cs-137	0.14
Gross Beta	2.5
pH	7.55
Boron	5230 ppm
Na	1420 ppm
Cl	2.45 ppm
Turb	5.4 NTU



NOTES:

- 1) C position ion exchangers in both positions are replaced by jumpers.
- 2) Cation positions are sand filters.

FIGURE 1.1
IIF PROCESSING FLOW SHEET

Chapter 2

IIF PROCESSING PLAN DESIGN CRITERIA

2.1 Introduction

The IIF Processing Plan is designed to use a high capacity submersible pump (DWC-P-1) the Submerged Demineralizer System (SDS) and portions of existing plant liquid radwaste disposal systems to decontaminate the RCS water. This will reduce plant personnel exposures and the possibility for off site radiation exposures. The design objectives of this processing plan are:

1. A system that is as independent as possible from existing radioactive waste systems at TMI-2. The SDS portion of this plan is a temporary system for the recovery of TMI-2. Only small sections of existing TMI-2 plant systems will be used.
2. A system that has proven performance in processing radioactive waste. The SDS portion of this processing plan has successfully decontaminated RCS water. Also, the reinjection path used for the IIF Processing Plan is the same path as was used for prehead lift RCS processing.

2.2 Design Basis

2.2.1 Submerged Demineralizer System

The Submerged Demineralizer System was designed in accordance with the following regulatory documents:

1. Code of Federal Regulations, 10CFR20, Standard for Protection against Radiation.
2. Code of Federal Regulations, 10CFR50, Licensing of Production and Utilization Facilities.
3. U.S. Regulatory Guide 1.21, dated June 1974.
4. U.S. Regulatory Guide 1.140, dated March 1978.
5. U.S. Regulatory Guide 1.143, dated July 1978.
6. U.S. Regulatory Guide 8.8, dated June 1978.
7. U.S. Regulatory Guide 8.10, dated May 1977.

The design basis for the SDS is presented in greater detail in Chapter 4 of the SDS Technical Evaluation Report.

2.2.2 Interfacing Systems

The interfacing systems with the SDS in the IIF Processing system are:

1. Reactor Coolant Liquid Waste Train.
2. Purification and Makeup System.

3. Auxiliary and Fuel Handling Buildings Heating Ventilation and Air Conditioning Systems.
4. Nitrogen Supply System.
5. Decay Heat Removal System.
6. Waste Gas System.
7. Standby Pressure Control System.
8. Solid Waste Handling System.
9. R.B. Jet Pump.
10. Fuel Transfer Canal Drain System.

The design criteria for these systems 1 through 6 above are presented in Chapter 3 of the TMI-2 FSAR. Conformance to these criteria is presented in the respective sections for these systems in the TMI-2 FSAR. Item 7 is addressed in the SPC System Description. Items 8 through 10 are included in the SDS System Description.

2.3 IIF Processing Plan Goal

The goal of the IIF Processing Plan is to maintain the Cs137 radionuclide concentration in the RCS to less than 1 $\mu\text{Ci/cc}$ and reduce the Sr90 concentration. The RCS chemistry will be maintained as follows as a minimum:

Chlorides	< 5 ppm
pH	> 7.5 but < 8.4
Boron	> 4750 ppm

The processing of water through the SDS does not have any effect on the chemical characteristics of the RCS water. The chemistry specified above will ensure that there will be no adverse effects on the RCS with respect to corrosion. The boron concentration will also ensure that sufficient boron is present to maintain the core in a noncritical safe condition.

Chapter 3

SYSTEM DESCRIPTION AND OPERATIONS

3.1 Introduction

The IIF Processing Plan is designed specifically for the controlled decontamination of the radioactive water in the Reactor Vessel & IIF and the treatment of the radioactive gases and solid radioactive waste which are produced. This plan will use the SDS as the means of decontamination of the IIF with support from other existing plant systems and a new suction pump. See Fig. 1.1 for a diagram of the IIF processing system flowpath.

3.1.1 Submerged Demineralizer System

The SDS consists of a liquid waste processing system, an off gas system, a monitoring and sampling system, and solid waste handling system. The liquid waste processing system decontaminates the RCS water by a process of filtration and demineralization. The off gas system collects, filters and absorbs radioactive gases produced during processing, sampling, dewatering and spent SDS liner venting. The sampling system provides measurements of process performance. The solid waste handling system is provided for moving, dewatering, vacuum drying, inertization, storage, and loading of filters and demineralizer vessels into the shipping cask.

3.1.2 Interfacing Systems

Rx coolant water is transferred from the IIF using a commercially available high capacity submersible pump. This pump (Indexing Fixture Processing Pump DWC-P-1) is supported from the IIF and takes suction approximately 2 1/2 ft above the Rx Vessel Flange. A 1 1/2 inch ID rubber hose with quick-disconnect two way shutoff type fitting connects the discharge of the pump to the fuel transfer canal drain manifold.

The manifold serves as a tie-in point for 3 systems: the Reactor Bldg. Basement Pump system, the fuel transfer canal drain system, and the IIF processing system. Double isolation of the IIF processing system from the other two is provided by air operated ball valve FCC-V003 and check valve FCC-V016 in addition to manual valves and disconnected/capped connections located on each of the other branches of the manifold. From the manifold, the system uses an existing flow path through Reactor Building penetration R-626, Fuel Handling Building penetration 1551 to tie-in and interface with the SDS system. Power for the pump is supplied from circuit 11 of distribution panel PDP-6A. Initial filling of the IIF is accomplished by transferring reactor coolant grade water to the IIF via the Fuel Transfer Canal Fill System, or via a waste transfer pump to an RCS cold leg.

Subsequent makeup to the IIF is accomplished by transferring reactor coolant grade water from RCBT-1A to the IIF via a waste transfer pump and an existing flow path through the WDL and MU systems to a cold leg of the reactor coolant system.

The roles of the RCBT's (1A & 1C) can be interchanged provided valves are properly realigned and the tank used to fill the IIF contains reactor coolant grade water.

Flow from the IIF may be manually throttled at valves CN-V-FL-1 or CN-V-FL-3 in SDS if desired. Flow to the IIF may be automatically controlled by valve MU-V-9 based on IIF water level or manually controlled using WDL-V-167 and WDL-V-36A. Shutoff of the IIF supply (via WDL-V-40) and discharge flows (via FCC-V-003) is achieved automatically in the event of unacceptable water levels in the IIF and may also be manually accomplished at several locations.

The Fuel Handling Building, Auxiliary Building, and Reactor Building HVAC systems provide tempered ventilating air and controlled air movement to prevent spread of airborne contamination with the plant and to the outside environment. The Nitrogen Supply system provides N_2 for blanketing the Reactor Coolant Bleed Tanks. Reactor Coolant grade water currently contained in the RCBT's provides borated water for injection into the RCS/IIF for the initial fill operation. The Waste Gas System processes the gases from the vents from the RCBT's.

The Standby Pressure Control System, installed as a temporary IMI-2 recovery system, will be used as a safety system to ensure that a second RCS injection path is available.

The principal components of the SDS are located in Spent Fuel Pool "B", as shown in Figure 3.1. The piping and components of the systems interfacing with the SDS are located in the Fuel Handling and Auxiliary Buildings. Tanks, pumps, valves, piping, and instruments are located in controlled access areas. Components and piping containing significant radiation sources are located in shielded cubicles, such as the Reactor Coolant Bleed Tanks and the Waste Transfer pumps WDL-P-5A and WDL-P-5B (see Figure 3.2).

3.2 IIF Transfer Operations

3.2.1 Normal Operation

Under normal operating conditions the IIF will be filled to the desired water level and normal start up will be required. To start the IIF processing system the valves must be aligned per reference 8 (or the reverse alignment as discussed in paragraph 4, section 3.1.2), SDS must be configured for reactor coolant processing, the automatic trip switches must be in the not-blocked position, the surface suction system must be flushed, and both the surface suction system and the fuel transfer canal drain system must be

isolated at the Fuel Transfer Canal Drain Manifold. The supply water to the IIF must be sampled to verify that it is within specification for reactor coolant grade water.

IIF processing system start-up is begun by starting waste transfer pump WDL-P-5B and opening valve WDL-V40. The pump will remain in minimum recirculation until flow to the IIF is required and MU-V-9 is opened. Valve FCC-V003 is remotely opened from SDS control panel CN-PNL-1, automatically starting the IIF processing pump to begin transferring water to the SDS. Valve MU-V9 automatically opens or is manually opened and maintains the IIF level.

3.2.2 Infrequent operation

The system has incorporated two hand switches (DWC-HIS-1A and DWC-HIS-1266-1) which are located on SDS control panel CN-PNL-1 which can be used to block automatic shutdown of the system for high or low levels. These switches will allow the operators to fill or drain the IIF to the desired water level as needed.

Relocation of the IIF processing pump within the IIF may be required to avoid interferences with post head removal activities. By using flexible hose with two-way shutoff "quick disconnect" couplings on the pump discharge, and the overlapping hanger design for the pump support, movement of the pump can easily be accomplished using overhead material handling equipment.

3.3 IIF Instrumentation & Control

On/off controls for the waste transfer pumps are located on radwaste panel 301B, and in the control room on control panel 9.

Valve WDL-V40 has existing open/close controls located on radwaste panel 301B and in the control room on the control panel 9. Additional open/close controls are located on SDS control panel CN-PNL-1. WDL-V40 terminates flow in the event of high or low water level in the IIF. A block switch is located on CN-PNL-1 which can be used to block the low level trip to permit filling the IIF to the desired level.

Normal control of valve FCC-V003 and the IIF processing pump is performed from SDS control panel CN-PNL-1. A single hand switch controls operation of both the valve and pump. A dual indicating light is provided on CN-PNL-1 for valve position. FCC-V003 stops flow in the event of high or low water level in the IIF. A block switch is located on CN-PNL-1 which can be used to block the high level trip to permit draining the IIF to the desired level.

Water level will be maintained manually or automatically at a prescribed level (approximately 327'6") in the IIF by valve MU-V9. The control signal to valve MU-V9 is provided by the reactor water level monitoring system (bubbler) through proportional controller RC-LIC-102 or from RC-LT-102 which is located on control room panel 5PC-PNL-3.

Emergency stop switches are provided at the IIF to close valves FCC-V003 and WDL-V40, thereby stopping flow to and from the IIF. (Closure of valve FCC-V003 will in turn trip pump DWC-P-1.) High and low level switches are provided on the bubbler panel to automatically stop flow to and from the IIF in the same manner as the emergency stop switches, and will sound alarms locally, in the control room on panel SPC-PNL-3 and at SDS panel CN-PNL-1.

IIF level indication is provided on panels SPC-PNL-3 and CN-PNL-1 and bubbler panel RC-LCPI.

3.4 IIF Processing by SDS

3.4.1 IIF Water Filtration

A flow diagram of the waste water filtering is shown in Figure 3.3. Two filters have been installed to filter out solids in the untreated contaminated water before the water is processed by the ion-exchangers. Both filters are sand type. The two sand filters are loaded in layers, using various sand sizings to optimize filter performance.

Mixed uniformly with the sand is approximately 6 pounds borosilicate glass which is at least 22 weight percent boron. The purpose of the borosilicate is to prevent the possibility of criticality should any fuel fines be transported in the letdown.

The flow capacity through each filter is 50 gpm. Reverse flow through filters is prevented by a check valve in the supply line to each filter.

Each filter is housed in a containment enclosure to enable leakage detection and confinement of potential leakage. The filters are submerged in the spent fuel pool for shielding considerations. Contaminated water is pumped (using DWC-P-1) through the filters and the RCS manifold to the ion exchangers.

Influent waste water may be sampled from a shielded sample box located above the water level to determine the activity of contaminated water prior to and following filtration.

