

 **Nuclear**

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February 16, 1988
4410-88-L-0012/0335P

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
Accident Generated Water Disposal System Description

The Accident Generated Water Disposal System Description is forwarded for your information. The system description is a compilation of the most accurate design information currently available, and may change as the final system design evolves. The Accident Generated Water Disposal System Description is an evolving document and is subject to change until the detailed system design is finalized.

GPU Nuclear has recently authorized the system vendor to proceed with the final design and fabrication of its evaporator system for the specific TMI-2 application. GPU Nuclear has decided to begin final design and fabrication prior to approval of Technical Specification Change Request (TSCR) No. 56 in anticipation that the ongoing Atomic Safety and Licensing Board review of TSCR No. 56 and the associated proposal to dispose of the Accident Generated Water by evaporation will result in Nuclear Regulatory Commission (NRC) approval to proceed as proposed and because design fabrication, installation, and test of the system would otherwise add some nine (9) months delay in commencing disposal of the water upon receipt of NRC approval. Delay in commencing water disposal would result in commensurate delays in the overall completion of Accident Generated Water disposal and completion of the clean up effort at TMI-2.

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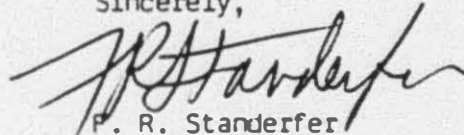
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February 16, 1988
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This system description is not intended as a substitute for the detailed Technical Evaluation Report (TER) and specific operating procedures required in accordance with Technical Specification 3.9.13 as revised by TSCR No. 56. The final system design and operational controls will be so documented. The TER and detailed operating procedures will be submitted to the Nuclear Regulatory Commission for review and approval as required by the TMI-2 Recovery Technical Specifications.

Sincerely,


P. R. Standerfer
Director, TMI-2

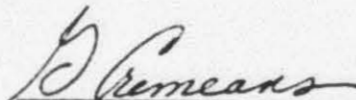
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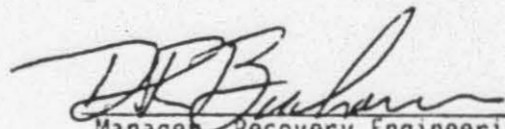
Attachment

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

PRELIMINARY SYSTEM DESCRIPTION
FOR
ACCIDENT GENERATED WATER DISPOSAL

Rev. 0


Prepared By
2-16-88
Date


Manager, Recovery Engineering
2/16/88
Date

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1.0 PURPOSE, SCOPE AND ORGANIZATION

1.1 Purpose

The purpose of this document is to describe the system and evolutions which will accomplish the controlled disposal of approximately 2.3 million gallons of "Accident Generated Water", hereinafter referred to as processed water.

1.2 Scope

The scope of this system description addresses the processing of this inventory by forced evaporation followed by a vaporization process and atmospheric release of the product distillate. It also includes the separation and final treatment of the solids removed and collected during the evaporation process and the preparation of the resulting waste product for shipment and burial at a commercial low level waste facility.

1.3 Organization

Section 2.0 describes the process and contains a system description of the evaporator, the vaporizer and the associated waste processing operations.

Section 3.0 describes the control of process and the operational options.

2.0 DESCRIPTION OF THE PROCESSED WATER DISPOSAL SYSTEM

2.1 Background

The TMI-2 accident resulted in the production of large volumes of contaminated water, herein referred to as processed water. Through mid-1981, when the submerged demineralizer system (SDS) began operation to process water contained in the reactor building, approximately 1.3 million gallons of water existed at TMI-2. Of this volume, about 640,000 gallons were located in the reactor building. Direct release from the reactor coolant system contributed 69% of this water. An additional 28% was river water introduced via leaks in Reactor Building air coolers and the remaining 3% was added via the containment spray system during the first several hours of the accident. Subsequent to 1981, most of the water was processed by both SDS and EPICOR II to reduce radionuclide levels to very low concentrations. In addition, approximately 570,000 gallons of water existed in the auxiliary and fuel handling building tanks, most of which had been processed by EPICOR II by mid-1981. The reactor coolant system contained an additional 96,000 gallons which also required processing by both the SDS and the defueling water clean-up system (DWCS). Since

1981, the total inventory of processed water has increased to the current volume of approximately 2.1 million gallons due to continued additions from support systems and condensation from the reactor building air coolers during the summer months. Considerable care has been exercised to minimize the additions of new water and to ensure that the commingling of non-contaminated water with the processed water is restricted. Even with exercising care to minimize additions of new water, the final volume of water requiring disposal is expected to be 2.3 million gallons (as stated in Section 1.1).

