11.0 RADIOACTIVE WASTE MANAGEMENT

11.1 SOURCE TERMS

Source terms and models used in the evaluation of radwaste treatment systems and effluent releases are based on operating plant data where available (Ref. 11.1-1).

Two source terms are presented; design basis and realistic. Design basis source terms for shielding design and component failures are based upon the same conservative model for reactor coolant activity. Shielding source terms are discussed in more detail in Section 12.2. The source terms for the effluent release analysis are based on the realistic model for reactor coolant activity presented in NUREG-0017 (Ref. 11.1-2).

Background information on tritium production and fuel operating experience are addressed in References 11.1-1 and 11.1-3, respectively.

Source terms for extended burnup fuel are discussed in Section 11.1.6. Applicability of the VANTAGE 5H fuel is discussed in Section 11.1.6.

11.1.1 Design Basis Radioactivity in Systems and Components

11.1.1.1 Reactor Coolant Activity. The parameters used in the calculation of the reactor coolant fission product inventories, together with the pertinent information concerning the expected coolant cleanup flow rate and demineralizer effectiveness, are summarized in Table 11.1-1. Calculated reactor coolant radionuclide design concentrations are presented in Table 11.1-2. In these calculations the defective fuel rods are assumed to be present at the initial core loading and to be uniformly distributed throughout the core; thus, the fission product escape rate coefficients are based upon average fuel temperature.

Fuel failure and burnup experience are presented in Chapter 4.

The fission product activities in the reactor coolant during operation with small cladding defects (fuel rods containing pinholes or fine cracks) are computed using the following differential equations:

For parent nuclides in the coolant:

$$\frac{dN_{c_i}}{dt} = \frac{R_i N_{F_i}}{M_c} - \left[\lambda_i + D_i + \frac{Q_L}{M_c} \frac{(S_i + DF_{i-1})}{DF_i} \right] N_{c_i}$$

or daughter nuclides in the coolant:

$$\frac{dN_{c_j}}{dt} = \frac{R_j N_{F_j}}{M_c} + f_i \lambda_i N_c - \left[\lambda_{j_i} + D_j + \frac{Q_L}{M_C} \frac{(S_j + DF_{j-1})}{DF_j} \right] N_{c_j}$$

where:

N_C = Concentration of nuclide in the reactor coolant (atoms/gram)

N_F = Population of nuclide in the fuel (atoms)

t = Operating time (seconds)

R = Nuclide release coefficient (1/sec) = F

F = Fraction of fuel rods with defective cladding

M_C = Mass of reactor coolant (grams)

λ = Nuclide decay constant (1/sec)

D = Dilution coefficient by feed and bleed (1/sec) = $\frac{\beta}{B - \beta t} \frac{1}{DF}$

B = Initial boron concentration (ppm)

β = Boron concentration reduction rate (ppm/sec)

DF = Nuclide demineralizer decontamination factor

Q_L = Purification or letdown mass flow rate (grams/sec)

S = Nuclide volume control tank stripping fraction

f = Fraction of parent nuclide decay events that result in the formation of the daughter nuclide.

Subscript i refers to the parent nuclide.

Subscript j refers to the daughter nuclide.

The fission products are removed by decay, cleanup in the Chemical and Volume Control System (CVCS), and letdown to the Boron Recycle System (BRS). In the volume control tank (VCT), the fission products are assumed to be removed by decay only, with no degassing to the Gaseous Waste Processing System (GWPS).

The corrosion product activities, which are independent of fuel defect level, are based upon measurements at operating reactors. The corrosion product concentrations are given in Table 11.1-2. These crud or corrosion product nuclides are formed by activation of eroded primary system materials. Plateout and subsequent reerosion takes place throughout the primary system.

11.1.1.2 Volume Control Tank Activity. Table 11.1-3 lists the calculated design and realistic vapor activities in the VCT using the assumptions summarized in Tables 11.1-1 and 11.1-6. The expected activities are based on a VCT purge of 0.7 scfm.

11.1.1.3 Secondary Coolant Activity Model. If defective steam generator (SG) tubes exist, radionuclides from the primary coolant are introduced to the secondary system with the primary-to-secondary leakage. The resulting radionuclide concentrations in the secondary coolant depend upon the SG leakage rate, the nuclide decay constant, and various parameters describing loss pathways in the secondary system.

Removal of radionuclides from the secondary system takes place by any of the following:

1. Condensate Demineralizer System treatment of condensate flow
2. Radioactive decay
3. Exhaust through the main condenser mechanical vacuum pump
4. Exhaust through the turbine gland seal
5. Main steam leakage to the Turbine Generator Building (TGB)
6. Condensate leakage to the sumps
7. Removal of nonrecyclable secondary samples
8. Removal through the blowdown system

The model used to determine the concentration of nuclides in the SG liquid is given by a set of differential equations, as follows:

$$M_s \frac{dN_{si}}{dt} = LN_{ci} - BN_{si} - M_s \lambda_i N_{si}$$

where:

N_{si}	=	Nuclide concentration in SG liquid, μCi/g
N_{ci}	=	Nuclide concentration in primary coolant, μCi/g
M_S	=	SG liquid mass, g
t	=	Time, days
L	=	Primary-to-secondary leakage rate, gal/day
B	=	Secondary system removal rate, gal/day
λ_i	=	Radioactive decay constant, per day

Under the assumption of constant reactor coolant concentrations, the nuclide concentration in the SG liquid at equilibrium is given by:

$$N_{si} = \frac{LN_{ci}}{B + M_s\lambda_i}$$

The nuclide concentration in the Reactor Coolant System (RCS) is assumed to be equal to the values presented in Table 11.1-2 for design basis conditions. Table 11.1-4 presents the parameters used to calculate the equilibrium secondary coolant concentrations.

For nuclides other than noble gases and tritium, these equations are used to calculate the secondary coolant liquid concentrations. The steam concentrations are then determined using the SG partition factor applicable for the nuclide.

The model used to estimate secondary tritium assumes that the tritium becomes uniformly distributed throughout the secondary coolant and that the tritium concentration is at equilibrium.

In the case of noble gases, the assumption made is that they are rapidly transported from the water in the SG and swept out of the vessel into the steam. Therefore, the concentration in the water is negligible, and the concentration in the steam is equal to the ratio of the SG release rate to the steam flow rate. These noble gases are removed from the system at the main condenser.

The concentrations of nuclides in the secondary system water and steam are given in Table 11.1-5.

11.1.2 Radioactivity Concentrations in the Fluid Systems, Realistic Basis

The parameters used to describe the South Texas Project Electric Generating Station (STPEGS) reactor are given in Table 11.1-6 together with nominal values and the range of values used by NUREG-0017 (Ref. 11.1-2). The actual STPEGS parameters have been used to adjust the standard coolant concentrations given in NUREG-0017 (Ref. 11.1-2). The adjustment of the standard coolant concentrations was performed using the standard formula presented in NUREG-0017.

Specific activities in the primary coolant, SG water, and the condenser, based upon the parameters of Table 11.1-6, are given in Table 11.1-7.

11.1.3 Tritium Production and Release to the Reactor Coolant

There are two principal contributors to tritium production within the STPEGS system: 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 and the burnable absorber control rods. Tritium production from different sources is shown in Table 11.1-8.

Additional background information on tritium production is given in Reference 11.1-1.

11.1.4 Activity in Radwaste Systems

The design basis source terms for shielding and component failures for the Radwaste Systems are based upon the concentrations shown in Table 11.1-2. The expected activities of the Radwaste Systems for effluent analysis are based upon the concentrations shown in Table 11.1-7. The Liquid

Radwaste System is further described in Section 11.2, the Gaseous Radwaste System in Section 11.3, and the Solid Radwaste System in Section 11.4. The shielding of these systems is described in Section 12.3.

11.1.5 Leakage Sources

The systems containing radioactive liquids are potential sources of leakage to the plant buildings and then to the environment. Leakage from the primary system to the Containment is expected to be less than 240 lb/day. This leakage comes from such sources as valve packings. Leakage from the systems located in the Mechanical Auxiliary Building (MAB) is expected to be less than 160 lb/day. This leakage comes from such potential sources as pump gland seals and valve packings. Total steam leakage in the TGB is expected to be less than 1,700 lb/hour, as discussed in Section 11.3.2.

These leakage sources and the resulting airborne concentrations are discussed more fully in Section 12.2.2.

Potential release points of radioactive effluents are discussed in Sections 11.2 and 11.3.

11.1.6 The Impact of Extended Burnup Fuel on Source Terms

The source terms presented in Sections 11.1.1 through 11.1.5 are based on an equilibrium fuel cycle using discharge burnup of 33,000 MWD/MTU. The use of extended burnup fuel at STPEGS has been reviewed in NUREG/CR-5009, "Assessment of the Use of Extended Burnup Fuel in Light Water Power Reactors" (References 11.1-4 and 11.1-5) and has been determined to not significantly change the results previously presented in safety analysis reports based on operation to 33,000 MWD/MTU discharge burnup.

For VANTAGE 5H fuel, source terms based on an equilibrium fuel cycle using batch average burnups of 20,000 MWD/MTU, 40,000 MWD/MTU, and 60,000 MWD/MTU (each at 1/3 core size) with fuel enriched to a nominal 5.0 w/o U-235 have been evaluated. The results do not significantly change the results in Sections 11.1.1 through 11.1.5.

11.1.7 The Impact of Operating at a Reduced Feedwater Temperature on Source Terms

The impact of operating at a feedwater temperature as low as 390˚F on the radiological source terms described in Section 11.1 has been evaluated. It was determined that operation under this scenario would have a negligible impact on the isotopic inventories presented in Section 11.1.

11.1.8 The Impact of Replacement Steam Generators on Source Terms

The impact of replacing the Westinghouse Model E steam generators with Westinghouse Model Delta 94 steam generators on the radiological source terms described in Section 11.1 has been evaluated. It was determined that operation with either type of steam generator would have a negligible impact on the isotopic inventories presented in Section 11.1.

