Nuclear

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March 23, 1982
4400-82-L-0043

MAR 23 1982

TMI Program Office
Attn: Dr. B. J. Snyder, Program Director
U. S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Sir:

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

Attached for your information and use is the Reactor Coolant Processing Plan which serves as an Addendum to the Submerged Demineralizer System (SDS) Technical Evaluation Report for the processing of Reactor Coolant System (RCS) water. This plan was prepared in response to the NRC order of June 18, 1981 which, in part, directed the processing of RCS water and it falls within the scope of the SDS Safety Evaluation Report. Thus, with the exception of changes to some RCS Chemistry Specifications detailed in the Recovery Operations Plan and approval of the procedures needed to process RCS water pursuant to Technical Specification 6.8.2, formal NRC approval for the processing of RCS water has already been granted. If, however, you have any questions on the attached document, please contact Mr. J. E. Larson of my staff.

To support the changes to the RCS chemistry referred to above, a Recovery Operations Plan Change Request is being developed. The anticipated submittal for the Recovery Operations Plan Change Request is April 19, 1982.

Sincerely,

J. J. Barton

J. J. Barton
Acting Director, TMI-2

JJB:JJB:djb

Attachment

cc: L. H. Barrett, Deputy Program Director, TMI Program Office

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Appendix No. 1

to

Submerged Demineralizer System

Technical Evaluation Report

Title

REACTOR COOLANT PROCESSING PLAN

March 1982

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 88,000 gallons of radioactively contaminated water. The activity level of this water is given in Table 1.1. 350,000 gallons of water for the bleed and feed of the RCS is estimated to be required. The first batch of water to be processed (50,000 gallons) will require the addition of new water to the RCS. The subsequent batches of 50,000 gallons will use processed water.

This report describes the processing of the Reactor Coolant System (RCS) by the Submerged Demineralizer System (SDS) and other interfacing plant systems for the expeditious cleanup and disposition of the RCS water. The design features of this processing method are:

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

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

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.

1.3 Alternatives Considered

As stated in the SDS TER, the use of volume reduction for the cleanup and disposition of contaminated water by the SDS is the most appropriate process. Several alternatives were evaluated for removing water from the RCS. These were:

1. Bleed and Feed.
2. Drain and Fill.
3. Drain, Bleed and Feed.

Presented as follows are the alternatives.

Alternative 1: Bleed and Feed

Discussion:

1. The bleed and feed process removes the same amount of water from the RCS that can be reinjected into the RCS.
2. This process requires maximum amounts of process water. Assuming normal mixing, this amounts to about 350,000 gallons to be processed.
3. Mixing of the RCS water is questionable. Time is required between batches of water to be processed to allow mixing to occur.
4. The reactor remains in the same mode of operation by maintaining the required pressure, temperature and chemistry. The reactor will be maintained in the safest conditions for this alternative.
5. The use of existing systems is maximized, thereby reducing radiation doses to plant personnel to as low as reasonably achievable (ALARA) as incorporated into the original design of the systems.

1.3 Alternatives Considered (continued)

Alternative 2: Drain and Fill

Discussion:

1. The drain and fill process involves draining the RCS to the maximum possible and refilling with clean water.
2. The amount of process water required will be reduced to 277,000 gallons.
3. Mixing of the RCS water is good.
4. The RCS will have to be provided with a nitrogen blanket during the draining of the RCS. The RCS will be required to have venting of this gas during the refill process.
5. Since this process is a new mode of operation, preparation of the safety evaluation needed for this method of operation would significantly delay RCS processing.

Alternative 3: Drain, Feed and Bleed

Discussion:

1. The drain, feed and bleed process drains the RCS to the maximum possible and then feeds and bleeds this minimum volume.
2. This process requires the least amount of water to be processed, approximately 184,000 gallons.
3. Mixing of the RCS is very doubtful.
4. A nitrogen blanket will be required to be maintained throughout the processing.
5. Since this process is a new mode of operation, prepartion of the safety evaluation needed for this method of operation would significantly delay RCS processing.

1.3 Alternatives Considered (continued)

Conclusion:

Analysis of the alternatives presented above resulted in the determination that, while all the alternatives are feasible, Alternative 1, using bleed and feed was the most appropriate method for RCS process water. This is based on:

1. The reactor is maintained in the same mode of operation at all times, thereby minimizing safety concerns.
2. The process requires minimum use of interfacing plant systems to maintain the reactor in a safe condition.

1.4 RCS Processing Description

Figure 1.1 shows a block diagram of the process flow to and from the RCS from the SDS. On a batch basis, radioactive RCS water is letdown to Reactor Coolant Bleed Tank (RCBT) "C" while clean water is injected into the RCS from RCBT "A". RCS water is then pumped from RCBT "C" through the prefilter and final filter, bypassing the SDS water storage tanks. RCS water then goes through the RCS manifold and the SDS ion exchangers. The effluent from the ion exchangers is routed through the post filter to RCBT "A" for chemical adjustment, if necessary, and injection back into the RCS as makeup. The above process is repeated until the RCS water is decontaminated. EPICOR II will not be used for processing RCS water.

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.

1.4 RCS Processing Description (continued)

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

TABLE 1.1

RCS RADIONUCLIDE and CHEMISTRY DATA

(Reference 2)

ISOTOPE	RADIONUCLIDE CONCENTRATION uCi/cc
H-3	0.034
Kr-85	0.051
Sr-90	13.0
I-129	1×10^{-6}
Cs-134	1.5
Cs-137	14.0
Gross Beta	31.8
pH	7.65
Boron	3803 ppm
Na	996 ppm
Cl	2.6 ppm
H_2	7 cc/kg
N_2	8 cc/kg
O_2	0.07 ppm

