11.0 RADIOACTIVE WASTE MANAGEMENT

11.1 Source Terms

The source term is a realistic model used to predict expected long-term average concentrations of radionuclides in the primary and secondary fluid stream and an average plant's releases over its lifetime. This realistic model, based on available measured nuclide concentrations during normal operation, was formulated as a standard for the American National Standard Source Term Specifications, ANSI N237[1], and is the source term model used in NUREG-0017[2].

11.1.1 Reactor Coolant Activity

11.1.1.1 Fission and Corrosion Products

The parameters used to describe the source term model are given in Table 11.1-1 together with the range of values utilized by ANSI N237-1976.

Corrections have been made according to the ANSI N237-1976 standard formulas. Operation of the gaseous waste processing system (GWPS) is assumed. The Y parameter is interpreted as equal to the stripping fraction and is calculated using the formula in Table 11.1-1. These stripping fractions apply to the gaseous waste management system. Stripping fractions (Y parameter) are listed in Table 11.1-1.

Specific activities in the primary coolant, based on the parameters of Table 11.1-1, are given in Table 11.1-2.

11.1.1.2 Tritium Production and Release to the Reactor Coolant

There are two principal contributors to tritium production: the ternary fission source and the dissolved boron in the reactor coolant. Additional contributions are made by lithium-6, lithium-7, and deuterium in the reactor water. Tritium production from the various sources is shown in Table 11.1-3.

Since tritium is found mainly as water, the concentration of tritium in the primary coolant is controlled by discharging tritiated water from the plant. The tritium concentration in the primary coolant is assumed to be controlled at 1.0 µci/g.

Additional background information on tritium production is given in Reference 3.

11.1.1.3 Activation of Water

Nitrogen-16 is produced by the O-16 (n, p) N-16 reaction. The N-16 activity in the primary coolant is the controlling radiation source in the design of the secondary shielding inside the containment. However, with a half-life of 7.11 sec., no N-16 is expected to be discharged to the environment through any process pathway during normal plant operation.

The principal source of carbon-14 is the thermal neutron reaction with oxygen-17 in the primary coolant: O-17 (n, α) C-14. Based on NUREG-0017, the C-14 production rate is 8 ci/yr with 1 ci/yr released by way of containment venting and the remainder discharged by the gaseous waste processing system.

11.1.2 Secondary Coolant Activity

Normal plant operation is anticipated to result in a certain degree of radioactivity within the secondary coolant systems through primary to secondary steam generator tube leakage.

The parameters used to describe the source term model are given in Table 11.1-1 together with the range of values utilized by ANSI N237-1976.

Corrections have been made according to the ANSI N237-1976 standard formulas. Operation of the gaseous waste processing system is assumed. The Y parameter is interpreted as equal to the stripping fraction and is calculated using the formula in Table 11.1-1. These stripping fractions apply to the gaseous waste management system. Stripping fractions (Y parameter) are listed in Table 11.1-1.

Specific activities in the secondary coolant, based on the parameters of Table 11.1-1, are given in Table 11.1-2.

11.1.3 Argon-41 Production in the Containment Atmosphere

Argon-41 is formed by neutron activation of stable, naturally occurring Ar-40 in the containment air surrounding the reactor vessel. The Ar-41 is released to the environment when the containment is vented or purged.

NUREG 0017 recommends an estimated annual release rate of 25 Ci/year for Ar-41 based on reported release data from 10 operating PWRs during the period of 1972 to 1974.

11.1.4 Volume Control Tank Vapor Space Activity

The vapor space in the chemical and volume control system's volume control tank (VCT) is normally purged to the gaseous waste processing system to remove fission gases from the reactor coolant. The activity in the VCT vapor space is based on the VCT stripping fractions given in Table 11.1-1 and the primary coolant source term given in Table 11.1-2. The VCT vapor space source term is given in Table 11.1-4.

11.1.5 Gaseous Releases to the Environment

The argon-41 produced in the containment is released to the environment when the containment is purged or vented, and the VCT purge flow is released to the environment by way of the gaseous waste processing system. In addition, gaseous radioactivity is released to the environment due to primary or secondary coolant leakage to the containment or other buildings, offgases from the main condenser evacuation system, and cover and vent gases from equipment containing radioactive material. Modeling of these releases is discussed in Subsection 11.3.3 of this module.

11.1.6 Radioactive Releases to the Environment by the Liquid Pathway

The activity level in the various liquids destined for discharge is generally defined as a fraction of primary or secondary coolant activity which are given in Table 11.1-2. The volumes and activity levels of liquids discharged to the environment are discussed in Subsection 11.2.

11.1.7 References

1. American National Standard Source Term Specification, ANSI N237-1976/ANS-18.1, approved May 11, 1976.

2. U. S. Nuclear Regulatory Commission, "Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from Pressurized Water Reactors," NUREG-0017, Office of Standard Development, April 1976.

3. "Source Term Data for Westinghouse Pressurized Water Reactors," WCAP-8253, Revision 1, February 1976.

TABLE 11.1-1 (SHEET 1 OF 2)
PARAMETERS USED TO DESCRIBE THE REACTOR SYSTEM-REALISTIC BASIS

Parameter	Symbol	Units	Value	ANSI N237 Range Maximum	ANSI N237 Range Minimum
Thermal power	P	MW_t	4200	3800	3000
Steam flowrate	FS	lb/h	1.7×10^7	1.7×10^7	1.3×10^7
Weight of water in reactor coolant system	WP	lb	6.7×10^5	6.0×10^5	5.0×10^5
Weight of water in all steam generators	WS	lb	5.4×10^5	5.0×10^5	4.0×10^5
Reactor coolant letdown flow (purification)	FD	lb/h	5.0×10^4	4.2×10^4	3.2×10^4
Reactor coolant letdown flow (yearly average for boron control)	FB	lb/h	8.7×10^2	1.0×10^3	25 x 10
Steam generator blowdown flow (total)	FBD	lb/h	5.4×10^4 (a)	1.0×10^5	5.0×10^4
Fraction of radioactivity in blowdown steam that is not returned to the secondary coolant system	NBD	-	1.0(a)	1.0	0.9
Flow through the purification system cation demineralizer	FA	lb/h	5.0×10^3	7.5×10^4	0.0
Ratio of condensate demineralizer flowrate to the total stream flowrate	NC	-	0.0(a)	0.01	0.0
Ratio of the total amount of noble gases routed to gaseous radwaste from the purification system to the total amount routed from the primary coolant system (not including the boron recycle system)	Y	-	(b)	0.01	0.0
Primary-to-secondary leak rate	-	lb/day	100	-	100

a. Assumed value for the purpose of calculating a secondary coolant source term. This parameter may change for any specific plant requiring a redetermination of the secondary coolant source term.
b. Volume control tank noble gas stripping fractions (based on 0.7 SCFM purge to the gaseous waste processing system)

TABLE 11.1-1 (SHEET 2 OF 2)

PARAMETERS USED TO DESCRIBE THE REACTOR SYSTEM-REALISTIC BASIS

Isotope	Stripping Fraction
Kr-83m	0.81
Kr-85m	0.67
Kr-85	0.32
Kr-87	0.86
Kr-88	0.75
Kr-89	0.99
Xe-131m	0.26
Xe-133m	0.30
Xe-133	0.27
Xe-135m	0.95
Xe-135	0.48
Xe-137	0.99
Xe-138	0.96

The nuclide stripping fractions are calculated using the following equation:

$$\Psi = 1 - \frac{KQ}{KQ + \lambda (KL + V) + P}$$

where:

Ψ = nuclide volume control tank stripping fraction.

$K = \frac{RT}{MH}$.

R = gas constant (45.59 $\frac{atm/cm^3}{g\ mol/°R}$).

T = nominal volume control tank temperature (590°R).

M = molecular weight of water (18.0 g/g mol).

H = Henry's Law constant equal to 3.32×10^4 atm/mol fraction for krypton and 2.39×10^4 atm/mol fraction for xenon, at 130°F

Q = letdown or purification flowrate (6.3×10^3 g/sec).

λ = nuclide decay constant (sec^{-1}).

L = volume control tank liquid mass (6.8×10^6 cm^3)

V = volume control tank vapor volume (1.02×10^7 g)

P = volume control tank purge rate to the gaseous waste management system, at volume control tank conditions (1.30×10^2 cm^3/sec).

TABLE 11.1-2 (SHEET 1 OF 3)

SPECIFIC ACTIVITIES IN PRINCIPAL FLUID STREAMS-REALISTIC BASIS

Normal Plant Operation Source Terms
(based on ANSI N237)

Volume Control Tank Purge of 1.30×10^{2} cm^3/s

Group I - Noble Gases

Nuclide	Reactor Coolant Activity (μCi/g)	Steam Gen. Liq. Activity (μCi/g)	Steam Gen. Steam Activity (μCi/g)
Kr-83m	1.8×10^{-2}	Nil	4.5×10^{-9}
Kr-85m	8.5×10^{-2}	Nil	2.1×10^{-8}
Kr-85	5.6×10^{-3}	Nil	1.4×10^{-9}
Kr-87	5.5×10^{-2}	Nil	1.3×10^{-8}
Kr-88	1.7×10^{-1}	Nil	4.0×10^{-8}
Kr-89	5.1×10^{-3}	Nil	1.2×10^{-9}
Xe-131m	1.6×10^{-2}	Nil	4.0×10^{-9}
Xe-133m	8.5×10^{-2}	Nil	2.1×10^{-8}
Xe-133	4.3×10^{0}	Nil	1.1×10^{-6}
Xe-135m	1.3×10^{-2}	Nil	3.1×10^{-9}
Xe-135	2.4×10^{-1}	Nil	5.9×10^{-8}
Xe-137	9.1×10^{-3}	Nil	2.2×10^{-9}
Xe-138	4.4×10^{-2}	Nil	1.0×10^{-8}

Group II - Halogens

Nuclide	Reactor Coolant Activity (μCi/g)	Steam Gen. Liq. Activity (μCi/g)	Steam Gen. Steam Activity (μCi/g)
Br-83	4.8×10^{-3}	9.9×10^{-8}	9.9×10^{-10}
Br-84	2.6×10^{-3}	1.6×10^{-8}	1.6×10^{-10}
Br-85	3.1×10^{-4}	1.7×10^{-10}	1.7×10^{-12}
I-130	2.0×10^{-3}	9.7×10^{-8}	9.7×10^{-10}
I-131	2.5×10^{-1}	1.9×10^{-5}	1.9×10^{-7}
I-132	1.0×10^{-1}	7.3×10^{-6}	7.3×10^{-8}
I-133	3.6×10^{-1}	2.0×10^{-5}	2.0×10^{-7}
I-134	4.7×10^{-2}	4.4×10^{-8}	4.4×10^{-9}
I-135	1.9×10^{-1}	6.9×10^{-6}	6.9×10^{-8}

TABLE 11.1-2 (SHEET 2 OF 3)

SPECIFIC ACTIVITIES IN PRINCIPAL FLUID STREAMS-REALISTIC BASIS

Group III - Rubidium and Cesium

Nuclide	Reactor Coolant Activity (μCi/g)	Steam Gen. Liq. Activity (μCi/g)	Steam Gen. Steam Activity (μCi/g)
Rb-86	7.8×10^{-5}	6.5×10^{-9}	6.5×10^{-12}
Rb-88	2.0×10^{-1}	6.6×10^{-6}	6.6×10^{-10}
Cs-134	2.3×10^{-2}	1.5×10^{-6}	1.5×10^{-9}
Cs-136	1.2×10^{-2}	8.3×10^{-7}	8.3×10^{-10}
Cs-137	1.6×10^{-2}	1.2×10^{-6}	1.2×10^{-9}
Ba-137m	1.6×10^{-2}	1.1×10^{-6}	1.1×10^{-9}

Group IV - Nitrogen-16

Nuclide	Reactor Coolant Activity (μCi/g)	Steam Gen. Liq. Activity (μCi/g)	Steam Gen. Steam Activity (μCi/g)
N-16	4.0×10^{1}	8.3×10^{-7}	8.3×10^{-8}

Group V - Tritium

Nuclide	Reactor Coolant Activity (μCi/g)	Steam Gen. Liq. Activity (μCi/g)	Steam Gen. Steam Activity (μCi/g)
H-3	1.0	1.0×10^{-3}	1.0×10^{-3}

TABLE 11.1-2 (SHEET 3 OF 3)

SPECIFIC ACTIVITIES IN PRINCIPAL FLUID STREAMS-REALISTIC BASIS

Group VI - Miscellaneous Isotopes

Nuclide	Reactor Coolant Activity (μCi/g)	Steam Gen. Liq. Activity (μCi/g)	Steam Gen. Steam Activity (μCi/g)
Cr-51	1.7×10^{-3}	1.2×10^{-7}	1.2×10^{-10}
Mn-54	2.8×10^{-4}	3.0×10^{-8}	3.0×10^{-11}
Fe-55	1.4×10^{-3}	1.0×10^{-7}	1.0×10^{-10}
Fe-59	9.0×10^{-4}	7.7×10^{-8}	7.7×10^{-11}
Co-58	1.4×10^{-2}	1.1×10^{-6}	1.1×10^{-9}
Co-60	1.8×10^{-3}	1.3×10^{-7}	1.3×10^{-10}
Sr-89	3.2×10^{-4}	3.1×10^{-8}	3.1×10^{-11}
Sr-90	9.0×10^{-6}	7.5×10^{-10}	7.5×10^{-13}
Sr-91	6.3×10^{-4}	2.6×10^{-8}	2.6×10^{-11}
Y-90	1.1×10^{-6}	4.2×10^{-10}	4.2×10^{-13}
Y-91m	3.6×10^{-4}	2.3×10^{-8}	2.3×10^{-11}
Y-91	5.8×10^{-5}	4.6×10^{-9}	4.6×10^{-12}
Y-93	3.3×10^{-5}	1.7×10^{-9}	1.7×10^{-12}
Zr-95	5.4×10^{-5}	4.6×10^{-9}	4.6×10^{-12}
Nb-95	4.5×10^{-5}	4.6×10^{-9}	4.6×10^{-12}
Mo-99	7.7×10^{-2}	6.3×10^{-6}	6.3×10^{-9}
Tc-99m	4.7×10^{-2}	1.5×10^{-5}	1.5×10^{-8}
Ru-103	4.1×10^{-5}	3.1×10^{-9}	3.1×10^{-12}
Ru-106	9.0×10^{-6}	7.5×10^{-10}	7.5×10^{-13}
Rh-103m	4.5×10^{-5}	1.5×10^{-8}	1.5×10^{-11}
Rh-106	1.0×10^{-5}	4.2×10^{-9}	4.2×10^{-12}
Te-125m	2.6×10^{-5}	1.4×10^{-9}	1.4×10^{-12}
Te-127m	2.5×10^{-4}	1.4×10^{-8}	1.4×10^{-11}
Te-127	8.2×10^{-4}	8.6×10^{-8}	8.6×10^{-11}
Te-129m	1.3×10^{-3}	9.3×10^{-8}	9.3×10^{-11}
Te-129	1.6×10^{-3}	4.4×10^{-7}	4.4×10^{-10}
Te-131m	2.3×10^{-3}	1.4×10^{-7}	1.4×10^{-10}
Te-131	1.1×10^{-3}	4.0×10^{-7}	4.0×10^{-10}
Te-132	2.5×10^{-2}	1.6×10^{-6}	1.6×10^{-9}
Ba-140	2.0×10^{-4}	1.5×10^{-8}	1.5×10^{-11}
La-140	1.4×10^{-4}	2.0×10^{-8}	2.0×10^{-11}
Ce-141	6.3×10^{-5}	4.7×10^{-9}	4.7×10^{-12}
Ce-143	3.7×10^{-5}	2.4×10^{-9}	2.4×10^{-12}
Ce-144	3.0×10^{-5}	3.0×10^{-9}	3.0×10^{-12}
Pr-143	4.5×10^{-5}	3.3×10^{-9}	3.3×10^{-12}
Pr-144	3.3×10^{-5}	1.6×10^{-8}	2.5×10^{-11}
Np-239	1.1×10^{-3}	6.6×10^{-8}	6.6×10^{-11}

TABLE 11.1-3

TRITIUM PRODUCTION[a]

Tritium Source	Total Produced (Ci/cycle)	Release Expected to Reactor Coolant (Ci/cycle)
Ternary fissions		
Initial cycle	23,520	2352
Equilibrium cycle	23,520	2352
Coolant (soluble boron)		
Initial cycle	420	420
Equilibrium cycle	530	530
Coolant (lithium, deuterium)		
Initial cycle	338	338
Equilibrium cycle	338	338
Total initial cycle	16,500	3110
Total equilibrium cycle	11,400	3220

a. The following parameters were used:

Power level, 4200 MWt
Release fraction from fuel, 10 percent
Lithium concentration (99.9 atom-percent lithium-7), 2.2 ppm
Initial cycle operating time, 13140 effective full-power h
Equilibrium cycle operating time, 13140 effective full-power h

TABLE 11.1-4

VOLUME CONTROL TANK
VAPOR SPACE ACTIVITIES[a]

Nuclide	Activity[b] (μCi/cm^3)
Kr-83m	7.7×10^{-2}
Kr-85m	6.1×10^{-1}
Kr-85	8.5×10^{-2}
Kr-87	1.7×10^{-1}
Kr-88	9.2×10^{-1}
Kr-89	8.1×10^{-4}
Xe-131m	1.9×10^{-1}
Xe-133m	9.5×10^{-1}
Xe-133	$5.0 \times 10^{+1}$
Xe-135m	9.4×10^{-3}
Xe-135	2.0
Xe-137	1.8×10^{-3}
Xe-138	3.0×10^{-2}

a. Based on parameters given in Table 11.1-1.

b. At 130°F and 30 psig.