Inlet, outlet, and vent connections on the filters are made with quick disconnect valved couplings which are remotely operated from the top of the pool. Inlet-outlet pressure gauges are provided to monitor and control solids loading. Load limits for the filters are based on filter differential pressure, filter influent and effluent sampling, and/or the surface dose limit for the filter vessel. A flush line is attached to the filter inlet to provide a source of water for flushing the filters prior to removal.

3.4.2 IIF Water Demineralization

A flow diagram of the ion exchange manifold and primary ion-exchange columns is shown in Figure 1.1. This system consists of eight underwater columns (24 1/2" x 54 1/2"), each capable of containing eight cubic feet inorganic zeolite sorbent. Homogeneously mixed Ion Siv IE-96 and LINDE-A zeolite are the medias of choice to efficiently immobilize the Cesium and Strontium in the RCS. Four zeolite beds are divided into two trains each containing two beds (A, B) with piping and valves provided to operate either train individually or both trains in parallel. In order to maintain the IIF radiation levels ALARA, higher SDS Process flow rates are necessary. Normal operation will consist of two trains of two vessels per train operating in parallel with a flow rate of 5-15 gpm per train. However deboration concerns and impracticability of more frequent samplings have limited the process flow rate to 6.5 gpm (total).

An in-line radiation monitor measures the activity level of the water exiting the last polishing filter. The valve manifold for controlling the operation of the primary ion exchange columns is located above the pool, inside a shielded enclosure that contains a built-in sump to collect leakage that might occur. Any such leakage is routed back to the RCS manifold via the off gas bottoms separator tank and pump. A line connects to the inlet of each ion exchanger to provide water for flushing the ion exchangers when they are loaded. Radionuclides loading of ion exchange vessels is determined by analyzing the influent and effluent from each

exchanger. Process water flow is measured by instruments placed in the line to each ion-exchange train. The effluents from the two trains of ion exchangers is routed through either of the two "cation" positions. However for IIF processing, these "cation" positions will contain sand polishing filters similar to the pre and final filters instead of zeolite beds. Sand filters are used to improve effluent clarity. The existing post filter is bypassed to reduce system differential pressure. Therefore the zeolite effluent will pass through a sand filter in either of the cation positions directly to one of the RCBT's.

Periodic sampling of the process stream will occur during the processing of a batch of water. At the completion of processing a batch, the contents of RCBT "A" will be sampled to determine acceptability for injection of this water into the RCS. If the water is within specification, it is injected into the RCS.

The types of samples to be taken at RCBT after letdown and prior to reinjection is shown in Table 3.1.

3.4.2 Leakage Detection and Processing

Each submerged vessel is located inside a secondary containment box that contains spent fuel pool water. During operation the secondary containment lid is closed. This lid is slotted to permit a calculated quantity of pool water to flow past the vessels and

connectors. Pool water from the containment boxes is continuously monitored to detect leakage and is circulated by a pump through one of the two leakage containment ion-exchangers. Any leakage which occurs during routine connection and disconnection of the quick-disconnects will be captured by the containment boxes, diluted by pool water, and treated by ion-exchange before being returned to the pool.

3.4.4 Off-Gas and Liquid Separation System

An off-gas and liquid separation system collects gaseous and liquid wastes resulting from the operation of the water treatment system. This system will be operated in the same manner for RCS water processing as it was for Reactor Building Sump water processing.

3.4.5 Sampling and Process Radiation Monitoring System

The sampling glove boxes are shielded enclosures which allow water samples to be taken for analysis of radionuclides and other contaminants. The piping entering the glove boxes permits the withdrawal of a volume limited amount of sample into a collection bottle. Cylinders are purged by positioning valves to permit the water to flow through them and return to a waste drain header and into the off-gas separator tank. A water line connects to the sample line to allow the line to be flushed after a sample has been taken.

The entire sampling sequence is performed in shielded glove boxes to minimize the possibility of inadvertent leakage and spread of contamination during routine operation.

3.4.5.1 Sampling System

Sampling of the SDS process to monitor performance is accomplished from three shielded sampling glove boxes. One glove box is for sampling the filtration system, the second is for sampling the feed and effluent for the first zeolite bed and the third from sampling the effluents of the remaining zeolite.

3.4.5.2 Process Radiation Monitoring System

The SDS is equipped with a process radiation monitoring system which provides indication of the radioactivity concentration in the process flow stream at the effluent point from the last ion exchanger vessel. The purpose of this monitoring system is to provide indication and alarm of radionuclide breakthrough.

3.4.5.3 Transuranic Element Monitoring

During IIF processing the need for TRU Monitoring is not required, as the majority of TRU is expected to deposit in the filters & Ion Exchangers before reaching the RCBT.

3.4.6 Ion-Exchanger and Filter Vessel Transfer in the Fuel Storage Pool

Prior to system operation, ion exchanger and filter vessels are placed inside the containment boxes and connected with quick-disconnect couplings. When it is determined that a vessel is loaded with radioactive contaminants to predetermined limits as specified in the Process Control Program, the system will be flushed with low-activity processed water. This procedure flushes away waterborne radioactivity, thus minimizing the potential for loss of contaminants into the pool water while decoupling vessels. Vessel decoupling is accomplished remotely. Vessels are transferred using the existing fuel handling crane utilizing a yoke attached to a long shaft. The purpose of this yoke-arm assembly is to prevent inadvertent lifting of the ion exchange bed or filter vessel to a height greater than eight feet below the surface of the water in the pool. This device is a safety tool that will mechanically prevent lifting a loaded vessel out of the water shielding and preclude the possibility of accidental exposure of operating personnel.

The ion-exchanger vessels are arranged to provide series processing through each of the beds; the influent waste water is treated by the bed in position "A", then by the bed in position "B", goes through a jumper in position "C", and finally by the sand filter in position "D".

3.5 Zeolite Mixtures

The SDS ion exchangers will contain a uniform mixture of IONSIV-96 and LINDE-A ion exchanger media. These two zeolites were selected for their proven capabilities while processing Reactor Building Sump water to remove radionuclides. IONSIV-96 primarily removes the isotopes of Cesium and LINDE-A removes the isotopes of Strontium.

The ratio of loading the two types of ion exchanger media will be determined by experimental data to determine the optimum loading.

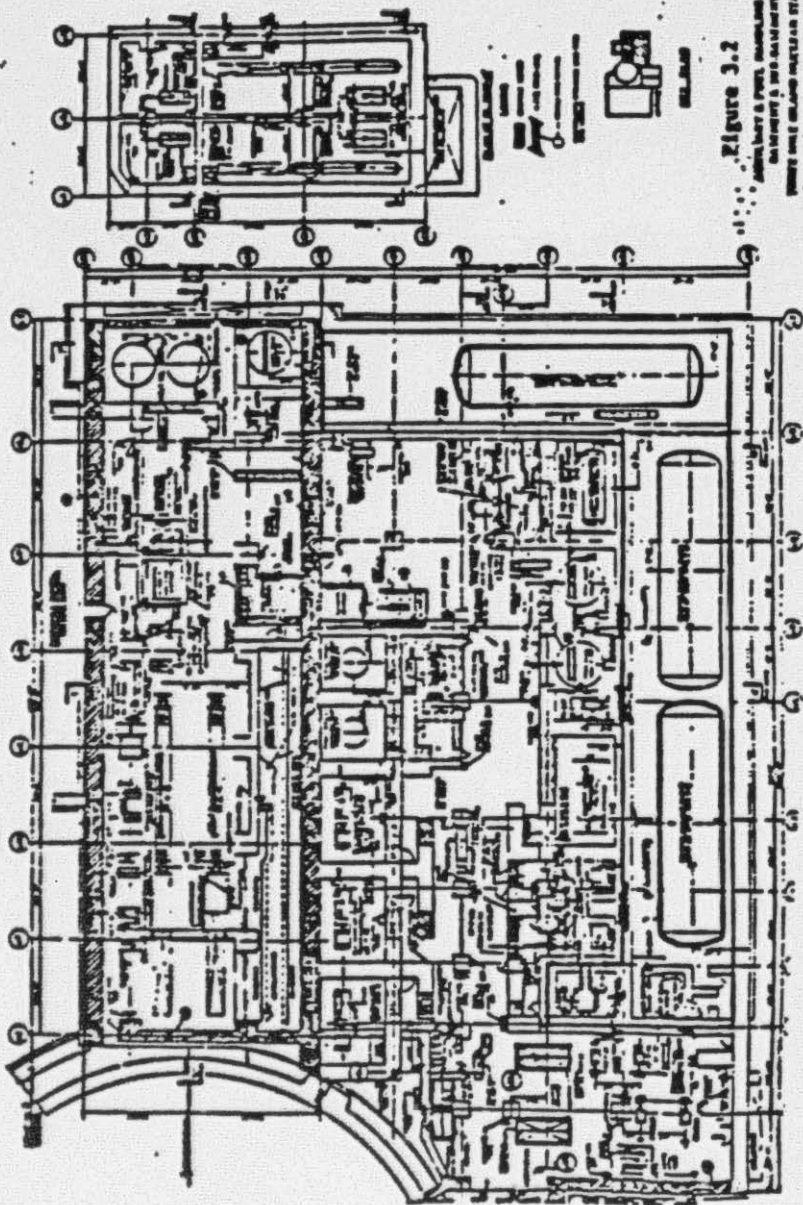
Periodic sampling of the process stream will be used to verify the performance of the ion exchange media. If necessary, revisions will be made to the loading ratios if conditions warrant to achieve the proper decontamination factors. Verification of the performance of the ion exchange media will be made in accordance with the Process Control Plan for IIF processing.

TABLE 3.1

RCBT WATER SAMPLING

RCBT INJECTION SAMPLE

Gamma Scan
Gross Beta - Gamma
Sr-90
pH at 77°F
Conductivity
Boron
Na
Cl
Sulfates
H-3
Oxygen
Fluorides



CHAPTER 4

Radiation Protection

4.1 Ensuring Occupational Radiation Exposures are ALARA

4.1.1 Overall Policy

The objectives with respect to RCS processing operations are to ensure that operations conducted in support of the on-going demineralization program are conducted in a radiologically safe manner, and further, that operations associated with radiation exposure will be approached from the standpoint of maintaining radiation exposure to levels that are as low as reasonably achievable.

During the operational period of the system the effective control of radiation exposure will be based on the following considerations:

1. Sound engineering design of the facilities and equipment.
2. The use of proper radiation protection practices, including work task planning for the proper use of the appropriate equipment by qualified personnel.
3. Strict adherence to the radiological controls procedures as developed for TMI-2.

4.1.2 SDS Design and Operation

The SDS design and operational considerations are given in Chapter 6 of the SDS IER. These design and operational considerations and features remain unchanged from this evaluation.

The radiation dose exposures to plant personnel during IIF processing will be lower due to the fact that the radionuclide concentration in the RCS water is significantly lower than those experienced during processing of Reactor Building sump water. The design basis for shielding the SDS equipment is to reduce radiation levels to less than 1 mrem/hr using the radionuclide concentration of 200 $\mu\text{Ci/cc}$ of predominately Cesium. The radionuclide concentration of Cesium in the RCS water is currently less than 0.5 $\mu\text{Ci/cc}$.

4.1.3 Existing Plant Considerations

The radiation protection features for the existing plant system which interface with the SDS are described in Chapter 12 of the TMI-2 FSAR. The existing radiation shielding within the Auxiliary Building for the following systems is adequate to reduce the radiation levels to below the design basis of 2 mrem/hr in areas requiring access:

1. Makeup and Purification System
2. Reactor Coolant Liquid Waste Chain
3. Miscellaneous Waste Chain
4. Waste Gas System

4.2 Dose Assessment

4.2.1 On Site Assessment

Operation of the SDS in the IIF processing mode is expected to require 50,000 gallons of processing per week from installation of the IIF processing system until plenum removal (approximately 14 months). This amount of processing is required to maintain Cs-137 concentration at less than 1.0 $\mu\text{Ci}/\text{ml}$ in order to maintain radiation levels in the reactor vessel head area as low as reasonably achievable. Based on current experience with the SDS this amount of processing is expected to result in an exposure for SDS operating area activities of 0.225 man-rem/week or approximately 13.5 man-rem over the 14 month period.