REFERENCES

Section 11.1:

11.1-1 "Source Term Data for Westinghouse Pressurized Water Reactors", WCAP-8253, Amendment 1, Westinghouse Electric Corporation, July 1975.

11.1-2 U. S. Nuclear Regulatory Commission, NUREG-0017, "Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from Pressurized Water Reactors (PWR-Gale Code)", April 1976.

11.1-3 "Operational Experience with Westinghouse Cores", WCAP-8183 (Latest edition).

11.1-4 U. S. Nuclear Regulatory Commission, NUREG/CR-5009, "Assessment of Extended Burnup Fuel in Light Water Power Reactors", February 1988.

11.1-5 U. S. Nuclear Regulatory Commission, NUREG-0781, "Safety Evaluation Report related to the operation of South Texas Project, Unit 2", Supplement 6, Docket No. 50-499, December 1988.

TABLE 11.1-1

PARAMETERS USED IN THE CALCULATION OF DESIGN BASIS FISSION AND CORROSION PRODUCT CONCENTRATIONS

1.	Ultimate core thermal power, MWt	4,100
2.	Clad defects, as a percent of rated core thermal power being generated by rods with clad defects	1.0
3.	Reactor coolant liquid volume, ft^3	13,103
4	Reactor core full power average temperature, °F	592
5.	Purification flow rate (normal), gal/min [(1)]	100
6.	Effective cation demineralizer flow, gal/min [(1)]	10
7.	Volume control tank volumes	
	a. Vapor, ft^3	300
	b. Liquid, ft^3	300
8.	Fission product escape rate coefficients[(2)]	
	a. Noble gas isotopes, sec^{-1}	6.5×10^{-8}
	b. Br, RB, I, and Cs isotopes, sec^{-1}	1.3×10^{-8}
	c. Te isotopes, sec^{-1}	1.0×10^{-9}
	d. Mo isotopes, sec^{-1}	2.0×10^{-9}
	e. Sr and Ba isotopes, sec^{-1}	1.0×10^{-11}
	f. Y, La, Ce, Pr isotopes, sec^{-1}	1.6×10^{-12}
9.	Mixed-bed demineralizer decontamination factors	
	a. Noble gases and Cs-134, 136, 137, Y-90, 91, and Mo-99	1.0
	b. All other isotopes including corrosion products	10.0

1. Volumetric flow rates are based upon 2,250 psia and 130°F.
2. The nuclide release coefficient is the product of the failed fuel fraction and the fission product escape rate coefficient.

TABLE 11.1-1 (Continued)

PARAMETERS USED IN THE CALCULATION OF DESIGN BASIS FISSION AND CORROSION PRODUCT CONCENTRATIONS

10.	Cation-bed demineralizer decontamination factor for Cs-134, 137, Rb-86	10.0
11.	Volume control tank noble gas stripping fractions[3]	

Isotope	Stripping Fraction
Kr-85	6.0×10^{-5}
Kr-85m	5.6×10^{-1}
Kr-87	8.2×10^{-1}
Kr-88	6.7×10^{-1}
Xe-131m	1.3×10^{-2}
Xe-133	3.0×10^{-2}
Xe-133m	6.8×10^{-2}
Xe-135	3.0×10^{-1}
Xe-135m	9.4×10^{-1}
Xe-138	9.4×10^{-1}

12.	Boron concentration and reduction rates	
	a. B_o (initial cycle), ppm	890
	B' (initial cycle), ppm/day	2.63
	b. B_o (equilibrium cycle), ppm	1,160
	B' (equilibrium cycle), ppm/day	3.69
13.	Pressurizer volumes	
	a. Vapor, ft^3	840
	b. Liquid, ft^3	1,260

3. No VCT purge is assumed.

TABLE 11.1-1 (Continued)

PARAMETERS USED IN THE CALCULATION OF DESIGN BASIS FISSION AND CORROSION PRODUCT CONCENTRATIONS

14.	Spray line flow, gal/min [1]	2.0
15.	Pressurizer stripping fractions	
	a. Noble gases	1.0
	b. Kr-85	0.9
	c. All other elements	0

1. Volumetric flow rates are based upon 2,250 psia and 130°F.

TABLE 11.1-2

REACTOR COOLANT DESIGN EQUILIBRIUM FISSIONAND CORROSION PRODUCT CONCENTRATIONS*

(Based upon parameters given in Table 11.1-1)

Nuclide	Activity (µci/gram)	Nuclide	Activity (µci/gram)
Kr-83m	4.5×10^{-1}	Mn-56[(b)]	1.4×10^{-2}
Kr-85m	2.0	Fe-55[(b)]	2.1×10^{-3}
Kr-85	7.3	Fe-59[(b)]	5.1×10^{-4}
Kr-87	1.2	Co-58[(b)]	1.2×10^{-2}
Kr-88	3.6	Co-60[(b)]	1.4×10^{-3}
Kr-89	1.1×10^{-1}	Sr-89	3.7×10^{-3}
Xe-131m	2.0	Sr-90	1.1×10^{-4}
Xe-133m	1.6×10^{1}	Sr-91	5.8×10^{-3}
Xe-133	2.5×10^{2}	Sr-92	1.2×10^{-3}
Xe-135m	4.6×10^{-1}	Y-90	2.9×10^{-5}
Xe-135	6.8	Y-91m	3.6×10^{-3}
Xe-137	1.8×10^{-1}	Y-91	4.9×10^{-4}
Xe-138	6.4×10^{-1}	Y-92	1.1×10^{-3}
Br-83	9.3×10^{-2}	Y-93	3.5×10^{-4}
Br-84	4.7×10^{-2}	Zr-95	5.6×10^{-4}
Br-85	6.0×10^{-3}	Nb-95	5.6×10^{-4}
I-127[(a)]	5.4×10^{-11}	Mo-99	6.6×10^{-1}
I-129	3.9×10^{-8}	Tc-99m	6.0×10^{-1}
I-130	1.9×10^{-2}	Ru-103	5.0×10^{-4}
I-131	2.4	Ru-106	1.2×10^{-4}
I-132	2.8	Rh-103m	5.0×10^{-4}
I-133	3.8	Rh-106	1.2×10^{-4}
I-134	5.7×10^{-1}	Ag-110m	1.3×10^{-3}
I-135	2.1	Te-125m	2.5×10^{-4}
Rb-86	2.0×10^{-2}	Te-127m	2.6×10^{-3}
Rb-88	4.8	Te-127	1.1×10^{-2}
Rb-89	2.2×10^{-1}	Te-129m	1.6×10^{-2}
Cs-134	2.0	Te-129	1.6×10^{-2}
Cs-136	2.9	Te-131m	2.3×10^{-2}
Cs-137	1.3	Te-131	1.2×10^{-2}
Ba-137m	1.2	Te-132	2.6×10^{-1}
Cs-138	9.7×10^{-1}	Te-134	3.0×10^{-2}
H-3	3.5 (maximum)	Ba-140	3.6×10^{-3}
Cr-51[(b)]	5.0×10^{-3}	La-140	1.2×10^{-3}
Mn-54[(b)]	3.9×10^{-4}	Ce-141	5.5×10^{-4}
Ce-143	4.5×10^{-4}	Pr-143	5.5×10^{-4}
Ce-144	3.4×10^{-4}	Pr-144	3.4×10^{-4}

a. Grams of I-127 per gram of coolant.
b. Corrosion products are based upon operating data.
* The values listed above bound the activities for V5H fuel.

TABLE 11.1-3

VOLUME CONTROL TANK VAPOR ACTIVITY

Isotope	Vapor Activity (Curies) Design Basis[a]	Realistic[b]
Kr-83m	3.0	8.6×10^{-2}
Kr-85	1.5×10^{2}	6.0×10^{-2}
Kr-85m	1.9×10^{1}	6.4×10^{-1}
Kr-87	5.0×10^{0}	2.2×10^{-1}
Kr-88	2.7×10^{1}	9.9×10^{-1}
Kr-89	2.2×10^{-2}	1×10^{-3}
Xe-131m	2.9×10^{1}	1.4×10^{-1}
Xe-133	3.6×10^{3}	3.9×10^{-1}
Xe-133m	2.3×10^{2}	7.8×10^{-1}
Xe-135	8.6×10^{1}	1.9
Xe-135m	7.2	1.1×10^{-2}
Xe-137	4.3×10^{-2}	2.2×10^{-3}
Xe-138	5.6×10^{-1}	3.6×10^{-2}

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

b. Based upon parameters given in Table 11.1-6 with a 0.7 scfm Volume Control Tank (VCT) purge to the Gaseous Waste Processing System (GWPS). The 0.7 scfm flow rate from the VCT to the GWPS may be increased proportionally as the reactor coolant system isotopic inventory (presented on Table 11.1-7) decreases. This will allow operation at a higher flow rate while preserving the activity flow rate (curies/min) into the GWPS. The isotopic releases, component activities, and GWPS inlet activity in Section 11.3 and the projected offsite releases and doses presented in Section 11.A will remain bounding.