2.2 Process Description

The processed water disposal program consists of: (a) a dual evaporator system designed to evaporate the processed water at a rate of five GPM; (b) an electric powered vaporizer designed to raise the evaporator distillate temperature to 240°F and release the resultant steam to the atmosphere via a flash tank and exhaust stack; (c) a waste concentrator designed to produce the final compact waste form, and (d) a packaging section designed to prepare the resultant waste for shipment consistent with commercial low level waste disposal regulations. If desired, the product distillate from the main evaporator can be routed to an interim staging tank for holding purposes, i.e.; to permit radiochemical analysis, batching evolutions and system shutdown, prior to being

routed to the vaporizer assembly for atmospheric release. The residual concentrate (bottoms) from the main evaporator section will be routed to the auxiliary evaporator for additional processing and then to the final concentrator where it will be processed into the final compact waste form. The project will employ well proven technology and be continually monitored and controlled with automatic shutdown capabilities designed to terminate the vaporizer and atmospheric release process. With the exception of two controlled release points, one at the vaporizer section, which will release the superheated steam to the atmosphere and the other at the waste processing section which will discharge the final waste to a collection point, the system will operate in a closed loop configuration.

2.3 System Description

The processed water disposal system consists of four major component groups. They are: (1) the evaporator, (2) the vaporizer, (3) the blender/dryer concentrator, and (4) the waste preparation sections. (See Attachment 1., Process Flow Diagram)

A contract agreement was entered into with the selected vendor for construction of these four component groups and authorization was issued February 1988 to proceed to final design and fabrication of the equipment for the specific TMI-2 application. Certain

definitive design details necessary to prepare a comprehensive system description are not currently available as these final designs are an on-going effort. The descriptive information that is available and used extensively in the preparation of this system description is: (a) the vendor's contract proposal, (b) a system description for a unit similar to the one proposed for this application, and (c) preliminary design information submitted by the vendor January 1988 for review/comment by GPU.

Given these limitations, the following provides a general system description pending completion of the final designs.

2.3.1 General

The main evaporator is a vapor recompression type unit with the designed flexibility to be configured as a spraying film or climbing film evaporator. Vapor recompression units are designed to continually recycle the latent heat of vaporization (heat necessary to change water into steam) to sustain continued boiling at reduced pressures and therefore at lower temperatures.

The main evaporator employs a vapor dome, positioned over a horizontal tube heat exchanger, to collect the natural rising vapor from the evaporator process. This vapor collection is through two 12 inch diametrically opposed uptake pipes which feed an entrainment separator housed within the dome. The entrained

water is screened by capillary action on the wires of two-stage mesh impingement screens that drain the separated solids to the bottom of the separator. There, the solids are extracted by the recycle pump and routed to the concentrate tank. The vapor compressor, taking a suction on the vapor dome, superheats this dried vapor by the heat of compression and discharges the heated vapor down through the tube side of the 520 ft² heat exchanger. The vapor is condensed and then routed to the skid mounted distillate tank for ultimate vaporization and atmospheric release. If desired, due to batching evolutions, system shutdown or radiochemical analysis, the distillate can be routed to an interim staging tank.

The product concentrate, separated by the two-stage impingement screens and collected in the concentrate tank, will be recycled back through the main evaporator for further processing or, depending on the level of its concentrate, routed to the settling tank for second stage treatment by the auxiliary evaporator. The second stage treatment consists of increasing the level of solids concentrate to 100,000 to 500,000 ppm by forced evaporation in the auxiliary evaporator section which is similar in design and employs the same method of solids separation as the main evaporator.

The increased concentrate from this separation process is collected at the bottom of the auxiliary evaporator separator where it is extracted by the second stage recycle pump and returned to the settling tank. This increased concentrate will be recycled through the auxiliary evaporator for further processing or, depending on the solids concentrate level, extracted by the concentrate feed pump and routed to the blender/dryer section via the concentrate holding tank for final treatment prior to packaging operations.

