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US Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, DC 20555

Dear Sirs:

Three Mile Island Nuclear Station, Unit 2 (TMI-2)
Operating License No. DPR-73
Docket No. 50-320
Annual Update of the System Description and Technical Evaluation Report for the TMI-2 Submerged Demineralizer System

Pursuant to NRC Letter dated February 4, 1982, the annual update to the System Description and Technical Evaluation Report for the TMI-2 Submerged Demineralizer System is forwarded for your information. This update, which constitutes Revision 6 to the System Description and Revision 5 to the Technical Evaluation Report, includes the following changes:

- Update of historical data concerning volumes processed and isotopic inventories.

- Deletion of Appendix 5 of the SDS TER and Appendix 20 of the SDS System Description which described the Early Defueling DWC Reactor Vessel Filtration System. Based on successful operation of the DWCS system, these appendices are no longer applicable to the actual operation of the system.

- Update of valve and component lists to reflect as-built conditions.

A001
1/1 Limited Dist.

The above changes are generally administrative in nature and reflect updates to the system and historical information which continue to evolve as system operations continue.

Sincerely,

F. P. Standerfer

F. P. Standerfer
Director, TMI-2

FRS/DHW/eml

Attachment

cc: Regional Administrator, Region 1 - W. T. Russell
Director, TMI-2 Cleanup Project Directorate - Dr. W. D. Travers

GPU Nuclear

TER 3527-006 REV 5

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☒ ITS
☐ NSR
☐ NITS

DIVISION

TECHNICAL EVALUATION REPORT

FOR

Submerged Demineralizer System

COG ENG [illegible] DATE 8/27/87

RTR [illegible] DATE 8-31-87

COG ENG MGR [illegible] DATE 8/31/87

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SUMMARY OF CHANGE

Rev.	SUMMARY OF CHANGE	Approval	Date
0	Initial issue per GPU Nuclear letter 4400-82-L-0066.		4/82
1	Reissue per GPU Nuclear letter 4410-83-L-0122.		6/83
2	Reissue per GPU Nuclear letter 4410-84-L-0109. Incorporates changes required by S-ECMs 1151 (Revision 0 through 3), 1163 (Revision 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, ECAs 07[illegible], 04[illegible], 047, 041, and 102.		8/85
4	Annual Update. Incorporates changes made by S-ECM 1058 Revision 2, ECAs [illegible], [illegible], [illegible], and 312.		8/86
5	Annual Update. Incorporates updates to the valve and component lists; updates historical data; deletes the Early Defueling DWC Reactor Vessel Filtration System which is no longer applicable.		9/87

TER 3527-006

TECHNICAL EVALUATION REPORT

SUBMERGED DEMINERALIZATION SYSTEM

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Chapter 1

Summary of Treatment Plan

1.1 Project Scope

To date the SDS system has processed almost 4.5 million gallons of contaminated water, including; 650,000 gallons of Reactor Building sump water, 500,000 gallons from RB decon and 1,200,000 gallons of RCS water. The continued decontamination of TMI-2 includes the repeated processing of the IIF/RCS using the Letdown/Makeup Method 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.

<u>Alternative I</u>: Leave Contaminated Water in Containment Indefinitely (No Volume Reduction)

<u>Discussion</u>

A. <u>Containment Sump Water</u>

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. <u>Reactor Coolant System Water</u>

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

<u>Conclusion</u>: 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.

<u>Alternative II</u>: 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 <u>SDS Operating Description</u>

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 ^{134}Cs and ^{137}Cs 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 t◦ 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

Isotope	Radionuclide Concentrations (μCi/ml) Reactor Coolant System	RB Sump Decon
Sampling Date	(4/87)	(2/87)
H3	0.038	0.12
Sr-90	1.1	0.11
Sb-125	0.039	0.015
Cs-134	0.003	0.082
Cs-137	0.16	3.5
pH	7.61	7.48
Boron	5340 ppm	3297 ppm
Na	1560 ppm	548 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.

- 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.

- Controls and instrumentation are located in low radiation areas.

- 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:

- Review of operating, maintenance and surveillance procedures to assure precautions and prerequisites are adequate.

- Review of the installed system to identify potential problems during operation and the implementation of corrective actions.

- Operational evaluations during preoperational testing and system training will be performed to update exposure estimates.

- 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:

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

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.

Chapter 3

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.

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

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

n = Fraction of Q used

E_w = Equivalent weight of the nuclide under consideration

C_f = 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 atrition 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^-, $(PO_2)_3^=$, 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 described 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 4,400,000 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 0.015 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[a] 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,[a] uCi/ml.						
			Zeolite columns				Effluent
	Feed	Filter	First	Second	Third	Fourth	EPICOR-II
^{3}H	0.88	0.88	0.88	0.88	0.88	0.88	0.88
^{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

a In μCi/ml as of February 1982 based on actual samples
b Not quantifiable by gamma spectroscopy due to overall sample activities.

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

RCS Processing

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

a In μCi/ml as of June 1984 based on actual samples
b Not quantifiable by gamma spectroscopy due to overall sample activities.

Chapter 4

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 μCi/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 objective 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:

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

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

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

- Overall Height — 54 1/2 inches
- Overall Diameter — 24 1/2 inches
- Materials — Stainless Steel
- 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.

Chapter 5

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 0.85 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-0591.

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 radiolosis of the water remaining in the liner.