TABLE 11.1-4

PARAMETERS USED IN THE CALCULATION
OF DESIGN BASIS SECONDARY COOLANT CONCENTRATIONS

Parameter	
Reactor coolant concentrations	Table 11.1-2
Primary-to-secondary leak rate, gal/min	1.0
Main steam flow rate, lb/hr	1.686×10^7
Steam generator blowdown rate, lb/hr	1.68×10^5
Steam generator liquid mass, lb	4.9×10^5
Steam generator partition factors:	
Nuclides other than tritium, halogens, and noble gases	0.001
Halogens	0.01
Tritium	1.0
Noble gases	See Section 11.1.1.3
Fraction of main steam reaching main condenser	0.540
Condensate demineralizer decontamination factors:	
All cations and anions except Cs, Rb	10
Cs, Rb	2
Corrosion products	10
Tritium	1
Leakage terms:	
Liquid leakage, lb/hr	4.5

TABLE 11.1-4 (Continued)

PARAMETERS USED IN THE CALCULATION
OF DESIGN BASIS SECONDARY COOLANT CONCENTRATIONS

Parameter		
Steam generator blowdown demineralizer decontamination factors:		
	Mixed-Bed #1	Mixed-Bed #2
Cs, Rb	10	10
All others except tritium	100	10
Tritium	1	1
Moisture Separator/Reheater partition factors:		
Halogens		1.0
Noble gases		See Section 11.1.1.3
Tritium		1.0
Others		0.65

TABLE 11.1-5

SECONDARY COOLANT DESIGN BASIS EQUILIBRIUM FISSION
AND CORROSION PRODUCT CONCENTRATIONS

(Based upon parameters given in Table 11.1-4)

Isotope	Steam Generator Activity (µCi/g)	Condenser Activity (µCi/g)
I-129	2.46×10^{-11}	6.86×10^{-13}
I-130	1.02×10^{-5}	2.94×10^{-7}
I-131	1.46×10^{-3}	4.17×10^{-5}
I-132	9.86×10^{-4}	2.70×10^{-5}
I-133	2.16×10^{-3}	6.13×10^{-5}
I-134	6.31×10^{-6}	3.43×10^{-6}
I-135	1.02×10^{-3}	2.94×10^{-5}
Br-83	3.39×10^{-5}	9.31×10^{-7}
Br-84	6.78×10^{-6}	1.72×10^{-7}
Br-85	9.86×10^{-8}	1.18×10^{-9}
Rb-86	2.00×10^{-5}	4.41×10^{-8}
Rb-88	4.47×10^{-4}	8.09×10^{-7}
Rb-89	1.85×10^{-5}	3.19×10^{-8}
CS-134	2.00×10^{-3}	4.41×10^{-6}
CS-136	2.93×10^{-3}	6.37×10^{-7}
CS-137	1.34×10^{-3}	2.94×10^{-6}
CS-138	1.51×10^{-4}	2.94×10^{-7}
Ba-137m	1.85×10^{-5}	2.70×10^{-7}
Cr-51	5.08×10^{-6}	9.56×10^{-9}
Mn-54	4.00×10^{-7}	7.35×10^{-10}
Mn-56	6.62×10^{-6}	1.20×10^{-8}
Fe-55	2.16×10^{-6}	3.92×10^{-9}

TABLE 11.1-5 (Continued)

SECONDARY COOLANT DESIGN BASIS EQUILIBRIUM FISSION AND CORROSION PRODUCT CONCENTRATIONS

(Based upon parameters given in Table 11.1-4)

Isotope	Steam Generator Activity (µCi/g)	Condenser Activity (µCi/g)
Fe-59	5.08×10^{-7}	9.56×10^{-10}
Co-58	1.20×10^{-5}	2.25×10^{-8}
Co-60	1.40×10^{-6}	2.70×10^{-9}
Sr-89	3.70×10^{-6}	7.11×10^{-9}
Sr-90	1.14×10^{-7}	2.16×10^{-10}
Sr-91	4.47×10^{-6}	8.33×10^{-9}
Sr-92	5.85×10^{-7}	1.08×10^{-9}
Y-90	2.77×10^{-8}	5.15×10^{-11}
Y-91m	8.16×10^{-7}	1.42×10^{-9}
Y-91	4.93×10^{-7}	9.31×10^{-10}
Y-92	6.31×10^{-7}	1.18×10^{-9}
Y-93	2.77×10^{-7}	5.15×10^{-10}
Zr-95	5.70×10^{-7}	1.05×10^{-9}
Nb-95	5.70×10^{-7}	1.05×10^{-9}
Mo-99	6.62×10^{-4}	1.25×10^{-6}
Tc-99m	4.16×10^{-4}	7.60×10^{-7}
Ru-103	5.08×10^{-7}	9.56×10^{-10}
Ru-106	1.20×10^{-7}	2.25×10^{-10}
Ag-110m	1.34×10^{-6}	2.45×10^{-9}
Te-125m	2.46×10^{-7}	4.66×10^{-10}
Te-127m	2.62×10^{-6}	4.90×10^{-9}
Te-127	8.78×10^{-6}	1.64×10^{-8}

TABLE 11.1-5 (Continued)

SECONDARY COOLANT DESIGN BASIS EQUILIBRIUM FISSION AND CORROSION PRODUCT CONCENTRATIONS

(Based upon parameters given in Table 11.1-4)

Isotope	Steam Generator Activity (μCi/g)	Condenser Activity (μCi/g)
Te-129m	1.69×10^{-5}	3.19×10^{-8}
Te-129	4.77×10^{-6}	8.33×10^{-9}
Te-131m	2.16×10^{-5}	3.92×10^{-8}
Te-131	1.54×10^{-6}	2.45×10^{-9}
Te-132	2.46×10^{-4}	4.66×10^{-7}
Te-134	6.01×10^{-6}	1.03×10^{-8}
Ba-140	3.54×10^{-6}	6.62×10^{-9}
La-140	1.12×10^{-6}	2.11×10^{-9}
Ce-141	5.54×10^{-7}	1.05×10^{-9}
Ce-143	4.16×10^{-7}	7.84×10^{-10}
Ce-144	3.39×10^{-7}	6.37×10^{-10}
Pr-143	5.54×10^{-7}	1.03×10^{-9}
Pr-144	3.08×10^{-8}	4.66×10^{-11}

TABLE 11.1-6

PARAMETERS USED TO DESCRIBE THE REACTOR SYSTEM – REALISTIC BASIS[(a)]

Parameter	Symbol	Units	Nominal Value	Range Maximum	Range Minimum	STPEGS
Core Thermal power	P	MWt	3,400	3,800	3,000	3,800
Steam flow rate	FS	lb/hr	1.5(7) [(b)]	1.7(7)	1.3(7)	1.686(7)
Weight of water in Reactor Coolant System	WP	lb	5.5(5)	6.0(5)	5.0(5)	5.73(5)
Weight of water in all steam generators	WS	lb	4.5(5)	5.0(5)	4.0(5)	4.9(5)
Reactor coolant letdown flow (purification)	FD	lb/hr	3.7(4)	4.2(4)	3.2(4)	4.97(4)
Reactor coolant letdown flow (yearly average for boron control)	FB	lb/hr	500	1,000	250	100
Steam generator blowdown flow (total)	FBD	lb/hr	75,000	100,000	50,000	1.68(5)
Fraction of radioactivity in blowdown stream which is not returned to the Secondary Coolant System	NBD	-	1.0	1.0	0.9	1.0
Flow through the Purification System cation demineralizer	FA	lb/hr	3,700	7,500	0.0	5,000
Ratio of condensate demineralizer flow rate to the total steam flow rate	NC	-	0.65	0.75	0.55	0.542

a. Based upon NUREG-0017 Assumptions.
b. Numbers in parentheses are power of 10, e.g., 1.5(7) = 1.5×10^7.

TABLE 11.1-6 (Continued)

PARAMETERS USED TO DESCRIBE THE REACTOR SYSTEM – REALISTIC BASIS[(a)]

Parameter	Symbol	Units	Nominal Value	Range		STPEGS
				Maximum	Minimum	
Ratio of the total amount of noble gases routed to gaseous radwaste from the purification system to the total amount of noble gases routed from the Primary Coolant System to the Purification System (not including the Boron Recovery System)	Y	-	0.0	0.01	0.0	See Section 11.1.2

a. Based upon NUREG-0017 Assumptions.

TABLE 11.1-7

SPECIFIC ACTIVITIES IN PRINCIPAL FLUID STREAMS – REALISTIC BASIS[(a)]

(μCi/G)

Isotope	Reactor Coolant[(b)]	Secondary Coolant Water [(c)]	Secondary Coolant Steam [(d)]
	Class 1 Noble Gases		
Kr 85m	1.0(-1) [(e)]	nil	2.6(-8)
Kr 85	6.8(-3)	nil	1.7(-9)
Kr 87	6.2(-2)	nil	1.5(-8)
Kr 88	2.0(-1)	nil	4.9(-8)
Xe 131m	1.6(-2)	nil	4.1(-9)
Xe 133m	9.4(-2)	nil	2.4(-8)
Xe 133	4.5	nil	1.1(-6)
Xe 135m	1.4(-2)	nil	3.4(-9)
Xe 135	3.0(-1)	nil	7.3(-8)
Xe 138	4.7(-2)	nil	1.1(-8)
	Class 2 Halogens		
Br 83	4.9(-3)	5.3(-8)	5.3(-10)
I-130	2.0(-3)	2.9(-8)	2.9(-10)
I 131	2.3(-1)	3.7(-6)	3.7(-8)
I 132	1.0(-1)	1.5(-6)	1.5(-8)
I 133	3.4(-1)	5.4(-6)	5.4(-8)
I 134	5.0(-2)	3.3(-7)	3.3(-9)
I 135	1.8(-1)	2.6(-6)	2.6(-8)
	Class 3 Cs, Rb		
Rb 86	6.7(-5)	1.6(-9)	1.6(-12)
Cs 134	1.9(-2)	4.7(-7)	4.7(-10)
Cs 136	1.0(-2)	2.5(-7)	2.5(-10)
Cs 137	1.4(-2)	3.4(-7)	3.4(-10)
Ba 137m	1.7(-2)	8.8(-7)	8.8(-10)

a. Based upon primary-to-secondary leak of 100 lb/day and 0.12% failed fuel.
b. The concentrations given are for reactor coolant entering letdown line.
c. The concentrations given are for water in the steam generator.
d. The concentrations given are for steam leaving a steam generator.
e. Numbers in parentheses are factors of 10; e.g., 2.1(-2) = 2.1 x 10^{-2}.