2.3.2 Evaporator

The principle utilized in a high vacuum vapor compressor distiller concentrator is similar to the refrigeration cycle except for the use of water as a refrigerant. As the system pressure is reduced, so is the boiling point of the product solution. Therefore, rapid evaporation takes place at a lower temperature and the latent heat of vaporization (heat necessary to change water into steam) can be continuously recycled by the use of a vapor compressor.

Vapor recompression evaporation requires steam heat to initiate start-up and occasional supplementary heat to make up for heat losses during operation and feed heating requirements. This auxiliary start-up and supplementary heat will be provided by the auxiliary evaporator which is designed to raise the start-up temperature to approximately 131°F. Once started, the main

evaporator will boil the processed water under a vacuum on the shell side of the heat exchanger tubes at temperatures of 130° to 140°F. The excessive evaporator feed, that feed above the designed rate of evaporation, will combine with the vapor generated and exit from the shell via twin 12 inch uptakes to the separator.

The foaming tendency of the water during this process will completely "wet" the tubes and the resultant vapor being generated will be in the form of minute vapor bubbles. This action prevents the formation of large vapor bubbles which would insulate the tubes, raise the hydrostatic head and reduce heat transfer rates. The evaporator twin uptakes, diametrically opposed, discharge the larger water particles of the excess feed to the bottom of the separator. Any fine mist carried upward by the vapor, impinges on the two-stage mesh where it coalesces and drops to the bottom of the separator for extraction and recycling by the concentrate recycle pump. This feed and bleed action not only assures continuous wetting of the heat exchanger tubes, it provides the maximum concentration of the liquid for discharge to the auxiliary evaporator for additional processing.

The compressor action is described in Paragraph 2.3.4. The superheated vapor from the vapor compressor is discharged down through the annulus between the 1 inch titanium sheaths of the heat exchanger where the vapor is condensed by the evaporating action

from the processed boiling water. The condensate (distillate) is propelled to the back end of the titanium sheaths where it is sucked out through 1/4 inch stainless steel tubes and discharged to the distillate collection tank.

2.3.3 Vaporizer

The vaporizer section takes a suction from the product distillate supply. It is used to raise the product distillate temperatures to approximately 240°F under pressure, release the heated distillate to atmospheric pressure via a flash tank and exhaust the resultant steam through a 100 foot high stack. The vaporizer assembly consists of: (a) three, 300 (KW) heaters used to elevate the distillate temperature to 240°F at 10 psig; (b) a 24 inch diameter by 60 inch high stainless steel flash tank, used to expose the 240°F distillate to atmospheric pressure and to contain the resultant steam; (c) a 7-1/2 HP pump, used to recirculate the distillate in the flash tank through the heaters; and (d) a 3 inch diameter by 100 foot high stainless steel exhaust stack, used to release the steam at a velocity of approximately 350 feet per second. The exhaust stack will be equipped with a sound abatement dampener to modulate the sound levels during exhaust operations.

2.3.4 Vapor Compressor

The vapor compressor is designed to take suction from the vapor dome after the vapor has been dried by passing through the two-stage mesh separators. Flexible expansion joints will be incorporated to relieve any strain on the compressor housing. The rotary lobe compressor is a positive displacement blower with a capacity of about 5230 CFM at full load speed of 1750 rpm on the 125 HP compressor motor.

Its designed application is to take suction on the rising vapor, heated by the latent heat of vaporization being collected in the vapor dome, and compress the vapor to create a rise in temperature due to the heat of compression. This superheated vapor is then discharged into the tube side of the evaporator heat exchanger.

2.3.5 Auxiliary Evaporator

A small waste heat auxiliary evaporator using heat generated from the before and after electric heater(s) and/or the 143°F product distillate from the main evaporator, will evaporate the product concentrate from the main evaporator at an approximate temperature of 130°F. The vapor from the process will be routed to the main evaporator vapor dome to provide supplementary or start-up heat to the main evaporator. The increased concentrate (bottoms) from the

auxiliary evaporator will be extracted by the recycle pump and routed to the settling tank. The concentrate will be recycled through the auxiliary evaporator and the settling tank until the level of concentrate is between 100,000 and 500,000 ppm at which time the a feed pump will take suction on the settling tank and route the concentrate to the concentrate holding tank.