11.2 Liquid Waste Management Systems

The liquid waste management systems include all systems that may be used to process for disposal liquids containing radioactive material. These include:

A. Boron recycle system (BRS) (Subsection 9.3.4 of RESAR-SP/90 PDA Module 13, "Auxiliary Systems").

B. Steam generator blowdown processing system (Subsection 10.4.8 of RESAR-SP/90 PDA Modules 6 and 8 (combined) "Secondary Side Safeguards System/Steam and Power Conversion System").

C. Turbine building floor drain system (Subsection 9.3.3 of RESAR-SP/90 PDA Module 13, "Auxiliary Systems").

D. Liquid waste processing system (LWPS) (Section 11.2).

This section primarily addresses the LWPS. The other systems are also addressed in Subsection 11.2.3 of this module, which discusses the expected releases from all liquid waste management systems.

The LWPS is designed to control, collect, process, handle, store, and dispose of liquid radioactive waste generated as the result of normal operation, including anticipated operational occurrences.

11.2.1 Design Bases

The conformance of the LWPS design with the criteria of applicable Regulatory Guides is discussed in Section 1.8 of this module.

11.2.1.1 Capacity

The projected flows of various liquid waste streams to the LWPS are specified in Table 11.2-1. The LWPS provides adequate capacity to meet the anticipated processing requirements of the plant.

The LWPS design can accept equipment malfunctions without affecting the capability of the system to handle both anticipated liquid waste flows and possible surge load due to excessive leakage. Surge capacity of individual tanks is discussed in Subsection 11.2.2.6.2.

Portions of the LWPS may become unavailable as a result of the malfunctions listed in Subsection 11.2.1.1.1 through 11.2.1.1.3.

Ample surge capacity of the system and the low load factor of the processing equipment permits the system to accommodate waste until failures can be repaired and normal plant operation resumed. In addition, the LWPS is designed to accommodate the anticipated operational occurrences described in Subsections 11.2.1.1.4 through 11.2.1.1.6.

11.2.1.1.1 Pump Failure

Where operation is not essential and surge capacity is available, a single pump is provided. Two reactor coolant drain tank (RCDT) pumps are provided because the relative inaccessibility of the containment during plant operation would hinder maintenance. Pump repair and replacement is facilitated by using two standard pump designs for the eight applications in the LWPS. To protect the pumps from damage due to loss of suction, each pump is interlocked to stop on a low level condition in the tank feeding the pump.

11.2.1.1.2 Filter, Strainer, or Demineralizer Plugging

Instrumentation is provided to give local indication of the pressure drop across all filters, strainers, and demineralizers. Periodic checks of the pressure drops provide indication of the equipment fouling, thus permitting corrective action to be taken before an excessive pressure drop is reached.

11.2.1.1.3 Waste Evaporator Failure

The waste holdup tank normally provides the only feed to the waste evaporator. The tank has sufficient surge capacity to accommodate approximately 35 days of normal inflow without evaporator processing. This is based on an initial tank level of 40 percent and inflow according to Table 11.2-1.

The floor drain tank contents normally do not require processing by the waste evaporator. However, if processing by the evaporator is required and it is not available, the tank has sufficient surge capacity to accommodate approximately three days of normal inflow. This is based on an initial tank level of 40% and inflow according to Table 11.2-1.

The monitor tank demineralizer may also be used to process the floor drain tank contents to reduce the activity level and permit discharge. Thus, unavailability of the evaporator is unlikely to have any impact on the ability to process waste liquid directed to the floor drain tank.

11.2.1.1.4 High Leakage Rate

The system is designed to handle a 1-gal/min primary coolant system leak in addition to the expected leakage during normal operation. Operation of the system is the same as for normal operation except that the load on the system is increased. A 1-gal/min leak into the RCDT is handled automatically but may increase the load factor of the recycle evaporator.

The extra leakage may be directed to the waste holdup tank or the floor drain tank. Each of these tanks has the capacity to accommodate over 48 hours of the increased inflow without evaporator processing based on an initial tank level of 30 percent. The floor drain tank contents are not necessarily processed through the evaporator; they may be discharged without treatment if sample analysis indicates that the waste quality is acceptable for discharge.

11.2.1.1.5 Refueling

During refueling the load on the LWPS is expected to increase, but operation is the same as for normal plant operation, and there is no significant effect on the performance capability of the LWPS.

11.2.1.2 Controlled Release of Radioactivity

The LWPS provides the capability to reduce the amounts of radioactive nuclides released in the liquid wastes through the use of demineralization, evaporative separation with disposal of concentrates and recycling of clean tritiated water for re-use in the reactor plant when possible, and time delay for decay of short-lived nuclides.

The assumed equipment decontamination factors are included in Table 11.2-2. The radioactive source terms and annual average flowrates that will be processed in the LWPS or discharged to the environment during normal operation are estimated in Table 11.2-1.

Before any liquid radioactive waste is discharged, it is pumped to a monitor tank. A sample of the monitor tank contents is analyzed and the results logged. In this way, a record is kept of all planned releases of radioactive liquid waste. The liquid waste is discharged from the monitor tank in a batch operation, and the discharge flowrate is restricted as necessary to maintain an acceptable concentration when diluted by the circulating water discharge flow. These provisions preclude uncontrolled releases of radioactivity. In addition, the discharge line contains a stop valve interlocked with radiation monitor on the system discharge line. The valve automatically closes and an alarm is actuated if the activity in the discharge stream reaches the monitor setpoint. The stop valve is also interlocked to isolate discharge flow if sufficient dilution flow is not available.

To minimize leakage from the LWPS, the system is of all-welded construction except where flanged connections are required to facilitate component maintenance. The use of canned rotor design pumps for most applications minimizes system leakage and the release of radioactive gas that might be entrained in the leaking fluid to the building atmosphere.

Provisions are made to preclude uncontrolled spills of radioactive liquids due to tank overflows. These provisions include tank level indication, level annunciation, and overflow disposition.

11.2.1.2.1 Expected Releases

THe LWPS design ensures that the annual average concentration limits established by 10 CFR 20 (Appendix B, table II, column 2) for liquid releases are not exceeded during plant operation with expected levels of fuel cladding defects. Subsection 11.2.3 of this module discusses the calculated releases of radioactive materials from the LWPS and other portions of the liquid waste management systems resulting from normal plant operation.

11.2.1.2.2 Off-Normal Operation

Subsection 11.2.1.1 discusses the capability of the LWPS to accommodate various equipment failures and anticipated operational occurrences. During these anticipated occurrences, the effectiveness of the LWPS in controlling releases of radioactivity remains essentially unaffected, so releases are limited to approximately the same as during normal operation.

The GALE code(1), used to calculate the release concentration described in Subsection 11.2.1.2.1, contains an adjustment factor of 0.15 Ci/year to account for abnormal occurrences resulting in unplanned releases.

11.2.1.3 Equipment Design

The LWPS equipment design parameters are provided in Table 11.2-2.

The seismic design classification and safety classification for the LWPS components and structures are listed in Table 3.2-1 of RESAR-SP/90 PDA Module 7, "Structural/Equipment Design". Safety class designations are also indicated on the LWPS piping and instrumentation diagram, Figure 11.2-1.

11.2.2 System Descriptions

The LWPS collects and processes potentially radioactive wastes for recycling, solidification, or release to the environment. Provisions are made to sample and analyze fluids before discharge. Based on the laboratory analysis, these wastes are either retained for further processing or released under controlled conditions through the cooling water system, which dilutes the discharge flow. A permanent record of liquid releases is provided by analyses of known volumes of effluent.

The bulk of the radioactive liquid discharged from the reactor coolant system (RCS) is processed and recycled by the boron recycle system (BRS). This limits input to the LWPS and results in the processing of relatively small quantities of what are generally low activity level wastes.

The LWPS is arranged to recycle as much reactor grade water entering the system as possible. This is implemented by the segregation of equipment drains and waste streams to prevent intermixing of liquid wastes. The LWPS can be divided into the following subsystems:

A. Reactor coolant drain tank (RCDT) subsystem

This portion of the LWPS collects nonaerated, reactor grade effluent from sources inside the containment for recycling.

B. Drain Channel A

This portion of the LWPS collects aerated, reactor grade effluent that normally can be recycled.

C. Drain Channel B

This portion of the LWPS processes all effluent that is normally to be discharged to the environment and is not suitable for recycling.

In addition, the LWPS provides capability for handling and storage of spent ion exchange resins.

The LWPS does not include provisions for processing secondary system wastes. Secondary system effluent is handled by the steam generator blowdown processing system (SGBPS) and by the turbine building drain system. Estimated releases from these systems are discussed in Subsection 11.2.3 of this module. The LWPS design, which segregates primary and secondary wastes, minimizes the amount of water that must be processed by the waste evaporator by discharging low activity wastes directly, where permissible, with no treatment.

Instrumentation and controls necessary for the operation of the LWPS are located on a control board in the auxiliary building. Any alarm on this control board is relayed to the main control board in the control room.

The piping and instrumentation diagram and process flow diagrams for the LWPS are shown on Figures 11.2-1 and 11.2-2, respectively. Table 11.2-1 lists the assumptions regarding flows and activity levels. Figure 11.2-2 also includes process flow diagrams for the letdown path in the chemical and volume control system, for the boron recycle system and for the steam generator blowdown processing system.

11.2.2.1 Reactor Coolant Drain Tank Subsystem

Recyclable reactor grade effluents enter this subsystem from valve leakoffs, the reactor coolant pump No. 2 seal leakoffs, the reactor vessel flange leakoff, and other deaerated, tritiated water sources inside the containment. This deaerated, tritiated liquid is normally processed by the BRS for reuse, but if desired, it can be sent to the LWPS drain channel A for processing. Connections are provided for draining the RCS loops and the safety injection system (SIS) accumulators and for cooling the pressurizer relief tank. In addition, refueling canal drains can be routed to the refueling water storage tank using the RCDT pumps.

The RCDT contents are continuously recirculated through the RCDT heat exchanger to maintain the desired temperature. Level is prevented from varying significantly from a control value which automatically opens a path from the recirculation line to the BRS when normal tank level is exceeded. The RCDT is also connected to the gaseous waste processing system (GWPS) vent header. Hydrogen gas bottles connected to the RCDT ensure a hydrogen blanket. Maintaining a constant level minimizes the amount of gas sent to the GWPS and minimizes the amount of hydrogen used. Provisions for sampling the gas are provided.

11.2.2.2 Drain Channel A Subsystem

Aerated, tritiated liquid enters drain channel A through lines connected to the waste holdup tank. Sources of this aerated liquid are as follows:

A. Accumulator drainage (via RCDT pump suction).

B. Sample room sink drains (excess primary sample volume only).

C. Ion exchangers, filter, pump, and other equipment drains.

If the quality of water in the containment sump or auxiliary building sump is acceptable for recycling, it may be directed to the waste holdup tank. If the water quality is not acceptable, it must be directed to the floor drain tank for disposal.

The collected aerated drainage is pumped or flows to the waste holdup tank, the initial collecting point for liquids processed through the waste evaporator before reuse.

The basic composition of the liquid collected in the waste holdup tank is boric acid and water with some radioactivity.

When there is sufficient liquid collected in the waste holdup tank, the waste evaporator feed pump delivers the contents of the waste holdup tank through a filter, to the waste evaporator package for removal of radioisotopes, boric acid, and air prior to reuse in the RCS. The gases are stripped and sent to the plant vent. The condensate leaving the waste evaporator passes through a waste evaporator condensate demineralizer and a filter to the waste evaporator condensate tank. The condensate can bypass the demineralizer when waste holdup tank samples indicate low radioactivity levels. This bypassing reduces the amount of waste resin to be solidified. When a sufficient quantity of water has been collected in the waste evaporator condensate tank, it is normally transferred to the reactor makeup water storage tank (RMWST) by the waste evaporator condensate pump for reuse. Samples are taken at sufficiently frequent intervals to ensure proper operation of the system and to minimize the need for reprocessing. If a sample indicates that further processing is required, the condensate can be passed through the waste condensate demineralizer or, if necessary, returned to the waste holdup tank for additional evaporation. The evaporator bottoms are discharged to the solid waste processing system for solidification.

11.2.2.3 Drain Channel B Subsystem

Drain channel B is provided to collect and process nonreactor grade liquid wastes. These include:

- Wastes from floor drains.
- Equipment drains containing nonreactor grade water.
- Laundry and hot shower drains.
- Other nonreactor grade sources.

Drain channel B is comprised of three drain subchannels, each associated with one of the following tanks.

A. Laundry and Hot Shower Tank

The laundry and hot shower tank is provided to collect and process waste effluents from the plant laundry and personnel decontamination showers and hand sinks.

Laundry and hot shower drains normally need no treatment for removal of radioactivity. This water is transferred to a waste monitor tank through the laundry and hot shower tank filter for eventual discharge. If sample analysis indicates that decontamination is necessary, the water can be directed through the waste monitor tank demineralizer for cleanup.

B. Floor Drain Tank

Water may enter the floor drain tank from system leaks inside the containment through the containment sump, and from system leaks in the auxiliary building through auxiliary building sumps and the floor drains. Sources of water to the containment sump and auxiliary building sumps and floor drains are the following:

1. Fan cooler leaks.

2. Secondary side steam and feedwater leaks.

3. Primary side process leaks.

4. Spent fuel pool liner leaks.

5. Component cooling water leaks.

6. Decontamination water.

If the quality of the water in the containment sump or auxiliary building sumps is acceptable for recycling, the water may be directed to the waste holdup tank. However, unless a large primary side leak develops, this liquid would probably not be directed to the waste holdup tank because it would be diluted and contaminated by water from other nonreactor grade sources.

Another source of water to the floor drain tank is the chemical laboratory drains. Excess nonreactor grade samples that are not chemically contaminated and laboratory equipment rinse water are drained to the floor drain tank.

Generally, the contents of the floor drain tank are discharged without processing by the waste evaporator. Floor drain tank contents are pumped to a waste monitor tank for ultimate discharge.