TABLE 11.1-7 (Continued)

SPECIFIC ACTIVITIES IN PRINCIPAL FLUID STREAMS – REALISTIC BASIS[(a)]

(μCi/G)

Isotope	Reactor Coolant[(b)]	Secondary Coolant Water [(c)]	Secondary Coolant Steam [(d)]
	Class 4 Water Activation Products		
N-16	4.0(1) [(e)]	1.0(-6)	1.0(-7)
	Class 5 Tritium		
H 3	1.0(0)	1.0(-3)	1.0(-3)
	Class 6 Other Isotopes		
Cr 51	1.6(-3)	3.5(-8)	3.6(-11)
Mn 54	2.6(-4)	7.8(-9)	7.8(-12)
Fe 55	1.3(-3)	3.1(-8)	3.1(-11)
Fe 59	8.2(-4)	2.4(-8)	2.4(-11)
Co 58	1.3(-2)	3.1(-7)	3.1(-10)
Co 60	1.6(-3)	3.5(-8)	3.5(-11)
Sr 89	2.9(-4)	7.9(-9)	7.9(-12)
Sr 91	6.1(-4)	1.0(-8)	1.1(-11)
Y 91	5.3(-5)	1.2(-9)	1.2(-12)
Y 91m	3.8(-4)	8.3(-9)	8.3(-12)
Zr 95	4.9(-5)	1.6(-9)	1.6(-12)
Mo 99	7.2(-2)	1.7(-6)	1.7(-9)
Tc 99m	4.7(-2)	1.7(-6)	1.7(-9)
Te 127m	2.3(-4)	3.9(-9)	3.9(-12)
Te 127	8.0(-4)	1.6(-8)	1.6(-11)
Te 129m	1.2(-3)	2.4(-8)	2.4(-11)
Te 129	1.7(-3)	4.7(-8)	4.7(-11)
Te 131m	2.2(-3)	4.4(-8)	4.4(-11)
Te 131	1.2(-3)	1.8(-8)	1.8(-11)
Te 132	2.3(-2)	4.1(-7)	4.1(-10)

a. Based upon primary-to-secondary leak of 100 lb/day and 0.12% failed fuel.
b. The concentrations given are for reactor coolant entering letdown line.
c. The concentrations given are for water in the steam generator.
d. The concentrations given are for steam leaving a steam generator.
e. Numbers in parentheses are factors of 10; e.g., 2.1(-2) = 2.1 x 10^{-2}.

TABLE 11.1-7 (Continued)

SPECIFIC ACTIVITIES IN PRINCIPAL FLUID STREAMS – REALISTIC BASIS[a]

(μCi/G)

Isotope	Reactor Coolant[b]	Secondary Coolant Water[c]	Secondary Coolant Steam[d]
		Class 6 Other Isotopes (Continued)	
Ba 140	1.8(-4)	4.0(-9)	4.0(-12)
La 140	1.3(-4)	3.0(-9)	3.0(-12)
Ce 141	5.8(-5)	1.6(-9)	1.6(-12)
Ce 144	2.7(-5)	7.8(-10)	7.8(-13)
Np 239	1.0(-3)	2.5(-8)	2.5(-11)

a. Based upon primary-to-secondary leak of 100 lb/day and 0.12% failed fuel.
b. The concentrations given are for reactor coolant entering letdown line.
c. The concentrations given are for water in the steam generator.
d. The concentrations given are for steam leaving a steam generator.
e. Numbers in parentheses are factors of 10; e.g., 2.1(-2) = 2.1×10^{-2}.

TABLE 11.1-8

TOTAL TRITIUM SOURCES

Expected Release to the Coolant (curies/cycle)

Tritium Source	Initial Cycle	Equilibrium Cycle
Produced in the core		
Ternary fission	1,666	1,250
Burnable absorber rod	276	0
Produced in the coolant		
Soluble boron	563	406
Soluble lithium	195	147
Deuterium	4	3
Total	2,704	1,806

1. Power level	4,100 MWt
2. Weight of boron-10 in absorber rods	7.19 kg
3. Initial boron concentrations	
Initial cycle	890 ppm
Equilibrium	1,160 ppm
4. Cycle operating time	
Initial cycle	9,550 EFPH*
Equilibrium	7,220 EFPH*
5. Lithium concentration (99.9 atom percent lithium)	2.2 ppm

* Effective full power hours

11.2 LIQUID WASTE MANAGEMENT SYSTEMS

This section describes the design and operating features of the Liquid Waste Processing Systems (LWPS). Total plant liquid releases from all sources are estimated and summarized in Section 11.2.3.5. The design meets the intent of Branch Technical Position (BTP) ETSB 11-1, Rev. 1.

11.2.1 Design Bases

The function of the LWPS is to collect and process radioactive liquid wastes generated from plant operation and maintenance, and to reduce radioactivity and chemical concentrations to levels acceptable for discharge or recycle.

The principal design objectives of the LWPS are:

- Collection of liquid wastes generated during anticipated plant operations which potentially contain radioactive nuclides.

- Provision of sufficient processing capability such that liquid waste may be discharged to the environment at concentrations below the regulatory limits of 10CFR20 and consistent with the as low as is reasonably achievable (ALARA) guidelines set forth in 10CFR50, Appendix I.

The impact of operating at a feedwater temperature as low as 390˚F on the radiological source terms has been evaluated. It was determined that operation under this scenario would have a negligible impact on the isotopic inventory of the liquid waste processing system and the radiological consequences of a LWPS failure, as described in Chapter 15.7.

Design considerations for shielding and the reduction of radiation exposure to personnel are given in Section 12.1.3.

Source terms used to determine shielding requirements are given in Table 11.1-2 (1 percent fuel cladding defects); dose design objectives are based upon the source terms in Table 11.1-7 (realistic basis).

Plant operational releases from the LWPS will be below regulatory and /or licensing requirements.

During operation with excessive reactor coolant leakage or temporary malfunction in the LWPS, additional and/or alternate processing capacity in the LWPS is available to limit releases to approximately the same as during normal operation.

Section 11.2.3.5 establishes that the LWPS adequately meets the above-listed design objective.

11.2.2 Systems Descriptions

11.2.2.1 <u>General Process Descriptions</u>. The LWPS collects and processes potentially radioactive wastes for release to the environment. Provisions are made to sample and analyze fluids before they are discharged. Based upon the laboratory analyses, these wastes are either released under controlled conditions into the discharge of the Circulating Water System (CWS) via the Open Loop Auxiliary Cooling Water (OLACW) System or retained for further processing. A permanent record of liquid releases is provided by laboratory analyses of known volumes of waste.

The LWPS has the capability of operating in various recycle modes. However, the design basis for the LWPS is complete discharge of all processed liquids.

The bulk of the radioactive liquids discharged by the Reactor Coolant System (RCS) can be processed or recycled by the LWPS or Boron Recycle System (BRS). Inputs into the LWPS from the BRS can be processed in the BRS prior to processing in the LWPS. The capability exists to route this waste to the condensate polishing regeneration waste collection tank (CPRWCT) or floor drain tank (FDT).

The LWPS is designed to monitor and release sufficient tritiated water to control tritium buildup in the plant. Since the normal mode of the LWPS is process and discharge, there will be no tritium buildup in the LWPS. The majority of other inputs to the LWPS are normally low activity; therefore, the bulk of the processing requirements for the LWPS are based on generally low activity wastes.

The capability for handling evaporator concentrates, as well as handling and storing spent demineralizer resins, is also provided in the system.

The capability exists to process high and low total dissolved solids (TDS) wastes from condensate polisher regeneration. Both low and high TDS wastes can be discharged directly through the LWPS and the effluent radiation monitor to the CWS if processing is not required. High TDS wastes are routed to the CPRWCT and may be processed through the waste evaporator and monitor tanks prior to discharge to the CWS. Normally, no LWPS processing is required. LWPS processing is only required in the case of excessive primary to secondary leakage. Normal condensate polishing regeneration waste (CPRW) processing is in the neutralization basin.

Instrumentation and controls necessary for the operation of the LWPS are located on a control board in the radwaste control room, which is located within the Mechanical Auxiliary Building (MAB), except as described in section 11.2.2.2.2.

Component locations are shown on the general arrangement drawings listed in Table 1.2-1 as Figure 1.2-26, Sheets 3 and 4, Figure 1.2-27, and Figure 1.2-38. Radioactive equipment is generally isolated in individual cubicles. Process flow diagrams and piping and instrumentation diagrams (P&IDs) are shown on Figures 11.2-1 through 11.2-12.

11.2.2.1.1 <u>Process and Equipment Description</u>: The LWPS is provided to collect and process BRS tritium control volume and nonreactor-grade liquid wastes. These include floor drains, equipment drains containing nonreactor-grade water, laundry and hot shower drains, contaminated wastes from the Condensate Polishing Regeneration System, and other nonreactor-grade sources. Equipment in the LWPS includes the reactor coolant drain tank (RCDT), the RCDT pumps and heat exchanger (HX), the waste holdup tank (WHT), WHT filter, WHT pumps, WHT purification demineralizer (WHTPD) and filter, two waste evaporator condensate tanks (WECT), an FDT, laundry and hot shower tank (LHST), CPRWCT, waste evaporator, waste evaporator condensate demineralizer (WECD) and strainer, auxiliary demineralizer (AD), mobile filtration/demineralizer unit (MFD), six waste monitor tanks (WMT), and pumps. A list of equipment is given in Table 11.2-3.

The WECTs can be made available to provide extra storage capacity for the WMTs and can be discharged through the effluent radiation monitor to the CWS. Additional surge capacity is provided by two surge tanks located in the Fuel Handling Building (FHB). Additional processing capability is provided by the MFD as shown on P&ID's (Figures 11.2-2 and 11.2-5). This Unit may be leased or purchased and will generally be used to supplement the permanently installed LWPS, but may also be utilized as the sole processing unit.

Processing consists of filtration, demineralization, evaporation, or any combination of these.

The processing mode is determined by the quality of the liquid to be processed.

The waste evaporator and associated components are available to be tested and placed in service in the event filtration and/or demineralization will not be effective in reducing discharge levels to below the 10CFR20 limits.

The waste evaporator is a forced circulation crystallizer with a 30-gal/min distillate processing flow rate. In addition, this evaporator can also be used as a backup to the BRS recycle evaporator.