2.3.6 Blender/Dryer

The blender/dryer will process the concentrate collected in the concentrate holding tank to the final waste form in a batch type process. The blender/dryer consists of a cylindrical, horizontal vessel equipped with an agitator for drying liquids and slurries to total dryness. The dryer body will be equipped with a 150 KW electrically heated jacket. The liquid in the waste slurry will be evaporated as it comes in contact with the heated body of the vessel as the agitator moves the waste slurry from both ends of the dryer vessel toward a center discharge valve. The agitator consists of rotating helical ribbons which continually scrape the dried product from the sides of the vessel and move the waste product to a center discharge valve. The drying process is controlled so that the waste batch is discharged when the liquid is removed, at which time the final waste product will be discharged directly into the collection section for packaging preparations.

The liquid from the dryer section will be returned to the main evaporator concentrate tank and reprocessed.

2.3.7 Packaging

Waste packaging options permit packaging by one of three methods, the selection of which is left to the discretion of the vendor. All options are acceptable methods, relative to applicable regulations, and all employ satisfactory volume reduction techniques. In the event a binder agent is required, to minimize the dispersion factors involved in calculation of release fractions during a postulated median transportation accident, its addition will not appreciably increase the estimated volume of waste generated as a result of any of these options. Option 1 utilizes a pelletizer to compact the waste into a pelletized form and then discharges the compressed product into a Spec. 17, 55 gallon transport drum. Option 2 discharges the waste product directly from the dryer into a 55 gallon drum, compacts the drum (and product) to a fraction of its original volume and loads the compacted drum into a transportation over-pac container. Option 3 discharges the waste product directly into a Spec. 17, 55 gallon transport drum and loads the drum, uncompacted, into a transportation over-pac container.

The volume of waste generated as a result of any of these techniques is estimated to be 4400 to 4500 ft³. This volume represents a significant reduction to the estimated waste volume presented in the PEIS Supplement 2 which used as the method of waste packaging solidifying the waste in 170 ft³ liners.

The base case presented in the PEIS Supplement 2, which addresses the solidification of waste with Portland cement in 170 ft³ liners, provides a waste volume estimate of between 27,000 to 46,000 ft³, for 25 wt. % solids and 16 wt. % solids respectively, assuming a 0.35 cement to waste volume ratio. The base case further estimated that in the event of chemical impurities retarding the curing rate and final strength of the concrete the projected volume of solidified waste could be as high as 88,000 ft³.

2.3.8 Instrumentation

The system design will provide conductivity monitoring at three independent system locations during the evaporator process. Each of these monitoring points will be equipped with a sample point station for the extraction of process fluids for radiochemical analysis and a conductivity probe for the steady state monitoring of process liquid quality. These monitoring locations are at the

main evaporator feed and at the main and auxiliary evaporator distillate discharge. Additionally, there will be a sample station located at the auxiliary evaporator concentrate discharge for concentrate sampling and a conductivity probe and sample station at the radiation monitor.

Operational experience and an accumulated data base accrued during actual evaporator operations will provide a sound basis for comparing these two methods of analysis, i.e., physical sampling with laboratory analysis and steady state conductivity monitoring. After adequate demonstration of comparable analytical results and conductivity data, operational procedures may be modified to rely more extensively on the steady state conductivity instrumentation. However, until a data base can be compiled based on actual system operations, the control method utilized in procedures and operating programs will be the physical sampling and laboratory analysis of process liquids. Radiation monitoring of the vaporizer influent will continue to be the essential method of process control of environmental release by the vaporizer assembly.

The vaporizer section of the system, which releases the vaporized distillate into the atmosphere, will be monitored and controlled by a gamma radiation detector. This detector, located in the vaporizer assembly flow path, will monitor levels of gamma radiation in the distillate prior to the distillate being routed to

the vaporizer heaters. The detector will be calibrated to sound an audible alarm and terminate atmospheric release by tripping off the vaporizer heaters and/or initiating valve closure to isolate the distillate supply to the vaporizer section. In the event an alarm condition occurs, the evaporator will continue to operate in a batch cycle mode, discharging the product distillate to a staging tank or recycling it through the system until the system is secured or the alarm condition is removed. The pre-determined set points of the radiation detector are based on insuring the present TMI-2 Technical Specification instantaneous release limit of $0.3 \mu\text{Ci/sec.}$ will not be exceeded. Monitoring equipment is available which will allow a setpoint at 25% of this instantaneous release rate limit for particulates which is $7.5\text{E-}2 \mu\text{Ci/sec.}$