4.2.2 Off-site Radiological Exposures

Source Terms for Liquid Effluents

Liquid effluent from the system will be returned to station tankage for further disposition. Therefore, no liquid source term is identified for this evaluation.

Source Terms for Gaseous Effluents

The plant vent system is a potential pathway for carrying airborne radioactive material and release. Radionuclides in the gaseous effluent arise from entrainment during transfer of contaminated water to various tanks, filters, ion exchange units, and also from water sampling. For further information, see section 6.3.2 of the SDS TER.

Chapter 5

CONDUCT OF OPERATIONS

5.1 System Performance

By processing the Reactor Building sump water and RCS successfully assurance has been granted that components developed specifically to meet the conditions imposed at TMI will perform in the intended manner.

The ion-exchange process is a well understood process. The SDS has demonstrated that high decontamination factors can be achieved by the use of zeolite ion exchange media.

During IIF processing, the SDS system flow rates will be higher than during all previous processing. An eight hour test was performed to assure that these increased flowrates will not adversely affect zeolite performance. Also, calculations have been performed by ORNL to demonstrate that system performance will not be jeopardized. Although radionuclide break through may occur sooner in the batch, it will progress more slowly. This breakthrough will be allowed to occur to extend zeolite life (minimize wastes) since the effluent is routed back to the IIF.

Zeolite media loading and dewatering can be accomplished in the intended manner and remote tools, necessary for the coupling and de-coupling of the vessels, operate in the intended manner.

5.2 System Testing

Prior to use in the SDS each vessel will be hydrostatically tested in conformance with the requirements of applicable portions of the ASME Boiler and Pressure Vessel Code. Upon completion of construction, the entire system was pneumatically tested to assure leak-free operations. The system will be retested prior to IIF processing at the design pressure.

Individual component operability will be assured during the preoperational testing. Motor/pump rotation and control schemes will be verified. The leakage collection sub-system, as well as the gas collection sub-system, will be tested to verify operability. Filters for the treatment of the collected gaseous waste will be tested prior to initial operation. System preoperational testing will be accomplished in accordance with approved procedures.

5.3 System Operations

System operations will be conducted in accordance with written and approved procedures. These procedures will be applicable to normal system operations, emergency situations, and required maintenance evolutions.

Prior to IIF operation, formal classroom instruction will be provided to systems operations personnel to ensure that adequate knowledge is gained to enable safe and efficient operation. During a system operations on-going operator evaluations will be conducted to ensure continuing safe and efficient system operation.

Chapter 5

ADDITIONAL ACCIDENT SCENARIOS

6.1 Possible Accident Scenarios

- 6.1.1 Overfill of the IIF could result in contamination of the pool area in the vicinity of the reactor vessel, and potentially increase airborne activity in the Reactor Building.
- 6.1.2 Lowering of the IIF water level would reduce the shielding provided thereby increasing worker exposure on the IIF platform.
- 6.1.3 Injection of below specification borated water into the IIF would violate technical specification requirements, and could lead to criticality.
- 6.1.4 A breach of the system pressure boundary during pumping of the reactor coolant to the RCBT could result in the release of reactor coolant which could cause additional contamination of reactor building or Aux/FHB surfaces.
- 6.1.5 If FCC-V003 remains open after pump DWC-P-1 stops, siphoning from the IIF would result in lowering the IIF water level.

6.2 Design Features to Mitigate Effects of Accident Events

6.2.1 When transferring water from the RCBT to the IIF, flow rate will be automatically controlled by MU-V9, or manually controlled using WDL-V-36A and WDL-V-167. Valve WDL-V40 will receive input from a hi-level switch, which will automatically close the valve in the event of high water level, terminate system operation, and sound local and remote alarms. Additionally, when initially filling the IIF, the water level will be monitored by visual inspection to prevent overfilling of the IIF.

6.2.2 When transferring reactor coolant from the IIF through SDS to the RCBT, reactor coolant will be pumped using DWC-P-1. Suction will be taken about 2 1/2 feet above the reactor vessel flange. This will allow a sufficient inventory of reactor coolant to remain in the reactor vessel for shielding as well as decay heat removal in the event the system does not automatically stop for low level. Valve FCC-V003 will automatically close and alarms sound in the event of low level. Closing valve FCC-V003 automatically trips the IIF processing pump and terminates system operation. An emergency stop switch provided at the IIF will allow workers to terminate system operation in the event of low level indication.

6.2.3 System procedures will require that the surface suction system be flushed and both the surface suction system and the fuel transfer

canal drain systems isolated before starting the IIF processing system. Double isolation is provided to prevent injection of below specification boroated water into the IIF from these sources. Sampling of the RCBT supplying the IIF is required before the system is placed in operation.

6.2.4 The discharge hose and pipe, including the manifold will be leaked tested in accordance with ANSI B31.1. Periodic visual inspection of the hose is required to assess its condition. The hose and couplings are rated higher than the IIF processing pump shutoff head (≈ 150 psig).

6.2.5 FCC-V003 is provided with a spring loaded actuator which will cause the valve to fail close on loss of air or electricity, thereby preventing siphoning from the IIF. Should the valve remain open, suction will be broken 2 1/2 feet above the reactor vessel flange, leaving a sufficient inventory of reactor coolant for shielding and decay heat removal. Should water level drop dramatically personnel will be restricted from the immediate area.

REFERENCES

1. MET ED letter LL2-81-0070 dated March 11, 1981, G. K. Hovey (MET ED) to L. Barrett (NRC), "Three Mile Island Nuclear Station, Unit 2, Operating License No. DPR-73, Docket No. 50-320, Submerged Demineralizer System."
2. TMI-2 Radiochemistry Summary Sheet, Sample No. 85-06536 dated June 3, 1985.
3. TMI-2 Burns and Roe Drawing No. 2024, Makeup and Purification System.
4. TMI-2 Burns and Roe Drawing No. 2027, Radwaste Disposal Reactor Coolant Liquids.
5. TMI-2 Burns and Roe Drawing No. 2045, Radwaste Disposal Miscellaneous Liquids.
6. GPUNC Drawing No. 2R-950-21-001, P&ID Composite: Submerged Demineralizer System.
7. TMI-2 Burns and Roe Drawing No. 2026, Decay Heat and Spent Fuel Cooling.
8. TMI-2 Bechtel Drawing No. 2-M75-DWC01 & 2, Schematic Diagram: IIF Processing System.

Appendix No. 3

to

Submerged Demineralizer System

Technical Evaluation Report

TITLE

FUEL TRANSFER CANAL DRAINING SYSTEM (FCC)

JUNE 1985

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- 1.2 Current Fuel Transfer Canal Activity and Chemistry
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Chapter 2 FCC Processing Plan Design Criteria

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 - 2.2.1 SDS
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Chapter 1

SUMMARY OF TREATMENT PLAN

1.1 Project Scope

The capability to maintain water clarity and radionuclide concentrations in the Fuel Transfer Canal (Deep End) during early defueling operations must be available. The design features of this processing method are:

1. Use of the proven processing capabilities of the SDS.
2. Use of existing plant systems in support of SDS.
3. Use of FCC-P-1 (canal drain pump).
4. Use of DWC system piping.

This report is presented as an addendum to the previously submitted SDS TER to provide greater detail in those aspects of system design and operation which are unique to the processing of the Fuel Transfer Canal.

1.2 Current Fuel Transfer Canal Activity & Chemistry

Water samples are taken weekly to monitor radionuclide activity and chemical parameters of the Fuel Transfer Canal. Current results are listed in Table 1.1. Activity decreases due to decay, however activity in water may increase due to leaching from plenum or activity on canisters being transferred through the Fuel Transfer Canal.

1.3 FCC Processing Description

Figure 1.1 shows a block diagram of the FCC processing flow path. The Fuel Transfer Canal may be processed on a continuous basis through the SDS pre & final filters, one or both trains of ion exchangers, and the cation sand filter with the effluent routed back to the FTC or the 'A' Spent Fuel Pool. In addition the FTC may be processed through the SDS to any of the RCBT's. The FCC processing will use the existing SDS filters and ion-exchangers. Existing sampling capabilities will be used to monitor the process as in past processing. Further information on the SDS system may be found in the main sections of the TER. This system will be in service until complete installation of the DWCS.

Table 1.1

FTC Radionuclide and Chemistry Data
(05/29/85)

Co ⁶⁰	5.9×10^{-4} μ Cl/ml
Sr ⁹⁰	0.14 μ Cl/ml
Ru ¹⁰⁶	6×10^{-6} μ Cl/ml
Sb ¹²⁵	4.9×10^{-4} μ Cl/ml
Cs ¹³⁴	2.3×10^{-4} μ Cl/ml
Cs ¹³⁷	6.4×10^{-4} μ Cl/ml
Ce ¹⁴⁴	5×10^{-5} μ Cl/ml
Boron	5150 ppm
Turbidity	3.4 NTU

Figure 1.1

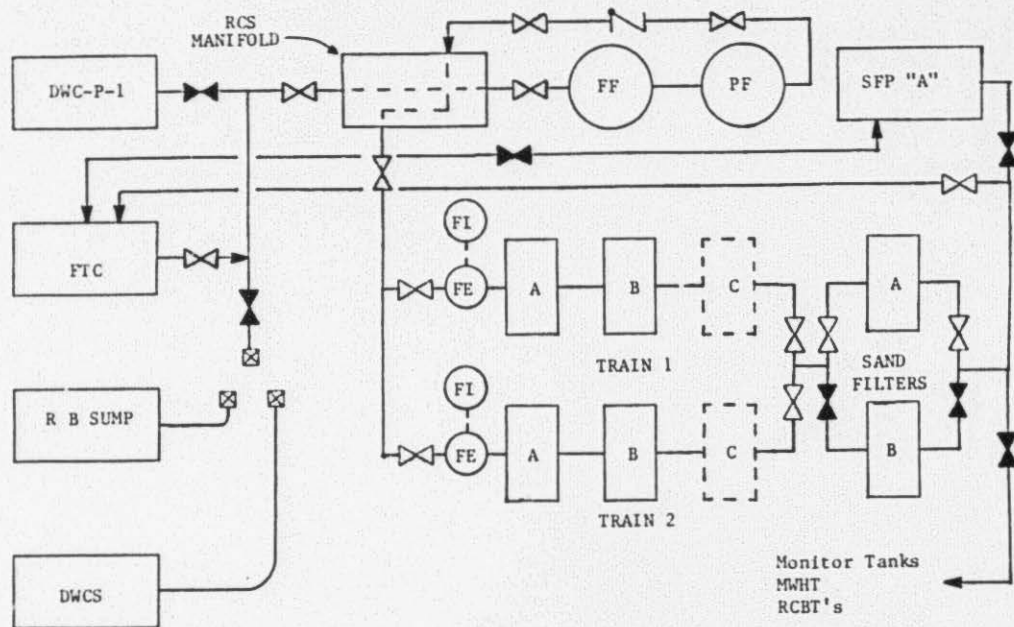


Figure 1.1
ITC Processing Flowsheet

Chapter 2

FCC PROCESSING PLAN DESIGN CRITERIA

2.1 Introduction

The FCC Processing Plan is designed to use a high capacity submersible pump (FCC-P-1), the Submerged Demineralizer System, and portions of the Defueling Water Cleanup System to maintain water clarity and activity levels in the Fuel Transfer Canal. The design objectives are:

1. A system to maintain FTC clarity and radioactivity levels.
2. A system that is as independent as possible from existing plant systems. The only portions of this system that are not temporary recovery systems are plant services connections (water, air, electric) and if water is to be processed to a RCBT, the inlet header to the RCBT's (WDL System).
3. A system that has proven performance in radioactive waste processing. The SDS has successfully decontaminated to date almost three million gallons of contaminated liquids.