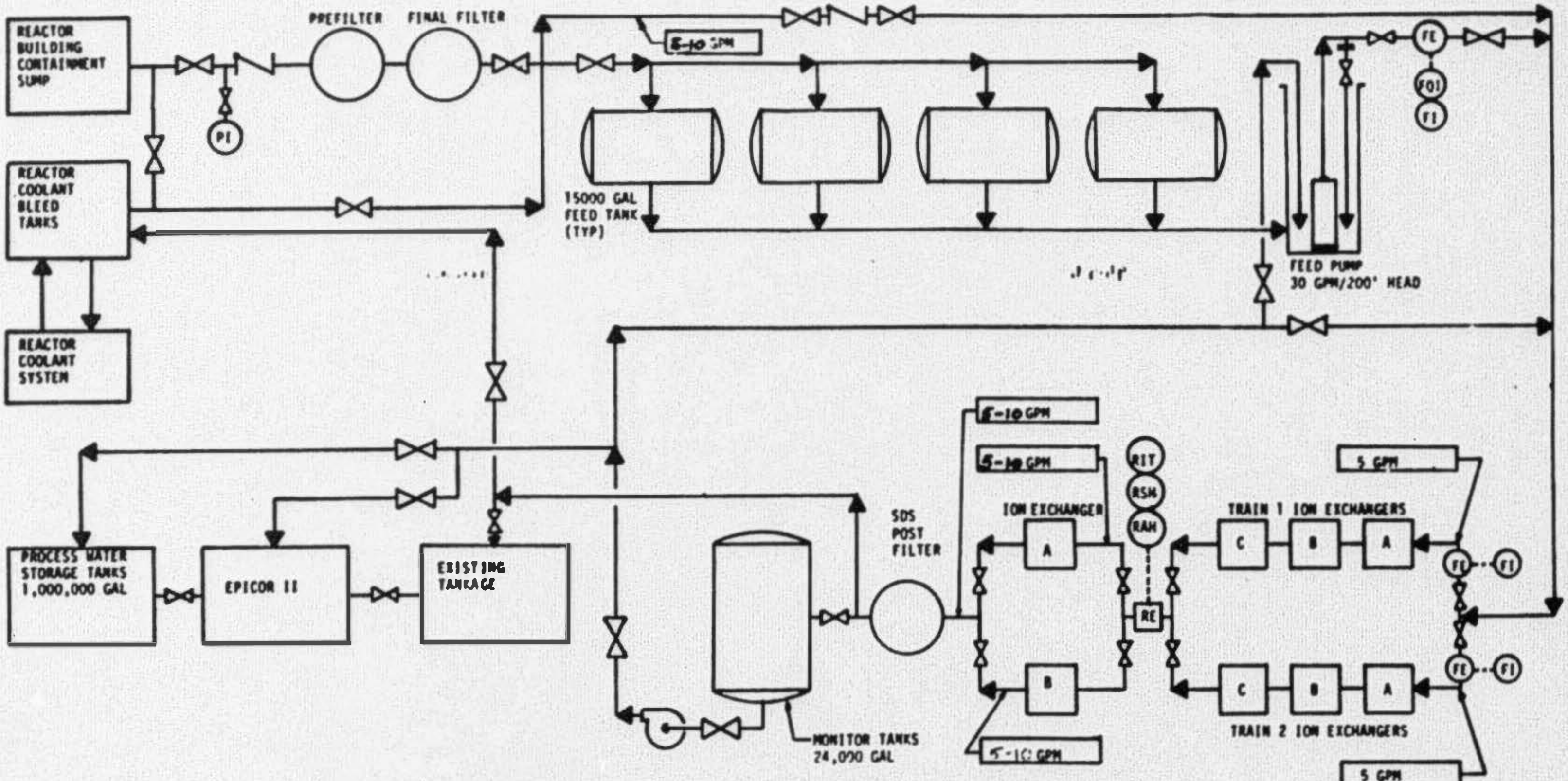


FIGURE 1.1
RCS PROCESSING FLOW SHEET

Chapter 2

RCS PROCESSING PLAN DESIGN CRITERIA

2.1 Introduction

The 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:

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 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.

2.2 Design Basis (continued)

2.2.1 Submerged Demineralizer System (continued)

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

2.2.2 Interfacing Systems

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

1. Reactor Coolant Liquid Waste Chain.
2. Purification and Makeup System.
3. Auxiliary and Fuel Handling Buildings Heating Ventilation and Air Conditioning Systems.
4. Nitrogen Supply System.
5. Decay Heat Removal System.
6. Waste Gas System.
7. Standby Pressure Control System

The design criteria for these systems 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.

2.3 RCS Process Plan Goal

The goal of the RCS Processing Plan is to reduce the total radionuclide concentration of Cs and Sr in the RCS to less than 1 uCi/cc. The RCS chemistry will be maintained as follows as a minimum:

Chlorides	5 ppm
Oxygen	Atmospheric Concentration
pH	> 7.5
Boron	> 3500 ppm

2.3 RCS Process Plan Goal (Continued)

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

A Recovery Operations Change Request is being developed to support the above chemistry specifications, which differ from those presently listed in the Recovery Operations Plan.

CHAPTER 3

SYSTEM DESCRIPTION AND OPERATIONS

3.1 Introduction

The RCS Processing Plan is designed specifically for the controlled decontamination of the radioactive water in the RCS and the treatement 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 absorbs 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.

3.1.2 Interfacing Systems

Interfacing with the above systems 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 Decay Heat Removal System provides borated

3.1.2 Interfacing Systems (continued)

water from the Borated Water Storage Tank for injecting into the RCS for the initial bleed and feed operation. 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 Standby Pressure Control System, installed as a temporary TMI-2 recovery system, will be used as a safety system to ensure that RCS pressure is maintained during RCS processing.

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

3.2 RCS Water Processing Preparation

3.2.1 RCS Preparation

Change in the RCS pressure for the bleed and feed operating will be required based upon the RCS chemistry conditions and/or the use of the Waste Transfer pumps. If chemical adjustment of the RCS is required after SDS processing and/or the Waste Transfer pumps are not used for injection of processed RCS water into the RCS, the RCS pressure will be maintained at its current 100 psig. If the Waste Transfer pumps are used for injection of processed

3.2.1 RCS Preparation

RCS water into the RCS for the bleed and feed process, the RCS pressure will be reduced from 100 psig to 50 psig. The purpose of reducing the pressure is to permit the use of the Waste Transfer pumps. The maximum discharge pressure of these pumps is 74 psig necessitating the decrease in RCS pressure.

The reduction in RCS pressure to 50 psig will have no effect on plant stability for the following reasons:

1. Saturation Margins

   Adequate pressure and subcooled temperature margins are maintained. The pressure and subcooled temperature margins were calculated at core exit and the high point in the hot legs, per the following assumptions:

   (a) The core exit temperature was 134.3^{o}F (highest incore thermocuple reading, location 3-F).

   (b) The hot leg temperature was 99.1^{o}F (average of the hot loops).

   (c) RCS pressure at these locations was corrected for elevation differences, 12.5 and 35.6 psig static pressures, respectively.

   The calculated saturation margins are stated below. They are adequate to ensure that phase change will not occur.

Location	Pressure Margin	Subcooled Temperature Margin
Core Exit	49.8 psi	149.5^{o}F
Hot Legs	28.2 psi	149.4^{o}F

2. Dissolved Gas Margins

   Dissolved gas margins will be maintained. The RCS coolant has dissolved gas consisting of H_2 and N_2 and small amounts of oxygen, krypton, and xenon. These gases must not come out of solution if RCS pressure is lowered to 50 psig on SPC-PI-15. Dissolved gas margins and their

3.2.1 RCS Preparation (continued)

2. Dissolved Gas Margins (continued)

corresponding allowable pressure margins were calculated at core exit and the high point in the hot legs, per the following assumptions:

(a) The RCS gas concentrations, H_2 and N_2, were each 9 cc/kg.

(b) The core exit average pressure and temperature was 35.5 psig and 106.0^{o}F, respectively.

(c) The hot leg average pressure and temperature was 14.4 psig and 99.1^{o}F, respectively.

(d) Henry's Law was applicable.

The calculated dissolved gas margins for H_2 or N_2, along with their corresponding allowable pressure margins, are stated below. They are adequate to ensure that gases will not be released provided RCS pressure is not lowered below the allowable pressure margin.

Location	Dissolved Gas Margin	Allowable Pressure Margin
Core Exit	15.5 cc/kg	31.7 psi
Hot Legs	5.0 cc/kg	10.5 psi

3. Water Head Margin

The elevation difference between SPC-PI-15 and the high point of the hot legs is 80 feet. This corresponds to a minimum head pressure on SPC-PI-15 of 35.6 psig to maintain the system filled. Thus, the water head margin is 14.4 psi.

4. Pressure Gauge Uncertainty

The uncertainty in the pressure gauge SPC-PI-15 from Foxboro Technical Literature is $\pm$ 10 psi. Therefore, provided 60 psig is maintained on the gauge, RCS pressure at this location will be above 50 psig.