If the activity in the floor drain tank liquid is such that the discharge limits cannot be met without cleanup, the liquid can be processed by the waste monitor tank demineralizer or by the waste evaporator. The waste evaporator condensate is pumped to a waste monitor tank for ultimate discharge and the concentrates are transferred to the solid waste processing system.

C. Chemical Drain Tank

Laboratory samples which contain reagent chemicals (and possibly tritiated liquid) are discarded through a sample room sink which drains to the chemical drain tank. Chemical drains requiring radwaste processing are sent to the solid waste management system.

Any liquids released to the environment by the LWPS are first directed to a waste monitor tank. Before releasing the contents of a waste monitor tank, a sample is taken for analysis. The findings are logged, and, if the activity level is within acceptable limits, the tank contents are released to the discharge canal. The discharge valve is interlocked with a process radiation monitor and closes automatically when the radioactivity concentration in the liquid discharge exceeds a preset limit. The radiation element is located upstream of the discharge valve at a distance sufficient to close the valve before passing the fluid that activated the detector trip signal. The stop valve is also interlocked with the circulating water pump to block flow if sufficient dilution water is not available. The radiation monitor is described in Section 11.5 of this module. A permanent record of the radioactive releases is provided by a sample analysis of known values of waste effluent released. Liquid waste discharge flow and volume are also recorded.

If the monitor tank contents are not acceptable for discharge, the fluid can be held for a time to allow activity to decay to acceptable levels, or it can be further processed by the waste evaporator or waste monitor tank demineralizer.

11.2.2.4 Spent Resin Handling Subsystem

This subsystem collects, handles, and processes spent resins from the primary fluid systems prior to their disposal.

Spent resin from the primary system demineralizers is transported to and stored in the spent resin storage tank prior to being drummed. The spent resin sluice portion of the LWPS consists of a spent resin sluice filter, spent resin sluice pump, and the spent resin storage tank. The resin sluice water, after being directed to an ion exchange vessel by the sluice pump, returns to the spent resin storage tank for reuse.

This sluicing of spent resin from primary plant demineralizers is accomplished without generating a large volume of liquid waste.

Resin slurry from the spent resin storage tank is sent to the solid waste processing system by pressurizing the tank with nitrogen.

11.2.2.5 Liquids from Sources Other Than the Liquid Waste Processing System

11.2.2.5.1 Steam Generator Blowdown Processing System

Blowdown from the steam generators of each unit is cooled, filtered, and demineralized. Normally it is then returned to the condensers for reuse as condensate makeup, but it may be discharged to the environment. The SGBPS is described in Subsection 10.4.8 of RESAR SP/90 PDA Modules 6 and 8 (combined), "Secondary Side Safeguards System/Steam and Power Conversion Systems".

11.2.2.5.2 Boron Recycle System

Water is processed by the BRS using an evaporator to concentrate boric acid solution to the concentration required in the boric acid tanks. Both evaporator condensate and concentrates are normally recycled; however, a fraction of the condensate is discharged for the purpose of avoiding excessive buildup of tritium in the reactor coolant water. The BRS is described in Subsection 9.3.4 of RESAR SP/90 PDA Module 13, "Auxiliary Systems".

11.2.2.5.3 Turbine Building Drain System

The function of the turbine building drain system is to collect the floor drains and sampling wastes in the turbine building and other miscellaneous drains.

11.2.2.6 Equipment Description

Principal design parameters for the LWPS equipment are given in Table 11.2-2. All parts or components in contact with borated water are fabricated from or clad with austenitic stainless steel. Pumps are provided with vent and drain connections.

Component safety classes, seismic design, and principal codes are shown in Table 3.2-1 of RESAR SP/90 PDA Module 7, "Structural/Equipment Design".

11.2.2.6.1 Pumps

Pumps in the LWPS have been standardized wherever possible. Where operation is not critical and surge capacity is available, a single pump has been provided. Spare pumps can be kept onsite in case any pump should fail. Quick replacement is possible because:

- o The pumps are flanged, not welded.
- o The system has surge capacity.
- o Adequate vent, flush, and drain capabilities are provided.
- o The pumps are standardized.

Two standard pump designs are utilized as described below.

Pumps with identical head-flow characteristics are used for the following applications:

- o Spent resin sluice pumps.
- o RCDT pumps.

Another pump design is used for the following applications:

- o Waste evaporator feed pumps.
- o Waste evaporator condensate tank pumps.
- o Chemical drain tank pump.
- o Waste monitor tank pumps.

- o Floor drain tank pump.
- o Laundry and hot shower tank pump.

Globe valves are installed in pump discharge lines where necessary to prevent pump runout. Pump miniflow lines have locked-in-position globe valves to ensure that the minimum pump flow requirements are met.

A. RCDT Pump

The design basis for this pump is that, in its function of RCS drain, the coolant level reaches the midplane of the reactor vessel nozzles within an 8-hr period. Two pumps are furnished because of the relative inaccessibility of the containment during plant operation. Both pumps are operated to meet the draining time requirement. One pump provides sufficient flow for normal operation of the RCDT portion of the LWPS. The liquid is sent to the recycle holdup tanks.

B. Waste Evaporator Feed Pump

This pump supplies feed to the waste evaporator from the waste holdup tank, and it can be used to transfer waste holdup tank contents to the floor drain tank, if desired.

C. Waste Evaporator Condensate Pump

The waste evaporator condensate tank pump is used to transfer the contents of the waste evaporator condensate tank to the RMWST or the BRS holdup tank.

D. Chemical Drain Tank Pump

This pump is used to transfer the liquid in the chemical drain tank to the solid waste processing system.

E. Spent Resin Sluice Pump

One pump is provided to sluice resins from primary side demineralizers to the spent resin storage tank. Its delivery flow is based on the velocity required to sluice resin in a 3-in. pipe.

F. Laundry and Hot Shower Tank Pump

This pump is used to transfer the water from the laundry and hot shower tank to a waste monitor tank.

G. Floor Drain Tank Pump

This pump is used to transfer water from the floor drain tank to the waste monitor tank. The pump can also be used to supply the waste evaporator.

H. Waste Monitor Tank Pumps

Two pumps are provided, one pump for each monitor tank to discharge water from the LWPS or for recycling if further processing is required. The pump may also be used for circulating the water in the waste monitor tank to obtain uniform tank contents, and therefore a representative sample, before discharge. These pumps can be throttled to achieve the desired discharge rate.

11.2.2.6.2 Tanks

A. Reactor Coolant Drain Tank

One tank is provided to collect leakoff-type drains inside the containment at a central collection point for further disposition through a single penetration via the RCDT pumps. The tank provides surge volume and net positive suction head (NPSH) to the pumps.

Only water which can be directed to the boron recycle holdup tanks enters the RCDT. The water must be compatible with reactor coolant and must not contain dissolved air or nitrogen.

A constant level is maintained in the tank to minimize the amount of gas sent to the GWPS and also to minimize the amount of hydrogen cover gas required. The level is maintained by one continuously running pump and by a control valve in the discharge line. This valve operates on a signal from a level controller to limit the flow out of the system. The remainder of the flow is recirculated to the tank.

Continuous flow is maintained through the heat exchanger in order to prevent loss of pump NPSH resulting from a sudden inflow of hot liquid into the RCDT.

B. Waste Holdup Tank

One atmospheric pressure tank is provided to collect:

1. Equipment drains.

2. Valve and pump seal leakoffs (outside the containment).

3. Boron recycle holdup tank overflows.

4. Other water from tritiated, aerated sources.

The tank size is adequate to accommodate approximately 35 days of expected influent during normal operation.

C. Waste Evaporator Condensate Tank

One tank with a diaphragm to exclude air is provided to collect condensate from the waste evaporator. The tank has sufficient capacity to allow a 25-gal/min evaporator to operate without interruption for a 3-hr period.

D. Chemical Drain Tank

One tank is provided to collect chemically contaminated, tritiated water from the laboratories. This tank has sufficient capacity to accept more than a month's laboratory waste during normal operation.

E. Spent Resin Storage Tank

The purpose of the spent resin storage tank is to provide a collection point for spent resin and to allow for decay of short-lived radionuclides before disposal. The tank also serves as a head tank for the spent resin sluice pump.

One vertical, cylindrical tank with sufficient capacity to handle the spent resin storage needs is provided. A vertical, cylindrical tank is used because the symmetrical bottom facilitates the removal of resin. The tank is designed so that sufficient pressure can be applied in the gas space of the tank to move the resin slurry to the solid waste processing system.

The spent resin storage tank and associated equipment which can contain radioactive material are shielded to limit the dose to personnel.

The level indicating system in the spent resin storage tank shows only total level and not the amount of resin and water separately. However, since the resin volumes flushed from demineralizers and the resin volumes transferred to the solid waste processing system are known, the resin volume in the tank is also known.

F. Laundry and Hot Shower Tank

This atmospheric pressure tank is provided to collect laundry and hot shower drains. The tank size is sufficient to furnish a 20-day capacity during normal operation and a 2-day capacity during refueling.

G. Floor Drain Tank

This atmospheric pressure tank is used to collect floor drains from the controlled areas of the primary system. The tank provides sufficient surge capacity for the floor drains within the collection area and, in connection with the waste holdup tank, provides surge capacity for abnormal primary system leaks. The tank size is adequate to accommodate almost 5 days of expected influent during normal operation or 2 days of expected influent during shutdown operation.

H. Waste Monitor Tanks

Two atmospheric pressure waste monitor tanks are provided to monitor liquid discharged from the plant site. Each tank is sized to hold a volume large enough that sampling requirements are minimized, thereby minimizing laboratory effluent.

I. Waste Evaporator Reagent Tank

This tank is provided to make it possible to add chemicals to the evaporator for cleaning the waste evaporator tubes and for similar activities.

11.2.2.6.3 Reactor Coolant Drain Tank Heat Exchanger

This heat exchanger is located in the discharge line of the RCDT pumps and is in constant service as part of the RCDT recirculation path. Continuous component cooling water flow is maintained to the heat exchanger to accommodate, without operator action, sudden flow of hot liquid to the RCDT. The heat exchanger can also be used to cool the contents of the pressurizer relief tank in the RCS.

The heat exchanger is sized for several modes of operation:

A. It can maintain the RCDT liquid below 170°F, assuming a 10-gal/min input of 600°F reactor coolant.

B. It can cool the contents of the pressurizer relief tank from 200°F to 120°F in less than 8 hr.

C. It can maintain the contents of the RCDT at less than 170°F, assuming a 25-gal/min input from the excess letdown heat exchanger (chemical and volume control system).

11.2.2.6.4 Demineralizers

As part of a program of pressurized water reactor operating plant followup, Westinghouse has obtained operational data on demineralizer decontamination factors for selected isotopes. The measured range of decontamination factors for these isotopes is given in Table 11.2-3.

These values were observed across mixed bed demineralizers containing cation resin in the lithium-7 form and anion resin in the borated form.

In considering the waste evaporator condensate demineralizer and the waste monitor tank demineralizer, it can be assumed that greater decontamination factors would be realized because the resin in both demineralizers is in the hydrogen-hydroxyl form. The minimum values in Table 11.2-3 were generally observed just before resin flushing and recharging; during the operating life of the demineralizer, decontamination factors were consistently closer to the maximum values.

Although speci ic operating decontamination factors were not measured for other isotopes, their behavior in a mixed bed demineralizer may be inferred from this data.

The process decontamination factor used for the demineralizers in the analysis of system performance is taken from Reference 1. These decontamination factors are given in Table 11.2-2.

A. Waste Evaporator Condensate Demineralizer

One mixed bed demineralizer is provided to remove trace ionic contaminants from the waste evaporator condensate stream that is to be recycled. Resin in the hydrogen-hydroxyl form is utilized in this demineralizer. The use of this demineralizer is optional, depending on the activity levels observed in the output from the waste evaporator.

B. Waste Monitor Tank Demineralizer

One mixed bed demineralizer is provided upstream of the waste monitor tanks to remove, if desired, trace ionic contaminants from waste evaporator condensates that are to be discharged. The demineralizer may also be used to clean up the monitor tank contents or floor drain tank contents without having the flow first go through the waste evaporator. The laundry and hot shower tank contents can also be processed through the demineralizer if such processing is necessary. Resin in the hydrogen-hydroxyl form is used in this demineralizer.

11.2.2.6.5 Filters

The following filters are provided in the LWPS:

- o Waste evaporator feed filter.
- o Laundry and hot shower tank filter.
- o Floor drain tank filter.
- o Spent resin sluice filter.
- o Waste evaporator condensate filter.
- o Waste monitor tank filter.

11.2.2.6.6 Strainers

Basket-type strainers of mesh construction are provided to prevent clogging of filters and lines downstream because of large particles being sluiced through the lines during liquid transfer operations.

The following strainers are provided in the LWPS:

- o Laundry and hot shower tank strainer.
- o Floor drain tank strainer.

11.2.2.6.7 Waste Evaporator

One forced circulation type waste evaporator is provided. Evaporator distillate is either recycled, reprocessed, or discharged, depending on its chemistry and activity and other plant operating factors. Evaporator bottoms are discharged to the solid waste management system.

The process decontamination factors used for the waste evaporator in the analysis of system performance are taken from Reference 1 and are listed in Table 11.2-2.

11.2.2.7 Instrumentation Design

The system instrumentation is shown on the LWPS piping and instrumentation diagram (Figure 11.2-1).

Instrumentation readout is located mainly on the waste processing system panel in the auxiliary building. Some instruments are read where the equipment is located.

All alarms are shown separately on the waste processing system panel and are further relayed to one common waste processing system annunciator on the main control board in the control room.

All pumps are protected against loss of suction pressure by a control setpoint on the level instrumentation for the respective vessels feeding the pumps. In addition, the RCDT pumps and the spent resin sluice pump are interlocked with flowrate instrumentation to stop the pumps when the delivery flows reach minimum setpoints.

Pressure indicators are provided to give local indication of pressure drops across demineralizers, filters, and strainers.

All releases to the environment are monitored for radioactivity. This instrumentation is described in Section 11.5 of this module.

Each tank is provided with level indication instrumentation that actuates an alarm on high liquid level in the tank, thus warning of potential tank overflow.

11.2.2.8 Operating Procedures

The LWPS is manually operated except for some functions of the RCDT circuit. The system includes adequate control equipment to protect components and adequate instrumentation and alarm functions to provide operator information to ensure proper system operation.

Operation of the LWPS is essentially the same during all phases of normal and defined off-normal reactor plant operation; the only differences are in the load on the system. The term "normal operation", as used here, means all phases of plant operation except operation under emergency or accident conditions. The LWPS is not regarded as an engineered safety features system.

11.2.2.8.1 Reactor Coolant Drain Tank Subsystem Recirculation

A. Reactor Coolant Drain Tank Recirculation

Reactor coolant is continuously circulated through the RCDT heat exchanger to maintain ≤170°F in the event of a hot reactor coolant leak to the RCDT. Level is maintained by a control valve which automatically opens a path from the recirculation line to the recycle holdup tanks. Normal operation of this mode is automatic and requires no operator action. The system can be put into the manual mode, if desired.

Leakage into the RCDT can be estimated by putting the system in the manual mode, stopping the pump, and monitoring the level change.

A venting system is provided to prevent wide pressure variations in the RCDT. A hydrogen blanket is automatically maintained between 2 and 6 psig. Hydrogen is supplied from bottles which must be replaced when the pressure drops to ~100 psig. During all other operations, the recirculation mode is stopped and the RCDT is isolated.

B. Pressurizer Relief Tank Cooling

The pressurizer relief tank may be cooled by a feed-and-bleed method, by spraying cold makeup water and pumping the water to the recycle holdup tanks with an RCDT pump through the RCDT heat exchanger. This is a rapid cooldown and can be used even if the heat exchanger is out of service. However, to minimize the addition of water to the system when a rapid cooldown is not necessary, the pressurizer relief tank may be cooled from 200°F to 120°F in less than 8 hrs. by using the RCDT heat exchanger and one pump in a recirculation mode without adding water.