Assuming the gamma emitting isotope Cs-137 is at a concentration of $3.7 \text{ E-}8 \mu\text{Ci/ml.}$, the level of concentration permissible for continuous release per Table 3-1 and the PEIS Supplement 2, is present in the vaporizer influent then a corresponding maximum continuous release rate of $2.8\text{E-}4 \mu\text{Ci/sec.}$ for all the radionuclides is also present. This is the permissible rate of continuous release as bounded by the PEIS Supplement 2.

This ratio of Cs-137 concentration to the maximum permissible continuous release rate yields a scaling factor of $1.32\text{E-}4$. Using this scaling factor and the determined instantaneous release rate

of $7.5\text{E}-2 \text{ } \mu\text{Ci/sec.}$, which is 25% of the Technical Specification maximum instantaneous release rate, it can be calculated that the Cs-137 concentration of $9.9\text{E}-6 \text{ } \mu\text{Ci/ml.}$ is the permissible limit for controlling the rate of instantaneous release.
 $(1.32\text{E}-4 \times 7.5\text{E}-2 = 9.9\text{E}-6).$

State of the art instrumentation will be installed which is capable of detecting this level of Cs-137 although it will be unable to detect minor variations in the extremely small quantities of most isotopes present. (Table 3-1 notes that 22 isotopes are expected to be present at levels <LLD). Others are of such small quantities as to be a small fraction of the Technical Specification limits. Therefore, this monitor is expected to detect "gross upsets" and terminate releases to the environment before the Technical Specification release limits are exceeded. Conservatively, assuming a 100% carryover of the particulate content through the vaporizer, radioisotopic content of the influent to the vaporizer (i.e., the evaporation distillate) is the process control mechanism and will be additionally controlled by sampling and conductivity monitoring. It is note worthy that the radiation alarm set point is approximately the same as the limit for the average Cs-137 concentrations permissible in the evaporator influent. Thus, the set point limit of the detector provides reasonable assurance that the evaporator is not by-passed.

TABLE 3-1

VAPORIZER INFLUENT CRITERIA

<u>Constituent</u>	<u>Quantity</u> <u>Ci</u>	<u>Continuous Release</u> ⁽¹⁾ <u>Concentration</u> <u>μCi/ml</u>
Tritium		
(Hydrogen-3)	1.02 x 10 ³	1.3 x 10 ⁻¹
Cesium-137	3.2 x 10 ⁻⁴	3.7 x 10 ⁻⁸
Cesium-134	7.66 x 10 ⁻⁶	8.8 x 10 ⁻¹⁰
Strontium-90	9.6 x 10 ⁻⁴	1.1 x 10 ⁻⁷
Antimony-125/ Tellurium-125m	2.0 x 10 ⁻⁵	2.3 x 10 ⁻⁹
Carbon-14	8.7 x 10 ⁻⁴	1.0 x 10 ⁻⁷
Technetium-99	8.7 x 10 ⁻⁶	1.0 x 10 ⁻⁹
Iron-55	4.2 x 10 ⁻⁶	4.8 x 10 ⁻¹⁰
Cobalt-60	4.2 x 10 ⁻⁶	4.8 x 10 ⁻¹⁰
Boron	0.15 tons H ₃ BO ₃	3.0 ppm B
Sodium	0.011 tons NaOH	.7 ppm Na ⁺
*Iodine-129	<5.2 x 10 ⁻³	<6.0 x 10 ⁻⁷
*Cerium-144	<1.4 x 10 ⁻⁵	<1.8 x 10 ⁻⁹
*Manganese-54	<3.5 x 10 ⁻⁷	<4.0 x 10 ⁻¹¹
*Cobalt-58	<3.5 x 10 ⁻⁷	<4.0 x 10 ⁻¹¹
*Nickel-63	<5.2 x 10 ⁻⁶	<6.0 x 10 ⁻¹⁰
*Zinc-65	<8.5 x 10 ⁻⁷	<9.8 x 10 ⁻¹¹
*Ruthenium-106/ Rhodium-106	<2.9 x 10 ⁻⁶	<3.3 x 10 ⁻¹⁰
*Silver-110m	<4.9 x 10 ⁻⁷	<5.6 x 10 ⁻¹¹
*Promethium-147	<4.2 x 10 ⁻⁵	<4.8 x 10 ⁻⁹
*Europium-152	<3.3 x 10 ⁻⁹	<3.8 x 10 ⁻¹³
*Europium-154	<3.8 x 10 ⁻⁷	<4.4 x 10 ⁻¹¹
*Europium-155	<9.6 x 10 ⁻⁷	<1.1 x 10 ⁻¹⁰
*Uranium-234	<8.7 x 10 ⁻⁸	<1.0 x 10 ⁻¹¹
*Uranium-235	<1.0 x 10 ⁻⁷	<1.2 x 10 ⁻¹¹
*Uranium-238	<1.0 x 10 ⁻⁷	<1.2 x 10 ⁻¹¹
*Plutonium-238	<1.0 x 10 ⁻⁷	<1.2 x 10 ⁻¹¹
*Plutonium-239	<1.2 x 10 ⁻⁷	<1.4 x 10 ⁻¹¹
*Plutonium-240	<1.2 x 10 ⁻⁷	<1.4 x 10 ⁻¹¹
*Plutonium-241	<5.7 x 10 ⁻⁶	<6.5 x 10 ⁻¹⁰
*Americium-241	<1.0 x 10 ⁻⁷	<1.2 x 10 ⁻¹¹
*Curium-242	<8.7 x 10 ⁻⁷	<1.0 x 10 ⁻¹⁰