2.2 Design Basis

2.2.1 SDS

The design basis of the SDS is presented in Chapter 4 of the SDS TER.

2.2.2 Interfacing Systems

The interfacing systems with the SDS in the FCC Processing system are:

1. Reactor Coolant Liquid Waste System
2. Reactor, Auxiliary and Fuel Handling Buildings Heating, Ventilation and Air Conditioning Systems.
3. Waste Gas System
4. Plant Air, Electric, Nitrogen and Demin. Water Systems
5. RB Jet Pump
6. DWCS-Reactor Vessel Filtration System
7. IIF Processing System/Fuel Transfer Canal Shallow End Drainage System.

The Design Criteria for Systems 1-4 above are presented in the TMI-2 FSAR. Systems 5 thru 7 are covered in the SDS System Description.

2.3 FCC Processing Plan Goal

The goal of the FCC Processing Plan is 1) to maintain Gross Beta activity less than 1×10^{-4} $\mu\text{Ci}/\text{ml}$ to minimize the source term and 2) to maintain turbidity less than 1NTU to maintain underwater visibility. The processing of this water through SDS has no effect on the chemical characteristics of the water.

SYSTEM DESCRIPTION AND OPERATIONS

3.1 Introduction

The FCC Processing Plan is designed to maintain radioactivity levels and water clarity in the Fuel Transfer Canal until the DWCS is completed and operational.

3.1.1 Submerged Demineralizer System

The SDS consists of a liquid waste processing system, an off gas system, a monitoring and sampling system, and solid waste handling system. The liquid waste processing system decontaminates the FTC water by a process of filtration and demineralization. The off gas system collects, filters and absorbs radioactive gases produced during processing, sampling, dewatering and spent SDS liner venting. The sampling system provides measurements of process performance. The solid waste handling system is provided for moving, dewatering, vacuum drying, inerrization, storage, and loading of filters and demineralizer vessels into the shipping cask.

3.1.2 Interfacing Systems

Canal water is transferred from the FTC using a commercially available high capacity submersible pump. This pump (Canal Drain Pump FCC-P-1) takes suction in the 4" drain located in the deep end of the canal. A 1 1/2 inch ID rubber hose with quick-disconnect two way shut-off type fitting connects the discharge of the pump to the fuel transfer canal drain manifold.

The manifold serves as a tie-in point for 3 systems; the Reactor Bldg. Basement Pump system, the fuel transfer canal drain system, and the IIF processing system/FTC Shall End Drainage System. Double isolation of the FCC processing system from the other two is provided by ball valves FCC-V003 and FCC-V002 in addition to disconnected/capped connections located on each of the other branches of the manifold. From the manifold, the system uses an existing flow path through Reactor Building penetration R-626, Fuel Handling Building penetration 1551 to tie-in and interface with the SDS system. Power for the pump is supplied from distribution panel PDP-6A, breaker #12.

Flow from the FTC may be manually throttled via CN-V-FL-1 or CN-V-FL-3 in SDS if desired.

The Fuel Handling Building, Auxiliary Building, and Reactor Building HVAC systems provide tempered ventilating air and controlled air movement to prevent spread of airborne contamination with the plant and to the outside environment. The Nitrogen Supply system provides N_2 for blanketing the Reactor Coolant Bleed Tanks, should the system effluent be routed to them. The Waste Gas System processes the gases from the vents from the RCBT's.

The principal components of the SDS are located in Spent Fuel Pool "B", as shown in Appendix No. 2 Figure 3.1. The piping and components of the systems interfacing with the SDS are located in the Fuel Handling and Auxiliary Buildings. Tanks, pumps, valves, piping, and instruments are located in controlled access areas. Components and piping containing significant radiation sources are located in shielded cubicles, such as the Reactor Coolant bleed Tanks and the Waste Transfer pumps WDL-P-5A and WDL-P-5B (see Appendix No. 2 Figure 3.2).

3.2 FCC Transfer Operations

3.2.1 Normal Operations

The FCC will be filled with RCS grade water. The function of the FCC system is to provide a controlled means of draining or processing this water from the canal.

To start the FCC processing stem, the valves must be aligned and the SDS must be configured per the approved operating procedure and both the connections from SWS-P-1 and DWC-P-1 must be disconnected. The pump FCC-P-1 is started and valves are operated per the procedure to ensure effluents is routed where desired.

3.3 FCC Instrumentation

Pump FCC-P-1 is controlled via hand indicating switch FCC-HIS-1, which is located on SDS control panel CN-PNL-1 at El. 347'-6" of the fuel handling building. The switch starts and stops the pump and shows, via a light, that power is being delivered to the pump. The starter^F FCC-STR-1, for the pump is mounted adjacent to panel CN-PNL-1.

Pressure gauge FCC-PI-3 is provided on the canal drain manifold to sense the line pressure downstream of the manifold isolation valves.

Fuel Transfer Canal Water Level FCC-LI-102 is provided by a bubbler (FCC-VICV-104) through proportional controller FCC-LT-102, with Local Level Indication FCC-LIS-103^G which also actuates high/low level alarms (FCC-LAHL-103).

To start the FCC processing stem, the valves must be aligned and the SDS must be configured per the approved operating procedure and both the connections from SWS-P-1 and DWC-P-1 must be disconnected. The pump FCC-P-1 is started and valves are operated per the procedure to ensure effluents is routed where desired.

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3.4 FCC Processing by SDS

3.4.1 FCC Water Filtration

Two filters are installed to filter out solids in the untreated contaminated water before the water is processed by the ion-exchanger. The filters are loaded in layers using various sand sizings to optimize filter performance. Mixed uniformly with the sand is approximately 6 pounds of borosilicate glass which is at least 22 weight percent boron, to prevent the remote possibility of criticality should any fuel fines be transported to the filters. The filters and their containment enclosures, sampling, etc. are unchanged from that in previous sections of this IER.

3.4.2 FCC Water Demineralization

This system consists of two trains of ion exchangers consisting of 2 or 3 ion exchangers each. Each ion exchanger contains eight cubic feet of ion organic zeolite sorbent. Piping and valves exist allowing operation of either train individually or both in parallel. The effluents from the two trains of ion exchangers is routed through one of two sand filters installed in the "cation" positions. These sand filters were installed in place of the original cartridge type post filter, and is used to trap zeolite fines and improve effluent clarity. These ion-exchangers, their containment enclosures, sampling, etc. are discussed in more detail in previous sections of this IER.

3.4.3 Leakage Detection and Processing

Each submerged vessel is located inside a secondary containment box that contains spent fuel pool water. During operation the secondary containment lid is closed. This lid is slotted to permit a calculated quantity of pool water to flow past the vessels and connectors. Pool water from the containment boxes is continuously monitored to detect leakage and is circulated by a pump through one of the two leakage containment ion-exchangers. Any leakage which occurs during routine connection and disconnection of the quick-disconnects will be captured by the containment boxes, diluted by pool water, and treated by ion-exchange before being returned to the pool.

3.4.4 Off-Gas and Liquid Separation System

An off-gas and liquid separation system collects gaseous and liquid wastes resulting from the operation of the water treatment system.

3.4.5 Sampling and Process Radiation Monitoring System

The sampling glove boxes are shielded enclosures which allow water samples to be taken for analysis of radionuclides and other contaminants. The piping entering the glove boxes permits the withdrawal of a volume limited amount of sample into a collection bottle. Cylinders are purged by positioning valves to permit the water to flow through them and return to a waste drain header and into the off-gas separator tank. A water line connects to the sample line to allow the line to be flushed after a sample has been taken.

The entire sampling sequence is performed in shielded glove boxes to minimize the possibility of inadvertent leakage and spread of contamination during routine operation.

3.4.5.1 Sampling System

Sampling of the SDS process to monitor performance is accomplished from three shielded sampling glove boxes. One glove box is for sampling the filtration system, the second is for sampling the feed and effluent for the first zeolite bed and the third from sampling the effluents of the remaining zeolite.

3.4.5.2 Process Radiation Monitoring System

The SDS is equipped with a process radiation monitoring system which provides indication of the radioactivity concentration in the process flow stream at the effluent point from the last ion exchanger vessel. The purpose of this monitoring system is to provide indication and alarm of radionuclide breakthrough.

3.4.6 Ion-Exchanger and Filter Vessel Transfer in the Fuel Storage Pool

Prior to system operation, ion exchanger and filter vessels are placed inside the containment boxes and connected with quick-disconnect couplings. When it is determined that a vessel is loaded with radioactive contaminants to predetermined limits as specified in the Process Control Program, the system will be flushed with low-activity processed water. This procedure flushes away waterborne radioactivity, thus minimizing the potential for loss of contaminants into the pool water while decoupling vessels. Vessel decoupling is accomplished remotely. Vessels are transferred using the existing fuel handling crane utilizing a yoke attached to a long shaft. The purpose of this yoke-arm assembly is to prevent inadvertent lifting of the ion exchange bed or filter vessel to a height greater than eight feet below the surface of the water in the pool. This device is a safety tool that will mechanically prevent lifting a loaded vessel out of the water shielding and preclude the possibility of accidental exposure of operating personnel.

The ion-exchanger vessels are arranged to provide series processing through each of the beds; the influent waste water is treated by the bed in position "A", then by the bed in position "B", goes through a bed or jumper in position "C", and finally by the sand filter in position "D".

3.5 Zeolite Mixtures

The SDS ion exchangers will contain a uniform mixture of IONSIV-96 and LINDE-A ion exchanger media. These two zeolites were selected for their proven capabilities while processing Reactor Building Sump water to remove radionuclides. IONSIV-96 primarily removes the isotopes of Cesium and LINDE-A removes the isotopes of Strontium.

The ratio of loading the two types of ion exchanger media will be determined by experimental data to determine the optimum loading.

Periodic sampling of the process stream will be used to verify the performance of the ion exchange media. If necessary, revisions will be made to the loading ratios if conditions warrant to achieve the proper decontamination factors.

CHAPTER 4

Radiation Protection

4.1 Ensuring Occupational Radiation Exposures are ALARA

4.1.1 Overall Policy

The objectives with respect to FCC processing operations are to ensure that operations conducted in support of the on-going demineralization program are conducted in a radiologically safe manner, and further, that operations associated with radiation exposure will be approached from the standpoint of maintaining radiation exposure to levels that are as low as reasonably achievable.

During the operational period of the system the effective control of radiation exposure will be based on the following considerations:

1. Sound engineering design of the facilities and equipment.
2. The use of proper radiation protection practices, including work task planning for the proper use of the appropriate equipment by qualified personnel.
3. Strict adherence to the radiological controls procedures as developed for IMI-2.

4.1.2 SDS Design and Operation

The SDS design and operational considerations are given in Chapter 6 of the SDS TER. These design and operational considerations and features remain unchanged from this evaluation.

The radiation dose exposures to plant personnel during FCC processing will be lower due to the fact that the radionuclide concentration in the FCC water is significantly lower than those experienced during processing of Reactor Building sump water. The design basis for shielding the SDS equipment is to reduce radiation levels to less than 1 mrem/hr using the radionuclide concentration of 200 $\mu\text{Ci/cc}$ of predominately Cesium. The radionuclide concentration of Cesium in the FCC water is currently much less than 0.1 $\mu\text{Ci/cc}$.