C. Loop Draining

Four RCS loops may be drained simultaneously to the midpoint of the reactor vessel nozzles in less than 8 hr when both RCDT pumps are running. The loops are vented to atmospheric pressure, then spool pieces are connected to the pumps' suction. The water is sent to the recycle holdup tanks in the BRS. Since the RCDT heat exchanger is not needed for cooling, it may be bypassed or used in parallel with the bypass.

D. Refueling Canal Draining and Cleanup

Refueling canal water is transferred, using the RCDT pumps, to the refueling water storage tank (draining), to the canal via the spent fuel pool cooling system (cleanup), or to the waste holdup tank (disposal). Since the RCDT heat exchanger is not needed for cooling, it may be bypassed or used in parallel with the bypass.

E. Accumulator Draining

This mode is available for accumulator maintenance. After the accumulator is vented to atmospheric pressure, the spool piece is connected to the RCDT pump suction for transfer of accumulator water to the waste holdup tank.

F. Excess Letdown Header

During normal plant heatup operations, excess letdown to the RCDT will permit faster heatup rate. Excess letdown flow is directed from the RCDT to the recycle holdup tanks.

11.2.2.8.2 Drain Channel A Subsystem Operation

Water is accumulated in the waste holdup tank until sufficient quantity exists to warrant an evaporator startup. The water volume for an evaporator startup is approximately 30 to 40 percent of tank capacity, which leaves the remainder as surge capacity available for abnormal situations. The waste evaporator feed pump is started and samples are taken from the miniflow line.

If it is not desired to recycle the water in the waste holdup tank and analysis indicates that decontamination by the waste evaporator is not necessary, the water may be sent to the floor drain tank for eventual discharge.

The waste holdup tank contents are processed by the waste evaporator. Evaporator feed is concentrated to 12-weight percent boric acid, 20-weight percent solids, or 40 $\mu Ci/cm^3$, whichever is achieved first. Concentrates are discharged to the solid waste processing system for solidification.

Gases stripped from the water by the evaporator are released to the plant vent.

After evaporation, the distillate in the waste evaporator condensate tank is checked for boron and activity concentration; if the analysis shows compatibility with reactor makeup grade water, it may be transferred directly to the RMWST. If the distillate is high in boron concentration or activity, it may be recirculated through the waste evaporator condensate demineralizer before being transferred to the RMWST. If reevaporation is required, the distillate can be transferred back to the waste holdup tank or to the boron recycle holdup tanks for processing by the boron recycle evaporator. If an overload forces some discharge, distillate may be directed to a waste monitor tank.

11.2.2.8.3 Drain Channel B Subsystem Operation

Drain channel B of the LWPS consists of the laundry and hot shower system, the floor drain tank system, and the chemical drain tank system.

Laundry and hot shower water enters the laundry and hot shower tank for holdup; it is sampled, filtered, and transferred to the monitor tank for discharge. This water is not processed by the waste evaporator because of the resultant soap fouling. If demineralization is required, the resin must be replaced with clean resin thereafter.

The floor drain tank contents are recirculated, and then samples are taken and analyzed. If the floor drain tank is overloaded or the water is recyclable, the water can be transferred to the waste holdup tank. If evaporation is necessary, the distillate is returned to a waste monitor tank directly or via the waste monitor tank demineralizer and filter. To prolong resin life, the demineralizer is normally used only after evaporation and if distillate sampling demands it. The evaporator concentrate is recycled or sent to the drumming station as determined by sample analysis.

One waste monitor tank is used only for floor drain tank contents and one for laundry water. This ensures segregated reprocessing methods. Before being discharged, water in the waste monitor tank is again sampled; it can be recirculated through the waste monitor tank demineralizer or returned to the floor drain tank for processing by the evaporator if further processing is required. Normally, sampling will indicate that waste monitor tank contents can be discharged into the plant discharge pipe. The rate of discharge flow is determined by the effluent activity concentration and the dilution flowrate. It is discharged into the cooling water system at a rate so as not to exceeded a small fraction of maximum permissible concentration for liquid releases.

Water leaving this system to the discharge canal is monitored for radiation. This radiation monitor is described in Section 11.5 of this module. If the radiation monitor closes the discharge valve, it must be cleared before the valve can be reopened. The monitor element can be cleared by flushing it with demineralized water from the temporary connection back to the waste monitor tank. During refueling, the load on this portion of the LWPS is increased, but there is no change in operation.

Spent samples with high chemical concentrations are held up in the chemical drain tank, then sampled. The contents are transferred to the solid waste processing system for solidification.

11.2.2.8.4 Spent Resin Handling Subsystem

A. Resin Fluffing

The demineralizer is valved out of service, and the flow path is aligned from the spent resin sluice pump through the process line of the demineralizer, through the Johnson screen at the top of the demineralizer and back to the spent resin storage tank. The resin bed is backflushed for about 10 min. to loosen it for sluicing. This operation may also be used to recover pressure drop caused by bed fouling by backwashing particulates from the top layer of the resin into the spent resin storage tank. Such a recovery is useful when the resin is not ionically depleted.

B. Resin Sluicing

The sluice pump is shut off after fluffing. The valves in the backflush circuit are closed, the sluice line to the bed screen is opened, and the sluice pump is started. The resin flows to the spent resin storage tank, initially at a slow rate; it continues for about 10 min. until sluicing is completed. Finally, the pump is stopped, and the sluice inlet and outlet valves are closed. If the pump suction line screen in the tank becomes resin plugged at any time, it can be cleared with a blast of nitrogen.

When resin activity in a demineralizer is low, the spent resin can be sluiced to a bulk disposal unit for low-level or nonradioactive waste instead of to the spent resin storage tank. Reactor makeup water is added to the spent resin storage tank to replace any sluice water lost to the bulk disposal facility.

C. Resin Fill

After sluicing is completed, fresh resin must be added. The path to the drain header from the demineralizer is opened to allow overflow. The resin fill line is opened and resin added. After fresh resin is added, the fill line valve is closed and the flow path is realigned for normal demineralizer operation.

D. Resin Disposal

The resin in the spent resin storage tank is loosened before disposal by sending pressurized nitrogen or sluice water through the six sparging nozzles in the tank. The valves in the resin transfer line are opened to direct the spent resin to the solid waste processing system.

The tank is then pressurized with nitrogen to force the resin up through the resin transfer line to the disposal area. A single nozzle in the spent resin storage tank is provided to allow local fluidization with sluice water at the opening of the discharge pipe. During resin transfer, this nozzle is used to ease the flow of the resin slurry. After resin transfer is complete, the tank is vented to the plant vent and returned to atmospheric pressure. The resin transfer line is then backflushed to the spent resin storage tank to clear it of resin.

Since a certain amount of resin remains in the tank after a disposal operation, it may hinder the backflush operation. Therefore, the fluidizing nozzle is again used to facilitate the backwash operation.

11.2.3 Radioactive Releases

11.2.3.1 Criteria for Discharge, Recycle, or Further Treatment of Liquid Waste

Processed liquids are recycled for reuse within the plant whenever possible, provided that the following criteria are satisfied:

- o The plant water inventory requires makeup.
- o The water to be reused satisfies system water quality requirements.
- o Tritium buildup is less than plant operating limits.

Processed liquids are discharged under the following conditions:

- o The processed water does not satisfy plant operating requirements for water quality and tritium buildup.
- o The effluent concentrations are within the limits specified by 10 CFR 20, Appendix B, Table II, column 2.

- o The discharge does not cause the limits of 10 CFR 50, Appendix I, to be exceeded.

Processed liquids are recycled within their respective treatment systems for additional processing when system water quality requirements are not satisfied and reuse within the plant is desirable, or when discharge of the processed liquid is planned but the discharge would result in exceeding either the concentration limits of 10 CFR 20, Appendix B, Table II, column 2, or the limits of 10 CFR 50, Appendix I.

11.2.3.2 Estimated Releases

The equipment utilized during liquid waste processing is at the discretion of the operator; therefore, the calculated releases conservatively do not address all possible treatment processes but only the expected process. Liquid releases are calculated using the PWR-GALE computer code[1] and parameters listed in Table 11.2-4, which are discussed in more detail below. Releases calculated assuming operation with expected levels of fuel cladding defects of 0.12 percent are presented in Table 11.2-5. Primary and secondary coolant activity levels are given in Section 11.1 for the realistic case. In agreement with Reference 1, the total releases include an adjustment factor of 0.15 Ci/year, using the same isotopic distribution as the calculated release, to account for anticipated operational occurrences.

Table 11.2-5 lists the calculated annual release from each of the process paths discussed below as well as the total annual release. Based on the annual average releases given in Table 11.2-5, the discharge of liquid wastes would require a dilution flow of greater than 40 gpm to achieve annual average effluent concentrations within the limits of 10 CFR 20 Appendix B, Table II, column 2. While the actual dilution flow is site dependent, it would be many times greater than the 40 gpm required to meet concentration limits.

A survey has been performed of liquid discharges from different Westinghouse pressurized water reactor plants, with results presented in Table 11.2-6. The data includes radionuclides released on an unidentified basis and are all within the permissible concentration for release of liquid containing an unidentified radionuclide mixture. The data in Table 11.2-6 clearly indicate that actual releases are highly dependent upon the actual operation of the plant and can vary significantly from year to year for a given plant as well as from plant to plant.

11.2.3.2.1 Boron Recycle System (BRS)

Primary coolant is withdrawn from the reactor coolant system (RCS) and processed through the chemical and volume control system (CVCS). A portion of the letdown stream is assumed to be diverted to the BRS as shim bleed. The shim bleed is combined with other reactor grade wastes that are collected by the reactor coolant drain tank (equipment drain wastes).

The combined shim bleed and equipment drain waste streams are processed through one of the recycle evaporator feed demineralizers and routed to one of the recycle holdup tanks. The contents of the recycle holdup tank are then processed through the recycle evaporator and recycle evaporator condensate demineralizer. The condensate is either pumped to the reactor makeup water storage tank for reuse in the plant or to a waste monitor tank for monitoring and discharge. The BRS has sufficient capacity to allow total reuse of the combined shim bleed and equipment drain wastes. However, in the release calculations, a discharge fraction of 0.214 is used because up to one and half RCS volumes of treated primary coolant per year may be discharged for tritium control.

Figure 11.2-2, sheets 1 & 2, shows a process flow diagram of this path.

11.2.3.2.2 Liquid Waste Processing System (LWPS)

A. Clean Wastes (Drain Channel A - Miscellaneous Wastes)

Clean wastes are collected in the waste holdup tank for eventual processing by the waste evaporator. The evaporator condensate is pumped to the waste evaporator condensate tank if the water is to be reused or to a waste monitor tank if the water is to be discharged. Based on sample analysis, the water in the monitor tank would either be discharged or processed further by recirculation through the waste monitor tank demineralizer until sample analysis indicated that it was acceptable for discharge. The LWPS has sufficient capacity to allow total reuse of the processed clean wastes. However, in the release calculations, a discharge fraction of 1.0 is used since reuse of this water is not expected.

Figure 11.2-2, sheet 3, shows a process flow diagram of this path.

B. Dirty Wastes (Drain Channel B - Miscellaneous Wastes)

Dirty wastes are collected in the floor drain tank. A sample is analyzed to determine whether the water can be discharged without processing. If cleanup is required, the liquid is processed either by the waste monitor tank demineralizer while it is pumped to the waste monitor tank, or by the waste evaporator with the condensate directed to the waste monitor tank. The processing method used is determined based on the amount of cleanup required. Based on sample analysis, the monitor tank contents are either discharged or processed further by recirculation through the monitor tank demineralizer until sample analysis indicates that the water is acceptable for discharge. Since all of the dirty wastes are normally discharged, a discharge fraction of 1.0 is used in the release calculations.

Figure 11.2-2, sheet 4, shows a process flow diagram of this flow path.

C. Detergent Wastes (Laundry and Hot Shower Tank)

Detergent wastes are normally released without treatment. The releases through this path are assumed to be the same as listed in Reference 1, Table 2-20.

Figure 11.2-2, sheet 5, shows a process flow diagram of this flow path.

11.2.3.2.3 Steam Generator Blowdown Processing System (SGBPS)

The SGBPS is not part of the nuclear power block. However, operation of a typical Westinghouse design SGBPS is assumed in order to estimate secondary side source terms and releases. Blowdown from the steam generators is normally processed by the two steam generator blowdown demineralizers (in series) and recycled back to the main condenser. If discharge of blowdown is desired, the demineralizers can be bypassed, however, in the event of a primary to secondary side leak, the demineralizers would be in use. For the release calculation, a 100 lb/day primary to secondary side leakage is assumed. Also, a total blowdown rate of 54,000 lb/hr is assumed with 10 percent of the flow being discharged. This blowdown rate is 30 percent of system capacity, which is the expected average blowdown flow.

No credit is taken for radioactive decay of the isotopes in the blowdown stream since the SGBPS design utilizes a through-flow process with no significant decay.

Figure 11.2-2, sheet 6, shows a process flow diagram of this flow path.

11.2.3.2.4 Condensate Cleanup System

The condensate cleanup system is not part of the nuclear power block. For the purpose of estimating secondary side source terms and releases, it is assumed that the characteristics of this system are identical to those used in the sample GALE run included in Reference 1.

11.2.3.2.5 Turbine Building Floor Drains

The processing of turbine building drains is not in the scope of the nuclear power block. The drain water volume, activity level, and decontamination factors are assumed within the body of the GALE code (Reference 1).

REFERENCES

1. U.S. Nuclear Regulatory Commission, "Calculation of Releases from Pressurized Water Reactors," PWR-GALE Computer Code, NUREG-0017, April 1976.

TABLE 11.2-1 (SHEET 1 OF 3)

PARAMETERS USED IN THE CALCULATION OF ESTIMATED ACTIVITY
IN LIQUID WASTES

Collection Tank and Sources	Expected Input Rates[a]	Activity[b]	Basis	Disposition
1. Reactor coolant drain tank	300 gal/day	1.0 x (RCS) tritium; 0.1 x (RCS) other nuclides	RC pump No. 2 seal leakoff of 0.05 gal/min per pump	Directed to BRS recycle holdup tanks for recycle
2. Waste holdup tank	160 gal/day	0.423 x (RCS)		Recycled to reactor makeup water storage tank after processing
a. Equipment drains	110 gal/day	0.55 x (RCS)	ANSI/ANS-55.6-1979	
b. Sample room drains	50 gal/day	0.143 x (RCS)	(d)	
3. Floor drain tank	2620 gal/day (normal)	0.028 x (RCS)		Discharged to environment after sampling
a. Auxiliary building sump[c]	570 gal/day	0.01 x (RCS)	ANSI/ANS-55.6-1979	
b. Containment sump[c]	570 gal/day	0.106 x (RCS)	ANSI/ANS-55.6-1979	
c. Lab equipment rinse water	140 gal/day	0.[illegible]1 x (RCS)	(d)	

TABLE 11.2-1 (SHEET 2 OF 3)

Collection Tank and Sources	Expected Input Rates[a]	Activity[b]	Basis	Disposition
d. Area decontamination	40 gal/day (normal)	0.01 x (RCS)	ANSI/ANS-55.6-1979	
	3000 gal/day (shutdown)	0.01 x (RCS)		
e. Spent fuel pool liner leakage	700 gal/day	0.001 x (RCS)	ANSI/ANS-55.6-1979	
4. Chemical drain tank	10 gal/day	0.148 x (RCS)	(d)	Transferred to solid waste processing system.
5. Laundry and hot shower tank	500 gal/day (normal)	(e)		Discharged to environment after sampling
	3900 gal/day (shutdown)	(e)		
a. Laundry waste	300 gal/day (normal)	(e)	ANSI/ANS-55.6-1979	
	2000 gal/day (shutdown)	(e)	ANSI/ANS-55.6-1979	
b. Hot shower waste	Negligible (normal)	(e)	ANSI/ANS-55.6-1979	
	400 gal/day (shutdown)	(e)	ANSI/ANS-55.6-1979	
c. Hand washes	200 gal/day (normal)	(e)	ANSI/ANS-55.6-1979	
	1500 gal/day (shutdown)	(e)	ANSI/ANS-55.6-1979	
6. Boron recycle system	600 gal/day	(f)	1.5 RCS volumes purged per year for tritium control.	Discharged to environment after sampling

TABLE 11.2-1 (SHEET 3 OF 3)

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a. These rates do not represent system capacity.

b. Activity of the liquid wastes entering the LWPS is given in terms of a fraction of primary coolant activity as given in Section 11.1 unless stated otherwise.

c. Each sump may be directed to either the waste holdup or floor drain tank, depending upon water quality.

d. Expected input rates are based on a total rate of 200 gal/day in accordance with ANSI/ANS-55.6-1979, Reactor Systems Sampling. The total rate is divided among sample room drains, lab rinse water, and chemically contaminated samples.

e. Laundry and hot shower waste activity is taken from NUREG-0017, April 1976.

f. The 500 gal/day coming from the boron recycle system is a fraction of the liquid processed by that system. The activity of the water is primary coolant activity in accordance with Section 11.1 but reduced by the processing performed by the boron recycle system.