Totals

Concentration (Average): 2.61 x 10⁻⁷ μCi/ml.

Continuous Rate of Release at 5 GPM: 8.23 x 10⁻⁵ μCi/sec.

*Denotes assumed constituents

< Denotes less than level of detection

(1) Release concentration average over any calendar quarter.

TABLE 3-2

CONTINUOUS CYCLE EVAPORATOR INFLUENT/EFFLUENT CRITERIA

<u>Constituent</u>	<u>Influent</u>		<u>Effluent</u>	
	<u>Quantity</u> <u>Ci</u>	<u>Concentration</u> <u>μCi/ml</u>	<u>Quantity</u> <u>Ci</u>	<u>Concentration</u> <u>μCi/ml</u>
Total volume	2,300,000 gal.			
Tritium				
(Hydrogen-3)	1.02×10^3	1.3×10^{-1}	1.02×10^3	1.3×10^{-1}
Cesium-137	3.2×10^{-1}	3.7×10^{-5}	3.2×10^{-4}	3.7×10^{-8}
Cesium-134	7.66×10^{-3}	8.8×10^{-7}	7.66×10^{-6}	8.8×10^{-10}
Strontium-90	9.6×10^{-1}	1.1×10^{-4}	9.6×10^{-4}	1.1×10^{-7}
Antimony-125/				
Tellurium-125m	2.0×10^{-2}	2.3×10^{-6}	2.0×10^{-5}	2.3×10^{-9}
Carbon-14	8.7×10^{-1}	1.0×10^{-4}	8.7×10^{-4}	1.0×10^{-7}
Technetium-99	8.7×10^{-3}	1.0×10^{-6}	8.7×10^{-6}	1.0×10^{-9}
Iron-55	4.2×10^{-3}	4.8×10^{-7}	4.2×10^{-6}	4.8×10^{-10}
Cobalt-60	4.2×10^{-3}	4.8×10^{-7}	4.2×10^{-6}	4.8×10^{-10}
Boron	150 tons	3000 ppm B	.15 tons	3.0 ppm B
	H_3BO_3		H_3BO_3	
Sodium	11 tons NaOH	700 ppm Na ⁺	.011 tons NaOH	.7 ppm Na ⁺
*Iodine-129	$<5.2 \times 10^{-3}$	$<6.0 \times 10^{-7}$	$<5.2 \times 10^{-3}$	$<6.0 \times 10^{-7}$
*Cerium-144	$<1.4 \times 10^{-2}$	$<1.8 \times 10^{-6}$	$<1.4 \times 10^{-5}$	$<1.8 \times 10^{-9}$
*Manganese-54	$<3.5 \times 10^{-4}$	$<4.0 \times 10^{-8}$	$<3.5 \times 10^{-7}$	$<4.0 \times 10^{-11}$
*Cobalt-58	$<3.5 \times 10^{-4}$	$<4.0 \times 10^{-8}$	$<3.5 \times 10^{-7}$	$<4.0 \times 10^{-11}$
*Nickel-63	$<5.2 \times 10^{-3}$	$<6.0 \times 10^{-7}$	$<5.2 \times 10^{-6}$	$<6.0 \times 10^{-10}$
*Zinc-65	$<8.5 \times 10^{-4}$	$<9.8 \times 10^{-8}$	$<8.5 \times 10^{-7}$	$<9.8 \times 10^{-11}$
*Ruthenium-106/				
Rhodium-106	$<2.9 \times 10^{-3}$	$<3.3 \times 10^{-7}$	$<2.9 \times 10^{-6}$	$<3.3 \times 10^{-10}$
*Silver-110m	$<4.9 \times 10^{-4}$	$<5.6 \times 10^{-8}$	$<4.9 \times 10^{-7}$	$<5.6 \times 10^{-11}$