4.1.3 Existing Plant Considerations

The radiation protection features for the existing plant system which interface with the SDS are described in Chapter 12 of the TMI-2 FSAR. The existing radiation shielding within the Auxiliary Building for the following systems is adequate to reduce the radiation levels to below the design basis of 2 mrem/hr in areas requiring access:

1. Reactor Coolant Liquid Waste Chain
2. Waste Gas System

4.2 Dose Assessment

4.2.1 On Site Assessment

Operation of the SDS in the FCC processing mode is expected to require Intermittent processing of the FCC as required to maintain water clarity and Gross $\beta\gamma$ activity $<1 \times 10^{-4}$ $\mu\text{Ci/ml}$ until DWCS is fully operational. Based on current experience with the SDS this amount of processing is expected to result in a negligible exposure for SDS operating area activities.

4.2.2 Off-site Radiological Exposures

Source Terms for Liquid Effluents

Liquid effluent from the system will be returned to station tankage for further disposition. Therefore, no liquid source term is identified for this evaluation.

Source Terms for Gaseous Effluents

The plant vent system is a potential pathway for carrying airborne radioactive material and release. Radionuclides in the gaseous effluent arise from entrainment during transfer of contaminated water to various tanks, filters, ion exchange units, and also from water sampling. For further information, see section 6.3.2 of the SDS TER.

Chapter 5
CONDUCT OF OPERATIONS

5.1 System Performance

By processing the Reactor Building sump water and RCS successfully assurance has been granted that components developed specifically to meet the conditions imposed at TMI will perform in the intended manner.

The ion-exchange process is a well understood process. The SDS has demonstrated that high decontamination factors can be achieved by the use of zeolite ion exchange media.

During FCC processing, the SDS system flow rates may be higher than during all previous processing. An eight hour test was performed to assure that these increased flowrates will not adversely affect zeolite performance. Also, calculations have been performed by ORNL to demonstrate that system performance will not be jeopardized. Although radionuclide breakthrough may occur sooner in the batch, it will progress more slowly. This breakthrough will be allowed to occur to extend zeolite life (minimize wastes) since the effluent is routed back to the Fuel Transfer Canal.

Zeolite media loading and dewatering can be accomplished in the intended manner and remote tools, necessary for the coupling and decoupling of the vessels, operate in the intended manner.

5.2 System Testing

Prior to use in the SDS each vessel will be hydrostatically tested in conformance with the requirements of applicable portions of the ASME Boiler and Pressure Vessel Code. Upon completion of construction, the entire system was pneumatically tested to assure leak-free operations. The system will be retested prior to IIF processing at the design pressure.

Individual component operability will be assured during the preoperational testing. Motor/pump rotation and, control schemes will be verified. The leakage collection sub-system, as well as the gas collection sub-system, will be tested to verify operability. Filters for the treatment of the collected gaseous waste will be tested prior to initial operation. System preoperational testing will be accomplished in accordance with approved procedures.

5.3 System Operations

System operations will be conducted in accordance with written and approved procedures. These procedures will be applicable to normal system operations, emergency situations, and required maintenance evolutions.

Prior to FCC operation, formal classroom instruction will be provided to systems operations personnel to ensure that adequate knowledge is gained to enable safe and efficient operation. During system operations on-going operator evaluations will be conducted to ensure continuing safe and efficient system operation.

Chapter 6

ADDITIONAL ACCIDENT SCENARIOS

6.1 Possible Accident Scenarios

6.1.1 A breach of the system pressure boundary while delivering water from the fuel transfer canal could result in additional contamination of reactor building surfaces.

6.1.2 Introduction of reactor building sump water into the fuel transfer canal would contaminate the canal and could result in a potential criticality problem.

6.2 Design Features to Mitigate Effects of Casualty Events

6.2.1 A hose or pipe break will result in loss of line pressure.

Pressure and flow indication are provided at various locations on the pump discharge flowpath. The piping and hoses are hydrostatically tested to 1.5 times their maximum operating pressure per ANSI B31.1. To ensure pressure boundary integrity, hoses are to be inspected prior to operation of the FCC canal drain network.

6.2.2 The fuel transfer canal drain system and the IIF processing or fuel transfer canal shallow end drainage system connections of the canal drain manifold contain double isolation, which includes a check valve in each line. This is to prevent reactor building sump and flush water from being delivered into the canal. In addition, the coupling connections on the canal drain and fuel transfer canal shallow end drainage branch lines of the manifold are 1 1/2-inches and incorporate a two-way shut-off feature. All other manifold coupling connections, including the reactor building basement jet pump system connection, are 1-inch diameter. This prevents connecting a 1 1/2-inch pump discharge hose to the 1-inch RB basement jet pump system connection which does not include a check valve. QC is to verify that each hose is connected to the proper manifold branch connection prior to system turnover.

REFERENCES

1. SDS System Description Appendix 13.
2. TMI-2 Radiochemistry Summary Sheet, Sample No. 85-06377 dated May 29, 1985.
3. Bechtel Dwg. No. 2-M75-DWC04, Schematic Diagram: Interim Fuel Transfer Canal Processing System.

Appendix No. 4

to

Submerged Demineralizer System
Technical Evaluation Report

TITLE

FUEL TRANSFER CANAL SHALLOW END DRAINAGE SYSTEM

JUNE 1985

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- 2.2 Design Basis
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5.1 System Performance

5.2 System Testing

5.3 System Operations

Chapter 6 Accident Scenarios

6.1 Casualty Events

6.2 Design Features to Mitigate Effects of Casualty Events

Chapter 1

SUMMARY PLAN

1.1 Project Scope

The capability to transfer water from the shallow end of the Fuel Transfer Canal to the deep end or a RCBT is necessary to deal with FTC dam leakage or overflow, or inleakage from some other source. This report is presented as an addendum to the previously submitted SDS TER to provide details of the transfer of water from the FTC shallow end.

1.2 FTC (shallow end) Activity Chemistry

There are a number of sources which may contribute water to the shallow end (IIF Leakage, FTC dam leakage, decon, etc.) and therefore it is impossible to state the actual activities or chemistry of the water to be transferred. However water from all of these sources has been transferred/processed through SDS in the past, and any possible sources have been covered in detail in previous sections of this TER.

1.3 Shallow End Drainage Description

Figure 1.1 shows a block diagram of the shallow end drainage flow paths. The shallow end of the FTC may be transferred to the deep end of the FTC, or the RCBT's, with or without filtration through the SDS pre- & final-filters.

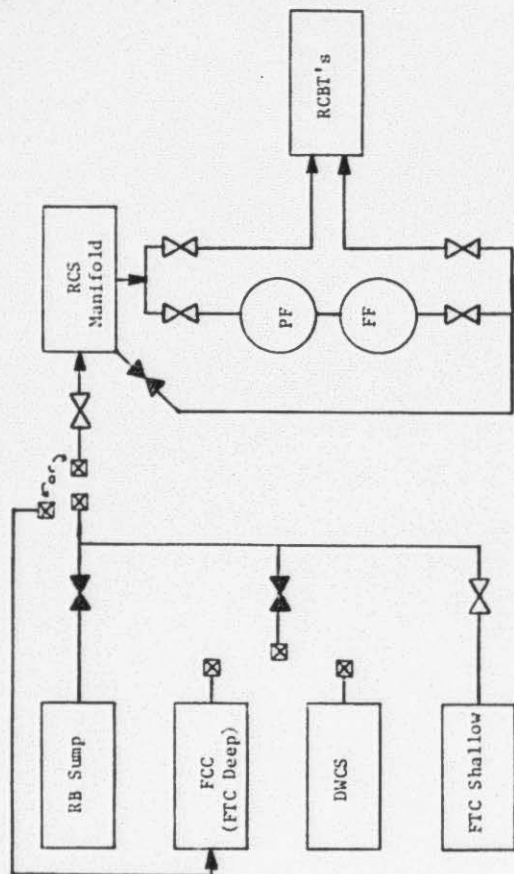


Figure 1.1

Figure 1.1.
FTC SHALLOW END TRANSFER FLOWSHEET

Chapter 2

DESIGN CRITERIA

2.1 Introduction

The FTC Shallow End Drainage System is designed to use a submersible pump (DWC-P-1) previously used as the IIF Processing Pump, and portions of: the SDS Feed & Filtration subsystem, the Reactor Coolant Liquid Waste Disposal System and the Fuel Transfer Canal Drain System. The Shallow End Drainage System design objectives are:

- 1) capability to drain shallow end by transfer to deep end or existing tankage.
- 2) as independent from existing plant system as possible.
- 3) use SDS or portions thereof.

2.2 Design Basis

2.2.1 SDS

See Chapter 4 of the SuS TER.

2.2.2 Interfacing Systems

The interfacing systems with the SDS in the Shallow End Drainage System are:

- 1) Reactor Coolant Liquid Waste System
- 2) Reactor, Auxiliary and Fuel Handling Building Heating, Ventilation and Air Conditioning System
- 3) Waste Gas System
- 4) Plant Services (Air, Electric, Nitrogen and Demin. Water)
- 5) RB Jet Pump
- 6) DWCS - Reactor Vessel Filtration System
- 7) FCC - Fuel Transfer Canal Drainage System

The design criteria for systems 1-4 are presented in the TMI-2 FSAR. The remaining systems are covered by the SDS System Description.

2.3 System Goal

The goal is to provide a system capable of transferring water from the shallow end of the RTC back to the deepend or the RCBT's.

Chapter 3

SYSTEM DESCRIPTION AND OPERATIONS

3.1 Introduction

The FTC Shallow End Drainage System is designed to allow pumping of water from the shallow end back to the deepend or to the RCBT's for future processing as necessary.

3.1.1 SDS

The portions of the SDS used, consist of a liquid filtering system, an off gas system and a sampling system. The liquid filtering system if used removes solids from the transfer stream. The off gas system collects, filters and absorbs radioactive gases produced during sampling, dewatering and vessel venting. The sampling system provides measurements of filtration performance.

3.1.2 Interfacing Systems

Canal water is transferred from the shallow end using a commercially available submersible pump. This pump, CWC-P-1 (formerly the IIF processing pump) is installed on Elev. 308'-0" and takes suction in an existing 4" drain located in the New Fuel Pit. A 1 1/2" ID rubber hose with quick-disconnect two way shut-off fitting connects the pump discharge to the FCC manifold.

The manifold serves as a tie-in point for 4 systems; the RB Jet Pump, the Fuel Transfer Canal Drain System (FCC), the DWCS-Reactor Vessel Filtration System (Early Defueling) and the FTC Shallow End Drainage System. Double isolation of all other systems from the Shallow End Drainage system is provided by manifold isolation valves and the disconnecting of the SWS, FCC and DWC hoses from the manifold. From the manifold, the discharge hose is either routed to the FTC deep end or through the existing flow path through RB penetration R-626 and FHB penetration 1551 to the RCS manifold at SDS. Power for the pump is supplied from circuit 11 of distribution panel PDP-6-A. From the RCS manifold, flow may be filtered through the SDS Pre and Final Filters, or may bypass the filters. The receiving tank in either case is one of the RCBT's.

The Fuel Handling, Auxiliary and Reactor Building's HVAC systems provide tempered ventilating air and controlled air movement to prevent the spread of airborne contamination within the plant or to the environment. The Nitrogen system provides N_2 for blanketing the RCBT's when transferring to them. The Waste Gas system stores and processes the gases from the RCBT vents.

3.2 Shallow End Drainage Operations

3.2.1 Normal Operations

The fuel transfer canal shallow end drainage system is a temporary modification in the reactor building designed to pump water from the shallow end of the canal and deliver the water to the deep end of the canal or the reactor coolant bleed tanks (RCBT)'s.

During defueling operations, the shallow end of the FIC may require drainage as a result of leakage, spills, or deliberate flooding of the canal. This system provides the means to accomplish this drainage.