TABLE 11.2-2 (SHEET 1 OF 10)

EQUIPMENT DESIGN PARAMETERS

Pumps

RCDT Pumps	
Number	2
Type	Horizontal, centrifugal
Design pressure (psig)	150
Design temperature (°F)	200
Design flow (gal/min)	100/150[a]
Design head (ft)	260/250[a]
Material	Stainless steel (SS)
Waste evaporator feed pump	
Number	1
Type	Horizontal, centrifugal
Design pressure (psig)	150
Design temperature (°F)	200
Design flow (gal/min)	35/100[a]
Design head (ft)	250/200[a]
Material	SS
Waste evaporator condensate pump	
Number	1
Type	Horizontal, centrifugal
Design pressure (psig)	150
Design temperature (°F)	200
Design flow (gal/min)	35/100[a]
Design head (ft)	250/200[a]
Material	SS

TABLE 11.2-2 (SHEET 2 OF 10)

Chemical drain tank pump	
Number	1
Type	Horizontal, centrifugal
Design pressure (psig)	150
Design temperature (°F)	200
Design flow (gal/min)	35/100[a]
Design head (ft)	250/200[a]
Material	SS
Spent resin sluice pump	
Number	1
Type	Horizontal, centrifugal
Design pressure (psig)	150
Design temperature (°F)	200
Design flow (gal/min)	100/150[a]
Design head (ft)	260/250[a]
Material	SS
Laundry and hot shower tank pump	
Number	1
Type	Horizontal, centrifugal
Design pressure (psig)	150
Design temperature (°F)	200
Design flow (gal/min)	35/100[a]
Design head (ft)	250/200[a]
Material	SS

Floor drain tank pump	
Number	1
Type	Horizontal, centrifugal
Design pressure (psig)	150
Design temperature (°F)	200
Design flow (gal/min)	35/100[a]
Design head (ft)	250/200[a]
Material	SS
Waste monitor tank pumps	
Number	2
Type	Horizontal, centrifugal
Design pressure (psig)	150
Design temperature (°F)	200
Design flow (gal/min)	35/100[a]
Design head (ft)	250/200[a]
Material	SS
<u>Filters</u>	
Waste evaporator feed filter	
Number	1
Type	Disposable cartridge
Design pressure (psig)	300
Design temperature (°F)	250
Design flow (gal/min)	250
Δp at design flow (psi)	5
Size of particles, 98% retention (μm) (nominal)	100
Materials	SS

TABLE 11.2-2 (SHEET 4 OF 10)

Waste evaporator condensate filter	
Number	1
Type	Disposable cartridge
Design pressure (psig)	200
Design temperature (°F)	250
Design flow (gal/min)	35
Δp at design flow (psi)	5
Size of particles, 98% retention (μm) (nominal)	25
Material	SS
Spent resin sluice filter	
Number	1
Type	Disposable cartridge
Design pressure (psig)	300
Design temperature (°F)	250
Design flow (gal/min)	250
Δp at design flow (psi) (unfouled)	5
Size of particles, 98% retention (μm) (nominal)	25
Material	SS
Laundry and hot shower tank filter	
Number	1
Type	Disposable cartridge
Design pressure (psig)	200
Design temperature (°F)	250
Design flow (gal/min)	35
Δp at design flow (psi) (unfouled)	5
Size of particles, 98% retention (μm) (nominal)	25
Material	SS

TABLE 11.2-2 (SHEET 5 OF 10)

Floor drain tank filter	
Number	1
Type	Disposable cartridge
Design pressure (psig)	300
Design temperature (°F)	250
Design flow (gal/min)	250
Δp at design flow (psi) (unfouled)	5
Size of particles, 98% retention (μm) (nominal)	100
Material	SS
Waste monitor tank filter	
Number	1
Type	Disposable cartridge
Design pressure (psig)	200
Design temperature (°F)	250
Design flow (gal/min)	35
Δp at design flow (psi) (unfouled)	5
Size of particles, 98% retention (μm) (nominal)	25
Material	SS

Strainers

Laundry and hot shower tank strainer	
Number	1
Type	Basket
Design pressure (psig)	150
Design temperature (°F)	200
Design flow (gal/min)	35
Δp at design flow (psi)	Negligible
Strainer mesh number	40
Material	SS

Floor drain tank strainer

Number	1
Type	Basket
Design pressure (psig)	150
Design temperature (°F)	200
Design flow (gal/min)	35
Δp at design flow (psi)	Negligible
Strainer mesh number	40
Material	SS

Evaporator

Waste evaporator

Number	1
Type	Forced circulation
Design flow (gal/min)	25
Feed concentration (ppm boron)	10-2,500
Bottoms concentration (ppm boron)	7000-21,000
Process decontamination factors(b)	1000 for iodine; 10,000 for cesium and all other nuclides

Heat Exchanger

RCDT heat exchanger

Number	1	
Type	U-tube	
Estimated UA (Btu/hr/°F)	70,000	
	Shell Side	Tube Side
Design pressure (psig)	150	240
Design temperature (°F)	250	200
Design flow (lb/hr)	112,000	44,600
Temperature inlet (°F)	105	180
Temperature outlet (°F)	125	130
Material	Carbon Steel	SS

TABLE 11.2-2 (SHEET 7 OF 10)

Demineralizers

Waste evaporator condensate demineralizer

Number	1
Type	Flushable
Design pressure (psig)	300
Design temperature (°F)	250
Design flow (gal/min)	120
Resin volume (ft^3)	30
Material	SS
Resin type	IRN-150[c]
Process decontamination factors[b]	10 for iodine; 10 for cesium; 10 for all other nuclides[d]

Waste monitor tank demineralizer

Number	1
Type	Flushable
Design pressure (psig)	300
Design temperature (°F)	250
Design flow (gal/min)	120
Resin volume (ft^3)	30
Material	SS
Resin type	IRN-150[c]
Process decontamination factors[b]	100 for iodine; 2 for cesium; 100 for all other nuclides[d]

TABLE 11.2-2 (SHEET 8 OF 10)

Tanks

Reactor Coolant Drain Tank	
Number	1
Usable volume (gal)	350
Type	Horizontal
Internal design pressure (psig)	100
External design pressure (psig)	60
Design temperature (°F)	250
Material	SS
Waste holdup tank	
Number	1
Usable volume (gal)	10,000
Type	Vertical
Design pressure (psig)	Atmospheric
Design temperature (°F)	200
Material	SS
Waste evaporator condensate tank	
Number	1
Usable volume (gal)	5000
Type	Vertical with diaphragm
Design pressure (psig)	Atmospheric
Design temperature (°F)	200
Material	SS

TABLE 11.2-2 (SHEET 9 OF 10)

Chemical drain tank	
Number	1
Usable volume (gal)	600
Type	Vertical
Design pressure (psig)	Atmospheric
Design temperature (°F)	200
Material	SS
Spent resin storage tank	
Number	1
Resin/total volume (ft^3)	250/550
Type	Vertical
Design pressure (psig)	150
Design temperature (°F)	200
Material	SS
Laundry and hot shower tank	
Number	1
Usable volume (gal)	10,000
Type	Vertical
Design pressure (psig)	Atmospheric
Design temperature (°F)	200
Material	SS
Floor drain tank	
Number	1
Usable volume (gal)	10,000
Type	Vertical
Design pressure (psig)	Atmospheric
Design temperature (°F)	200
Material	SS

TABLE 11.2-2 (SHEET 10 OF 10)

Waste monitor tank	
Number	2
Usable volume (gal)	5000
Type	Vertical
Design pressure (psig)	Atmospheric
Design temperature (°F)	200
Material	SS
Waste evaporator reagent tank	
Number	1
Usable volume (gal)	5
Type	Vertical
Design pressure (psig)	150
Design temperature (°F)	200
Material	SS

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a. Denotes two design conditions.

b. Decontamination factors are taken from "Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from Pressurized Water Reactors (PWR-GALE Code)," Office of Standards Development, U.S. Nuclear Regulatory Commission, NUREG-0017, April 1976.

c. Rohm and Haas Amberlite or equivalent (H+ OH- form).

d. The process decontamination factor is 10 for iodine, cesium, and all other nuclides when used as a second demineralizer in a series.

TABLE 11.2-3

RANGE OF MEASURED DECONTAMINATION
FACTORS FOR SELECTED ISOTOPES

Isotope	Minimum	Maximum
I-131	1.1×10^1	1.6×10^4
I-133	1.1×10^1	1.8×10^4
I-135	1.4×10^1	2.0×10^4
Cs-137	2.4	1.3×10^3
F-18	1.73×10^1	1.5×10^3
Co-58	3.2×10^1	8.2×10^3
Mn-54	$>2.5 \times 10^1$	$>1.3 \times 10^2$

These values were observed across mixed bed demineralizers containing cation resin in the lithium-7 form and anion resin in the borated form.

TABLE 11.2-4 (SHEET 1 OF 4)

PARAMETERS SPECIFIED BY REGULATORY GUIDE 1.112 APPENDIX B
(INPUT PARAMETERS FOR THE GALE COMPUTER CODE)

Description	Value
Thermal power level (MWt)	4200
Mass of primary coolant (lb)	6.7×10^5
Primary system letdown rate (gal/min)	100
Letdown cation demineralizer flowrate (gal/min)	10
Number of steam generators	4
Total steam flow (lb/hr)	1.708×10^7
Mass of steam in each steam generator (lb)	1.05×10^4
Mass of liquid in each steam generator (lb)	1.245×10^5
Total mass of secondary coolant	2.16×10^6
Total blowdown rate (lb/hr)	5.4×10^4
Condensate demineralizer regeneration time, days	28
Condensate demineralizer flow fraction	0.65
Radwaste dilution flow (gal/min)	Later
Shim Bleed	
Shim bleed flowrate (gal/day)	2.5×10^3
Decontamination factor for I	10^5
Decontamination factor for Cs and Rb	4×10^4
Decontamination factor for others	10^6
Collection time (day)	28.7
Process and discharge time (day)	1.9
Fraction discharged	0.214

TABLE 11.2-4 (SHEET 2 OF 4)

Description	Value
Equipment Drains	
Equipment drains flowrate (gal/day)	300
Fraction of reactor coolant activity	1.0
Decontamination factor for I	10^5
Decontamination factor for Cs and Rb	4×10^4
Decontamination factor for others	10^6
Collection time (day)	28.7
Process and discharge time (day)	1.9
Fraction discharged	0.214
Clean Waste	
Clean waste input flowrate (gal/day)	160
Fraction of reactor coolant activity	0.423
Decontamination factor for I	10^3
Decontamination factor for Cs and Rb	10^4
Decontamination factor for others	10^4
Collection time (day)	25
Process and discharge time (day)	0.11
Fraction discharged	1.0

TABLE 11.2-4 (SHEET 3 OF 4)

Description	Value
Dirty Waste	
Dirty waste input flowrate (gal/day)	2.62×10^3
Fraction of reactor coolant activity	0.028
Decontamination factor for I	10^3
Decontamination factor for Cs and Rb	10^4
Decontamination factor for others	10^4
Collection time (day)	1.5
Process and discharge time (day)	0.11
Fraction discharged	1.0
Blowdown Waste	
Blowdown fraction processed	1.0
Decontamination factor for I	10^3
Decontamination factor for Cs and Rb	10^2
Decontamination factor for others	10^3
Collection time (day)	0.0
Process and discharge time (day)	0.0
Fraction discharged	0.1
Condensate Demineralizer Regenerant Solution	
Regenerant Flowrate (gal/day)	
Decontamination factor for I	10^4
Decontamination factor for Cs and Rb	10^5
Decontamination factor for others	10^5

TABLE 11.2-4 (SHEET 4 OF 4)

Description	Value
Collection time (day)	4.8
Process and discharge time (day)	0.44
Fraction discharged	0.1
Gaseous Waste System	
Holdup time for xenon (day)	60
Holdup time for krypton (day)	3
Fill time of decay tanks for gas stripper	0.0
Gas waste system: HEPA?	No
Auxiliary building: charcoal?	No
Auxiliary building: HEPA?	Yes
Containment volume (ft^3)	3.1×10^6
Containment atmosphere cleanup rate (ft^3/min)	25×10^3
Containment shutdown purge: charcoal?, HEPA?	No, yes
Number purge per year	24
Containment normal purge rate (ft^3/min); charcoal?, HEPA?	0.0, NA, NA
Fraction of iodine released from blowdown tank vent	0
Fraction of iodine released from main condenser air ejector	1.0
Detergent waste decontamination factor	1.0

TABLE 11.2-5 (SHEET 1 OF 3)