The LWPS waste evaporator is designed to operate on a batch basis and the contents are concentrated to optimum operational levels as specified in the Process Control Program.

The largest sources of liquid volume to the LWPS are excess reactor coolant via the BRS, equipment floor drains and Condensate Polishing System regeneration waste. The equipment floor drains and excess reactor coolant represent a relatively continuous source to the LWPS whereas the condensate polishing system regeneration waste is an infrequent high-volume, short-duration, batch source. The Condensate Polishing System regeneration waste is a source to the LWPS only during periods of off-normal operations when processing is required to prevent exceeding ODCM limits. At these times the regeneration waste is directed to the CPRWCT as discussed in Section 10.4.6.2; during these periods the equipment and floor drains are directed to the FDT. Processing of this waste in the CPRWCT is identical to the processing specified for waste in the FDT. The system also provides the capability to discharge the FDT, LHST, and the condensate polishing regeneration waste directly to the CWS if processing is not required.

Laundry and hot shower drains are normally transferred to WMT for release. The waste evaporator is capable of processing the laundry and hot shower waste after addition of an antifoaming agent, if evaporation of these wastes is required prior to their release.

Reactor grade water which enters the LWPS from equipment leaks and drains, valve leakoffs, pumps seal leakoff, tank overflows, excess sample purges of reactor coolant, and other tritiated and aerated water sources are collected in the WHT.

The sampling room contains two sinks. Excess sample purges of reactor-grade coolant are drained from one sink to the WHT. The other sink is used for draining nonreactor-grade excess samples to the CPRWCT. The sinks in the radiochemistry laboratory drain to the CPRWCT.

The basic composition of the liquid collected in the WHT is boric acid and water with some radioactivity. Liquid collected in the WHT is processed through a filter, and/or demineralizer, and sent to the FDT, CPRWCT, or WMTs. The capability exists to recycle condensate from the evaporators to the reactor makeup water storage tank (RMWST) if water chemistry is acceptable. The contents of the WHT can also be processed through the BRS recycle evaporator. Samples are taken at sufficiently frequent intervals to assure proper operation of the system to minimize the need for reprocessing. If the analysis of the sample indicates that further processing is required, the condensate may be returned to the WHT for additional processing.

The contents of the FDT and CPRWCT are directed to one of six WMTs for sampling prior to discharge to the CWS. The CPRWCT and LHST contents can be directed to the LWPS discharge header, upstream of the radiation monitor bypassing the WMTs. The discharge from the WMTs is monitored for radioactivity and the volume of the discharge recorded. The discharge valve is interlocked with the radiation monitor, which alarms in the radwaste control room and main control room and diverts the 3-way discharge valve to recirculation to the tank being discharged in the event radioactivity concentration in the effluent stream exceeds the preset limits. The radiation monitor is discussed in Section 11.5. The discharge from the CWS is directed to the Main Cooling Reservoir (MCR). Expected concentrations of radionuclides in the MCR can be found in Table 11.2-7.2. The resulting doses are discussed in Appendix 11.A.

11.2.2.1.2 Waste From Spent Resin: The spent resin sluice portion of the LWPS consists of two separate systems: the high activity spent resin system and the low activity spent resin system. The system consists of two Spent Resin Storage Tanks, one for high activity and one for low activity, (SRST and LASRST), a spent resin sluice pump, and two spent resin transfer pumps. A common spent resin sluice pump filter is connected to the sluice pump discharge lines.

The high activity spent resin system normally accommodates resin from the Chemical and Volume Control System (CVCS) cation and mixed-bed demineralizers, the recycle evaporator feed demineralizers, the concentrated boric acid demineralizers, and the steam generator blowdown mixed-bed demineralizers.

The low activity spent resin system normally accommodates resin from the boron thermal regeneration demineralizers, the spent fuel pool demineralizers, the boron recycle evaporator condensate demineralizers, LWPS, AD, WECD, and WHTPD. The two spent resins systems are cross connected to allow operations flexibility.

The purpose of this system is to receive, transport, and store resin in the SRST and LASRST without generating large volumes of waste liquid. The SRST and LASRST provide time for decay of radioactivity in the resins.

11.2.2.2 System Design.

11.2.2.2.1 Component Design: Design descriptions for the LWPS equipment are given in Table 11.2-3.

The components of the LWPS are designed as nonseismic equipment; however, all components, with the exception of WMTs D, E, and F, the MFD, and their associated pumps are located in either the Reactor Containment Building (RCB), Fuel Handling Building (FHB) or the MAB, all being seismic Category I structures. The WMTs D, E, and F, are located outside the MAB in the yard. The MFD is located in the MAB truck bay.

The LWPS is classified as non-nuclear safety. The safety classification, code requirements and quality assurance requirements for equipment in the LWPS are provided in Section 3.2. In addition, the following design bases are applied to the system and its components:

1. The LWPS is designed to prevent uncontrolled releases of radioactive materials due to spillage in buildings or from outdoor storage tanks which may contain radioactive material. Retention capabilities are provided for:

    a. Potential spills from outdoor tanks or rupture of one WMT, by providing curbs sufficient to contain the tank contents. Capability for returning the spillage to the LWPS is provided.

    b. Potential spills from indoor tanks by connecting floor drains to the LWPS, or installing curbs around equipment and tanks, or elevating thresholds. (See Section 9.3.3.2 for additional information).

2. Materials for piping, valves, and components handling radioactive liquids conform to the requirements of specifications for materials listed in Section II of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel (B&PV) Code, 1974, as per BTP ETSB 11-1, Rev. 1. The above material requirements do not apply to items such as shafts, stems, trim, bushings, springs, wear plates, seals, packings, gaskets, and valve seats. Materials manufacturers' certificates of compliance with the material specifications are provided in lieu of certified materials test reports.

    Hoses used for the MFD conform to manufacturers' requirements and are tested at operating pressure after each connection.

    Materials for piping and valves in interfacing systems which do not handle radioactive liquids such as steam, cooling water, and demineralized water, conform to the requirements of the applicable codes and standards of the respective interfacing system.

3. Screwed connections in which threads provide the only seal are not used except for instrumentation connections where welded connections are not suitable and for small demineralized water supply lines. Process lines are not less than 3/4 inches. Screwed connections backed up by seal welding, socket welding, or mechanical joints may be used on lines greater than 3/4 in. but less than 2-1/2 in. nominal size. For lines 2-1/2 in. nominal pipe size and above, pipe welds are of the butt-joint type. Backing rings are not used in lines carrying resins or other particulate material. All welding constituting the pressure boundary of pressure-retaining components is performed utilizing welding procedures in accordance with ASME B&PV Code, Section IX.

4. Completed process systems are pressure tested to the maximum practicable extent. Piping systems are hydrostatically tested in their entirety, except at atmospheric tank connections where no isolation valves exist. Testing of piping systems is performed in accordance with American National Standards Institute (ANSI) B31.1 or ASME Section III, NC-6200, as applicable, but in no case is less than 75 psig. The test pressure is held for a minimum of 10 minutes with no leakage indicated.

11.2.2.2.2 Instrumentation Design: The system instrumentation is shown on the P&IDs (Figures 11.2-1 through 11.2-11).

The LWPS parameters are indicated, and alarms are annunciated, on the LWPS control panels in the radwaste control room located in the MAB, with the exception of the tanks described below. Instrumentation for the RCDT equipment indicates and alarms in the main control room, where the operator can determine the collected leakage rate from the RCS. RT-8038 also alarms in the main control room.

Processing pumps in the system are protected against loss of suction pressure by a control setpoint on the level instrumentation for their respective tanks. In addition, the RCDT pumps are interlocked with flow rate instrumentation to stop the pumps when the respective delivery flow reaches minimum setpoints.

Pump redundancy is provided by cross-connection of the pump suction lines of the (1) WECTs, (2) WMTs ABC, (3) WMTs DEF, and (4) LHST with CPRWCT. Cross connection is provided using a remote operated isolation valve (s). Should a discharge line be blocked, the operator is alerted by a high pressure alarm, with the exception of WMTs DEF.

Pressure instruments are provided on filters, strainers, and demineralizers to alert the operator in the event one of the components becomes blocked or builds up excessive pressure drop.

Tanks in the system, with the exception of the RCDT, have level indication on the LWPS control panel. Level indication for the RCDT is provided at the main control room. SRST and LASRST level indicates water, air, and resin levels on a control panel located in the MAB.

Temperature is measured in the RCDT and at the WECD, AD, and WHT purification demineralizer inlets. An RCDT temperature rise indicates increased flow of hot reactor coolant into the tank. The temperature indicator and alarm on the demineralizers' inlets alert the operator to high-temperature inlet fluid which could melt or degrade the demineralizer resins.

The discharge liquid from the LWPS is monitored by the LWPS radiation monitor as described in Section 11.5.

11.2.2.3 System Operation Description. The LWPS is manually operated with the exceptions of automatic control for normal operating modes of the RCDT and the waste evaporator. The system includes adequate control equipment to protect the system components and adequate instrumentation and alarm functions to provide the operator with sufficient information to assure proper system operation. Flow paths for the various operating modes are shown on Figure 11.2-12.

The LWPS is designed to handle leakages, surges, or equipment malfunction during normal operating and shutdown conditions.

11.2.2.3.1 Normal Operation: Operation of the LWPS is essentially the same during normal, refueling, and shutdown operations; the only differences are in the load on the system. The operation of the system is discussed in the following sections. In this discussion, the term "normal operation" should be taken to mean the various phases of operation except operation under emergency or accident conditions.

11.2.2.3.1.1 Waste Holdup Tank and Evaporator – Water is accumulated in the WHT until a sufficient quantity exists for processing. The contents of the WHT can be processed through demineralizers and/or filters, the waste evaporator, or the BRS recycle evaporator. When processing through the waste evaporator, the distillate from the waste evaporator passes through the WHT purification demineralizer and filter prior to collection in the WMTs or WECTs. If sampling of the WECTs shows low radionuclide concentrations, the contents can be discharged directly to the CWS. If, during the discharge operation, the activity exceeds the setpoint of the effluent radiation monitor, the contents are automatically diverted to one of the WMTs. If the initial sample determines that the contents require further processing, they can be transferred to the FDT or CPRWCT and routed through demineralizers and/or filters. When processing through the waste evaporator, the bottoms are concentrated and transferred to the concentrates tank for solidification.