The fuel transfer canal shallow end drainage operation is started and stopped by opening or closing valve FCC-V003 and using on/off hand switch DWC-HIS-1. This, in turn, automatically starts or stops pump DWC-P-1.

3.3 Shallow End Drainage Instrumentation

Pump DWC-P-1 is controlled via hand indicating switch DWC-HIS-1, which is located on SDS control panel CN-PNL-1 at E1. 347'-6" of the fuel handling building. The switch starts and stops the pump and contains indicating lights for pump status. The starter, DWC-STR-1, for the pump is mounted adjacent to panel CN-PNL-1.

A local emergency stop switch, DWC-HS-1, is located in the Reactor Building near the pump on E1. 347'-6". This local switch overrides the indicating switch, and the pump can be started again only after the local switch has been reset.

Pressure gauge FCC-PI-3 is provided on the canal drain manifold to sense the line pressure downstream of the manifold isolation valves.

Air-operated valve FCC-V003 is interlocked with the pump such that the valve must be opened before the pump will start.

A high level alarm is provided at control panel CN-PNL-1 to inform the operator to begin draining the pit. A low level alarm is also provided at CN-PNL-1 to inform the operator to stop the pump. The low level alarm will not alarm when the pump is off.

3.4 Shallow End Filtration by SDS

3.4.1 Filtration

Two sand filters are installed to remove solids from the canal water prior to storage in tanks for future processing. The filters contain layers of variously sized sand uniformly mixed with borosilicate glass which is added to preclude criticality concerns. The filters and related SDS subsystems are unchanged from that discussed in previous sections of this TER.

3.4.2 Leakage Detection and Processing

The filters are located inside submerged containment boxes which are monitored and recirculated through the SDS Leakage Containment System which is unchanged from that discussed in previous sections of this TER.

3.4.3 Off-Gas and Liquid Separation System

An off-gas and liquid separation system collects gaseous and liquid wastes resulting from the operation of the filtration system and sampling.

3.4.4 Sampling System

Sampling of the filtration influent and effluent to monitor filter performance is accomplished using the shielded High Rad Filter Sample Glove Box. This system is discussed in detail elsewhere in this TER.

3.4.5 Filter Vessel Transfer in the Fuel Storage Pad

Prior to system operation, filter vessels are placed inside the containment boxes and connected to the system using quick-disconnect couplings. When it is determined that a filter is loaded with solids (based on Δp), the filter is flushed with low-activity processed water, transferred to a storage location in the pool or the dewatering station, and replaced with a new filter.

RADIATION PROTECTION

4.1 Ensuring Occupational Radiation Exposures are ALARA

4.1.1 Overall Policy

The objectives with respect to Shallow End Drainage Operations are to ensure operations are conducted in a radiologically safe manner and radiation exposure will be maintained as low as reasonably achievable.

The effective control of radiation exposure will be based on the following considerations:

1. Sound engineering design of facilities and equipment.
2. Use of proper radiation protection practices and qualified personnel.
3. Strict adherence to IMI-2 radiological controls procedures.

4.1.2 SDS Design and Operation

The SDS design and operational considerations are given in Chapter 6 of the SDS IFR. These design and operational considerations and features remain unchanged from this evaluation. The radiation dose exposures to plant personnel during Shallow End Drainage operations will be lower due to the fact that

activities of canal water should be significantly lower than that experienced during processing of RB sump or initial RCS processing. The SDS shielding design basis is levels less than 1 mrem/yr using 200 $\mu\text{Ci/cc}$ Cesium.

4.1.3 Existing Plant Considerations

The radiation protection features for the existing plant and systems which interface with the SDS are described in Chapter 12 of the JMI-2 FSAR.

4.2 Dose Assessment

4.2.1 On Site Assessment

Operation of the SDS Filtration system in the FTC Shallow End Drainage mode may be required intermittently to drain the shallow end of the canal. Based on past SDS operating experience, the exposure for SDS operating area activities due to this operation is expected to be negligible.

4.2.2 Offsite Assessment

Source Terms for Liquid Effluents

All liquid effluent from the system will be retained in station tankage.

Source Terms for Gaseous Effluents

The plant vent system is a potential pathway for gaseous or airborne release, see section 6.3.2 of this IER.

Chapter 5

CONDUCT OF OPERATIONS

5.1 System Performance

Past processing experience i.e., filtering RB sump and Tank Farm water, assures that the filtration system will perform in the intended manner.

During Shallow End Drainage Operations, the flow rates through the filters may approach 50 gpm. Filters will be taken out of service on high differential pressure. Filter changeout and dewatering can be accomplished in the intended manner using remote long-handled tools.

5.2 System Testing

Prior to use, each SDS vessel will be hydrostatically tested in conformance with the requirements of applicable portions of the ASME Boiler and Pressure Vessel Code. Upon completion of construction, the entire system was pneumatically tested to assure leak-free operations. Individual component and subsystem operability was preoperationally tested satisfactorily in accordance with approved procedures.

5.3 System Operations

System operations will be conducted in accordance with written and approved procedures. These procedures will be applicable to normal system operations, emergency operations, and required maintenance evolutions. During system operations on-going operator training and evaluation will be conducted to ensure continuing safe and efficient system operations.

Chapter 6
ACCIDENT SCENARIOS

6.1 Casualty Events

6.1.1 A breach of the system pressure boundary while removing water from the shallow end of the fuel transfer canal could result in additional contamination of reactor building surfaces.

6.1.2 Introduction of this water into the fuel transfer canal could contaminate the canal.

6.2 Design Features to Mitigate Effects of Casualty Events

6.2.1 A hose or pipe break will result in loss of line pressure.

Pressure and flow indication are provided at various locations on the pump discharge flowpath. The piping and hoses are hydrostatically tested to 1.5 times their maximum operating pressure per ANSI B31.1. To ensure pressure boundary integrity, hoses are to be inspected prior to operation of the canal shallow end drainage network.

6.2.2 The fuel transfer canal and the shallow end drainage system branch connections of the fuel canal drain manifold contain double isolation, which includes a check valve in each line. This is to prevent reactor building sump and flush water from being delivered into the canal. In addition, the coupling connections on the canal drain and shallow end drain lines of the manifold are 1 1/2-inches and incorporate a two-way shut-off feature. All other manifold coupling connections, including the reactor building SWS system connection, are 1-inch diameter. This prevents connecting a 1 1/2-inch pump discharge hose to the 1-inch SWS system connection which does not include a check valve. QC is to verify that each hose is connected to the proper manifold branch connection prior to system turnover.

Appendix No. 5

to

Submerged Demineralizer System

Technical Evaluation Report

TITLE

EARLY DEFUELING DMC REACTOR VESSEL FILTRATION SYSTEM

JUNE 1985

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Chapter 1

SUMMARY OF TREATMENT PLAN

1.1 Project Scope

During early defueling, after the removal of the IIF pump, Reactor Vessel water clarity will be maintained using the Reactor Vessel Filtration portion of the DWCS. Prior to the completion of the remaining portions of the DWCS, a capability of processing the RCS must be available to maintain or decrease activity levels in the water and respective dose rates to workers over the vessel. To achieve this, a slipstream from the Reactor Vessel Filter Trains will be routed through the Filter Canister Post Filter and hosed to the existing FCC Drain Manifold/flow path to SDS for demineralization. The effluent from SDS will be routed to a RCBT while concurrently making up to the RCS from another RCBT.

This report describes the post IIF pump removal processing of the RCS by the Reactor Vessel Filtration System, SDS and other interfacing plant systems for the maintenance of RCS water clarity and radionuclide concentrations.

This report is presented as an addendum to the previously submitted SDS Technical Evaluation Report (TER) to provide greater detail in those aspects of system design and operation which are unique to the processing of the RCS using the Early Defueling DWCS Reactor Vessel Filtration System.

1.2 Current RCS Radionuclide Inventory and Chemistry

Water samples are taken weekly from the RCS to identify radionuclide concentrations and water chemistry. Current results are listed in Table 1.1. RCS activity decreases due to decay, leakage and subsequent makeup, and RCS processing. RCS activity may increase due to leaching or disturbance of core material. The RCS activity when the Reactor Vessel Filtration System begins operation is expected to be essentially the same as listed in Table 1.1 (Antimony activity may increase by a factor of 2).

1.3 Early Defueling DFC Reactor Vessel Filtration System Description

Figure 1.1 shows a block diagram of the Early Defueling DFC Reactor Vessel Filtration System flowpath. RCS water is continuously filtered through one or both filter trains and returned to the Reactor Vessel at a rate of up to 200 gpm per filtration. If water requires demineralization due to increasing radionuclide concentration, a shipstream from the filter train effluents may be processed through SDS at up to 15 gpm to a RCBT while concurrently making up with RCS grade water to the RCS from another RCBT.

The flow path from the filter train effluents passes through the Filter Train Postfilter and is hoses to the FCC Drain Manifold on to SDS and the receiving RCBT. The return (makeup) flow path is identical to that used during IIF processing and pre-headlift processing.

The processing system will use the existing ion exchangers and effluent sand filters of the SDS. Existing sampling connections will be used on the influent and effluent of all SDS filters and ion exchangers to determine radionuclide and chemical composition of the process stream before and after processing.

As described in the SDS TER, the sandfilters and ion exchangers, their locations, operation and handling of, remain unchanged from the mode of operation used for DF and pre headlift processing. Both trains of ion-exchangers may be used.

TABLE 1.1
RCS RADIONUCLIDE AND CHEMISTRY DATA
 (06/17/85)

<u>ISOTOPE</u>	<u>RADIONUCLIDE CONCENTRATION</u> <u>μCi/cc</u>
H-3	0.07
Co-60	0.009
Sr-90	3.0
Sb-125	0.065
Cs-134	0.005
Cs-137	0.17
Gross Bq	3.0
<u>CHEMISTRY</u>	
pH	7.56
Boron	5160 ppm
Na	1400 ppm
Cl	1.85 ppm
Turb	5 NTU

Figure 1.1

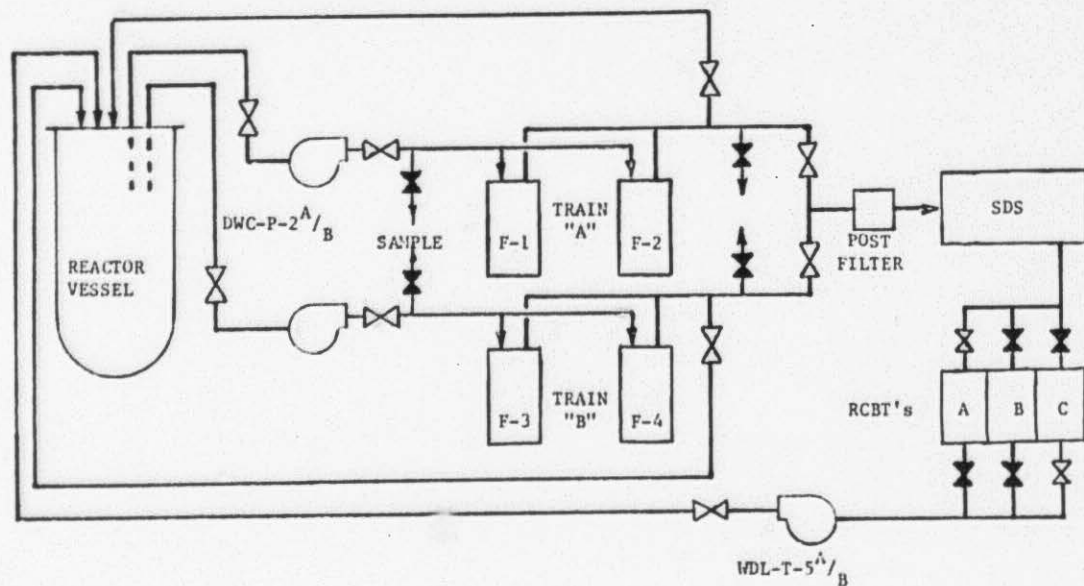


Figure 1.1

EARLY DEFUELING DWL REACTOR VESSEL FILTRATION SYSTEM FLOWSHEET

Chapter 2

RV FILTRATION PROCESSING PLAN DESIGN CRITERIA

2.1 Introduction

The Early Defueling DWC Processing Plan is designed to use high capacity submersible pumps (DWC-P-2A and B) and two trains each consisting of two filters. Additionally, portions of both the SDS and existing plant Liquid radwaste disposal systems are used to clarify and decontaminate the RCS water. This will reduce radiation exposure to plant personnel and will reduce the possibilities for off-site radiation exposures. The design objectives of this processing plan are:

- 1) to filter the water in the Reactor Vessel and RCS to remove suspended solids and maintain water clarity at or below 1 NTU.
- 2) to remove soluble fission products from the water through demineralization by batch processing through SDS to the RCBT's, thus reducing the dose rate contribution of the water to defueling personnel;
- 3) to use the SDS which has proven its performance in the decontamination of RCS water.
- 4) to use the proven reinjection pathway to the RCS previously used during IIF and prehead lift processing of the RCS.