CALCULATED RELEASES OF RADIOACTIVE MATERIALS IN LIQUID
EFFLUENTS ASSUMING EXPECTED FUEL LEAKAGE

ANNUAL RELEASES TO DISCHARGE CANAL

Nuclide	Boron Recycle (Curies)	Misc. Wastes (Curies)	Secondary (Curies)	Turb Bldg (Curies)	Total LWS (Curies)	Adjusted Total (Curies)	Detergent Wastes (Curies)	Total (Curies)
CR 51	1.92E-07	2.93E-05	2.71E-09	1.06E-06	3.05E-05	1.00E-04	a	1.00E-04
MN 54	4.43E-08	5.43E-06	9.15E-10	2.38E-07	5.71E-06	1.88E-05	1.00E-03	1.00E-03
FE 55	2.35E-07	2.83E-05	3.77E-09	9.51E-07	2.95E-05	9.69E-05	a	9.70E-05
FE 59	1.17E-07	1.62E-05	2.15E-09	7.10E-07	1.70E-05	5.59E-05	a	5.60E-05
CO 58	2.03E-06	2.68E-04	3.18E-08	9.49E-06	2.80E-04	9.18E-04	4.00E-03	4.90E-03
CO 60	2.95E-07	3.55E-05	4.27E-09	1.07E-06	3.68E-05	1.21E-04	8.70E-03	8.80E-03
BR 83	7.90E-14	2.31E-05	b	1.20E-06	2.43E-05	7.97E-05	a	8.00E-05
BR 84	b	1.89E-07	b	5.50E-10	1.89E-07	6.22E-07	a	6.22E-07
RB 86	5.10E-07	1.23E-06	6.41E-11	5.32E-08	1.80E-06	5.90E-06	a	5.90E-06
RB 88	b	5.40E-08	b	5.63E-12	5.40E-08	1.77E-07	a	1.77E-07
SR 89	4.21E-08	5.74E-06	7.44E-10	2.37E-07	6.02E-06	1.98E-05	a	2.00E-05
SR 90	1.48E-09	1.78E-07	1.91E-11	4.76E-09	1.84E-07	6.04E-07	a	6.04E-07
Y 90	1.50E-09	1.01E-07	1.92E-11	1.18E-09	1.04E-07	3.41E-07	a	3.41E-07
SR 91	7.86E-11	2.00E-06	2.27E-15	1.45E-07	2.14E-06	7.03E-06	a	7.03E-06
Y 91M	5.07E-11	1.29E-06	1.47E-15	9.35E-08	1.38E-06	4.54E-06	a	4.54E-06
Y 91	8.50E-09	1.13E-06	1.20E-10	3.61E-08	1.17E-06	3.85E-06	a	3.85E-06
Y 93	5.13E-12	1.10E-07	1.92E-16	7.46E-09	1.17E-07	3.85E-07	a	3.85E-07
ZR 95	7.52E-09	9.99E-07	1.56E-10	4.74E-08	1.05E-06	3.46E-06	1.4E-03	1.40E-3
NB 95	7.56E-09	8.99E-07	1.84E-10	4.75E-08	9.55E-07	3.13E-06	2.0E-03	2.00E-3
MO 99	1.11E-06	7.54E-04	7.42E-09	4.43E-05	8.00E-04	2.63E-03	a	2.60E-03
TC 99M	1.06E-06	6.69E-04	7.09E-09	3.61E-05	7.07E-04	2.32E-03	a	2.30E-03
RU103	5.08E-09	7.21E-07	6.89E-11	2.37E-08	7.50E-07	2.46E-06	1.40E-04	1.40E-04
RH103M	5.09E-09	7.24E-07	6.90E-11	2.36E-08	7.53E-07	2.47E-06	a	2.47E-06
RU106	1.44E-09	1.76E-07	1.84E-11	4.75E-09	1.82E-07	5.97E-07	2.40E-03	2.40E-03
RH106	1.44E-09	1.76E-07	1.84E-11	4.75E-09	1.82E-07	5.97E-07	a	5.97E-07
AG110M	b	b	b	b	b	b	4.40E-04	4.40E-04

TABLE 11.2-5 (SHEET 2 OF 3)

CALCULATED RELEASES OF RADIOACTIVE MATERIALS IN LIQUID EFFLUENTS ASSUMING EXPECTED FUEL LEAKAGE

ANNUAL RELEASES TO DISCHARGE CANAL

Nuclide	Boron Recycle (Curies)	Misc. Wastes (Curies)	Secondary (Curies)	Turb Bldg (Curies)	Total LWS (Curies)	Adjusted Total (Curies)	Detergent Wastes (Curies)	Total (Curies)
TE125M	3.56E-09	4.79E-07	3.81E-11	1.19E-08	4.95E-07	1.62E-06	a	1.62E-06
TE127M	3.75E-08	4.78E-06	4.23E-10	1.19E-07	4.94E-06	1.62E-05	a	1.60E-05
TE127	3.72E-08	6.53E-06	4.19E-10	2.57E-07	6.82E-06	2.24E-05	a	2.20E-05
TE129M	1.51E-07	2.21E-05	1.96E-09	7.09E-07	2.30E-05	7.54E-05	a	7.50E-05
TE129	9.71E-08	1.43E-05	1.26E-09	4.58E-07	1.49E-05	4.88E-05	a	4.90E-05
I130	6.65E-09	8.06E-05	4.28E-12	3.24E-06	8.39E-05	2.75E-04	a	2.80E-04
TE131M	8.36E-09	1.67E-05	1.65E-11	1.01E-06	1.77E-05	5.81E-05	a	5.80E-05
TE131	1.53E-09	3.05E-06	3.01E-12	1.85E-07	3.23E-06	1.06E-05	a	1.10E-05
I131	1.27E-04	3.28E-02	6.31E-06	6.42E-04	3.36E-02	1.10E-01	6.20E-05	1.10E-01
TE132	4.41E-07	2.54E-04	2.59E-09	1.12E-05	2.66E-04	8.72E-04	a	8.70E-04
I132	4.54E-07	1.76E-03	3.77E-09	3.98E-05	1.80E-03	5.90E-03	a	5.90E-03
I133	5.71E-06	2.11E-02	2.48E-08	7.17E-04	2.18E-02	7.16E-02	a	7.20E-02
I134	b	2.23E-05	b	3.19E-07	2.26E-05	7.43E-05	a	7.40E-05
CS134	2.57E-04	4.41E-04	3.63E-08	1.59E-05	7.13E-04	2.34E-03	1.30E-02	1.50E-02
I135	3.77E-08	3.95E-03	4.83E-13	2.02E-04	4.15E-03	1.36E-02	a	1.40E-02
CS136	6.31E-05	1.76E-04	7.48E-09	8.06E-06	2.47E-04	8.12E-04	a	8.10E-04
CS137	1.87E-04	3.19E-04	2.67E-08	1.15E-05	5.18E-04	1.70E-03	2.40E-02	2.60E-02
BA137M	1.75E-04	2.98E-04	2.50E-08	1.07E-05	4.84E-04	1.59E-03	a	1.60E-03
BA140	1.50E-08	2.98E-06	1.85E-10	1.17E-07	3.11E-06	1.02E-05	a	1.00E-05
LA140	1.70E-08	2.73E-06	2.12E-10	8.55E-08	2.84E-06	9.31E-06	a	9.31E-06
CE141	7.46E-09	1.10E-06	1.28E-10	4.73E-08	1.15E-06	3.79E-06	a	3.79E-06
CE143	1.62E-10	2.78E-07	2.37E-13	1.03E-08	2.89E-07	9.48E-07	a	9.48E-07
PR143	3.88E-09	7.18E-07	4.13E-11	2.36E-08	7.46E-07	2.45E-06	a	2.45E-06
CE144	4.71E-09	5.78E-07	9.12E-11	2.38E-08	6.06E-07	1.99E-06	5.20E-03	5.20E-03
PR144	4.71E-09	5.78E-07	9.12E-11	2.38E-08	6.06E-07	1.99E-06	a	1.99E-06

TABLE 11.2-5 (SHEET 3 OF 3)

CALCULATED RELEASES OF RADIOACTIVE MATERIALS IN LIQUID EFFLUENTS ASSUMING EXPECTED FUEL LEAKAGE

ANNUAL RELEASES TO DISCHARGE CANAL

Nuclide	Boron Recycle (Curies)	Misc. Wastes (Curies)	Secondary (Curies)	Turb Bldg (Curies)	Total LWS (Curies)	Adjusted Total (Curies)	Detergent Wastes (Curies)	Total (Curies)
NP239	1.22E-08	1.02E-05	7.33E-11	6.56E-07	1.09E-05	3.57E-05	a	3.57E-05
All others	1.36E-10	8.87E-09	3.03E-12	4.30E-11	9.05E-09	2.97E-08	a	2.97E-08
TOTAL (Except tritium)	8.22E-04	6.31E-02	6.50E-06	1.76E-03	6.57E-02	2.16E-01	6.23E-02	2.80E-01

Tritium Release 840 curies per year

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a. No value provided in the source term utilized in the GALE code.
b. Value is less than 10^{-15}.

TABLE 11.2-6 (SHEET 1 OF 2)

RADIOACTIVE LIQUID RELEASES FROM WESTINGHOUSE-DESIGNED PRESSURIZED WATER REACTOR PLANTS (ZIRCALOY FUEL CLADDING)

Plant	Year	Primary Coolant[a] Activity, Fraction of Design Basis	Total Annual Release (Ci)	Average Discharge Concentration (μCi/ml)
R. E. Ginna	1972	0.126	0.375	5.18×10^{-10}
	1973	0.023	0.074	9.74×10^{-11}
	1974	0.025	0.138	2.15×10^{-10}
	1975	0.013	0.420	6.09×10^{-10}
	1976	0.064	0.689	1.09×10^{-9}
	1977	0.033	0.065	9.01×10^{-11}
H. B. Robinson 2	1972	0.006	0.371	3.4×10^{-9}
	1973	0.003	0.306	2.1×10^{-9}
	1974	0.003	2.9	5.2×10^{-9}
	1975	0.002	0.44	6.79×10^{-10}
	1976	<0.001	0.375	6.07×10^{-10}
	1977	<0.001	0.329	4.7×10^{-10}
Point Beach 1 and 2	1972	0.062	0.934	1.9×10^{-9}
	1973	0.015	0.746	7.39×10^{-10}
	1974	0.101	0.196	3.29×10^{-10}
	1975	0.049	3.35	6.03×10^{-9}
	1976	0.012	3.24	6.17×10^{-9}
	1977	0.009	1.5	2.6×10^{-9}
Surry 1 and 2	1972	<0.001	0.083	6.04×10^{-10}
	1973	0.001	0.145	2.[illegible]5 $\times 10^{-10}$
	1974	<0.001	29.2	2.32×10^{-8}
	1975	0.002	27.5	1.12×10^{-8}
	1976	0.011	33.7	1.45×10^{-8}
	1977	0.005	65.5	2.58×10^{-8}

TABLE 11.2-6 (SHEET 2 OF 2)

Plant	Year	Primary Coolant[a] Activity, Fraction of Design Basis	Total Annual Release (Ci)	Average Discharge Concentration (μCi/ml)
Turkey Point 3 and 4	1973	<0.001	0.037	1.97×10^{-10}
	1974	0.010	1.69	3.21×10^{-9}
	1975	0.012	3.07	2.31×10^{-9}
	1976	0.006	8.65	2.92×10^{-10}
	1977	0.005	8.9	5.06×10^{-9}
Zion 1 and 2	1973	<0.001	<0.001	2.77×10^{-13}
	1974	<0.001	0.005	8.03×10^{-12}
	1975	0.003	0.0087	1.18×10^{-11}
	1976	0.013	0.16	1.58×10^{-11}
	1977	0.009	0.95	8.33×10^{-10}
Prairie Island 1 and 2	1974	0.002	<0.001	2.29×10^{-12}
	1975	0.006	0.45	1.18×10^{-9}
	1976	0.008	<0.012	$<3.59 \times 10^{-11}$
	1977	0.008	0.013	1.41×10^{-11}
Kewaunee	1974	0.012	0.422	3.49×10^{-9}
	1975	0.005	0.447	2.68×10^{-9}
	1976	0.002	2.85	2.32×10^{-8}
	1977	<0.001	1.26	8.69×10^{-9}
Donald C. Cook 1	1975	<0.001	0.26	3.19×10^{-9}
	1976	0.003	1.87	2.69×10^{-8}
	1977	0.005	1.52	2.09×10^{-8}

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a. Inferred by radioiodine in reactor coolant - includes diffusion and recoil sources.

FIGURE 11.2-1 SHEET 1
(FOLDOUT)
PROPRIETARY

FIGURE 11.2-1 SHEET 2
(FOLDOUT)
PROPRIETARY

FIGURE 11.2-1 SHEET 3
(FOLDOUT)
PROPRIETARY

FIGURE 11.2-1 SHEET 4
(FOLDOUT)
PROPRIETARY

(a,c)

Chemical and Volume Control System

Figure 11.2-2
(Sheet 1)

Liquid Waste Management Systems

Process Flow Diagram

(a,c)

Boron Recycle System

Figure 11.2-2
(Sheet 2)

Liquid Waste Management Systems

Process Flow Diagram

(a,c)

Liquid Waste Processing System
Train "A" - Clean Waste

Figure 11.2-2
(Sheet 3)

Liquid Waste Management Systems

Process Flow Diagram

(a,c)

Liquid Waste Processing System
Train "B" - Dirty Waste

Figure 11.2-2
(Sheet 4)

Liquid Waste Management System
Process Flow Diagram

(a,c)

Liquid Waste Processing System
Laundry and Hot Shower Waste

Figure 11.2-2
(Sheet 5)

Liquid Waste Management Systems

Process Flow Diagram

(a,c)

Steam Generator
Blowdown Processing System

Figure 11.2-2
(Sheet 6)

Liquid Waste Management System

Process Flow Diagram

11.3 GASEOUS WASTE PROCESSING SYSTEM (GWPS)

During reactor operation, radioactive isotopes of xenon, krypton and iodine are created as fission products. A portion of these radionuclides are released to the reactor coolant due to a small number of fuel cladding defects. Any leakage of reactor coolant thus results in a release to the atmosphere of the noble gases and a portion of the iodines contained. Therefore, to limit airborne releases it is necessary not only to restrict reactor coolant leakage but to restrict the concentrations of radioactive noble gases and iodines. Iodine removal is accomplished by ion exchange process in the chemical and waste processing system (CVCS) as indicated on Figure 11.2-2, Sheet 1. The noble gases are removed from the reactor coolant by a continuous purge of the CVCS volume control tank (VCT) vapor space. The purge flow is directed to the GWPS for processing to minimize the releases of radioactive noble gases to the environment. The GWPS performs this function by using temporary adsorption of xenon and krypton on charcoal to permit most of the radioactivity to decay away before it is released to the atmosphere.

11.3.1 Design Bases

11.3.1.1 Source Terms

Virtually all the radioactive gas flowing into the GWPS enters as trace contamination in a stream of hydrogen.

The primary source of radioactive gas is the volume control tank (VCT) purge. Hydrogen gas enters the VCT, stripping the fission gases from the vapor phase as it is vented to the GWPS.

The source term model is a realistic one and is used to determine expected GWPS inventory and releases. This model is based on the American National Standard Source Specification, N-237. Table 11.1-4 lists the activities in the VCT vapor space that are associated with this model and Table 11.1-2 lists the primary and secondary coolant activities.

11.3.1.2 Expected Releases and Doses

The GWPS is designed to collect, process, and delay release of radioactive gaseous wastes generated due to plant operations including anticipated operational occurrences. The system is designed to assure that during normal operation the release of gaseous effluent from the plant and the expected offsite doses are as low as reasonably achievable (ALARA) as defined in Appendix I of 10CFR50. An evaluation of plant conformance to Appendix I is given in Section 11.3.3.

The GWPS is designed to continuously discharge gaseous waste to the environment with activity levels reduced by radioactive decay. A decay period of 60 days is provided for xenon isotopes and 3 days for krypton isotopes through the temporary adsorption of these gases on the charcoal beds in the process path. In this way, the GWPS conforms to the requirements of General Design Criterion 60.

11.3.1.3 Accommodation of Surges

The design of the GWPS is based on a continuous inflow of 0.7 scfm from the VCT purge. Venting of other equipment to the GWPS does not create surges in the VCT purge processing since these vent gases are handled separately, eventually being transferred to the VCT.

The GWPS is designed to be free from surges in the process flow path leading through the charcoal adsorption beds. This flow path does not experience flow surges as a result of plant startups, plant shutdowns, or equipment downtime.

The purge flow from the VCT can be administratively increased above the normal 0.7 scfm. The delay times for krypton and xenon would be reduced proportionately to the increase in total flow through the charcoal. The maximum VCT purge flow to the GWPS would be 1.2 scfm.

11.3.1.4 System Leakage

The GWPS operates at pressures not far above atmospheric thus limiting the potential for leakage. Leakage from the GWPS is further limited through the use of welded connections wherever not restricted due to maintenance requirements. All control valves are provided with bellows seals to minimize leakage through the valve topworks. Wherever possible, manual valves are of the diaphragm type to prevent leakage.

11.3.1.5 Monitoring Releases

Releases from the GWPS are continuously monitored by a radiation monitor in the plant vent. In addition, the system design includes provisions for taking grab samples of the discharge flow stream for analysis. In this manner, the requirements of General Design Criterion 64 are responded to.

11.3.1.6 Control of Releases Due to Operator Error or Equipment Malfunction

In order to control the release of radioactive gases resulting from equipment failure or operator error, the discharge line from the GWPS is automatically isolated on a high plant vent radiation signal. The GWPS design is such that an equipment failure might require that the system be isolated for maintenance but no significant inadvertent release would occur.