3.2.1 RCS Preparation (continued)

5. Decay Heat Removal

The current mode of passive decay heat removal will be unaffected since the criteria addressed in items 1, 2, and 3 yield adequate margins and the requirement of item 4 will be imposed. The Mini-Decay Heat System remains unaffected by this pressure reduction and convective cooling will not be effected since the RCS remains full of water.

6. WDL 5A/5B Injection Limit

The discharge head on WDL-5A/5B at 40 gpm (injection plus recirculation) is 167 ft or 74 psi. Since these pumps are located at the same elevation as SPC-PI-15 and injection line losses are negligible at 10 gpm, they will be capable of maintaining greater than 70 psig on SPC-PI-15.

7. RCS Sampling/Leakage

RCS sampling and leakage rates will both be affected by lowering RCS pressure to 50 psig. RCS sampling purge times will be a factor of 1.4 longer and RCS leakage rate will decrease by a factor 0.7.

3.2.2 SPC Operation

The Standby Pressure Control System (SPC) will serve as a safety system to ensure that the RCS pressure is maintained during RCS processing. The injection pressure of the SPC will be reduced to a pressure below RCS processing pressure.

3.2.3 Reactor Coolant Liquid Waste Chain

Also prior to starting RCS water processing, the RCBT "A" will be filled with 50,000 gallons of water from the Borated Water Storage Tank or other suitable processed water source. The radionuclide and chemistry data for this water is shown in Table 3.1. Chemicals will be added to this water to ensure that this water complies with the plant chemistry specificed in section 2.3.

Chapter 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 pressure and water volume constant. The bleed and feed process will be controlled from the Control Room in coordination with the Radwaste Control Panel. A flow diagram of the letdown of the RCS water is shown in Figure 3.3. The principle design parameters of components are given in the TMI-2 FSAR, Chapter 11. 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 either 5 or 10 gallons per minute depending on mode of injection. The letdown rate is 5 gpm if the Waste Transfer pumps are used or 10 gpm if a newly installed sandpiper pump is used for injection of water into the RCS. The RCS water is letdown through the letdown coolers to RCBT "C" (Figure 3.4). The plugged block orifice and isolated Makeup Demineralizers and Filters are bypassed. As the RCBT water is letdown, simultaneously the borated processed water located in RCBT "A" is injected to the RCS. After RCBT "C" has been filled to 50,000 gallons, the letdown and injection of water from and to the RCS will be secured. RCBT "C" will be sampled prior to processing. After sampling, decontamination of the RCS radioactive water by the SDS will commence.

3.4 RCS Processing by SDS

3.4.1 RCS Water Filtration

A flow diagram of the waste water filtering is shown in Figure 3.5 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

3.4.1 RCS Water Filtration (continued)

700 pounds of 0.85 mm sand and the second layer is 200 pounds of 0.45 mm sand. Mixed uniformly with the sand is approximately 6 pounds borosilicate glass which is at least 22 weight percent boron. The purpose of the borosilicate is to prevent the possibility of criticality should any fuel fines be transported in the letdown. The flow capacity through each filter is 50 gpm. Reverse flow through filters is prevented by a check valve in the supply line to each filter.

Each filter is housed in a containment enclosure to enable leakage detection and confinement of potential leakage. The filters are submerged in the spent fuel pool for shielding considerations. Contaminated water can be pumped through the filters and the RCS manifold to the ion exchangers. The Waste Storage tanks in the SDS are bypassed, thus minimizing oxygenation of the RCS water.

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

A flow diagram of the ion exchange manifold and primary ion-exchange columns is shown in Figure 3.6. This system consists of eight underwater columns (24½" x 54½"), 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 three beds (A, B, C) with piping and valves provided to operate either train individually or both trains in parallel.

The effluent from the six zeolite beds flows through either of the remaining two zeolite ion exchangers. 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 back to the feed tank standpipe via the off gas bottoms separation 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 and at the post filter effluent by a turbine flow meter. The effluent from the last ion exchanger is routed through the post filter back to the RCBT "A", as shown in Figure 3.4. The remaining SDS equipment and EPICOR II are not used for RCS water processing.

3.4 RCS Processing by SDS (continued)

3.4.2 RCS Water Demineralization (continued)

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

The types of samples to be taken at RCBT after letdown and prior to reinjection is shown in Table 3.2.

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 (See Figure 3.5). 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. The off-gas system is illustrated in Figure 3.7. This system will be operated in the same manner for RCS water processing as it was for Reactor Building Sump water processing.

3.4.5 Sampling and Process Radiation Monitoring System

The sampling glove boxes are shielded enclosures which allow water samples to be taken for analysis of radionuclides and other contaminants. The piping entering the glove boxes permits the 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.

3.4.5.3 Tranauranic Element Monitoring

Radiation monitoring is being provided to detect the presence of transuranic elements during RCS processing. Spent fuel may be transported into the process stream during letdown into the RCBT's. It is important to prevent a criticality accident during RCS water processing. TRU monitoring is provided at the RCBT's to detect the presence of fuel. This monitoring consists of a two (2) channel analyzer to detect the present of Ce-144/Pr-144 since these isotopes are extremely insoluble and provide a good indication of the presence of spent fuel.

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

3.4.7 Ion-Exchanger and Filter Vessel Transfer in the Fuel Storage Pool (continued)

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 position "D".

3.5 Zeolite Mixtures

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

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

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

3.6 Waste Produced

Based on operating experience processing the Reactor Building sump water, the useful life of a zeolite resin bed is about 100,000 gallons of waste water processed. At this point the DF of the zeolite bed for Strontium goes to 1. Since about 350,000 gallons of water will require processing, it is estimated that four zeolite liners will be generated by processing RCS radioactive water.