The WHT contents can also be processed through the BRS after passing through the WHT purification demineralizer and filter. The bottoms in the BRS recycle evaporator are concentrated and transferred to the boric acid storage tanks if acceptable for recycle.

The RCDT collects deaerated, tritiated leakoffs from inside the Containment and the contents are transferred by the RCDT pumps through the RCDT HX (for cooling to less than 130°F) to the WHT. For the normal operating mode, a level band is maintained automatically in the RCDT and the system requires no operator action. In addition, the RCDT contents can be transferred directly to the BRS for processing.

11.2.2.3.1.2 Processing Operation – Inputs to the LWPS can be segregated according to their chemical makeup: detergent wastes are routed to the LHST, Condensate Polishing System contaminated regeneration wastes are routed to the CPRWCT, and sumps and gravity drains are routed to the FDT or CPRWCT.

Three parallel modes of operation are available in the LWPS:

1. The normal flow path for CPRW is to the neutralization basin (Section 10.4.6). During periods where 10CFR20 limits could not be met without processing, high and low TDS waste streams from the Condensate Polishing System demineralizer regeneration are collected in the CPRWCT or FDT. The regenerants are processed through demineralizers and/or filters and sent to the WMTs, or WE (Waste Evaporator). Discharge is to the CWS; the effluent radiation monitor is used to verify acceptable activity levels. If the activity exceeds the setpoint, the flow is diverted back to the discharging tank for reprocessing. During operation

with no primary-to-secondary leakage, CPRW regenerants can be discharged directly to the CWS using the LWPS discharge header and effluent radiation monitor.

2. MAB floor drains and contents of the RCDT may be processed through the WHT and filter. Capability exists to process the low TDS waste and MAB floor drains in parallel. MAB floor drains are sent to the FDT or CPRWCT and, if necessary, processed through filters and/or demineralizers.

3. The contents of the LHST are normally transferred to a WMT. The contents of the FDT and CPRWCT can be transferred directly to a WMT, or processed through filters and/or demineralizers.

   The contents of the WMTs are discharged to the CWS after sampling. A discharge permit will be issued for each release. The water being discharged from the LWPS to the CWS is monitored for radioactivity level. In the event a higher radioactivity level than set is reached, the 3-way valve in the discharge line will divert the flow back to the WMT being discharged. The contents of the WMTs can be returned to the FDT, CPRWCT, or Surge Tanks if additional processing is required.

11.2.2.3.1.3 Laboratory Drains - The laboratory drains consist of a reactor-grade sink, a nonreactor-grade sink, and their respective drain lines. Reactor coolant samples are disposed of via the reactor-grade sink to the WHT. Equipment rinse water and other nonreactor-grade water is disposed of via the nonreactor-grade sink to the CPRWCT. Chemical wastes are sent to the CPRWCT.

11.2.2.3.1.4 Spent Resin Sluice Portion – This portion of the system sluices resin from the demineralizers in the MAB demineralizer cubicle to the SRST or LASRST. There is sufficient storage capacity in the systems to allow time for decay of radioactivity and offsite shipment.

11.2.2.3.2 Faults of Moderate Frequency: The following equipment faults were considered when designing the capacity of the LWPS:

1. Single Major Equipment Item Failure

There are enough redundant processing paths and components in the LWPS that a single major equipment failure will not adversely affect the capability of the system to perform design functions.

2. Excessive Liquid Waste Generation

The system is designed to handle equipment leakage due to maintenance in addition to the anticipated leakage and excess reactor coolant during normal operation. The increased leakage into the RCDT is handled automatically with only a slight increase in the load factor of the LWPS.

A second source of excessive liquid waste considered in the system design is maximum input of contaminated regeneration waste from the Condensate Polishing System described in Section 10.4.6. This condition will occur only during periods of significant primary-to-secondary system leakage and condenser inleakage. However, sufficient surge capacity is incorporated in the CPRWCT and the holdup tank in the Condensate Polishing System (TDS tanks) to allow flexibility in processing the wastes.

3. Design Basis Fission Product Leakage

Overall system decontamination factors are sufficient to reduce radionuclide concentrations in the LWPS effluents to acceptable levels. Shielding calculations for all LWPS components are based upon operation at design basis fission product leakage (Tables 11.1-1 and 11.1-2). Tank radionuclide inventories, including both design basis and realistic source terms, are listed in Tables 11.2-4.1 and 11.2-4.2. The assumptions used to generate these source terms are consistent with those found in Table 11.2-7.1.

11.2.2.4 Process Decontamination Factors. The decontamination factors (DFs) from NUREG-0017 were used in the formulation of Tables 11.2-4.1, 11.2-4.2, 11.2-7.1, and 11.2-7.2. (DF = ratio of the concentration of radioactive material in the influent stream to its concentration in the effluent).

11.2.3 Radioactive Releases

The sources of plant liquid releases are the LWPS, the Turbine Generator Building (TGB) drains, and the Condensate Polishing Demineralizer System (CPDS) regenerants. Descriptions of the liquid released from the LWPS are contained in Section 11.2.3. Expected releases from these sources are listed in Table 11.2-7.2.

The BRS is designed to process recyclable liquid from normal plant operations and various off-normal conditions. A flow for tritium control from the RCS is directed to the LWPS from the BRS. Backup for the BRS recycle evaporator is provided by the LWPS waste evaporator, if necessary.

The surge capacity of the LWPS and the existence of alternate processing flow paths permit the system to accommodate waste until equipment malfunctions have been repaired and normal operation is resumed.

11.2.3.1 Releases from the Liquid Waste Processing System. The quantities and isotopic concentration in the liquid discharge from the LWPS are highly dependent upon the operation of the plant. The presented analysis for a 3,800-MWt, four-loop unit is based upon normal operation (including anticipated operational occurrences) of the plant and the LWPS, and a realistic estimation of the potential input sources based upon plant operating experience.

The input sources assumed in the study are summarized in Table 11.2-7.1 and the radioactive releases are listed in Table 11.2-7.2. The expected releases described in Table 11.2-7.2 bound the release with the mobile filtration demineralizer (MFD) processing LWPS liquid inputs.

11.2.3.2 Releases from the Steam Generator Blowdown. Under normal conditions there will be no release from the Steam Generator Blowdown System (SGBS). The blowdown water can be processed by the two SGBS demineralizers in series and sent back to the main condensers. If the demineralizers are bypassed, the blowdown fluid is sent directly to the condenser. Fluid from the condenser is processed through the condensate polishing demineralizers. For a further discussion on the SGBS see Section 10.4.8.

11.2.3.3 Releases from the Condensate Polishing System. Regenerative batches are transferred to the high TDS tank. If the activity is within acceptable limits based on sampling or radiation monitor indication, the liquid is discharged to the neutralization basin. Radionuclide concentrations in the Condensate Polishing System regenerative waste is dependent upon primary-to-secondary leakage. If an unacceptable level of radioactivity is detected, the liquid is transferred to the LWPS for further processing and controlled discharge to the CWS.

11.2.3.4 Releases from the Turbine Generator Building Drains. A leak rate of 5 gal/min is assumed for the TGB from equipment which could contain contaminated liquid. Some potential sources of leakage are the condensate pump, the low pressure heater drip pump, and the moisture separator drip pump seal leakoff, and packing leaks. Feedwater (FW) pump seal leakages are returned to the condenser.

The radionuclide releases for each of the sources of liquid leakage in the TGB were calculated using main steam concentrations from Table 11.1-7 and a leakage rate of 5 gal/min (NUREG-0017).

The expected radionuclide discharges from the TGB drains are included in the releases found in Table 11.2-7.2.

11.2.3.5 Estimated Total Liquid Releases. The potential releases from each source were evaluated as indicated in above sections. As shown in Table 11.2-7.2, the expected radionuclide concentrations in liquid releases from both units meet the requirements of 10CFR20, Appendix B. Hence, the releases from the plant are in accordance with the design objectives as outlined in Section 11.2.1 and are within acceptable limits. LWPS releases pass through the effluent monitor which automatically terminates the release in the event preset setpoints are exceeded.

The reactor releases listed in Table 11.2-7.2 are releases from both units. These releases are then directed via the discharge of the CWS to the MCR. The entire MCR is within the South Texas Project Electric Generating Station (STPEGS) site boundary and open access to this MCR by the general public is prohibited.

Uncontrolled release of radioactive liquid from overflow of indoor and outdoor radwaste system storage tanks is precluded by provisions in the system design. Tanks that would potentially contain radioactive liquids and could overflow, releasing a portion of their contents, are listed in Table 11.2-5.

11.2.3.5.1 Capability to Detect and Alarm: For tanks listed in Table 11.2-4.1, the capability to detect a potential tank overflow is provided by level instrumentation. A high-level alarm is initiated when the tank water inventory reaches the high-level setpoint. Upon receipt of a high-level alarm, which can be verified by checking the level indicator, action can be initiated by prevent tank overflow. LWPS tank monitoring provisions are listed in Table 11.2-5A.

11.2.3.5.2 Capability to Safely Handle Liquid Overflows: For tanks located in the MAB, the ability to safely handle overflows is provided by the Equipment and Floor Drain System

(EFDS) discussed in Section 9.3.3. Overflows for tanks in the MAB, which contain potentially radioactive liquids, are routed to a local floor sump which can be pumped to either the FDT, CPRWCT or WHT. The FDT is located in a watertight cubicle capable of handling approximately 63,000 gallons in the event of a rupture of the FDT. Outdoor tanks are provided with curb of sufficient height to hold the contents of a tank.