6. Provide vacuum to defueling canisters at the DS to allow canister gas sampling.

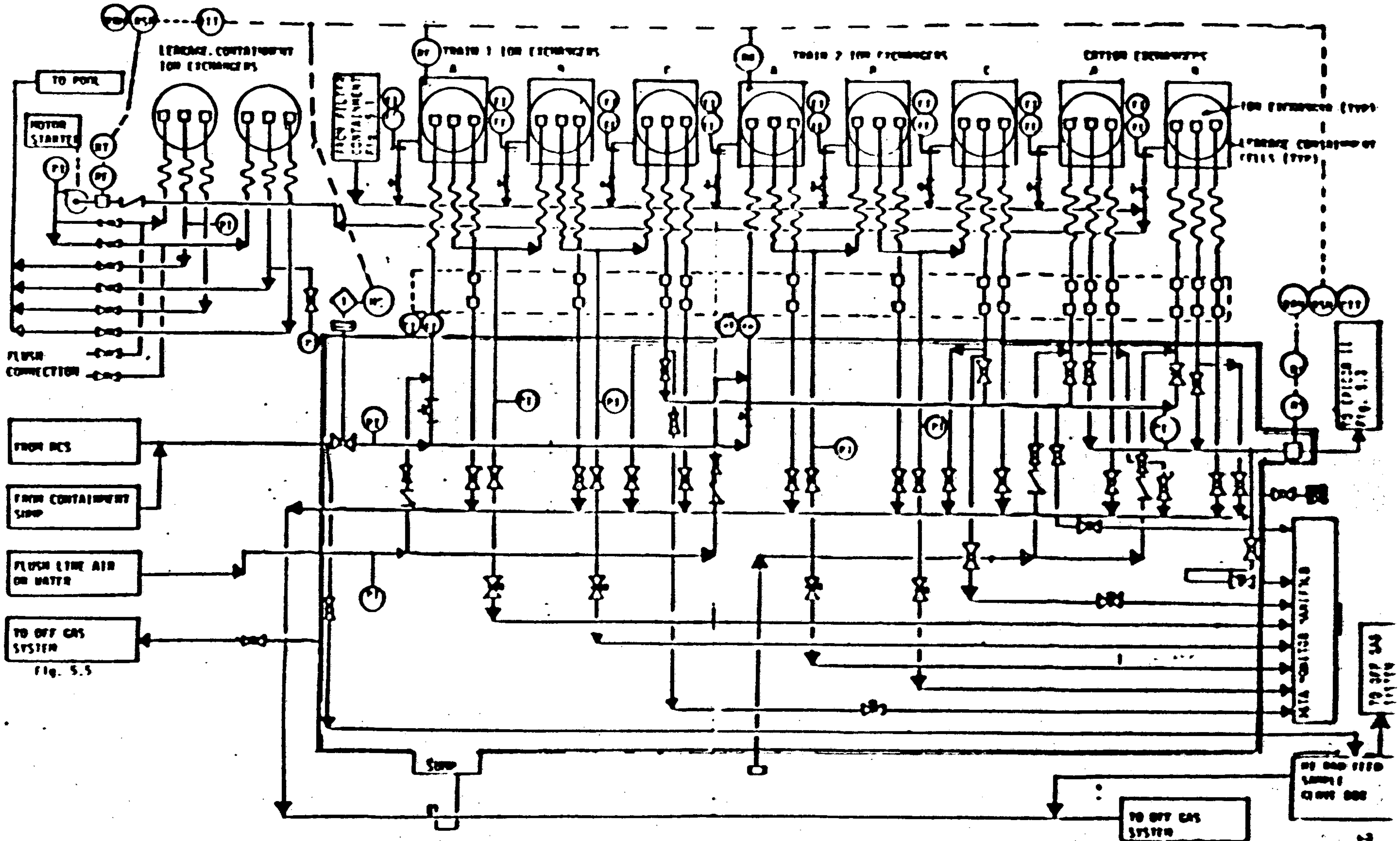


FIGURE 5.2
ION EXCHANGER TRAINS.