*Promethium-147	$<4.2 \times 10^{-2}$	$<4.8 \times 10^{-6}$	$<4.2 \times 10^{-5}$	$<4.8 \times 10^{-9}$
*Europium-152	$<3.3 \times 10^{-6}$	$<3.8 \times 10^{-10}$	$<3.3 \times 10^{-9}$	$<3.8 \times 10^{-13}$
*Europium-154	$<3.8 \times 10^{-4}$	$<4.4 \times 10^{-8}$	$<3.8 \times 10^{-7}$	$<4.4 \times 10^{-11}$
*Europium-155	$<9.6 \times 10^{-4}$	$<1.1 \times 10^{-7}$	$<9.6 \times 10^{-7}$	$<1.1 \times 10^{-10}$
*Uranium-234	$<8.7 \times 10^{-5}$	$<1.0 \times 10^{-8}$	$<8.7 \times 10^{-8}$	$<1.0 \times 10^{-11}$
*Uranium-235	$<1.0 \times 10^{-4}$	$<1.2 \times 10^{-8}$	$<1.0 \times 10^{-7}$	$<1.2 \times 10^{-11}$
*Uranium-238	$<1.0 \times 10^{-4}$	$<1.2 \times 10^{-8}$	$<1.0 \times 10^{-7}$	$<1.2 \times 10^{-11}$
*Plutonium-238	$<1.0 \times 10^{-4}$	$<1.2 \times 10^{-8}$	$<1.0 \times 10^{-7}$	$<1.2 \times 10^{-11}$
*Plutonium-239	$<1.2 \times 10^{-4}$	$<1.4 \times 10^{-8}$	$<1.2 \times 10^{-7}$	$<1.4 \times 10^{-11}$
*Plutonium-240	$<1.2 \times 10^{-4}$	$<1.4 \times 10^{-8}$	$<1.2 \times 10^{-7}$	$<1.4 \times 10^{-11}$
*Plutonium-241	$<5.7 \times 10^{-3}$	$<6.5 \times 10^{-7}$	$<5.7 \times 10^{-6}$	$<6.5 \times 10^{-10}$
*Americium-241	$<1.0 \times 10^{-4}$	$<1.2 \times 10^{-8}$	$<1.0 \times 10^{-7}$	$<1.2 \times 10^{-11}$
*Curium-242	$<8.7 \times 10^{-4}$	$<1.0 \times 10^{-7}$	$<8.7 \times 10^{-7}$	$<1.0 \times 10^{-10}$

Effluent Totals

Particulate Concentration: 2.61×10^{-7} μCi/ml.
Continuous Rate of
Particulate Release at 5 GPM: 8.23×10^{-5} μCi/sec.

*Denotes assumed constituents

< Denotes less than level of detection

3.0 PROCESS CONTROL AND OPERATIONAL OPTIONS

3.1 Process Control

The process control of atmospheric releases during the evaporator and vaporization process will be implemented via the radiation monitoring and radiochemical sampling of the influent to the vaporizer section. Establishing process control at the vaporizer influent conservatively assumes a 100% carry-over fraction through the vaporizer assembly. There is no credit for plate out or solids separation in the heaters, flash tank or exhaust stack.