11.2.3.5.3 Analysis of Uncontrolled Release: The ability to detect, and therefore prevent, a potential overflow is discussed in Section 11.2.3.5.1. Assuming an uncontrolled release (total tank failure) of an indoor tank, the release would be confined to the lower level of the MAB. Evaluation of LWPS accidents is discussed in Section 15.7.3.

The action required to collect the liquid released from a storage tank would depend upon the size of the release.

11.2.3.6 Release Points. The only system release point for discharge from the LWPS is shown on Figure 11.2-5. The releases from the MCR are through the MCR Blowdown System to the Colorado River. The location of the MCR Blowdown pipeline is provided in the site plot plan, Figure 1.2-2.

11.2.4 Dilution Factors

Refer to Appendix 11.A.

11.2.5 Estimated Doses

Refer to Appendix 11.A.

TABLE 11.2-3

EQUIPMENT DESIGN DESCRIPTIONS

A. HEAT EXCHANGER

1. Reactor Coolant Drain Tank Heat Exchanger

Function: Cooldown of reactor coolant drain tank (RCDT) contents from 170°F to 130°F at maximum recirculation flow rate. Cooldown of pressurizer relief tank contents from 200°F to 120°F in less than 8 hrs.

Number:	1
Type:	U-tube
Duty, Btu/hr:	2.24×10^6
Design pressure, psig – shell:	150
– tube:	150
Design temp, °F – shell:	250
– tube:	250
Material – shell:	CS (carbon steel)
– tube:	SS (stainless steel)

B. PUMPS

1. Reactor Coolant Drain Tank Pumps

Function: Provides sufficient flow for recirculation of RCDT contents and various transfer requirements.

Number:	2
Type:	Standard centrifugal w/single mechanical seal
Design pressure, psig:	150
Design temperature, °F:	200
Capacity:	100 gal/min @ 200 ft total developed head (TDH)
Motor:	15 hp, induction, 3600 rpm, 480 V
Material:	SS

TABLE 11.2-3 (Continued)

EQUIPMENT DESIGN DESCRIPTIONS

2. Waste Holdup Tank Pump

Function: Transfer of contents of waste holdup tank (WHT) to the FDT, CPRWCT, waste evaporator, or Boron Recycle System (BRS) recycle evaporator. Recirculation of WHT contents.

Number:	1
Type:	Standard centrifugal w/double mechanical seals and seal flush
Design pressure, psig:	150
Design temperature, °F:	200
Capacity:	100 gal/min @ 200 ft TDH
Motor:	15 hp, induction, 3600 rpm, 480 V
Material :	SS

3. Waste Evaporator Condensate Tank Pump

Function: Transfer of contents of waste evaporator condensate tanks (WECTs) to WMTS. Discharge of WECT contents to Circulating Water System (CWS). Recirculation of WECT contents.

Number:	2
Type:	Standard centrifugal w/single mechanical seal
Design pressure, psig:	150
Design temperature, °F:	200
Capacity:	100 gal/min @ 200 ft TDH
Motor:	15 hp, induction, 3600 rpm, 480 V
Material :	SS

TABLE 11.2-3 (Continued)

EQUIPMENT DESIGN DESCRIPTIONS

4. Condensate Polishing Regeneration Waste Collection Tank Pump

Function:	Transfer of condensate polishing regeneration waste collection tank (CPRWCT) contents to the FDT, waste monitor tanks, surge tanks, or waste evaporator. Recirculation of CPRWCT contents.
Number:	1
Type:	Standard centrifugal w/double mechanical seals and seal flush
Design pressure, psig:	150
Design temperature, °F:	200
Capacity:	100 gal/min @ 200 ft TDH
Motor:	15 hp, induction, 3600 rpm, 480 V
Material :	SS

5. Spent Resin Sluice Pumps

Function:	Transfer of water in high activity and low activity spent resin storage tank (SRST and LASRST) to demineralizers in the Mechanical Auxiliary Building (MAB) to sluice resins back to SRST and LASRST. Recirculation of water in SRST and LASRST for resin fluffing prior to solidification. Pump out water from SRST and LASRST to LWPS.
Number:	2
Type:	Standard centrifugal w/double mechanical seals and seal flush
Design pressure, psig:	150
Design temperature, °F:	200
Capacity:	Pump A, 125 gal/min @ 250 ft TDH, based on flow orifice Pump B, 140 gal/min @ 152 ft TDH
Motor:	Pump A 20 hp, Pump B 15 hp, induction, 3600 rpm, 480 V
Material:	SS

TABLE 11.2-3 (Continued)

EQUIPMENT DESIGN DESCRIPTIONS

6. Laundry and Hot Shower Tank Pump

Function: Transfer of laundry and hot shower tank (LHST) contents to the FDT, CPRWCT, WMTs, or the waste evaporator (after addition of antifoam agent). Recirculation of LHST contents. Discharge of LHST contents to CWS.

Number:	1
Type:	Standard centrifugal w/double mechanical seals and seal flush
Design pressure, psig:	150
Design temperature, °F:	200
Capacity:	100 gal/min @ 200 ft TDH
Motor:	15 hp, induction, 3600 rpm, 480 V
Material:	SS

7. Floor Drain Tank Pump

Function: Transfer of FDT contents to waste the WMTS, Surge Tanks, waste evaporator or WMT. Recirculation of FDT contents.

Number:	2
Type:	Standard centrifugal w/double mechanical seals and seal flush
Design pressure, psig:	150
Design temperature, °F:	200
Capacity:	100 gal/min @ 200 ft TDH
Motor:	15 hp, induction, 3600 rpm, 480 V
Material:	SS

TABLE 11.2-3 (Continued)

EQUIPMENT DESIGN DESCRIPTIONS

8. Waste Monitor Tanks A, B, C Pumps

Function: Discharge of waste monitor tanks A, B, and C contents to the CWS. Transfer of WMT contents to the FDT, CPRWCT, Surge Tanks or waste evaporator. Recirculation of WMT contents.

Number:	3
Type:	Standard centrifugal w/single mechanical seal
Design pressure, psig:	150
Design temperature, °F:	200
Capacity:	100 gal/min @ 200 ft TDH
Motor:	15 hp, induction, 3600 rpm, 480 V
Material:	SS

9. Waste Monitor Tanks D, E, F Pumps

Function: Discharge of WMTs D, E, and F contents to the CWS. Transfer of WMT contents to the FDT, CPRWCT, Surge Tanks or waste evaporator. Recirculation of WMT contents.

Number:	3
Type:	Standard centrifugal w/single mechanical seal
Design pressure, psig:	150
Design temperature, °F:	200
Capacity:	250 gal/min @ 141 ft TDH
Motor:	15 hp, induction, 3600 rpm, 480 V
Material:	SS

TABLE 11.2-3 (Continued)

EQUIPMENT DESIGN DESCRIPTIONS

10. Surge Tanks A, B Pumps

Function: Transfer and recirculation of Surge Tanks A and B.

Number:	2
Type:	Standard centrifugal w/double mechanical seal and seal flow
Design pressure, psig:	150
Design temperature, °F:	200
Capacity:	250 gal/min @ 80 ft TDH
Motor:	10 hp, induction, 3600 rpm, 480 V
Material:	SS

11. Sump Emptying Pump

Function: Transfers the content of the external and internal WMT sumps, directing discharge to WMTD or LWPS.

Number:	1
Type:	Standard centrifugal
Design pressure, psig:	150
Design temperature, °F:	200
Capacity:	50 gal/min @ 90 ft TDH
Motor:	10 hp, induction, 3500 rpm, 480 V
Material:	SS

TABLE 11.2-3 (Continued)

EQUIPMENT DESIGN DESCRIPTIONS

12. Spent Resin Transfer Pumps

Function: Transfers the spent resin from the SRST and LASRST to mobile solidification/dewatering.

Number:	2
Type:	Progressive cavity
Design pressure, psig:	150
Design temperature, °F:	200
Capacity:	50 gal/min @ 100 ft TDH
Motor:	10 hp, induction, 1800 rpm, 480 V
Material:	SS

13. Mobile Filtration Demineralization System Booster Pump

Function: Transfer of liquid waste from the Floor Drain Tank Filter outlet through the Mobile Filtration/Demineralization vessels to the Waste Monitor Tanks.

Number:	1
Type:	Standard centrifugal w/single mechanical seal
Design pressure, psig:	275
Design temperature, °F:	100
Capacity:	150 gpm @ 275 ft
Motor:	9.1 hp, (Unit 1), 14 hp (Unit 2), induction, 3600 rpm, 480 V
Material:	SS

TABLE 11.2-3 (Continued)

EQUIPMENT DESIGN DESCRIPTIONS

14. Mobile Filtration Demineralization System Coagulant Pump

Function:	Injects coagulant into the Mobile Filtration Demineralization System.
Number:	1
Type:	Positive displacement w/packed seal
Design pressure, psig:	1300
Design temperature, °F:	100
Capacity:	4.45 gph
Motor:	0.33 hp, induction, 1750 rph, 120 V
Material:	SS

C. TANKS

1. Reactor Coolant Drain Tank

Function:	Collection of deaerated leakage inside Containment for transfer to the processing system in the MAB. Input to the RCDT includes reactor coolant pump (RCP) seal leakoffs, reactor vessel flange leakoff (none expected during normal operation) and excess letdown heat exchanger flow. Provides surge capacity and net positive suction head (NPSH) requirements for the RCDT pumps. Level control band is maintained to minimize the volume of gas vented to the Gaseous Waste Processing System (GWPS).
Number:	1
Volume, gal:	350
Type:	Horizontal
Design pressure, psig*:	100
Design temperature, °F:	250
Special features:	Nitrogen cover gas to prevent air inleakage
Material:	SS
Design Code:	ASME VIII, Division 1

* External design pressure – 60 psig

TABLE 11.2-3 (Continued)

EQUIPMENT DESIGN DESCRIPTIONS

2. Waste Holdup Tank

Function: Collection of reactor grade leakage and other tritiated and aerated water sources in the MAB. (Several inputs to the WHT can be routed to the FDT, if necessary).