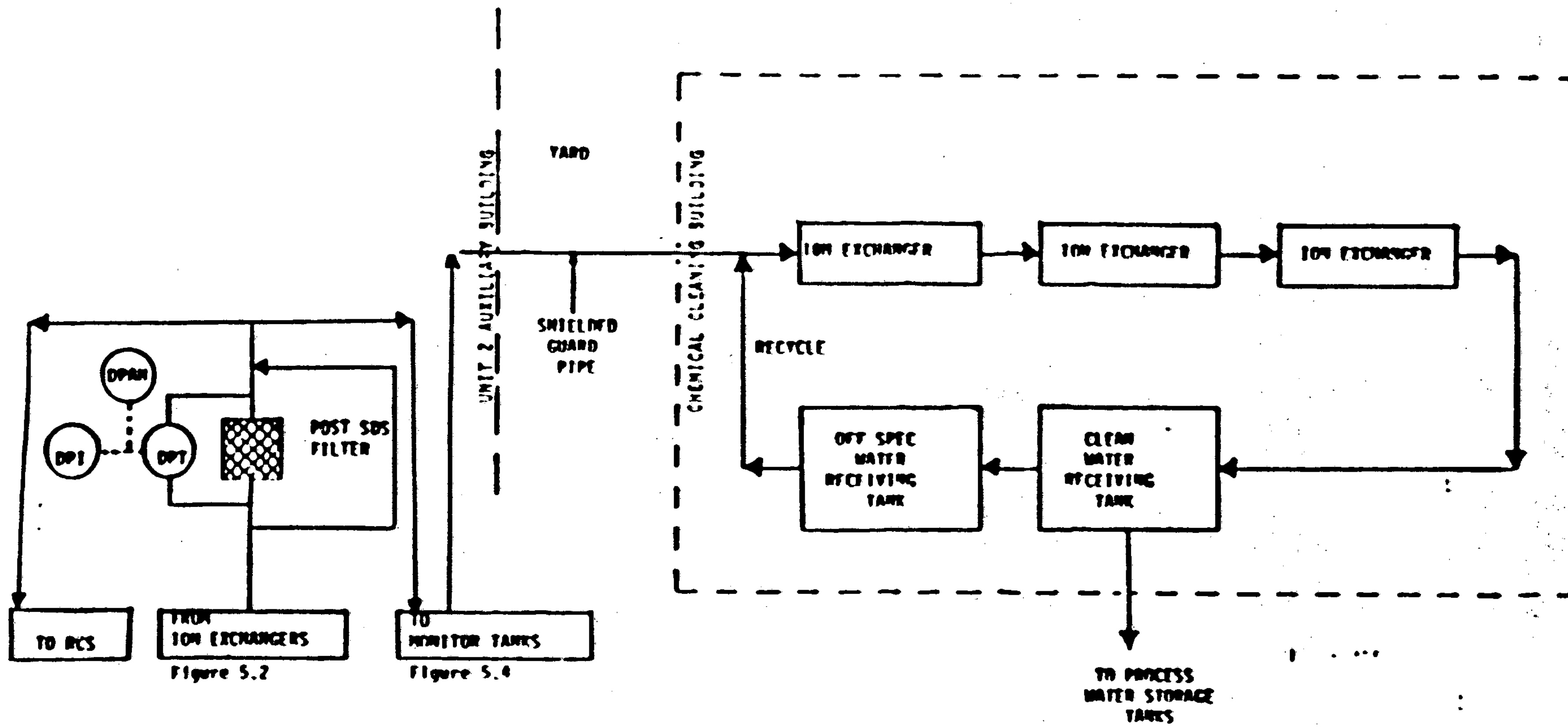


Figure 5.3 Liquid Flow Path of EPICOR II Processing System

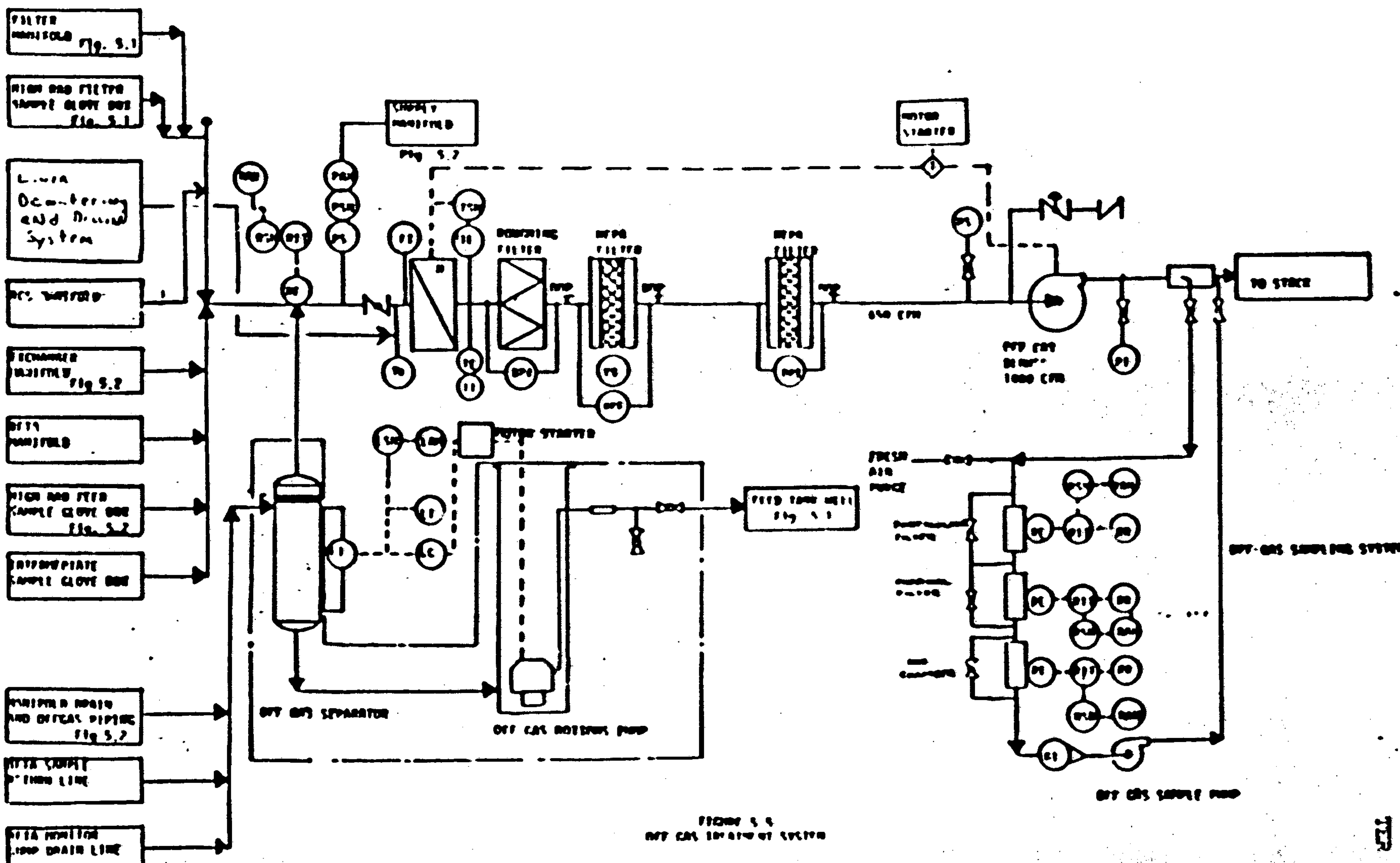


FIGURE 5.5
OFF GAS TREATMENT SYSTEM

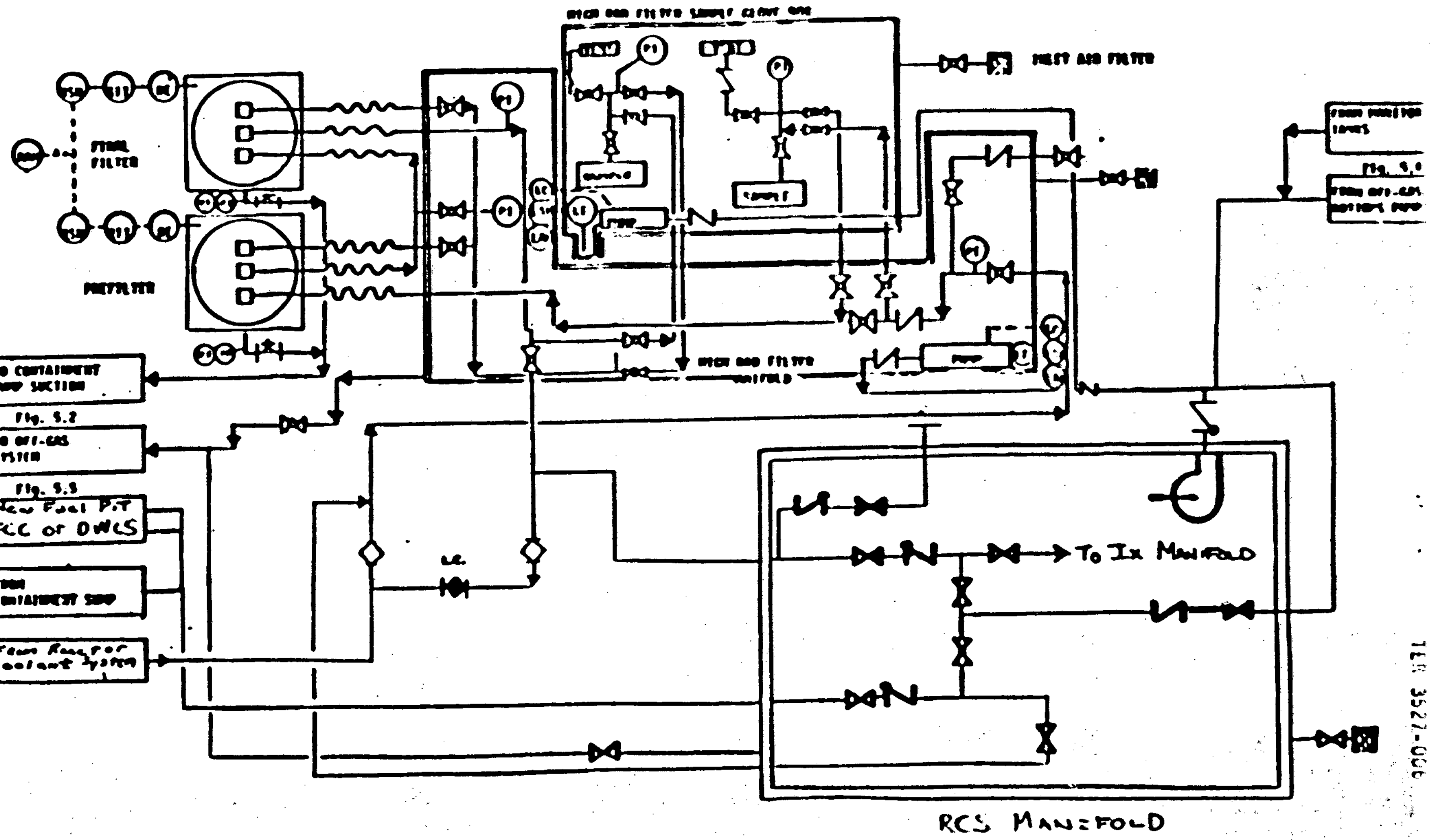


FIGURE 5.1
WASTE WATER TREATMENT SYSTEM

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 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 TMI 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 minimiz: 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 conductive 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. 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)

Isotope	Concentration (μCi/ml)	Uncertainty
Ag-110m	<1.5E-2	
Ce-144	1.1E+0	4.0E-2
Co-60	1.7E-1	1.0E-2
Cs-134	2.3E-1	1.0E-2
Cs-137	4.9E+0	4.2E-2
Ru-106	3.2E-1	5.8E-2
Sb-125	5.5E-1	3.1E-2
gross α	1.2E-3	6.1E-4
gross β	1.9E+1	2.6E-1
H-3	3.5E-2	2.2%
Sr-90	9.9E+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 10^3 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 µCi/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.