TABLE 3.1

BWST WATER DATA*

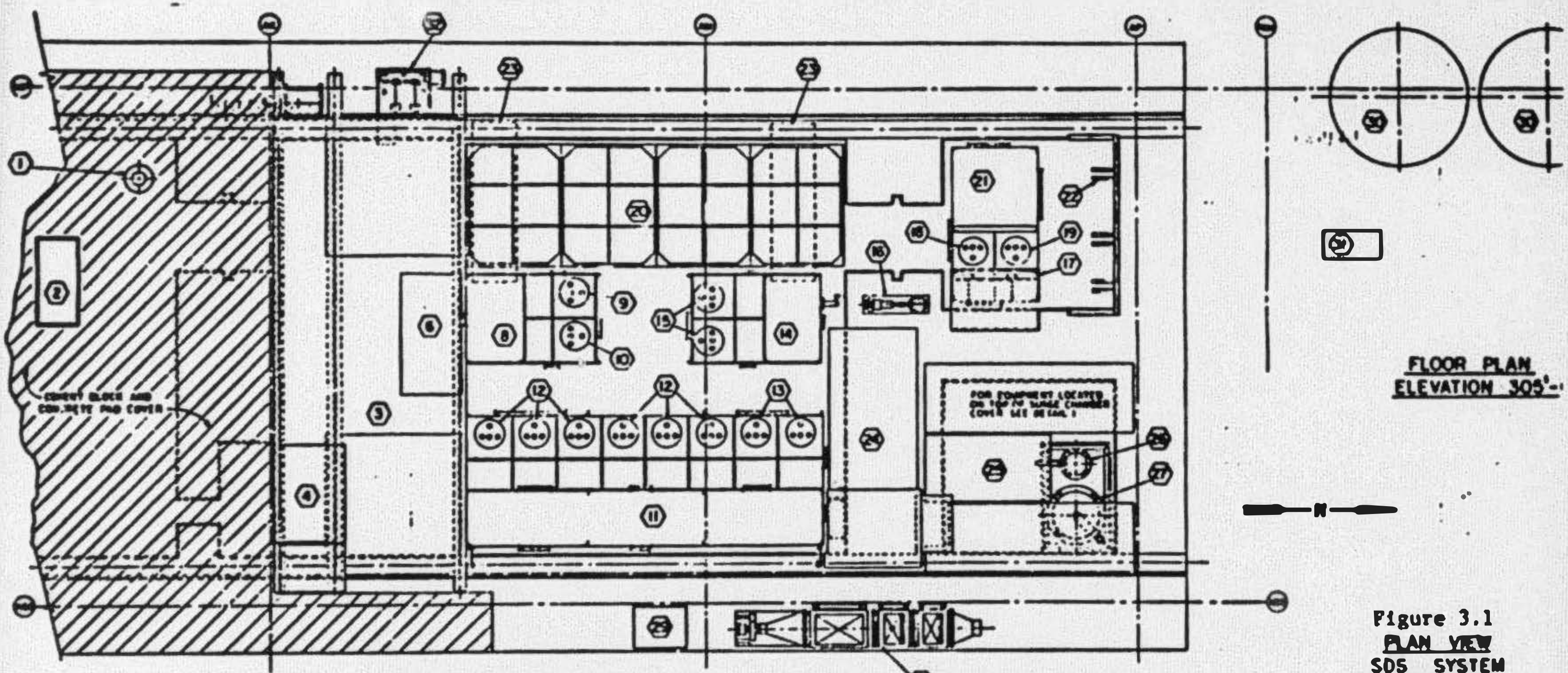
NUCLIDE	CONCENTRATION
H-3	9.02E-02
Co-60	1.30E-05
Cs-134	1.10E-04
Cs-137	3.70E-04
Cl	0.14 ppm
pH	5.95
B	3538 ppm
SO_4	$<$ 5 ppm

*References 3 and 4

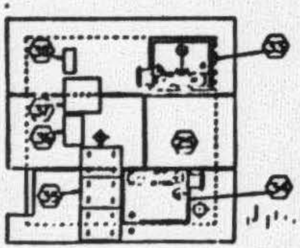
TABLE 3.2

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



FLOOR PLAN ELEVATION 347'-6"



DETAIL 1

Figure 3.1
PLAN VIEW
SDS SYSTEM

1	FEED PUMP STAND PIPE	17	DEWATERING STATION SUPPORT RACK	33	HI-RAD FEED SAMPLE GLOVE BOX
2	FEED PUMP MANIFOLD	18	ION EXCHANGER DEWATERING STATION	34	INTERMEDIATE LEVEL SAMPLE GLOVE BO
3	CASK SUPPORT PLATFORM	19	FILTER DEWATERING STATION	35	BETA MONITOR MANIFOLD
4	RCS CLEAN-UP MANIFOLD	20	SPENT EXCHANGER STORAGE RACK	36	ANNUNCIATOR PANEL
5		21	SHIPPING CASK SUPPORT PLATFORM	37	RAD MONITOR PANEL
6	FILTER MANIFOLD	22	YOKE HANGER	38	OFF-GAS SEPARATOR LEVEL INSTR. PANEL
7		23	MOVEABLE PERSONNEL BRIDGE		
8	FILTER SUPPORT RACK	24	EXCHANGER MANIFOLD		
9	PRE-FILTER	25	SURGE CHAMBER COVER		
10	FINAL FILTER	26	OFF-GAS PUMP STAND PIPE		
11	EXCHANGER SUPPORT RACK	27	OFF-GAS SEPARATOR		
12	ION EXCHANGER	28	OFF-GAS FILTER UNIT		
13	ION EXCHANGER	29	OFF-GAS SAMPLING		
14	LEAKAGE CONTAINMENT SUPPORT RACK	30	MONITORING TANK		
15	LEAKAGE CONTAINMENT ION EXCHANGER	31	MONITORING TANK PUMP		
16	LEAKAGE CONTAINMENT PUMP	32	HI-RAD FILTER GLOVE BOX		