Few operator actions are required during GWPS operation since, once aligned for operation, the GWPS operates automatically in response to the control signals from the instrumentation supplied. The potential for operator error is therefore small.

11.3.1.7 Protection From Explosion

Since the GWPS process stream consists mainly of hydrogen, there is the potential for an explosion should a significant amount of oxygen enter the system. Instead of designing the GWPS to withstand an explosion, the system is provided with redundant oxygen analyzers at two locations in the system.

One set of analyzers monitors the incoming VCT purge gas stream while the other set monitors the combined vent gases coming from all other equipment. Each analyzer has a high alarm and a high-high alarm. Coincident with the high-high alarm, corrective actions are automatically taken to avoid continued buildup of oxygen concentration. Connections are provided to the nitrogen supply header to allow the gas stream to be diluted with nitrogen if desired.

11.3.1.8 Component Design Parameters

The GWPS component design parameters are listed in Table 11.3-1.

11.3.1.9 Seismic and Safety Classification

The GWPS components and piping are not designed to withstand a seismic event and are classified as Non-Nuclear Safety Class. The GWPS design is consistent with the guidelines of NRC Regulatory Guide 1.143, Revision 1, in these regards.

11.3.2 System Description

The GWPS receives and delays release of fission gases that have been stripped from the reactor coolant in the VCT by a hydrogen gas purge flow. The flow to the GWPS thus consists of hydrogen with trace amounts of fission gases. The constant removal of the fission gases by the hydrogen purge of the VCT maintains the fission gas concentration in the reactor coolant at a low residual level. This minimizes the escape of radioactive gases during maintenance operations on the reactor coolant system (RCS) or resulting from leakage of reactor coolant liquid.

The GWPS uses charcoal at ambient temperature to slow the passage of radioactive gases through the system. When operating at design conditions the mass of charcoal provided in the GWPS is sufficient to provide a minimum of 60 days delay from xenon and a minimum of 3 days delay for krypton. The carrier gases (hydrogen or nitrogen) are not delayed by the charcoal.

Sampling capability is provided downstream of the charcoal adsorption tanks. Analyses of these samples provides indication of the GWPS performance when they are compared with VCT vapor space sample analyses.

With the GWPS normally containing a hydrogen flow stream, care is taken to assure that oxygen is excluded from the system. The GWPS is operated at positive pressure at all times to prevent any possibility of oxygen inleakage. Gases entering the GWPS are continuously monitored by redundant oxygen analyzers. The analyzers provide alarms and automatic actuation of equipment if oxygen levels above preset limits are detected, thus preventing the gas stream from reaching a potentially flammable hydrogen-oxygen mixture. The operator may inject nitrogen into the GWPS to obtain dilution. Nitrogen purge is also used to clear a portion of the system of hydrogen before performing maintenance or of oxygen after maintenance is complete. Thus, the possibility of hydrogen ignition is very remote and the GWPS is not designed to withstand one.

The dilution of the hydrogen stream, when it is discharged into the plant vent, is so great that the 4 percent flammability limit for hydrogen in air will never be reached. Discharge from the GWPS is automatically terminated on low dilution flow.

Besides processing the VCT purge flow, the GWPS collects non-oxygen bearing vent gases and injects them into the VCT. In this manner, these gases are eventually returned to the GWPS via the VCT purge path where any fission gases will be subjected to the charcoal adsorption process thus delaying their release. By treating the vent gases in this manner there is the additional advantage that the flow through the charcoal beds is not subjected to flow surges.

In addition, the GWPS contains the nitrogen and hydrogen distribution headers.

The GWPS design is shown in detail in the piping and instrumentation diagram, Figure 11.3-1.

11.3.2.1 System Operation

11.3.2.1.1 Normal VCT Purge Flow Processing

During normal power operation, hydrogen is continuously purged through the VCT and to the GWPS to strip fission gases from the reactor coolant. After entering the GWPS, the gas stream passes through two redundant oxygen analyzers that continuously monitor the gas stream oxygen content. If the concentration of oxygen in the hydrogen stream approaches explosive limits, the inflow of gas to the GWPS is automatically terminated. Alarms are provided to annunciate high oxygen levels.

After leaving the oxygen analyzers, the gas stream is processed by the refrigerated waste gas dryer to remove water vapor. Removing moisture from the gas stream is necessary for proper operation of the GWPS since adsorption of water on the charcoal in the charcoal adsorption tanks would diminish the capability of the charcoal to adsorb fission gases. An analyzer monitors the gas stream leaving the gas dryer for humidity and automatically closes a downstream valve and actuates an alarm if a high humidity level is detected. After treatment by the gas dryer, the gas stream flows through one of two charcoal guard beds which are installed in parallel. The charcoal guard bed is provided to protect the downstream charcoal adsorption tanks from being exposed to the high humidity gas stream that would result from a failure of the refrigerated waste gas dryer and of the humidity analyzer. During normal operation the charcoal guard bed removes iodines and any residual moisture in the gas stream. A humidity analyzer downstream of the guard beds actuates an alarm if the guard bed in service becomes ineffective due to saturation. If this occurs, the flow path is realigned to pass through what had been the standby charcoal guard bed and to isolate the guard bed that had been in service.

Following the guard bed, the gas stream flows through a series of charcoal adsorption tanks which delay the passage of xenon and krypton isotopes. At design flow through the charcoal adsorption tanks, xenon is delayed by 60 days and krypton is delayed by 3 days while the hydrogen passes through without delay. These delay times allow all of the isotopes of concern, except krypton-85, to decay to very small fractions of the concentrations entering the GWPS. Because of its long half-life, the concentration of krypton-85 in the gas stream remains essentially unchanged by the 3 day delay.

Provisions are made to take a grab sample of the gas stream leaving the charcoal adsorption tanks.

The flow stream leaving the charcoal adsorption tanks next passes through the charcoal fines filter and then is directed either to the plant vent or to the gas surge tank and recycle line compressors for reuse as hydrogen purge flow to the VCT.

If the gas stream is being discharged to the plant vent, the discharge line will be automatically isolated on either a high plant vent radiation signal or a high plant vent hydrogen concentration signal.

Operation of the GWPS with the discharge hydrogen stream being recycled conserves hydrogen gas. With the exception of krypton-85, all gaseous isotopes in the hydrogen stream have decayed sufficiently during the transit of the GWPS to have no significant effect on the reactor coolant concentrations when the gas stream is recycled to the VCT. However, due to the long half-life of krypton-85, its concentration in the GWPS outlet stream is essentially the same as in the inlet stream with the result that, when the hydrogen stream is recycled, the concentration of krypton-85 in the reactor coolant will rise. To avoid excessive krypton-85 buildup in the reactor coolant, the GWPS must be operated in the release mode at least part of the time. Reactor coolant sample analysis would detect any excessive buildup of krypton-85 so that corrective action could be taken.

In the recycle mode, the hydrogen stream is directed to the inlet of the recycle line compressors. One or both of the compressors may be utilized depending on gas surge tank pressure. The gas surge tank provides a large volume to prevent rapid changes in pressure upstream of the compressor.

11.3.2.1.2 Equipment Vent Gas Processing

Besides processing the VCT purge flow, the GWPS receives vent gases from a number of components in the boron recycle system (BRS), the liquid waste processing system (LWPS), and the RCS.

Vent gases from the following components can be directed to the GWPS:

1. BRS recycle evaporator package
2. BRS recycle holdup tanks
3. LWPS reactor coolant drain tank
4. RCS pressurizer relief tank

The vent lines from the recycle evaporator package and the reactor coolant drain tank are normally open to the GWPS.

Venting of the recycle holdup tanks is performed administratively after a recycle holdup tank has accumulated a specified amount of gas under its diaphragm. The gas is pumped to the GWPS by the recycle holdup tank vent compressor. Provisions are included to permit taking a grab sample of the recycle holdup tank vent gas.

The pressurizer relief tank is vented to the GWPS only during maintenance operations.

The vent gases are all collected in the gas surge tank. Periodically, as controlled by gas surge tank pressure, the gas surge tank contents are pumped to the VCT by a recycle line compressor. In this way, the vent gases are not released directly but eventually are returned to the GWPS via the VCT purge path where they are subjected to the charcoal adsorption process thus delaying their release and reducing their activity by radioactive decay.

Before going to the compressors, the gas stream passes through two redundant oxygen analyzers that continuously monitor the gas stream. If the concentration of oxygen approaches its specified limit the compressors are automatically stopped. Alarms are provided to annunciate high oxygen levels.

11.3.2.1.3 Startup

Initial startup commences with the GWPS flushed free of air using nitrogen. This can be accomplished by either repeated pressurization of the system using nitrogen, each time venting to the plant vent, or by a feed and bleed process. Both nitrogen and oxygen pass through the charcoal beds without delay.

Initially during plant startup, the VCT purge flow is aligned to discharge directly to the plant vent. Upon removal of the air from the reactor coolant using nitrogen purge of the VCT, a hydrogen purge to the VCT is initiated to strip the nitrogen from the reactor coolant. When the reactor coolant hydrogen concentration reaches the required level, the VCT purge flow is directed to the charcoal beds and operation of the GWPS is resumed as described in Subsection 11.3.2.1.1.

11.3.2.1.4 Shutdown and Degassing of the RCS

If the unit is shutdown and it is necessary to remove the residual fission gases and hydrogen from the reactor coolant, operation of the GWPS remains unchanged until after the reactor coolant fission gas concentration is reduced to the required level. Then the VCT hydrogen supply is isolated, the VCT purge flow is directed to the plant vent, and a nitrogen purge of 5 scfm is initiated through the VCT to strip the hydrogen from the reactor coolant. The nitrogen purge is continued until the desired low hydrogen concentration in the reactor coolant is reached. Degassing is then complete and the RCS may be opened for maintenance or refueling. The charcoal beds are not in use and that portion of the system is isolated, maintaining a hydrogen atmosphere.

11.3.2.2 Component Description

Component parameters are given in Table 11.3-1. In keeping with the guidance of Regulatory Guide 1.143, Revision 1, the GWPS equipment is classified as Non-Nuclear Safety class and is not designed to withstand a seismic event.

11.3.2.2.1 Refrigerated Waste Gas Dryer

The refrigerated waste gas dryer cools the hydrogen purge stream from the VCT and condenses and removes water vapor to a dew point of 40°F before the gas enters the charcoal adsorption beds. Removal of the water vapor from the gas stream prolongs the life of the charcoal adsorption beds. The refrigerated waste gas dryer consists of a refrigerated chiller unit to cool the gas stream, and a separator to remove the condensed water vapor.

A humidity analyzer downstream of the gas dryer is provided to detect inadequate moisture removal.

11.3.2.2.2 Charcoal Guard Beds

Two charcoal guard beds are provided in parallel between the refrigerated waste gas dryer and the charcoal adsorption tanks. One guard bed is in service to protect the downstream charcoal adsorption tanks from being contaminated by water if failure occurs in both the refrigerated waste gas dryer and in the automatic process isolation on high humidity. During normal operation, the guard bed removes iodines and any residual moisture in the gas stream. The second guard bed is held in reserve to be brought into service if the first guard bed becomes ineffective in removing water vapor. A humidity analyzer downstream of the guard beds actuates an alarm if the gas stream water content exceeds desired limits.

The charcoal guard beds have provisions to allow replacement of the charcoal should it prove necessary.

Although the guard bed does provide fission gas adsorption capacity, no credit is assumed in designing the GWPS process delay for krypton and xenon since water adsorption on the guard bed results in declining effectiveness in noble gas adsorption.

11.3.2.2.3 Charcoal Adsorption Tanks

The charcoal adsorption tanks are vertical tanks connected in series to provide a long charcoal filled flow path for the waste gas stream. At design flow and temperature the total delay time provided by the charcoal adsorption tanks is 60 days for xenon and 3 days for krypton.

Although it is highly unlikely that charcoal would need to be replaced, each tank has provisions to facilitate charcoal replacement.

11.3.2.2.4 Charcoal Fines Filter

The charcoal fines filter is a disposable cartridge type filter placed downstream of the charcoal adsorption tanks. Its purpose is to filter out any charcoal particles that might be entrained in the hydrogen gas stream as the gas stream leaves the adsorption tanks. Filter cartridge change-outs are expected to be very infrequent.

11.3.2.2.5 Gas Surge Tank

Surge capacity in the recycle line compressor suction line is provided by the gas surge tank. The tank is provided to stabilize the pressure in the suction line to the compressors so the compressors will not be spuriously started or stopped by pressure surges. Gas surges from any of the various equipment vent lines will be dampened by the gas surge tank volume. The surge tank volume also stabilizes the pressure at the recycle line compressor suction while a compressor is running.

11.3.2.2.6 Recycle Holdup Tank Vent Compressor

The recycle holdup tank vent compressor is provided to pump the gases that have accumulated under a BRS recycle holdup tank diaphragm into the gas surge tank. The vent compressor is designed to accommodate any water that will condense out of the vent gas under compression. Operation of the vent compressor is initiated administratively and can be stopped manually or operated until a low suction pressure signal stops it automatically. The vent compressor is also stopped automatically on a high discharge pressure signal.

11.3.2.2.7 Recycle Line Compressors

Two recycle line compressors are provided to transfer gases from the GWPS to the VCT. The compressors are designed to accommodate any water that will condense out of the process gas under compression.

In the "discharge" mode of operation, normally only one compressor is required to operate. Either compressor can be used. The operator initially chooses one compressor to act as the intermittently run compressor, and the second compressor acts as the backup. The intermittent-running compressor starts on high suction pressure. Both compressors start on high-high suction tank pressure or manually. The intermittent-running compressor stops on low suction pressure.

In the "recycle" mode, one compressor is running continuously and one is used intermittently to relieve the gas surge tank pressure as necessary. The compressor chosen to run intermittently can be started manually or by high suction pressure. It is stopped manually or by low suction pressure.

Each compressor automatically stops on high discharge pressure, low suction pressure, or high-high suction oxygen concentration.

11.3.2.3 Instrumentation and Control

The GWPS instrumentation is shown on the piping and instrumentation diagram, Figure 11.3-1.

Instrumentation having remote readouts have the readouts on the GWPS panel. All alarms are shown separately on the GWPS panel and, in addition, any alarm on the GWPS panel also actuates one common GWPS annunciator on the main control board.

11.3.2.3.1 Flow Instrumentation

VCT Purge Flow (1-FT-1094)

This instrument monitors normal purge flow entering the GWPS from the VCT. Indication and high alarm function are provided on the GWPS panel. Instrument calibration is based on a hydrogen process stream.

VCT Purge Flow to Plant Vent (FT-1057)

This instrument provides local indication of purge flow bypassing the charcoal beds to the plant vent. Instrument calibration is based on a nitrogen process stream.

Recycle Holdup Tank Vent Flow (FT-1089)

This instrument provides local indication of the flow rate of recycle holdup tank vent line when vent gases are being pumped to the gas surge tank.

11.3.2.3.2 Pressure Instrumentation

Pressure instruments located in portions of the system that may contain radioactive gases are provided with diaphragm seals to prevent outleakage through the instrument.

Hydrogen Supply Header Pressure (PT-1065)

This instrument provides indication of the hydrogen supply header pressure locally and on the GWPS panel. A low alarm is provided on the GWPS panel.

Nitrogen Supply Header Pressure (PT-1066)

This instrument provides indication of the nitrogen supply header pressure locally and on the GWPS panel. A low alarm is provided on the GWPS panel.

Nitrogen Purge Pressure (PI-1047)

This instrument provides local indication of pressure in the GWPS nitrogen purge line downstream of the pressure control valve.

VCT Purge Pressure (1-PI-1095)

This instrument locally indicates the pressure in the VCT purge line at a point downstream of the pressure control valve.

Charcoal Fines Filter Pressure (PI-1038, PI-1039)

Local pressure indicators are located on the upstream and downstream sides of the charcoal fines filter to indicate the pressure drop across the filter.