Isotope	Quantity (μCi)
H-3	5.20×10^{8} μCi
Sr-90	11.5μCi
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 7.18E-1 Curies.

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

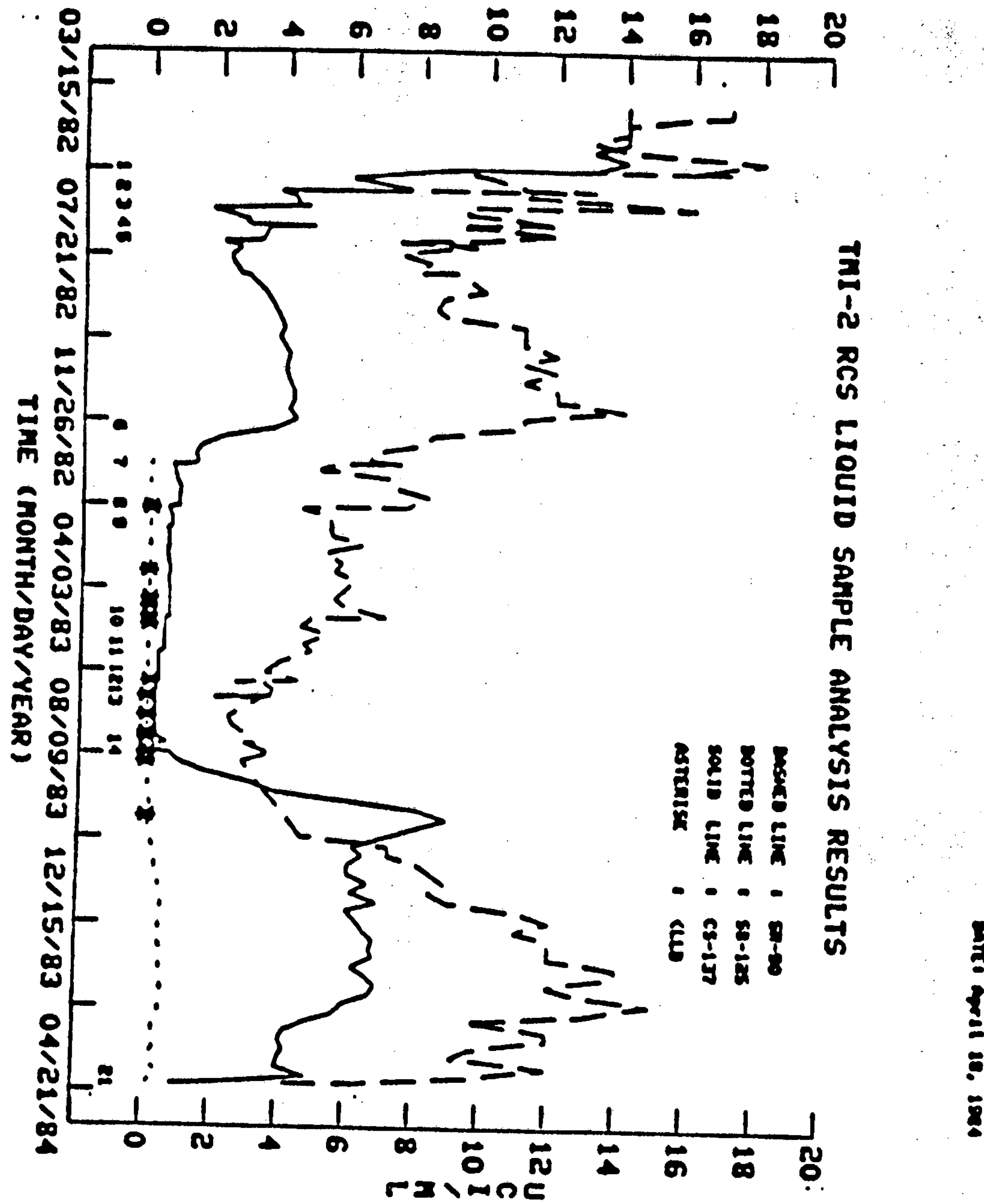
The SDS Off-gas system feeds to the exhaust ventilation of the Fuel Handling Building at 1000 cfm. The point of insertion into the Fuel Handling Building exhaust is before the HEPA filters, therefore, no increase in particulate is seen at the station vent. In addition, the Fuel Handling Building exhaust 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 7.18E-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 H-3). The highest value of X/Q from this table in 3.996 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 1.5×10^{-5} 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.



EACH RCS CLEANUP BATCH 'FEED & BLEED' PERIOD IS NUMBERED ABOVE THE APPROPRIATE POINT ON THE TIME AXIS. BATCH NUMBERS REPRESENTING RCS SAMPLING BATCHES ARE NOT SHOWN.

NOTE: BETWEEN 08/01/83 AND 04/11/84, RCS WAS SAMPLED VIA CRDM H-8 ORIFICE IN THE REACTOR HEAD; BEFORE AND AFTER, VIA THE TEMPORARY NUCLEAR SAMPLING SINK.

0564X

Table 6.1

Positive Particulate Samples Identified as Cs-137

Dates	Curies of Cs-137	Curies of Cs-134
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 x 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. (μCi/ml)	Ci/sec.	Conc. at 0.5 units (Ci/m5)	10 CFR 20 Table II Col. 1	$\frac{Cx}{MPCx}$
Ag-110m	<1.5E-2	<4.7E-18	<1.9E-23	3E-10	<6.3E-14
Ce-144	1.1E+0	3.4E-16	1.4E-21	2E-10	7.0E-12
Co-60	1.7E-1	5.3E-17	2.1E-22	3E-10	7.0E-13
Cs-134	2.3E-1	7.0E-17	2.8E-22	4E-10	7.0E-13
Cs-137	4.9E+0	1.5E-15	6.0E-21	5E-10	1.2E-11
Ru-106	3.2E-1	9.9E-17	3.9E-22	2E-12	2.0E-12
Sb-125	5.0E-1	1.6E-16	6.4E-22	9E-10	7.1E-13
Sr-90	9.9E+0	3.2E-15	1.3E-20	3E-11	4.3E-10
H-3	3.5E-2	2.9E-9	1.2E-14	2E-7	6.0E-8
U-235*	3.8E-7	1.2E-22	4.8E-28	4E-12	1.2E-16
U-238*	2.4E-6	7.4E-22	3.0E-27	3E-12	1.0E-15
Pu-238*	4.7E-7	1.5E-22	6.0E-28	7E-14	8.6E-15
Pu-239*	8.4E-4	2.6E-19	1.0E-24	6E-14	1.7E-11
Pu-240*	2.1E-4	6.5E-20	2.6E-25	6E-14	4.3E-12
Pu-241*	1.4E-2	4.3E-18	1.7E-23	3E-12	5.7E-12
Am-241*	1.4E-4	4.3E-20	1.7E-25	2E-13	8.5E-13
Np-237*	1.1E-7	3.4E-23	1.4E-28	1E-13	1.4E-15
Np-339*	1.7E-8	5.3E-24	2.1E-29	2E-8	1.1E-21
(Gross α)	(1.2E-3)	(3.7E-19)	(1.5E-24)	(2E-14)	-.-----
TOTAL $\frac{Cx}{MPCx}$					= 6.05E-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.