2.2 Design Basis

2.2.1 SDS

The design basis for the SDS is presented in detail in Chapter 4 of the SDS TER.

2.2.2 Interfacing Systems

The interfacing systems with the RV Filtration System/SDS are:

- 1) Reactor Coolant Liquid Waste Train.
- 2) Purification and Makeup System
- 3) AFHB HVAC.
- 4) Nitrogen Supply System.
- 5) Waste Gas System.
- 6) SPC System.
- 7) Instrument Air System.
- 8) Fuel Transfer Canal Drain System.

The Design Criteria for systems 1-5 and 7 above are presented in Chapter 3 of the TMI-2 FSAR. System 6 is covered in the SPC System Description. System 8 is covered in the SDS System Description.

2.3 RV Filtration Processing Plan Goal

The goal of this system is to maintain reactor vessel water clarity at 1 NTU or less, and the concentrations of Cs^{137} and Sb^{125} less than or equal to 0.02 μ Ci/ml and 0.15 μ Ci/ml respectively. It should be noted that Sb^{125} will be limited by processing through EPICOR as necessary. The RCS chemistry will be maintained as follows:

Chlorides < 5 ppm

pH > 7.5 but < 8.4

Boron > 4750 ppm

The filtering/processing of RCS water by the RV Filtration System/SDS does not have any effect on the chemical characteristics of the RCS water. The specified chemistry will ensure there are no adverse effects on the SDS with respect to corrosion while ensuring boration sufficient to maintain the core in a noncritical safe condition.

Chapter 3

SYSTEM DESCRIPTION AND OPERATIONS

3.1 Introduction

The Early Defueling DWC Reactor Vessel Filtration system is a temporary liquid processing system which is designed to process water contained in the reactor vessel. The system is comprised of the filtration portion of the Reactor Vessel Cleanup System, the Submerged Demineralizer System (SDS), Reactor Coolant Bleed Tanks (RCBT) and the return pathway from the RCBTs to the reactor vessel used for the IIF Processing System. See Figure 1.1 for a simplified diagram of the DWC RV Filtration System Flowpath.

3.1.1 SDS

The SDS consists of a liquid waste processing system, an off gas system, a monitoring and sampling system, and solid waste handling system. The liquid waste processing system decontaminates the RCS water by a process of filtration and demineralization. The off-gas system collects, filters and absorbs radioactive gases produced during processing, sampling, dewatering and spent SDS liner venting. The sampling system provides measurements of process performance. The solid waste handling system is provided for moving, dewatering, vacuum drying, inertization, storage, and loading of filters and demineralizer vessels into the shipping cask.

3.1.2 Interfacing Systems

The RCS water is transferred from the RV/IIF using two commercially available submersible pumps (DWC-P-2 A/B). The water is filtered by one or both of the RV Filtration System Filter trains and returned to the RV/IIF. A slip stream from the filter train effluents may be routed through the filter train postfilter and hosed to the FCC Drain Manifold.

The manifold serves as a tie-in point for 4 systems; the Reactor Bldg. Basement Pump system, the Fuel Transfer Canal Drain System, the New Fuel Pit Drain System, and the Reactor Vessel Filtration (DWC) System. Double isolation of the DWC system from the other three is provided by air operated ball valve FCC-V003 and check valve FCC-V016 in addition to manual valves and disconnected/capped connections located on each of the other branches of the manifold. From the manifold, the system uses an existing flow path through Reactor Building penetration R-626, Fuel Handling Building penetration 1551 to tie-in and interface with the SDS system.

Subsequent makeup to the RV/IIF is accomplished by transferring reactor coolant grade water from RCBT-1A to the RV/IIF via a waste transfer pump and an existing flow path through the WDL and MU systems to a cold leg of the reactor coolant system.

The roles of the RCBT's (1A & 1C) can be interchanged provided valves are properly realigned and the tank used to fill the IIF contains reactor coolant grade water.

Flow from the RV/IIF may be manually throttled at valves CN-V-IX-25 and CN-V-IX-26 in SDS if desired. Flow to the RV/IIF may be automatically controlled by valve MU-V9 based on RV/IIF water level or manually controlled using WDL-V-167 and WDL-V-36A. Shutoff of the RV/IIF supply (via WDL-V40) is achieved automatically in the event of unacceptable water level in the IIF and may also be manually accomplished at several locations.

The Fuel Handling Building, Auxiliary Building, and Reactor Building HVAC systems provide tempered ventilating air and controlled air movement to prevent spread of airborne contamination with the plant and to the outside environment. The Nitrogen Supply system provides N_2 for blanketing the Reactor Coolant Bleed Tanks. Reactor Coolant grade water currently contained in the RCBT's provides borated water for injection into the RV/IIF for the initial fill operation. The Waste Gas System processed the gases from the vents from the RCBT's.

The Standby Pressure Control System, installed as a temporary TMI-2 recovery system, will be used as a safety system to ensure that a second RCS injection path is available.

The principal components of the SDS are located in Spent Fuel Pool "B". The piping and components of the systems interfacing with the SDS are located in the Fuel Handling and Auxiliary Buildings. Tanks, pumps, valves, piping, and instruments are located in controlled access areas. Components and piping containing

significant radiation sources are located in shielded cubicles, such as the Reactor Coolant Bleed Tanks and the Waste Transfer pumps WDL-P-5A and WDL-P-5B.

3.2 Reactor Vessel Filtration System Operations

3.2.1 Normal Operations

Normal operation of the system is in one of the modes shown in Table 1. The mode of operation chosen is based on the particulate and radioactivity concentrations in the Reactor Vessel.

Table 1

Early Defueling DWG RV Filtration System Operational Configurations

FILTER FLOW (GPM) Return to Reactor Vessel	SDS FLOW (GPM) With Equivalent Return to Reactor Vessel
400 (200)	0
385 (185)	15

(Numbers in brackets indicate flow if only one train is in operation.)

The operational mode is determined by the solids loading in the reactor vessel. Normally, 400 gpm from the reactor vessel is filtered and 7 to 15 gpm of the filtrate is demineralized.

As the filters load up, the pressure differential across the filter train increases. As the differential pressure increases, the flow rate is maintained constant by manually adjusting remote valves VO15A and VO15B (RV-30A and 30B).

3.2.2 Infrequent Operations

Flushing of the system may be performed when the internal contamination level gets high or prior to internal maintenance work. The system is shutdown prior to flushing.

One flushing option allows a gravity flush from SPC-T-4. Borated water is stored in the charging water storage tank, SPC-T-4, located at the 347 ft. elevation in the Fuel Handling Building. This tank is connected to the Early Defueling DWC RV Filtration System. Either filter train may be flushed without stopping flow through the other.

Flushing may be accomplished by opening one of the inlet valves from the flushing system (depending on which portion of the system is to be flushed) and then opening the drain valve to the fuel transfer canal. After sufficient time has been allowed to flush the system, the drain valve is closed and then the inlet valve is closed. The system is then restarted.

System inventory can be decreased or increased as needed by mismatching flow routed to/from the RCBT's. This may be done by changing the set point on RC-LIC-102. Also, the water can be routed to the RCBT as required for processing to remove Sb-125.

3.3 Reactor Vessel Filtration System Instrumentation and Control

3.3.1 Controls

The majority of system control is handled remotely from a control panel which is located in the Fuel Handling Building. This is due to the fact that much of the system is located in the Reactor Building which has limited access. The reactor vessel cleanup pumps do have local hand switches to shut the pumps down.

Filtered water flow back to the reactor vessel is monitored by the operator and adjusted by remotely controlled valves V015A and V015B (HV30A&B).

On/off controls for the waste transfer pumps are located on radwaste panel 301B, and in the control room on control panel 9.

Valve WDL-40 has existing open/close controls located on radwaste panel 301B and in the control room on control panel 9. Additional open/close controls are located on SDS control panel CN-PNL-1. WDL-V40 terminates flow in the event of high or low water level in the IIF. A block switch is located on CN-PNL-1 which can be used to block the low level trip to permit filling the IIF to the desired level.

Water level is automatically maintained at a prescribed level (approximately 327'-6") in the IIF by valve MU-V9. Section 2.2 documents the actual set points. The control signal to valve MU-V9 is provided by the reactor water level monitoring system (bubbler) through proportional controller RC-LIC-102 which is located on control panel SPC-PNL-3.

3.3.2 Power

The pump motors are supplied with 480V power through a motor control center (2-32C) which is energized by an existing unit substation located in the Auxiliary Building. 120 VAC power will be supplied from the control panel or local sources.

3.3.3 Monitoring

Monitoring equipment is provided to evaluate the performance of the system and to aid in proper operation of the system.

The discharge pressure of the submersible well pumps is monitored (PI-4A & 4B) to determine if the pump is operating correctly and also to provide another indication that the pump is operating.

In order to determine the degree of filter loading, the primary filter canisters and the secondary post filter are equipped with remote indication of differential pressure across the filters (DPI-5A, DPI-5B and DPI-33). The differential pressure across the canisters will be used to determine when the filters are loaded to capacity.

The process fluid conditions are monitored to determine the effectiveness of the system. The turbidity level in the fluid is monitored (AI 43A & 43B) prior to its return to the source. Also, the capability to obtain grab samples of process fluid has been provided for at several locations in the system.

3.3.4 Trips and Interlocks

The reactor vessel cleanup well pumps, P-2A/B, are provided with low level setpoint trips to ensure that the pumps do not operate under potential cavitation conditions. A low level in the IIF will also trip pumps P-2A and P-2B.

The reactor vessel cleanup well pumps, P-2A/B are equipped with interlocks to prevent them from being started during a low level condition.

Valve WDL-V40 will be tripped closed on high level in the IIF. This prevents over filling of the IIF.

3.4 RV/IIF Processing by Reactor Vessel Filtration System/SDS

3.4.1 Filtration

The system has two submersible type pumps (deep well pumps), P-2A and 2B, which are housed in wells and located in the fuel storage pit in the shallow end of the fuel transfer canal in the Reactor

Building. The suction from the reactor vessel is through the Westinghouse work platform via hoses which connect the nozzles provided on the work platform to the wells.

The system has four particulate filters, F-1, 2, 3 and 4. The filters are composed of sintered filter media which is contained in modified fuel canisters. These filters are capable of removing debris, mainly fuel fines (UO_2) and core debris (ZrO_2), down to a 0.5 micron rating. Since the canisters contain fuel fines, they are designed to prevent a criticality condition from existing when they have been loaded. Also, the filters are submersed in the transfer canal to provide the appropriate radiation shielding.