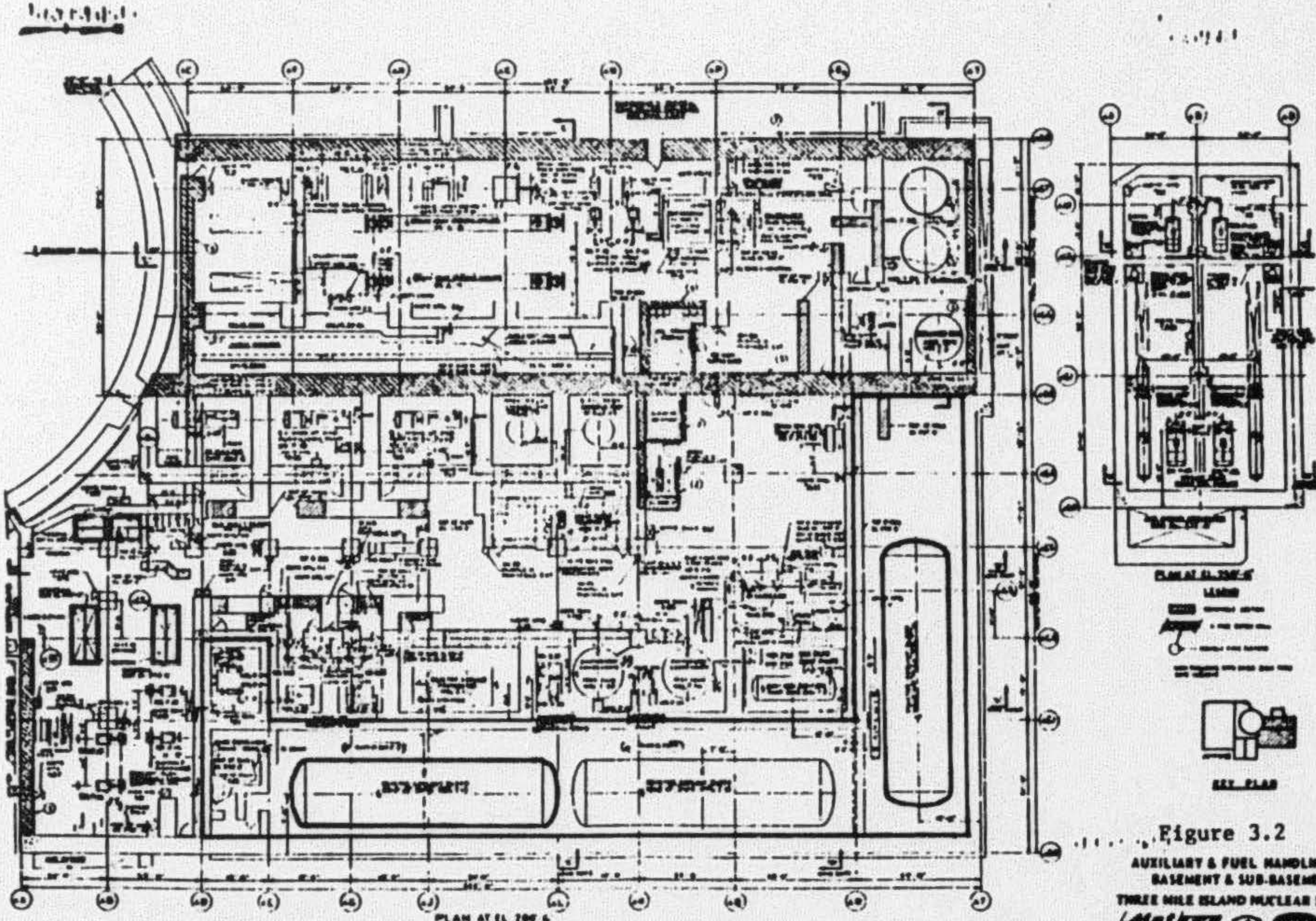


Figure 3.2
AUXILIARY & FUEL HANDLING BUILDING
BASEMENT & SUB-BASEMENT PLAN
THREE MILE ISLAND NUCLEAR STATION UNIT 2

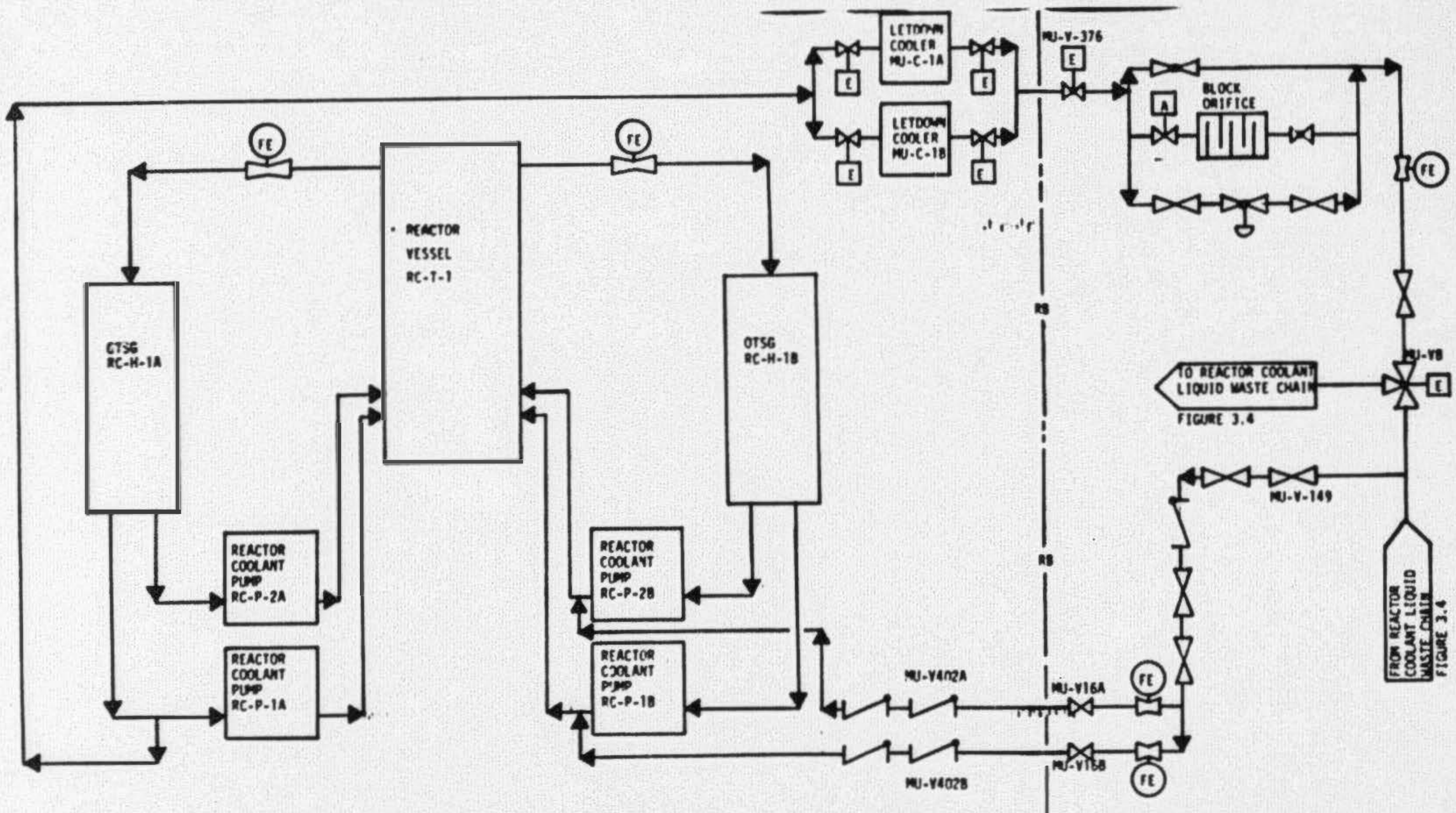


FIGURE 3.3
RCS LETDOWN AND INJECTION PATHS

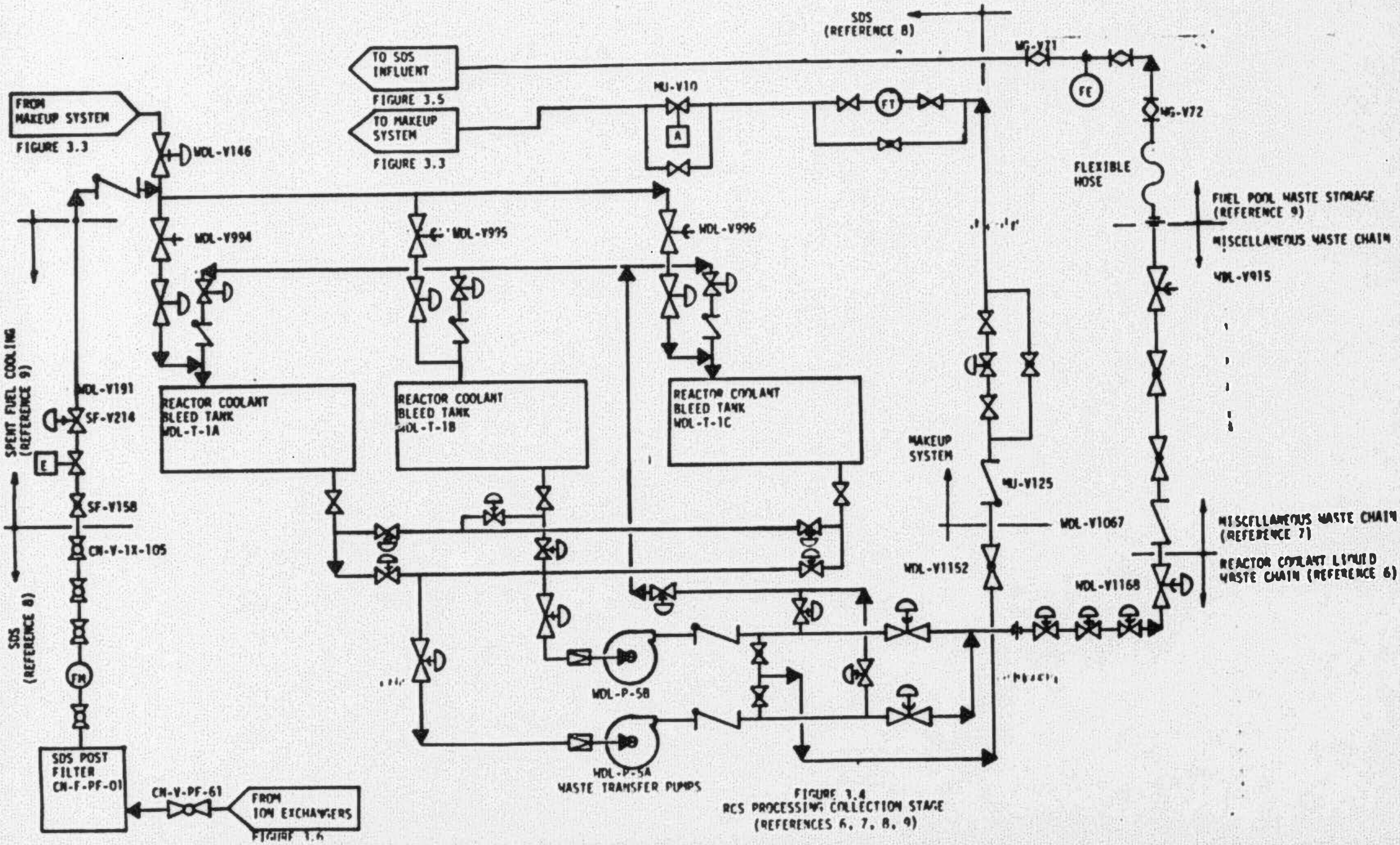


FIGURE 3.4
RCS PROCESSING COLLECTION STAGE
(REFERENCES 6, 7, 8, 9)