Chapter 7

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 μCi/ml of total activity or of 0.0075 μCi/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. C_i/MPC_i 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/M3) (at 610m with X/Q=1.3x10-3 S/M3)*	Cx/MPCx
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
			TOTAL $\frac{C_i}{MPC_i}$ =	0.786

* The X/Q value chosen for this analysis (1.3×10^{-3} S/M^3) 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 $\frac{Cx}{MPC_x}$ is only 79% of the 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

Campbell, D.O,. E.D. Collins, L.J. King, J.B. Knauer, "Evaluation of the Submerged Demineralizer System (SDS) Flowsheet for Decontamination of High-Activity-Level Water at the Three Mile Island Unit 2 Nuclear Power Station," ORNL/TM-744:, July 1980.

Clark, W.E., "The Use of Ion-Exchange to Treat Radioactive Liquids in Light-Water-Reactor Nuclear Reactor Power Plants," NUREG/CR-0143, ORNL/NUREG/TM-204 (August 1978).

Ga, J. H., E. W. Murbach, and A. K. Williams, 1979, "Experience and Plans for Effluent Control at LWR Fuel Reprocessing Plants", in Proc. Conf. on Controlling Airborne Effluents from Fuel Cycle Plants, AICHE Topical Meeting.

Lin, K. H., "Use of Ion-Exchange for the Treatment of Liquids in Nuclear Power Plants," ORNL-4792 (December 1973).

Lin, K. H., "Performance of Ion-Exchange Systems in Nuclear Power Plants," AICHE Symposium, Ser. 71 (152), pp 224-35 (1975).

Willingham, W. E., 1972, "The Vitro Engineering ISOSHLD User's Manual," VITRO-R-153.

U.S. Department of Health, Education, and Welfare, 1970, Radiological Health Handbook, U.S. Government Printing Office, Washington, D.C.

Chapter 8

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

CONTENTS

CONTENTS (continued)

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 μCi/cc to the present value of approximately 0.016 μCi/cc.

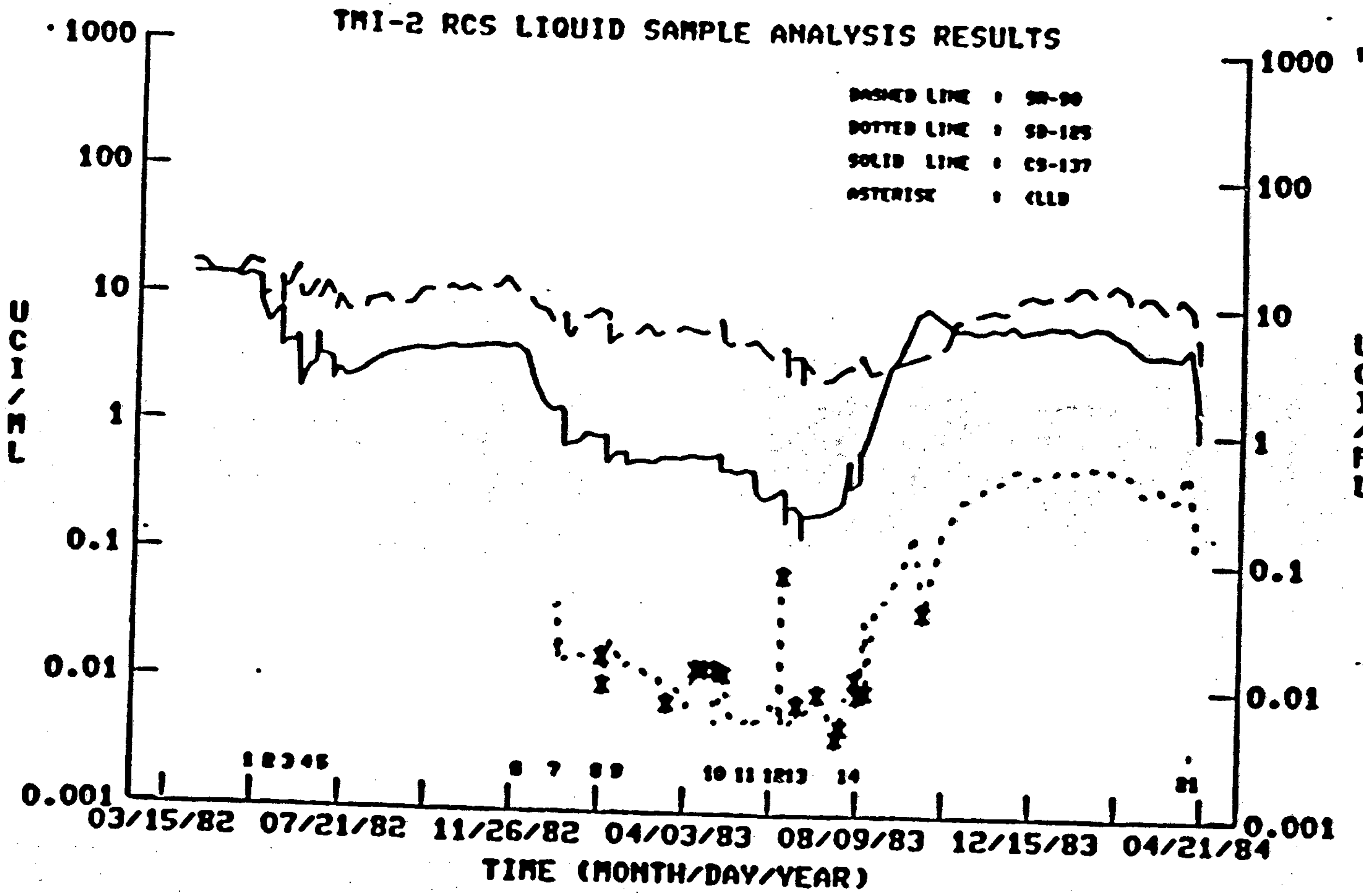
This report describes the processing of the RCS by the SDS while maintaining the RCS in the partially drained, open condition. The design features of this processing method will utilize:

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.

DATE: April 18, 1984



EACH RCS CLEANUP BATCH "FEED & BLEED" PERIOD IS NUMBERED ABOVE THE APPROPRIATE POINT ON THE TIME AXIS. BATCH NUMBERS REPRESENTING RCS SAMPLING BATCHES ARE NOT SHOWN.

NOTE: BETWEEN 08/01/83 AND 04/11/84, RCS WAS SAMPLED VIA CRDM H-8 ORIFICE IN THE REACTOR HEAD; BEFORE AND AFTER, VIA THE TEMPORARY NUCLEAR SAMPLING SINK.