To establish a basis for this influent acceptability the criteria established in Section 2.0 of the PEIS Supplement II was used as a basis for comparison of the radiological constituents and respective concentrations acceptable for release to the atmosphere during operation of the vaporizer assembly. The average influent to the vaporizer assembly, noted in Table 3-1 is approximately $2.61\text{E-}7$ $\mu\text{Ci/ml}$. This concentration, discharged at a rate of 5 GPM limits the continuous release of non-tritium radioactive material, principally cesium-137, strontium-90, and carbon-14 to approximately $8.23\text{E-}5$ $\mu\text{Ci/sec}$. This rate is less than 0.4% of the continuous particulate release rate permitted by the TMI-2 Recovery Technical Specifications (0.024 $\mu\text{Ci/sec}$.) when averaged

over any calendar quarter. It is also less than the rate of release stated in the PEIS Supplement II, section 3.1.1.2 (0.00028 $\mu\text{Ci/sec.}$ (2.8 E-4)) which was calculated at a flow rate of 20 GPM.

The radionuclides and their permissible level of concentrations as influent to the vaporizer assembly for atmospheric release are listed in Table 3-1. This table conservatively assumes that certain radionuclides, not positively identified in the process water samples, nevertheless exist at the stated lowest limit of detection. These assumed radionuclides, identified by an asterisk, are included in the table.

3.2 Operational Options

The designed flexibility of the evaporator/vaporizer equipment permits the evaporator assembly to be de-coupled from the vaporizer assembly. In this configuration, the evaporator operates independent of the vaporizer and processes the water in a batch cycle method of operation. Conversely, if the vaporizer is coupled to the evaporator during operations, the water will be processed in a continuous type method of operation. The operational options addressed in this section describe these two methods of process operations.

3.2.1 Batch Cycle Operations

In this configuration, the evaporator assembly will process water independent of the vaporizer assembly. The product distillate from the evaporator will be collected in a staging tank for sampling and radiochemical analysis. The benefits realized by this operational method are primarily in the area of radiological waste volume and occupational exposure reductions. By using the evaporator assembly as a pretreatment technique for certain of the volumes of water, pretreatment by one of the ion exchange systems and the resulting contamination of demineralizer resins would be eliminated. Thus, the handling and shipping of the resin liners for disposal purposes is eliminated.

The collected product distillates, sampled at the staging tank, will be radiochemically analyzed for compliance with the controlling concentrations noted in Tables 3-1 or 3-2. Process operations by the evaporator coupled to the vaporizer assembly or by the vaporizer assembly independent of the evaporator, will not be permitted until after it has been analytically determined by NRC approved process control procedures that the controlling constituents of the distillate are at or below those levels of concentrations noted in the influent column of the applicable table, (i.e., Table 3-1, vaporizer influent criteria, and Table 3-2, continuous cycle evaporator influent criteria).

3.2.2 Continuous Cycle Operations

In this configuration, the evaporator and vaporizer assemblies will be coupled and operate as a continuous cycle unit. The control of this operation will be initially established by the isolation of the body of water scheduled for continuous cycle evaporation. Once this isolation is complete, a physical radiochemical analysis will be performed on the water and compared to the controlling radioactive constituents noted in Table 3-2. Process operations by the evaporator and vaporizer equipment will not be permitted until after it has been analytically determined by NRC approved process control procedures that the controlling constituents are at or below those levels of concentration noted in the influent column of the table.

The imposition of these evaporator influent limits coupled with a conservative carry-over fraction of 0.1% assumed during evaporator operations, will assure that the rate of atmospheric release of particulate radioactive material will be in compliance with the permissible release concentrations established in Section 3.1.

Operational experience and historical data accrued during actual operations (i.e., batch and continuous cycle operations) will provide a sound basis for the continued use of a 0.1% carry-over fraction for operational limits. Development of an operational

data base using physical sampling and radiochemical analysis may demonstrate that a less conservative carry-over fraction may be applied and the operational procedures modified accordingly. However, until compilation of this data base during actual system operations, the 0.1% carry-over fraction will be assumed as the procedural control limit for continuous cycle operations.

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