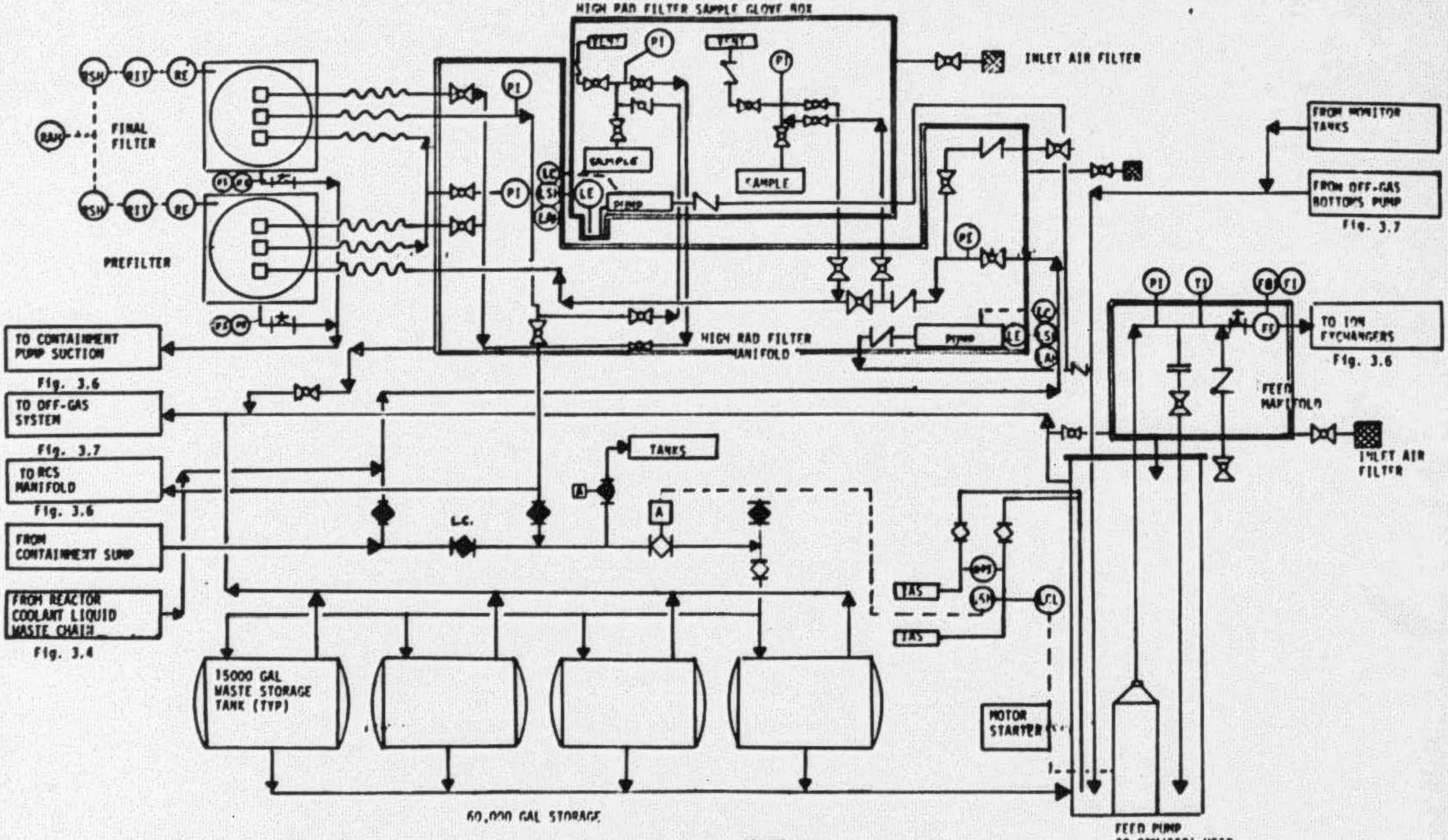


FIGURE 3.5
WASTE WATER INFLUENT SYSTEM

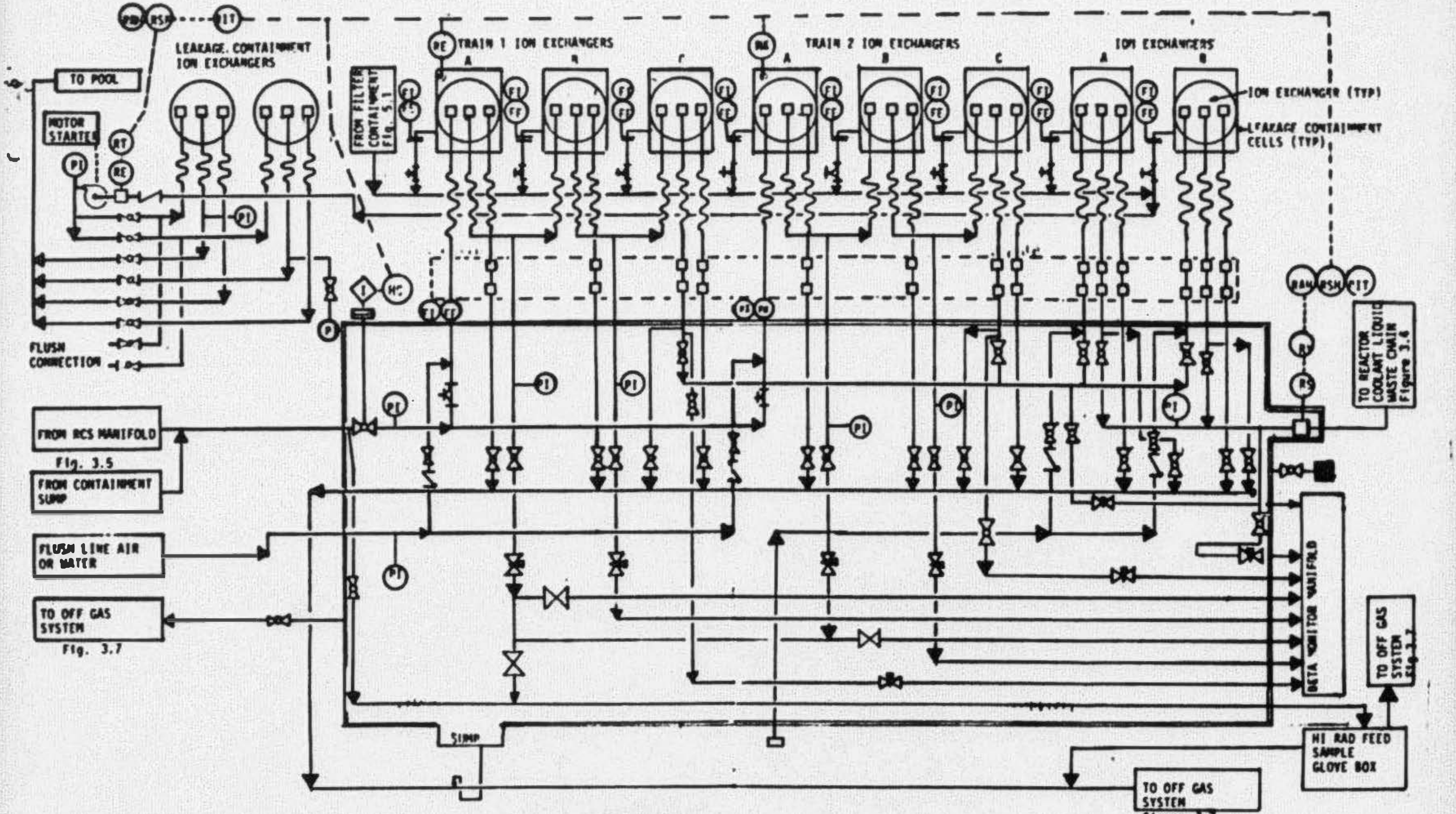


FIGURE 3.6
ION EXCHANGER TRAINS.

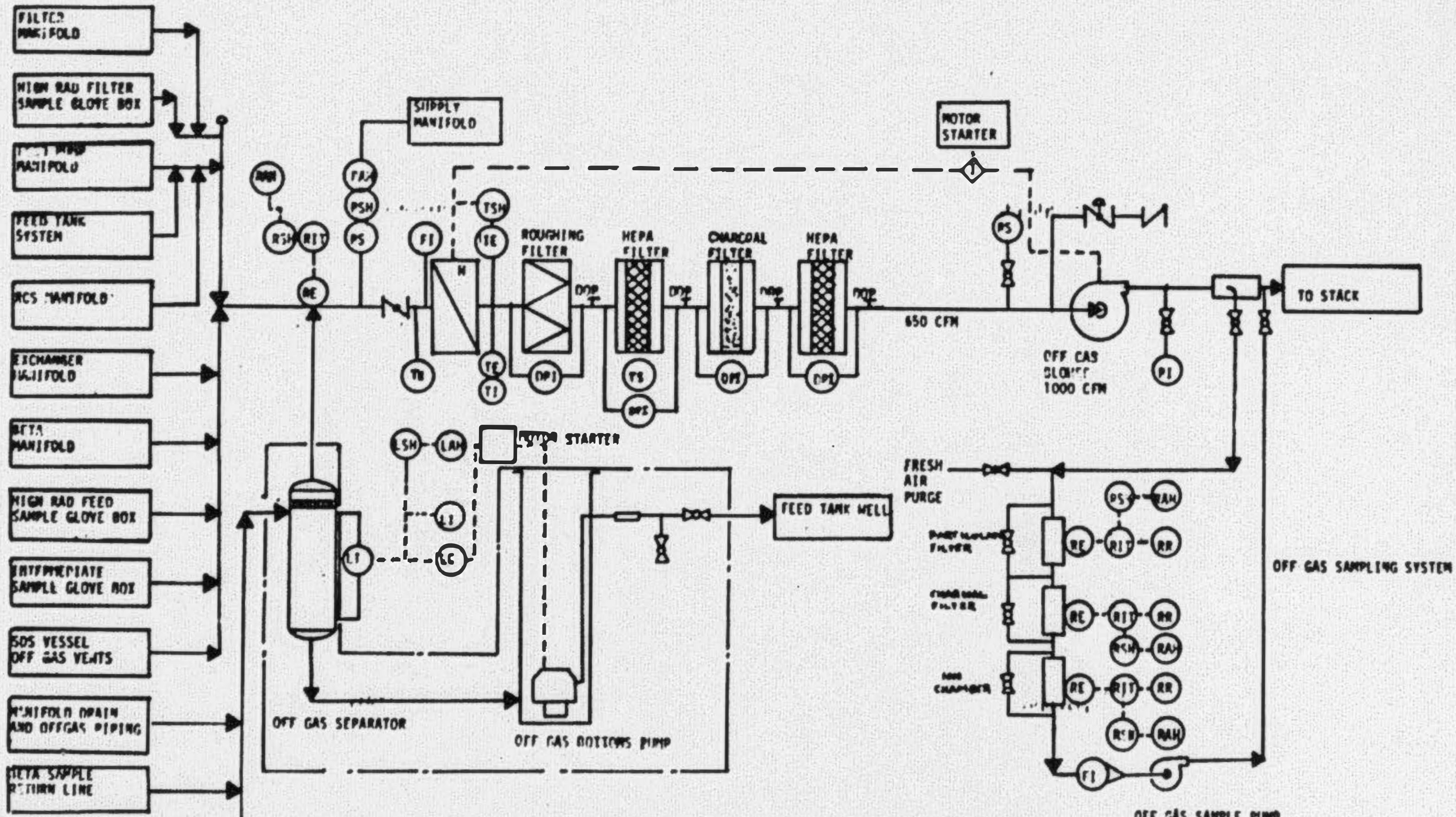


FIGURE 3.7
OFF GAS TREATMENT SYSTEM

CHAPTER 4

Radiation Protection

4.1 Ensuring Occupational Radiation Exposures are ALARA

4.1.1 Overall Policy

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

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

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

4.1.2 SDS Design and Operation

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

The radiation dose exposures to plant personnel will be lower due to the fact that the radionuclide concentration in the RCS water is significantly lower than the 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 RCS water is currently about 20 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. Makeup and Purification System
2. Reactor Coolant Liquid Waste Chain
3. Miscellaneous Waste Chain
4. Waste Gas System.

4.2 Dose Assessment

4.2.1 On Site Assessment

During operation of the SDS processing gallons of Reactor Building Sump water and RCBT water through December 31, 1981, 7.37 man-rem of exposure had been accumulated. This exposure takes into account operation, maintenance, outages, Health Physics, chemistry, and management. This is approximately one-third of the total radiation exposure estimated for all operations by the SDS by the NRC in the SER for the SDS (21 man-rem). Since the RCS waste water has significantly lower radioactivity levels, it is expected that the processing of the RCS water, when added to completion of Reactor Building sump water processing, will fall within this estimate.

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. The plant Waste Gas System will be assumed to be the release point from the plant enveloping the SDS off gas system.