Figure 1.2

TER 3527-006

0862X

1.3 RCS Processing Description

On a batch basis, radioactive RCS water is letdown to a Reactor Coolant Bleed Tank (RCBT) while clean water is injected into the RCS from another RCBT. RCS water is then pumped from the receiving RCBT 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 another RCBT 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 are 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
(May 1986)

ISOTOPE	RADIONUCLIDE CONCENTRATION μCi/cc
H-3	0.085
Sr-90	2.4
Cs-134	0.01
Cs-137	0.35
pH	7.58
Boron	5460 ppm
Na	1500 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 this TER.

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 μCi/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 in accordance with approved operating procedure.

Chapter 3

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 TER.

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 RCBT'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 TMI-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, an RCBT 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 a RCBT. 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 another RCBT is injected into the RCS. After the RCBT has been filled to more than 50,000 gallons, the letdown and injection of water from and to the RCS will be secured. The RCBT 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-96 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.

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 a RCBT, as shown in Figure 3.3. The remaining SDS equipment and EPICOR II are not used for RCS water processing.

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 the receiving RCBT 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.

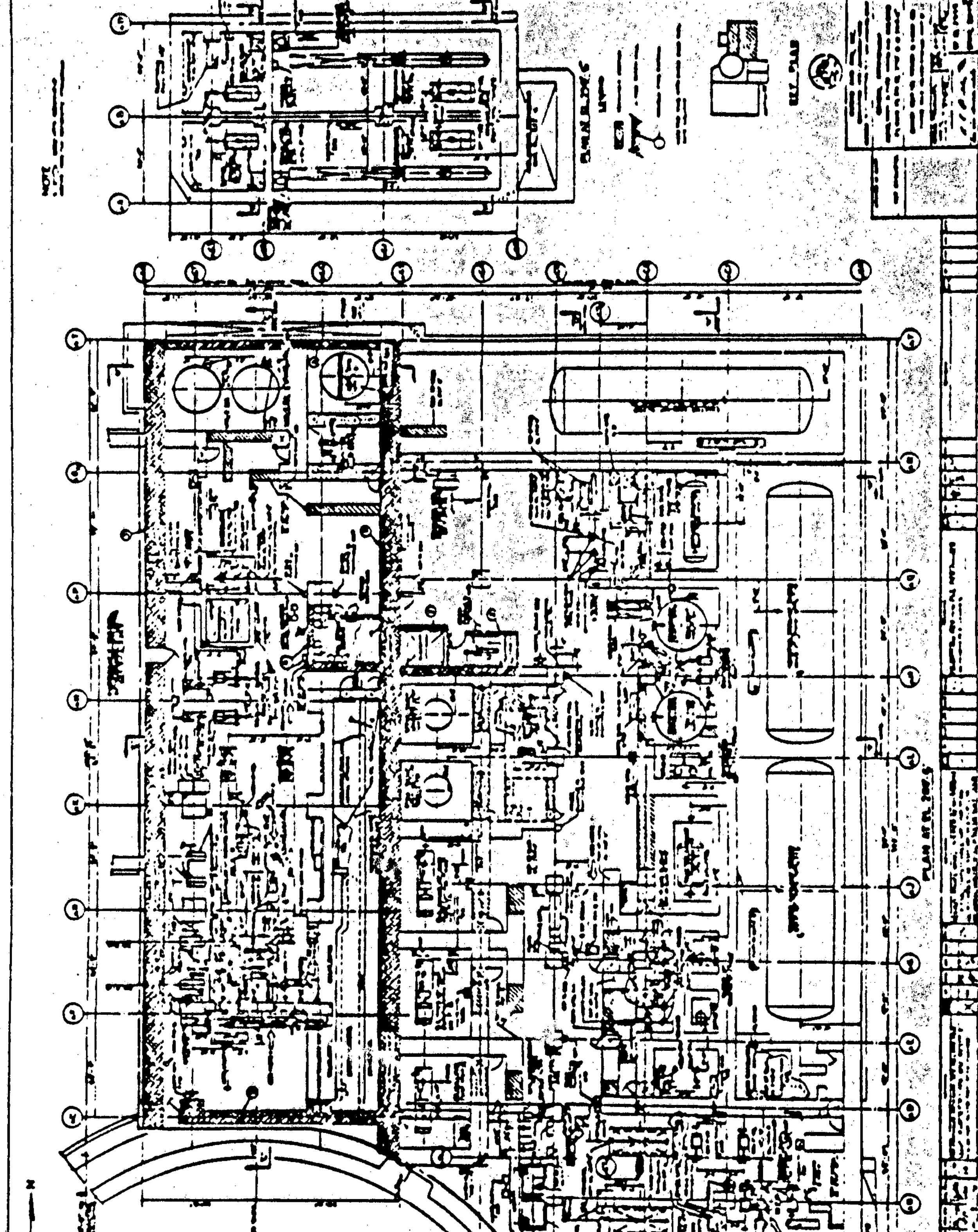
3.6 Waste Produced

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



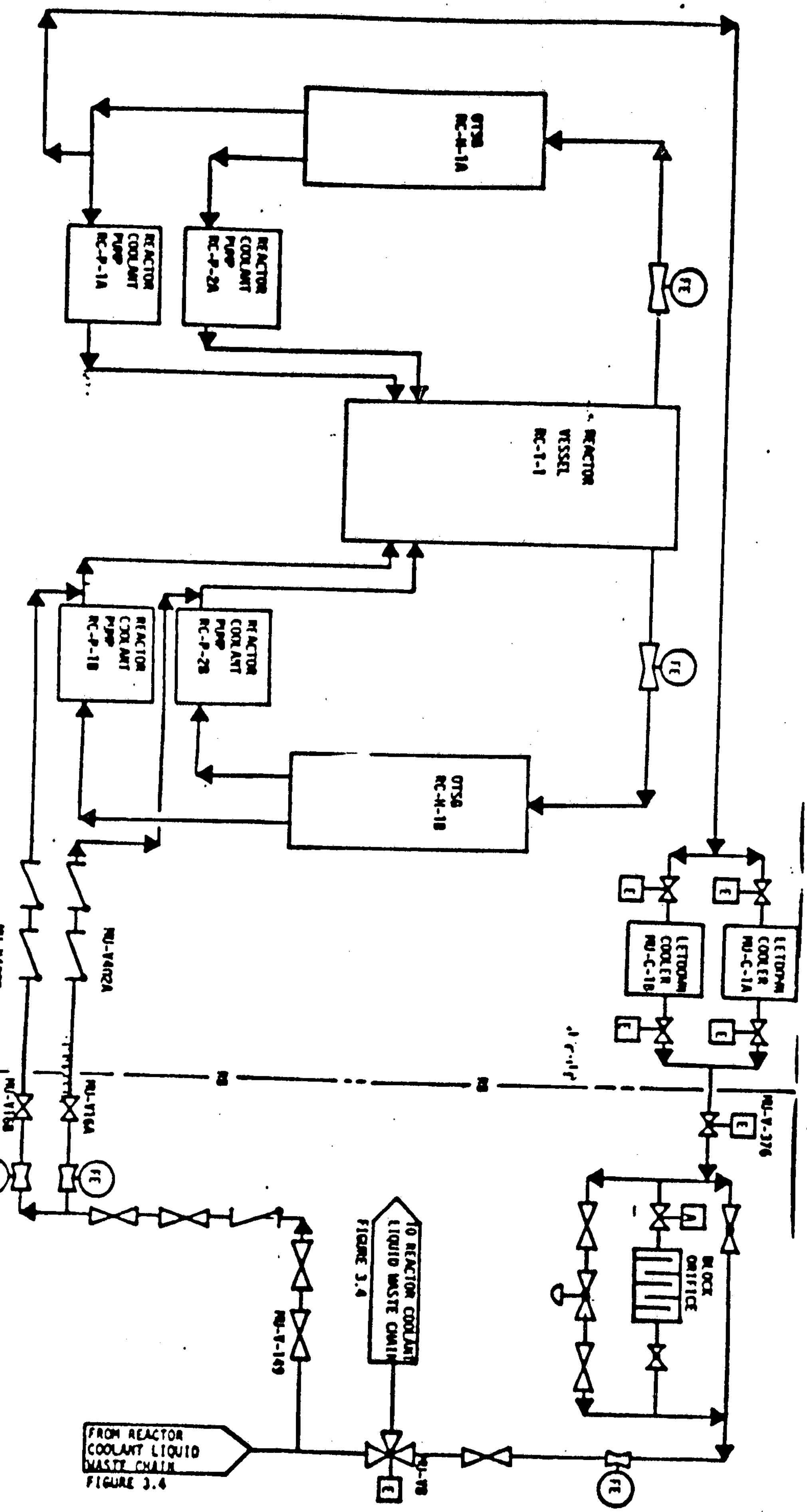


FIGURE 3.3
RCS LETDOWN AND INJECTION PATHS

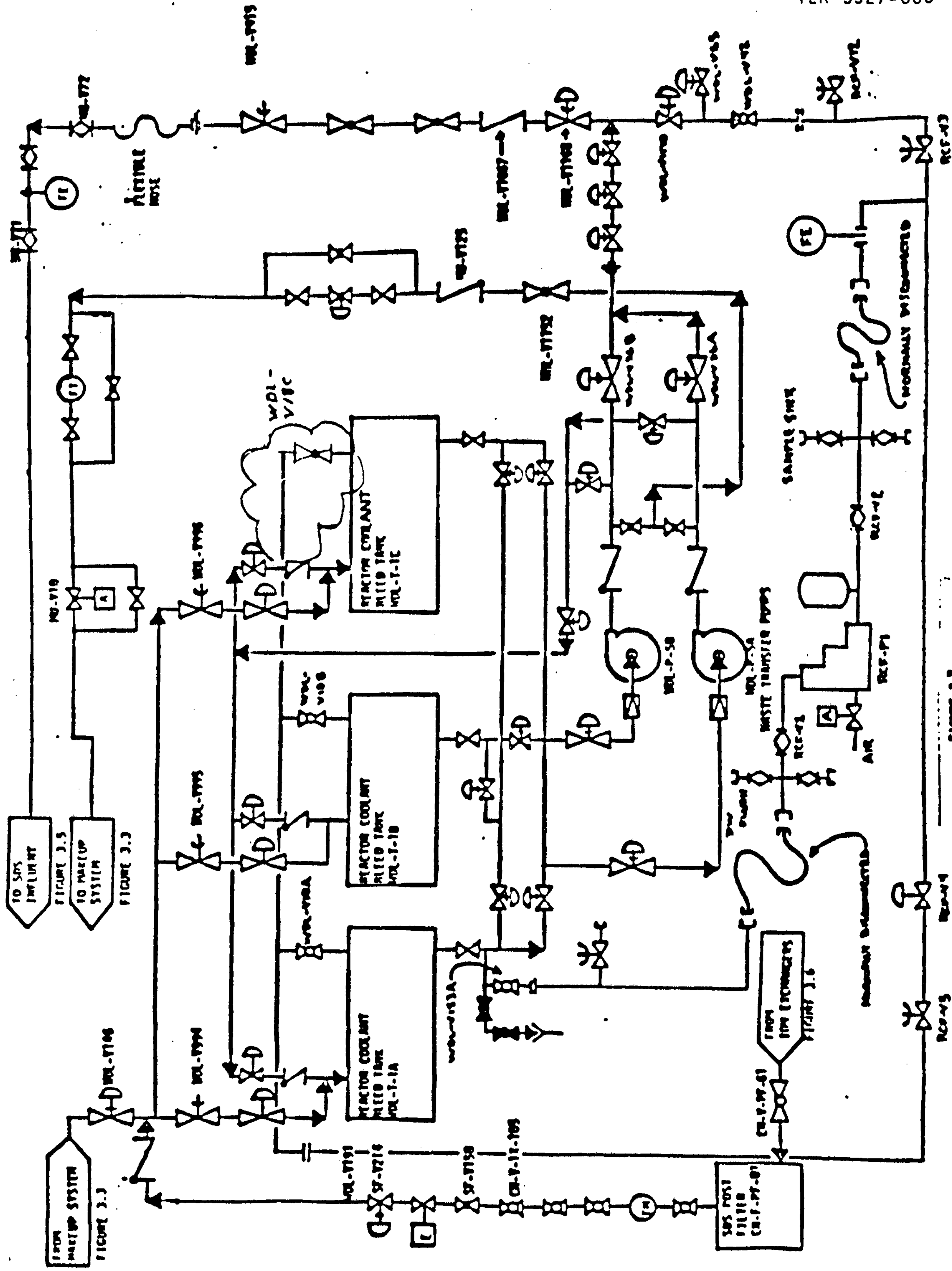


FIGURE 3.3
RCS PROCESSING COLLECTION STAGE
(REFERENCES 6, 7, 8, 9)

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" ± 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

(Deleted)

Appendix No. 3

to

Submerged Demineralizer System

Technical Evaluation Report

TITLE

FUEL TRANSFER CANAL DRAINING SYSTEM (FCC)

JUNE 1985

CONTENTS

CONTENTS (continued)

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 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.

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.

Table 1.1

FTC Radionuclide and Chemistry Data
(05/14/86)

Co^{60}	3×10^{-4} μCi/ml
Sr^{90}	3.3×10^{-2} μCi/ml
Ru^{106}	$< 6.1 \times 10^{-5}$ μCi/ml
Sb^{125}	3.3×10^{-3} μCi/ml
Cs^{134}	3.2×10^{-4} μCi/ml
Cs^{137}	1.3×10^{-2} μCi/ml
Ce^{144}	$< 4.8 \times 10^{-5}$ μCi/ml
Boron	4990 ppm
Turbidity	1.25 NTU