The two pumps and four filters are arranged so that one pump discharges to two filters. Therefore, the filtration portion of the system is divided into two trains, each train contains one pump which feeds two filter canisters. The two pump arrangement allows for greater flexibility in system operations and provides redundancy to allow system operation during maintenance.

A filter is used continuously until the differential pressure reaches a predetermined setpoint. At this point the system is shutdown and then, after a waiting period (approximately 5 min.), it is restarted. The differential pressure is noted and if it returns to a low value the system will be run again to the pressure setpoint. This process is repeated until the differential pressure

at restart reaches a value near the shutdown setpoint. When this occurs within one hour, the train is shutdown and the filters are replaced.

Loaded canisters are expected to generate small quantities of oxygen and hydrogen gas due to radiolysis of water. Pressure relief valves R-4, R-5, R-6, and R-7 are provided on the filter canister outlet lines upstream of their isolation valves. Their purpose is to prevent overpressuring the filter canisters when isolated due to the small quantities of H_2 and O_2 produced (approximately 0.029 ft³/day.)

Once the water has been filtered, all, or a portion of, the flow can be returned to the Reactor Vessel. The amount of water returned is controlled by remotely adjusted valves V015A & B (HV30A&B). Each of these lines will connect, via flexible hoses, to the separate inlet nozzles on the work platform. A sparger has been placed on each return line to maintain a positive pressure in the attached hoses.

Sample points are provided upstream and downstream of each filter train. These samples are routed to sample box 1, a glove box located in the FHB. The glove box has a self contained blower and HEPA filter which discharge to the FHB ventilation system.

3.4.2 Demineralization

To remove soluble fission products, filtrate not returned to the reactor vessel, can be batch processed through SDS and then routed to RCBT-1C while concurrently returning an equal amount of reactor coolant grade water to the RV from RCBT-1A. A 1 1/2 inch hose, equipped with "quick disconnect" two way shutoff fittings, connects the Early Defueling DWC RV Filtration System to the SDS via the fuel transfer canal drain manifold.

The manifold serves as a tie-in point for 3 other systems: the surface suction system (sump-sucker), the fuel transfer canal drain system, and the IIF processing/shallow end drainage system. Double Isolation of the IIF processing/shallow end drainage system from the other two is provided by air operated ball valve FCC-V003 and check valve FCC-V016 in addition to manual valves located on each of the other branches of the manifold. The Early Defueling DWC RV Filtration System will use the same connections to the manifold as otherwise used by the fuel transfer canal drain system.

From the manifold, the system uses an existing flow path through Reactor Building penetration R-626 and fuel handling building penetration 1551 to SDS and then to RCBT 1C. The SDS pre and final filters may be bypassed when processing using the Early Defueling DWC Reactor Vessel Filtration system.

The roles of the RCBT's (1A & 1C) can be Interchanged provided valves are properly realigned and the tank used to fill the IIF contains reactor coolant grade water.

Flow from the IIF may be manually throttled at valves CN-V-IX-25 and/or CN-V-IX-26 in SDS if desired. Flow to the IIF is controlled automatically or manually by valve MU-V9 based on IIF water level. Shutoff of the IIF supply (via WDL-V40) achieved automatically in the event of unacceptable water levels in the IIF and may also be manually accomplished at several locations. The details of the SDS ion exchanger trains and related components may be found elsewhere in this TER. (See Appendix No. 2, sections 3.4.2 through 3.5).

CHAPTER 4

Radiation Protection

4.1 Ensuring Occupational Radiation Exposures are ALARA

4.1.1 Overall Policy

The objectives with respect to RCS processing operations are to ensure that operations conducted in support of the on-going demineralization program are conducted in a radiologically safe manner, and further, that operations associated with radiation exposure will be approached from the standpoint of maintaining radiation exposure to levels that are as low as reasonably achievable.

During the operational period of the system the effective control of radiation exposure will be based on the following considerations:

1. Sound engineering design of the facilities and equipment.
2. The use of proper radiation protection practices, including work task planning for the proper use of the appropriate equipment by qualified personnel.
3. Strict adherence to the radiological controls procedures as developed for TMI-2.

4.1.2 SDS Design and Operation

The SDS design and operational considerations are given in Chapter 6 of the SDS TER. These design and operational considerations and features remain unchanged from this evaluation.

The radiation dose exposures to plant personnel during RV/IIF processing will be lower due to the fact that the radionuclide concentration in the RCS water is significantly lower than those experienced during processing of prehead lift RCS water, IIF water and Reactor Building sump water. The design basis for shielding the SDS equipment is to reduce radiation levels to less than 1 mrem/hr using the radionuclide concentration of 200 $\mu\text{Ci/cc}$ of predominately Cesium. The radionuclide concentration of Cesium in the RCS water is currently less than 0.5 $\mu\text{Ci/cc}$.

4.1.3 Existing Plant Considerations

The radiation protection features for the existing plant system which interface with the SDS are described in Chapter 12 of the TMI-2 FSAR. The existing radiation shielding within the Auxiliary Building for the following systems is adequate to reduce the radiation levels to below the design basis of 2 mrem/hr in areas requiring access:

1. Makeup and Purification System
2. Reactor Coolant Liquid Waste Chain
3. Miscellaneous Waste Chain
4. Waste Gas System

4.2 Dose Assessment

4.2.1 On Site Assessment

Operation of the SDS in the RV/IIF processing mode is expected to require 50,000 gallons of processing per week from installation of the Reactor Vessel Filtration system until the completion of the Defueling Water Cleanup System. This amount of processing is required to maintain Cs-137 concentration at less than 0.1 $\mu\text{Ci/ml}$ in order to maintain radiation levels in the reactor vessel head area as low as reasonably achievable. Based on current experience with the SDS this amount of processing is expected to result in an exposure for SDS operating area activities of < 0.225 man-rem/week.

4.2.2 Off-site Radiological Exposures

Source Terms for Liquid Effluents

Liquid effluent from the system will be returned to station tankage for further disposition. Therefore, no liquid source term is identified for this evaluation.

Source Terms for Gaseous Effluents

The plant vent system is a potential pathway for carrying airborne radioactive material and release. Radionuclides in the gaseous effluent arise from entrainment during transfer of contaminated water to various tanks, filters, ion exchange units, and also from water sampling. For further information, see section 6.3.2 of the SDS TER.

CONDUCT OF OPERATIONS

5.1 System Performance

By processing the Reactor Building sump water and RCS successfully assurance has been granted that components developed specifically to meet the conditions imposed at IMI will perform in the intended manner.

The ion-exchange process is a well understood process. The SDS has demonstrated that high decontamination factors can be achieved by the use of zeolite ion exchange media.

During RV/IIF processing, the SDS system flow rates will be higher than during all previous processing. An eight hour test was performed to assure that these increased flowrates will not adversely affect zeolite performance. Also, calculations have been performed by ORNL to demonstrate that system performance will not be jeopardized. Although radionuclide break through may occur sooner in the batch, it will progress more slowly. This breakthrough will be allowed to occur to extend zeolite life (minimize wastes) since the effluent is routed back to the RV/IIF.

Zeolite media loading and dewatering can be accomplished in the intended manner and remote tools, necessary for the coupling and de-coupling of the vessels, operate in the intended manner.

5.2 System Testing

Prior to use in the SDS each vessel will be hydrostatically tested in conformance with the requirements of applicable portions of the ASME Boiler and Pressure Vessel Code. Upon completion of construction, the entire system was pneumatically tested to assure leak-free operations. The system will be retested prior to IIF processing at the design pressure.

Individual component operability will be assured during the preoperational testing. Motor/pump rotation and control schemes will be verified. The leakage collection sub-system, as well as the gas collection sub-system, will be tested to verify operability. Filters for the treatment of the collected gaseous waste will be tested prior to initial operation. System preoperational testing will be accomplished in accordance with approved procedures.

5.3 System Operations

System operations will be conducted in accordance with written and approved procedures. These procedures will be applicable to normal system operations, emergency situations, and required maintenance evolutions.

Prior to RV Filtration System operation, formal classroom instruction will be provided to systems operations personnel to ensure that adequate knowledge is gained to enable safe and efficient operation. During a system operations on-going operator evaluations will be conducted to ensure continuing safe and efficient system operation.

Chapter 5

ADDITIONAL ACCIDENT SCENARIOS

6.1 Possible Accident Scenarios and Design Features to Mitigate their Effects

6.1.1 Loss of Power

A loss of power to the entire system would simply shut the system down. A loss of power to the well pumps would shutdown the filtration portion of the system which would in turn cause level control RC-LC-102 to close MU-V9 terminating flow from the RCBT.

Loss of power to individual components would place the component in its safe mode. An air operated valve, for example, would fail to a position that ensures no damage to other components.

Loss of power to the control panel would cause the loss of all information and fail all control and solenoid operated valves. The system would be shutdown until power is restored.

6.1.2 Loss of Instrumentation/Instrument Air

Loss of instrumentation would hamper operations but no adverse conditions would result and the system could be safely shut down until the problem is resolved.

Loss of a single instrument channel will result in the loss of indication for that channel and, for those channels that have control features, a flow mismatch. This flow mismatch will result in an automatic shutdown of the affected portion of the system.

Loss of the internals indexing fixture (IIF) level indication system (bubbler) will result in an erroneous level indication which will be noted when compared with a redundant level indication system. Since this system has no control features, no adverse system conditions will result.

Loss of instrument air will take the individual components to their fail safe position. Flow mismatches induced by loss of air will result in automatic trips. Loss of air to the IIF level monitoring system will initiate a low air supply pressure alarm.

6.1.3 Filter Media Rupture

A failure of the filter media in the canister could potentially release fuel fines to the SDS portion of the system. A post filter is located downstream of both filter trains in the line to the SDS. This filter will trap any fuel fines which would be transported past the filter canisters in the event of filter failure. The post filter is designed to be criticality safe and is sized so that a small accumulation of debris will increase the differential pressure to the alarm setpoint. Also, the nephelometers in the return line would alert the operator to a possible media rupture since the turbidity would increase rapidly.

The recovery procedure is to isolate the filter trains and find the ruptured filter by observing the differential pressure versus flow for each individual canister. Lower differential pressure for a given flow will indicate that this filter is ruptured. That canister or canisters and the post filter cartridge would be replaced and the system restarted.

6.1.4 Line and Hose Break

The consequences of any line and hose break is a loss of reactor vessel inventory. The system has been designed to mitigate the consequences of such an incident to the extent possible.

To help prevent a hose rupture, all process hoses are armored. In case of a hose rupture or line rupture, downstream of the reactor vessel pumps, P-2A & 2B, the system is equipped to trip these pumps on the IIF low level and alarm to the control panel. This event could deliver approximately 500 to 1000 gallons of reactor vessel water to the area of the break. The potential areas affected would be the Reactor Building and the Fuel Handling Building, each of which has sumps or drains to the Aux. Bldg. sumps to contain the spill.

If a suction hose to the well pumps or a return hose to the reactor vessel should rupture, a siphoning of reactor vessel water would take place. The two 4 inch suction connections provided in the Westinghouse work platform are provided with two 3/4 inch holes drilled 18 inches below the water level which will act as a siphon

breaker. The three 2 inch return lines are equipped with spargers, which are simply holes drilled into the pipes. The first holes are drilled 18 inches below the water level which will act as a siphon breaker. The sample return line is terminated 18 inches below the water level. Therefore, a maximum of approximately 3000 gallons of reactor vessel water would spill into the fuel transfer canal following a hose rupture. Approximately half of this water would be contained in the New Fuel Pit.

The recovery from these events would be accomplished by isolating the ruptured section and replacing the ruptured hose/pipe.

6.1.5 Deboration

Boron dilution of the Defueling Water Cleanup System will be addressed in Revision 2 of the GPU Nuclear TMI-2 Division "Hazards Analysis Potential for Boron Dilution of RCS" (4430-84-007R).