Recycle Holdup Tank Vent Compressor Suction Pressure (PT-1029)

This instrument indicates locally the pressure on the suction side of the compressor. If the suction pressure should fall below 7-inches water column vacuum, the compressor is automatically switched off and an alarm on the GWPS panel is sounded.

Recycle Holdup Tank Vent Compressor Discharge Pressure (PT-1055)

This instrument indicates on the GWPS panel the pressure on the discharge side of the compressor. If the pressure in the compressor discharge line rises above the maximum discharge pressure of the compressor, the compressor is automatically switched off and an alarm is sounded on the GWPS panel. Indication is provided locally and on the GWPS panel.

Recycle Line Compressors Suction Pressure (PT-1052)

This instrument provides indications of compressor suction pressure on the GWPS panel. When the pressure in the suction line rises to the high setpoint, one of the recycle line compressors is automatically started. If the pressure drops to the low setpoint, the compressor is automatically stopped.

A high-high pressure switch is also provided. On reaching the high-high setpoint, the backup recycle line compressor is automatically started, the VCT purge line isolation valve is automatically closed and an alarm is actuated to alert the operator that the pressure in the gas surge tank is approaching the upper limit for proper operation of the BRS recycle evaporator.

Recycle Line Compressor Suction Pressure (PT-1053, PT-1054)

These instruments indicate, on the GWPS panel, the pressure on the suction side of each compressor. If the pressure in the suction line should approach atmospheric pressure, the compressor automatically is switched off and an alarm is sounded on the GWPS panel. This protects the compressors from being operated with the suction line valved closed.

Recycle Line Compressor Discharge Pressure (PT-1079, PT-1088)

These instruments measure the pressure on the discharge side of each compressor. If the pressure in the discharge line should rise to the maximum discharge pressure of the compressor, the compressor is switched off and an alarm is sounded. Indication is provided both locally and on the GWPS panel.

11.3.2.3.3 Gas Analysis Instrumentation

VCT Purge Line Oxygen Analyzers (AE-1074, AE-1075)

These redundant analyzers are provided upstream of the refrigerated waste gas dryer to detect the presence of oxygen. Indication is provided both locally and on the GWPS panel for each of the analyzers. The high alarm setpoint is well below the flammability limit for oxygen in hydrogen. If the oxygen concentration does approach the explosive limit, a high-high alarm is actuated and the VCT purge flow is automatically terminated. There is normally no oxygen in the flow stream.

Recycle Line Compressor Oxygen Analyzers (AE-1077, AE-1078)

These redundant analyzers are provided upstream of the recycle line compressors to detect the presence of oxygen. Indication is provided both locally and on the GWPS panel for each of the analyzers. The high alarm setpoint is well below the flammability limit for oxygen in hydrogen. If the oxygen concentration does approach the explosive limit, a high-high alarm is actuated and the recycle line compressors are stopped. There is normally no oxygen in the flow stream.

Refrigerated Waste Gas Dryer Outlet Humidity Analyzer (AE-1036)

This instrument monitors the humidity level of the waste gas stream leaving the refrigerated gas dryer. If the high setpoint is reached a valve downstream of the analyzer is automatically closed and a high alarm is actuated. Indication is provided both locally and on the GWPS panel.

Guard Bed Outlet Humidity Analyzer (AE-1037)

This instrument monitors the humidity level of the waste gas stream leaving the guard bed. A high alarm is provided to alert the operator that the guard bed is allowing moisture to pass through and that the gas stream should be diverted to pass through the standby guard bed. Indication is provided locally.

Plant Vent Hydrogen Analyzer (AE-1073)

This instrument monitors the hydrogen concentration within the plant vent to assure enough ventilation flow exists for proper hydrogen dilution. The discharge line to the plant vent is isolated and a high alarm is sounded on high hydrogen concentration in the plant vent. Indication is provided on the GWPS panel.

11.3.2.3.4 Radiation Instrumentation

Plant Vent Radiation (RE-014)

A radiation monitor is provided in the plant vent. Readout and high alarms from this monitor are provided on the GWPS and radiation monitoring systems panels. The discharge line to plant vent is isolated on high radiation.

11.3.3 Radioactive Releases

11.3.3.1 Discharge Requirements

Radioactive gaseous effluents and particulates discharged from the plant may not exceed the concentration limits specified in 10 CFR 20, Appendix B, Table II, column 1, or the dose limits specified in 10 CFR 50, Appendix I.

11.3.3.2 Estimated Releases

Radioactive effluent releases from the plant for normal operation are given in Table 11.3-2. These release rates were calculated using the PWR-GALE code (Reference 1) and plant operating parameters listed in Table 11.2-4.

Table 11.3-2 lists the calculated total annual release as well as the annual release from each of the following pathways:

1. GWPS
2. Containment ventilation
3. Aux bldg
4. Turbine bldg ventilation
5. Air ejector exhaust

11.3.3.3 Release Points for Determination of Dilution Factors

Gaseous and particulate radioactive effluents may be normally released through the plant vent and the turbine building vent.

11.3.3.4 Effluent Concentration and Dilution Factors

A comparison of offsite (at site boundary) airborne gaseous and particulate effluent concentrations with 10 CFR 20 limits is given in Table 11.3-3. These concentrations are based on the total annual releases given in Table 11.3-2 and on an assumed dilution factor of 2.75×10^{-5} sec/m^3 which is conservative for the large majority of nuclear plant sites.

11.3.3.5 Estimated Doses from Atmospheric Releases

Estimated annual average doses from continuous exposure at the site boundary to noble gases released to the atmosphere from the plant during normal operation are given in Table 11.3-4. These calculated doses are well within the guidelines of Appendix I to 10 CFR 50. Doses due to the release of iodines and particulates are not estimated since there is no site information providing definition of the various exposure pathways.

REFERENCES

1. U.S. Nuclear Regulatory Commission, "Calculation of Releases from Pressurized Water Reactors," PWR-GALE Computer Code, NUREG-0017, April 1976.

TABLE 11.3-1 (Sheet 1 of 3)

GWPS COMPONENT DESIGN PARAMETERS

REFRIGERATED WASTE GAS DRYER

Quantity	1
Design Temperature, °F	200
Design Pressure, psig	150
Design Flow, SCFM H_2	0.7
Material	SS
Operating Temperature (Inlet), °F	115
Operating Pressure, psig	2-15
Dew Point (Outlet), °F	40

CHARCOAL GUARD BEDS

Quantity	2
Design Temperature, °F	200
Design Pressure, psig	150
Design Flow, SCFM H_2	0.7
Material	SS
Operating Temperature °F	100
Operating Pressure, psig	2
Bed Life, years	40
Charcoal/Bed, lbs.	2140

TABLE 11.3-1 (Sheet 2 of 3)

GWPS COMPONENT DESIGN PARAMETERS

CHARCOAL ADSORPTION TANKS

Quantity	6
Design Temperature, °F	200
Design Pressure, psig	150
Design Flow, SCFM H_2	0.7
Material	CS
Operating Temperature °F	100
Operating Pressure, psig	2
Bed Life, years	40
Charcoal/Bed, lbs.	4300

CHARCOAL FINES FILTER

Quantity	1
Type	Disposable cartridge
Design Temperature, °F	200
Design Pressure, psig	150
Design Flow, SCFM H_2	1.4
ΔP at Design Flow, psi	0.1
ΔP Fouled, psi	0.5
Retention of 0.3μ particles, %	99.7
Material	SS
Operating Temperature °F	100
Operating Pressure, psig	2

TABLE 11.3-1 (Sheet 3 of 3)

GWPS COMPONENT DESIGN PARAMETERS

RECYCLE LINE COMPRESSORS

Quantity	2
Type	Diaphragm
Design Temperature, °F	200
Design Pressure, psig	150
Design Flow, SCFM H_2	1.4
Material	SS
Operating Temperature °F	100
Operating Pressure, psig	2
Operating Discharge Pressure, psig	15-40
Operating Flow, SCFM H_2	0.7

GAS SURGE TANK

Quantity	1
Type	Vertical, cylindrical
Design Temperature, °F	200
Design Pressure, psig	150
Volume, ft^3	300
Material	SS
Operating Temperature °F	100
Operating Pressure, psig	1.5 - 2

BRS RHT VENT COMPRESSOR

Quantity	1
Type	Diaphragm
Design Temperature, °F	200
Design Pressure, psig	150
Design Flow, SCFM H_2	1.0
Material	SS
Operating Temperature °F	115
Operating Suction Pressure, psig	0
Operating Discharge Pressure, psig	2
Operating Flow, SCFM H_2	1.0

TABLE 11.3-2

EXPECTED ANNUAL AVERAGE RELEASE OF AIRBORNE RADIONUCLIDES

Gaseous Release Rate (Ci/year)

Nuclide	GWPS	Building Ventilation: Containment	Building Ventilation: Auxiliary	Building Ventilation: Turbine	Air Ejector Exhaust	Total
Kr-83m	6.9E-10	1.5E-01	3.9E-01	2.5E-05	2.5E-01	7.9E-01
Kr-85m	3.6E-02	1.6E+00	1.8E+00	1.1E-04	1.1E+00	4.5E+00
Kr-85	3.5E+02	5.0E+00	1.2E-01	7.7E-06	7.8E-02	3.6E+02
Kr-87	a.	3.1E-01	1.1E+00	7.0E-05	7.0E-01	2.1E+00
Kr-88	8.2E-05	2.0E+00	3.6E+00	2.2E-04	2.2E+00	7.8E+00
Kr-89	a.	1.2E-03	1.1E-01	6.7E-06	6.8E-02	1.8E-01
Xe-131m	2.4E+01	1.0E+01	3.4E-01	2.2E-05	2.2E-01	3.5E+01
Xe-133m	3.1E-05	2.0E+01	1.8E+00	1.2E-04	1.2E+00	2.3E+01
Xe-133	7.9E+01	2.0E+03	9.1E+01	6.1E-03	6.1E+01	2.3E+03
Xe-135m	a.	1.5E-02	2.8E-01	1.6E-05	1.6E-01	4.6E-01
Xe-135	a.	1.0E+01	5.2E+00	3.2E-04	3.3E+00	1.9E+01
Xe-137	a.	2.5E-03	1.9E-01	1.2E-05	1.2E-01	3.2E-01
Xe-138	a.	5.5E-02	9.4E-01	5.2E-05	5.3E-01	1.5E+00
I-131	a.	3.6E-03	3.9E-02	1.0E-03	7.0E-02	1.1E-01
I-133	a.	3.4E-03	5.7E-02	1.1E-03	8.0E-02	1.4E-01

Tritium gaseous release = 840 Ci/yr
C-14 gaseous release = 8 Ci/yr
Ar-41 gaseous release = 25 Ci/yr

Airborne Particulate Release Rate (Ci/year)

Nuclide	Waste Gas System	Building Ventilation: Containment	Building Ventilation: Auxiliary	Total
Mn-54	4.5E-03	3.3E-06	1.8E-04	4.7E-03
Fe-59	1.5E-03	1.1E-06	6.0E-05	1.6E-03
Co-58	1.5E-02	1.1E-05	6.0E-04	1.6E-02
Co-60	7.0E-03	5.0E-06	2.7E-04	7.3E-03
Sr-89	3.3E-04	2.5E-07	1.3E-05	3.4E-04
Sr-90	6.0E-05	4.4E-08	2.4E-06	6.2E-05
Cs-134	4.5E-03	3.3E-06	1.8E-04	4.7E-03
Cs-137	7.5E-03	5.6E-06	3.0E-04	7.8E-03

a. Less than 10^{-10} Ci/yr.

TABLE 11.3-3

COMPARISON OF CALCULATED MAXIMUM OFFSITE
AIRBORNE CONCENTRATION WITH 10 CFR 20
ASSUMING EXPECTED FUEL LEAKAGE

Isotope	Total Annual Release (Ci/year)	Maximum Site Boundary Concentration(a) (μCi/ml)	Maximum Permissible Concentration (MPC)(b) (μCi/ml)	Fraction of MPC
H-3	8.4E+2	7.3E-10	2.0E-07	3.6E-03
C-14	8.0E+0	7.0E-12	1.0E-07	7.0E-05
Ar-41	2.5E+1	2.2E-11	4.0E-08	5.5E-08
Kr-83m	7.9E-01	6.9E-13	1.0E-10	6.9E-03
Kr-85m	4.5E+00	3.9E-12	1.0E-07	3.9E-05
Kr-85	3.6E+02	3.1E-10	3.0E-07	1.0E-03
Kr-87	2.1E+00	1.8E-12	2.0E-08	9.0E-05
Kr-88	7.8E+00	6.8E-12	2.0E-08	3.4E-04
Xe-131m	3.5E+01	3.1E-11	4.0E-07	7.8E-05
Xe-133m	2.3E+01	2.0E-11	3.0E-07	6.7E-05
Xe-133	2.3E+03	2.0E-09	3.0E-07	6.7E-03
Xe-135	1.9E+01	1.7E-11	1.0E-07	1.7E-04
I-131	1.1E-01	9.6E-14	1.0E-10	9.6E-04
I-133	1.4E-01	1.2E-13	4.0E-10	3.0E-04
Mn-54	4.7E-03	4.1E-15	1.0E-09	4.1E-06
Fe-59	1.6E-03	1.4E-15	2.0E-09	7.0E-07
Co-58	1.6E-02	1.4E-14	2.0E-09	7.0E-07
Co-60	7.3E-03	6.4E-15	3.0E-10	2.1E-05
Sr-89	3.4E-04	3.0E-16	3.0E-10	1.0E-06
Sr-90	6.2E-05	5.4E-17	3.0E-11	1.8E-06
Cs-134	4.7E-03	4.1E-15	4.0E-10	1.0E-05
Cs-137	7.8E-03	6.8E-15	5.0E-10	1.4E-05
			Total	2.0E-02

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a. Based on the annual releases from Table 11.3-2 and an assumed X/Q of 2.75×10^{-5} sec/m^3.

b. From 10 CFR 20, Appendix B, Table II, column 1.

TABLE 11.3-4

ESTIMATED ANNUAL DOSES TO AN
INDIVIDUAL FROM GASEOUS EFFLUENTS
ASSUMING CONTINUOUS PRESENCE AT THE SITE BOUNDARY

	Calculated Dose (mrem/yr)[a]	10 CFR 50, Appendix I Dose Limit (mrem/yr)
Whole body dose	1.0	5.0
Skin Dose	2.4	15.0

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a. Based on the annual releases from Table 11.3-2 and an assumed X/Q of 2.75×10^{-5} sec/m^3. Doses are calculated utilizing the method described in Reg. Guide 1.109, Appendix B.

FIGURE 11.3-1 SHEET 1
(FOLDOUT)
PROPRIETARY

FIGURE 11.3-1 SHEET 2
(FOLDOUT)
PROPRIETARY

11.4 SOLID WASTE PROCESSING SYSTEM

The solid waste processing system serves to collect, process, and package radioactive wastes generated as a result of normal plant operation, including anticipated operational occurrences. The packaged waste is stored until it is shipped offsite to a licensed burial site.

The design of the solid waste processing system is the responsibility of the plant specific applicant.

11.4.1 Design Bases

The solid waste processing system shall be designed to meet the following objectives:

A. Provide remote transfer and holdup capability for spent radioactive resins from the liquid waste processing and steam generator blowdown processing systems.

B. Solidify and package spent resins from the liquid waste processing system and the steam generator blowdown processing system.

C. Solidify, and package liquid waste solutions from the chemical drain tank, liquid waste evaporator, and boron recycle evaporator.

D. Provide a means to semiremotely remove and transfer the spent filter cartridges from filter vessels to shielded drums in the manner which minimizes radiation exposure to operating personnel and the spread of contamination.

E. Provide a means for compacting and packaging miscellaneous dry radioactive materials, such as paper, rags, and contaminated clothing.