Figure 1.1

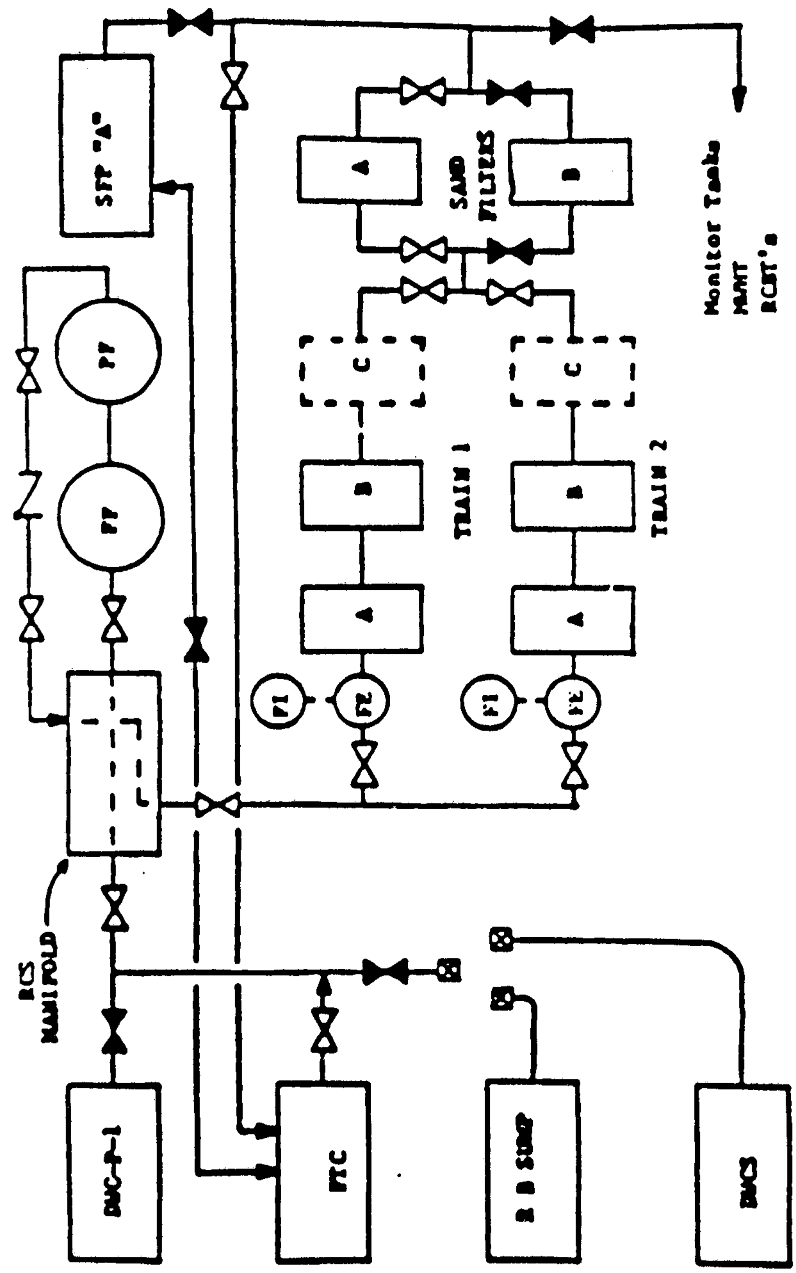


Figure 1.1

FTC 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 4.5 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. 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 $\beta\gamma$ activity less than 1×10^{-4} μCi/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.

Chapter 3

SYSTEM DESCRIPTION AND OPERATIONS

3.1 Introduction

The FCC is designed to maintain liquid levels and water clarity in the Fuel Transfer Canal.

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 FTC Shallow 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 FTC will be filled with RCS grade water. The function of the FCC system is to possible 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 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 which also actuates high/low level alarms (FCC-LAHL-103).

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 TER.

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 TER.

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 withdrawl 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 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 FCC processing will be lower due to the fact that the radionuclide concentration in the FTC 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 μCi/cc of predominately Cesium. The radionuclide concentration of Cesium in the FTC water is currently much less than 0.1 μCi/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 intermitted processing of the FTC as required to maintain water clarity and Gross $\beta\gamma$ activity $<1 \times 10^{-4}$ $\mu Ci/ml$ as required. 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 breech 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 18.

2. TMI-2 Radiochemistry Summary Sheet, Sample No. 86-07106 dated May 14, 1986.

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

CONTENTS

CONTENTS (continued)

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

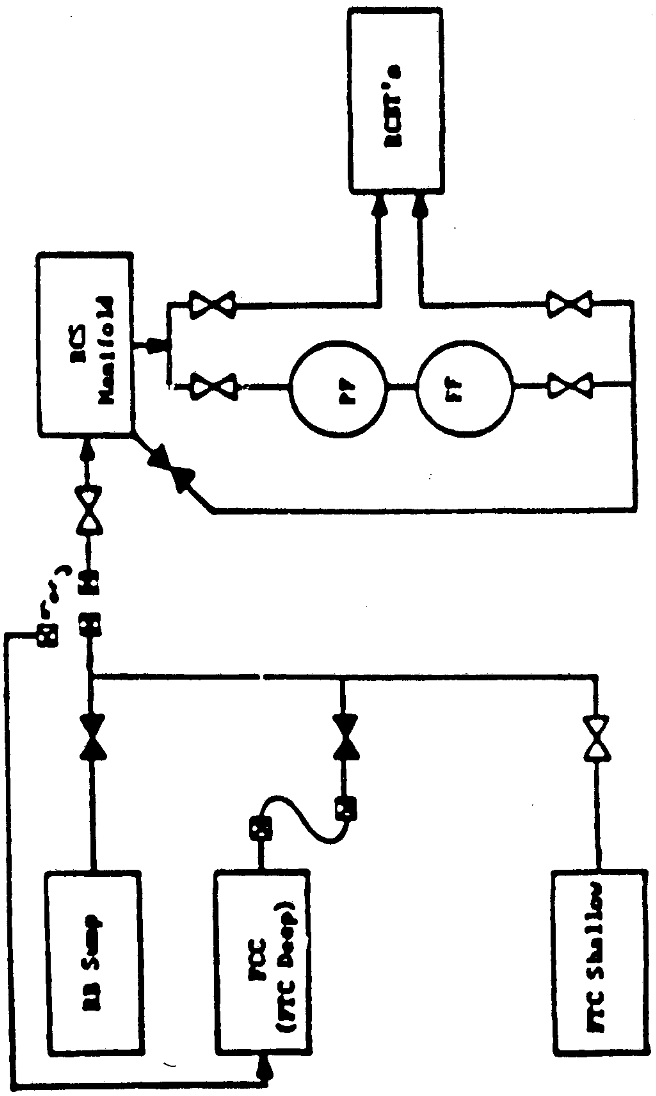


Figure 1.1.
FTC SHALLOW END TRANSFER FLOWSHEET

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 SDS 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, DWC-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 server 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 deepend of the canal or the reactor coolant bleed tanks (RCBT)'s.

During defueling operations, the shallow end of the FTC 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 El. 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 El. 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 Seperation 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.

Chapter 4

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 qualifiable personnel.
3. Strict adherence to TMI-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 TER. These design and operational considerations and features remain unchanged from this evaluation. The radiation dose exposures to plant personnel during Shallow End Drainage oper‹tions 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 mr/hr using 200 μCi/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 TMI-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 pathways for gaseous or airborne release, see section 6.3.2 of this TER.

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 breech 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 DWC REACTOR VESSEL FILTRATION SYSTEM

JUNE 1985
(Deleted)