Gaseous effluent source terms (in uCi/s released to the atmosphere) were developed by assuming the system operated on the principle of evaporation. For this reason, an entrainment factor of 10^{-6} is assumed for the particulate radionuclides escaping from the liquid to the vapor. An entrainment factor of 7.5×10^{-3} is assumed for I-129. In the case of evaporation by boiling, a higher rate of release of radionuclides with off-gas vapors occurs than would be expected from routine operation of pumps, valves, and water transfer. Therefore, these entrainment factors are considered to be conservative for the solution-vent system during pump transfer of water.

The release of tritium from the plant vents is calculated by assuming the air discharged from the vent was saturated with water vapor at $80^{o}F$. At this temperature, 1 ft^3 of air would carry 2×10^{-4} gallons of water vapor and correlates to 2.01×10^{-6} uCi/cm^3 of ^3H.

It is assumed that the air in the Waste Gas System has been in contact with water in the RCS, which at the time of this evalution, contains the highest specific activity of radionuclides. This activity is entrained and vented out the plant with no time delay.

Methodology

The radiological impact of the SDS is assessed by calculating radiation doses to individuals and populations living in the vicinity of the Three Mile Island Nuclear Generating Station. Potential pathways for internal and external exposure to man from radionuclides released to the atmosphere include inhalation, ingestion of contaminated foods, ingestion of contaminated water, exposure from contaminated surfaces, and exposure from immersion in the plume.

As in the SDS TER, the radiological impact is estimated using the methodology proposed in Regulatory Guide 1.109 (USNRC, 1977).

For the purpose of calculating dose to the maximally exposed individual from processing RCS, X/Q (sec/m^3) values were taken from previously published data and updated to 1980. The data are calculated for a semi-elevated point of release including building wake effects for the SDS Off-gas system. Data indicates that the point of maximum exposure to a hypothetical individual living near the site is 2413m away in the NNE direction since the most significant radiation release is from plant vent stack. The (X/Q) for this point is 1.46×10^{-6} sec/m^3.

Total dose commitments are calculated for the specified amount of each isotope released during 12 days of continuous release.

A decontamination factor (DF) of 100 is assumed for particulates and iodine in the plant Waste Gas system. No effluent treatment (i.e., a DF of 1) is assumed for ^{3}H or ^{85}Kr. The release rate through the plant Waste Gas system is 0.67 ft^{3}/min.

Radionuclides in the gas of the plant Waste Gas system are diluted as they are mixed with existing gaseous effluent at TMI-2, giving a total off-gas volume flow rate of 100,000 CFM (plant vent stack). It is further assumed that particulates and iodine pass through HEPA filters in place at TMI-2 to give an additional DF of 100. However, no further effluent treatment is assumed for either ^{3}H or ^{85}Kr. Therefore, the total DF for particulates and iodine including both the plant Waste Gas system and treatment previously existing at TMI-2 is 10^{4}. For ^{3}H and ^{85}Kr the DF is 1.

Table 4.1 lists the concentration of the RCS water. This data is based on the measured values given in Chapter 1 of this report. The pumping rate of water through the cleanup system is assumed to be 5 gpm. From the assumed entrainment factor the amount of radioactivity introduced into the off-gas is (3.785×10^{-2}) (f_i)Ci/min where f_i is the activity of an isotope per ml.

Table 4.2 lists the release rate for the various radionuclides. As can be seen by Table 4.2, the concentrations in the plant effluent are below detectable levels.

Analysis of Maximum Individual Dose

The maximum dose to a hypothetical adult individual is calculated for the four organs and assumes the processing of 88,000 gallons of water. These estimated dose exposure levels are:

Total body	2.14×10^{-5} mrem
Bone	8.43×10^{-5} mrem
Thyroid	7.41×10^{-6} mrem
GI Tract	4.52×10^{-5} mrem
Skin	1.06×10^{-3} mrem

This level of exposure to the total body represents approximately 4×10^{-4}% of the allowable dose exposure recommended in 10 CFR 50, Appendix I, of 5 mrem. It is also less than 1% of the exposure reported in the SDS TER.

Analysis of Population Dose

The population dose for RCS processing to be less than 1% of the exposure for the total SDS operation.

4.3 Accident Analyses

The RCS Process plan involves processing RCS water with significantly less activity than Reactor Building Sump water. Therefore, the accident analyses performed in Chapter 7 of the SDS TER, which used Reactor Building sump water as a basis, envelope the same accidents if performed using RCS water. The entire process and all equipment is housed in the Auxiliary and Fuel Handling Buildings which are Seismic I structures with air handling and ventilation systems, and radiation monitoring equipment.

TABLE 4.1

ACTIVITY LEVEL OF WATER
(February 4, 1982)

ISOTOPE	REACTOR COOLANT SYSTEM uCi/ml
^{3}H	0.034
^{85}Kr	0.051
^{90}Sr	13.0
^{129}I	1×10^{-6}
^{134}Cs	1.5
^{137}Cs	14.0

TABLE 4.2

SOURCE TERMS FOR GASEOUS EFFLUENT

Radionuclide	Concentration In Plant Effluent uCi/cc	Release Rate uCi/sec
H-3	6.08×10^{-12}	2.87×10^{-4}
Kr-85	3.41×10^{-5}	1.61×10^{1}
Sr-90	8.71×10^{-13}	4.11×10^{-7}
I-129	3.01×10^{-16}	1.42×10^{-8}
Cs-134	2.12×10^{-16}	4.72×10^{-8}
Cs-137	8.94×10^{-15}	4.22×10^{-7}

(a) This the radionuclide concentration in the off-gas (100,000 ft^3/min) from TMI-2 as it enters the atmosphere. A DF of 10^4 is assumed for particulates and iodine, however, no treatment is assumed for ^{85}Kr or ^{3}H.

CHAPTER 5

Conduct of Operations

5.1 System Performance

By processing the Reactor Building sump water 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 achieve by the use of zeolite ion exchange media.

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

5.2 System Testing

Prior to use in the SDS each vessel will be hydrostatically tested in conformance with the requirements of applicable portions of the ASME Boiler and Pressure Vessel Code. Upon completion of construction, the entire system will be pneumatically tested to assure leak-free operations. The system will be tested to an internal pressure of no less than 1.1 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.

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 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 oepration.

REFERENCES

1. MET ED letter LL2-81-0070 dated March 11, 1981, G. K. Hovey (MET ED) to L. Barrett (NRC), "Three Mile Island Nuclear Station, Unit 2, Operating License No. DPR-73, Docket No. 50-320, Submerged Demineralizer System."

2. TMI-2 Radiochemistry Summary Sheet, Sample No. 77518 dated February 4, 1982.

3. TMI-2 Radiochemistry Summary Sheet, Sample No. 76280 dated January 13, 1982.

4. TMI-2 Radiochemistry Summary Sheet, Sample No. 77095 dated January 26, 1982.

5. TMI-2 Burns and Roe Drawing No. 2024, Makeup and Purification System.

6. TMI-2 Burns and Roe Drawing No. 2027, Radwaste Disposal Reactor Coolant Liquids.

7. TMI-2 Burns and Roe Drawing No. 2045, Radwaste Disposal Miscellaneous Liquids.

8. GPUNC Drawing No. 2R-950-21-001, P&ID Composite: Submerged Demineralizer System.

8. TMI-2 Burns and Roe Drawing No. 2026, Decay Heat and Spent Fuel Cooling.