Number:	1
Volume, gal:	10,000
Type:	Vertical
Design pressure, psig:	Atmospheric
Design temperature, °F:	200
Material:	SS
Design Code:	API 650

3. Waste Evaporator Condensate Tank

Function: Collection of condensate (distillate) from the waste evaporator.

Number:	2
Volume, gal:	5,000
Type:	Vertical
Design pressure, psig:	Atmospheric
Design temperature, °F:	200
Material:	SS
Design Code:	API 650

TABLE 11.2-3 (Continued)

EQUIPMENT DESIGN DESCRIPTIONS

4. Condensate Polishing Regeneration Waste Collection Tank

Function: Collection of floor and equipment drains, CPRW batches, BRS letdown flow and all nonreactor grade drains from the laboratory and sample room.

Number:	1
Volume, gal:	22,800
Type:	Vertical
Design pressure, psig:	Atmospheric
Design temperature, °F:	200
Material:	SS
Design Code:	API 650

5. Spent Resin Storage Tanks

Function: Collection of spent resin from the demineralizers in the MAB to allow for decay of short-lived radionuclides prior to solidification/dewatering. Provides NPSH requirements for spent resin sluice pump. Capable of being pressurized with nitrogen to provide assistance to the spent resin transfer pump when transferring resins for solidification/dewatering.

Number:	2
Volume ft^3:	SRST 700 (5,000 gal) LASRST 800 (6,000 gal)
Type:	Vertical
Design pressure, psig:	100
Design temperature, °F:	200
Material:	SS
Design Code:	ASME VIII, Division 1

TABLE 11.2-3 (Continued)

EQUIPMENT DESIGN DESCRIPTIONS

6. Laundry and Hot Shower Tank

Function:	Collection of drains from the laundry and hot shower facility.
Number:	1
Volume, gal:	10,000
Type:	Vertical
Design pressure, psig:	Atmospheric
Design temperature, °F:	200
Material:	SS
Design Code:	API 650

7. Floor Drain Tank

Function:	Collection of floor drains from the Containment, MAB and Fuel Handling Building (FHB). If necessary, can receive contents of the WMTs, WHT, Surge Tanks, and CPRWCT. (Reactor grade inputs to the FDT can be routed to the WHT, if required).
Number:	1
Volume, gal	33,00
Type:	Vertical
Design pressure, psig:	Atmospheric
Design temperature, °F:	200
Material:	SS
Design Code:	API 650

TABLE 11.2-3 (Continued)

EQUIPMENT DESIGN DESCRIPTIONS

8. Waste Monitor Tanks

Function: Collection of processed water for monitoring prior to release to the CWS.

Number:	6
Volume, gal:	5,000 (Nos. 1A & 1B) 10,000 (No. 1C) 20,000 (Nos. 1D, 1E, 1F)
Type:	Vertical
Design pressure, psig:	Atmospheric
Design temperature, °F:	200
Material:	SS
Design Code:	API 650

D. DEMINERALIZERS

1. Waste Evaporator Condensate Demineralizer

Function: Removal of ionic contaminants in LWPS liquids and condensate (distillate) from the waste evaporator.

Number:	1
Type:	Flushable
Design pressure, psig:	150
Design temperature, °F:	200
Design flow, gal/min:	35
Resin volume, ft^3:	75
Material:	SS
Resin type:	To be determined based upon waste stream characteristics
Design process decontamination factor:	See Section 11.2.2.4

TABLE 11.2-3 (Continued)

EQUIPMENT DESIGN DESCRIPTIONS

2. Waste Holdup Tank Purification Demineralizer

Function: Removal of dissolved impurities in WHT contents.

Number:	1
Type:	Flushable
Design pressure, psig:	150
Design temperature, °F:	200
Design flow, gal/min:	30
Resin volume, ft^3:	35
Material:	SS
Resin type	To be determined based upon waste stream characteristics
Design process decontamination factor:	See Section 11.2.2.4

3. Auxiliary Demineralizer

Function: Removal of ionic contaminants from LWPS liquids.

Number:	1
Type:	Flushable
Design pressure, psig:	150
Design temperature, °F:	200
Design flow, gal/min:	35
Resin volume, ft^3:	75
Material:	SS
Resin type:	To be determined based upon waste stream characteristics
Design process decontamination factor:	See Section 11.2.2.4

TABLE 11.2-3 (Continued)

EQUIPMENT DESIGN DESCRIPTIONS

4. Mobile Filtration Demineralizer

Function: Removal of ionic and particulate contaminants from contents of the WHT, FDT, CPRWCT, WST, WMTs.

Number:	3
Type:	Flushable
Design pressure, psig:	150
Design temperature, °F:	150
Design flow, gal/min:	100
Media volume, ft3:	50
Material:	SS
Media type:	To be determined based upon waste stream characteristics
Design process decontamination factor:	See Section 11.2.2.4

E. FILTERS

1. Waste Holdup Tank Filter

Function: Removal of suspended solids from contents of WHT.

Number:		1
Type:		Cartridge
Design pressure, psig:		150
Design temperature, °F:		200
Design flow, gal/min:		150
ΔP at design flow (clean), psi:		5
Materials:	Housing:	SS
	Filter element:	As determined by Engineering

TABLE 11.2-3 (Continued)

EQUIPMENT DESIGN DESCRIPTIONS

2. Waste Evaporator Condensate Demineralizer Filter

Function: Collection of resin fines from WECD.

Number:		1
Type:		Cartridge
Design pressure, psig:		150
Design temperature, °F:		200
Design flow, gal/min:		150
ΔP at design flow (clean), psi:		5
Materials:	Housing:	SS
	Filter element:	As determined by Engineering

3. Spent Resin Sluice Filter

Function: Collection of resin fines and other suspended solids from the SRST and LASRST.

Number:		1
Type:		Cartridge
Design pressure, psig:		150
Design temperature, °F:		200
Design flow, gal/min:		150
ΔP at design flow (clean), psi:		5
Materials:	Housing:	SS
	Filter element:	As determined by Engineering

TABLE 11.2-3 (Continued)

EQUIPMENT DESIGN DESCRIPTIONS

4. Laundry and Hot Shower Tank Filter

Function: Removal of suspended solids from contents of LHST.

Number:	1
Type:	Cartridge
Design pressure, psig:	150
Design temperature, °F:	200
Design flow, gal/min:	150
Special note:	The filter cartridge may be removed from the filter housing if filtration is not required for the proper processing of tank contents.

5. Floor Drain Tank Filter

Function: Removal of suspended solids from contents of FDT.

Number:	1
Type:	Cartridge
Design pressure, psig:	150
Design temperature, °F:	200
Design flow, gal/min:	150
Special note:	The filter cartridge may be removed from the filter housing if filtration is not required for the proper processing of tank contents.

TABLE 11.2-3 (Continued)

EQUIPMENT DESIGN DESCRIPTIONS

6. Waste Holdup Tank Purification Demineralizer Filter

Function: Collection of resin fines from WHT purification demineralizer.

Number:		1
Type:		Cartridge
Design pressure, psig:		150
Design temperature, °F:		200
Design flow, gal/min:		150
ΔP at design flow (clean), psi:		5
Materials:	Housing:	SS
	Filter elements:	As determined by Engineering

7. Condensate Polishing Regeneration Waste Collection Tank Filter

Function: Removal of suspended solids from contents of CPRWCT.

Number:	1
Type:	Cartridge
Design pressure, psig:	150
Design temperature, °F:	200
Design flow, gal/min:	150
Special note:	The filter cartridge may be removed from the filter housing if filtration is not required for the proper processing of tank contents.

TABLE 11.2-3 (Continued)

EQUIPMENT DESIGN DESCRIPTIONS

F. STRAINERS

1. Pump Suction Strainers

Function: Duplex basket strainer to trap only large particles that could cause pump damage and excessive filter loading. Strainers are changed on high differential pressure and are not expected to contain significant concentrations of radioactivity. Strainers used on FDT, CPRWCT, Surge Tanks, and LHST pumps.

Number:	3
Type:	Basket
Design temperature, °F:	200
Design flow, gal/min:	100
ΔP at design flow (clean), psi:	0.5
Nominal rating, microns:	840 (20 mesh)
Materials:	SS

2. Auxiliary Demineralizer Strainer

Function: Collection of resin fines from AD.

Number:	1
Type:	Basket
Design pressure, psig:	150
Design temperature, °F:	200
Design flow, gal/min:	100
ΔP at design flow (clean), psi:	0.5
Nominal rating, microns:	74 (200 mesh)
Materials:	SS

TABLE 11.2-3 (Continued)

EQUIPMENT DESIGN DESCRIPTIONS

3. Startup Strainers

Function: In-line startup strainers are provided in all pump suction piping to prevent pump damage from large particles in the fluid streams anticipated during initial testing and flushing.

G. EVAPORATORS

1. Waste Evaporator

Function: The waste evaporator is capable of processing the contents of the FDT, CPRWCT, and WHT. The waste evaporator and BRS recycle evaporator are cross-connected such that the BRS evaporator can be used in place of the waste evaporator for WHT contents only.

Number:	1
Type:	Forced circulation crystallizer
Steam Design pressure, psig:	20
Design flow, gal/min:	30
Feed concentration, percent dissolved solids:	0 – 1.6
Bottoms concentration, percent dissolved solids:	12 - 50
Material in contact with:	
Feed:	SS
Condensate:	SS
Concentrate:	Incoloy 825
Steam:	CS
Component Cooling Water:	CS

TABLE 11.2-4.1

RADIONUCLIDE INVENTORY OF LWPS TANKS/UNIT
(Realistic Basis)

Nuclide	WHT/RCDT (μCi/g)	FDT (μCi/g)	WMT/WECT (μCi/g)	LHST (μCi/g)	CPRWCT (μCi/g)
H-3	1.0	.11	1.0	--	--
Rb-86	7.7×10^{-5}	8.5×10^{-6}	7.7×10^{-9}	--	3.8×10^{-8}
Sr-89	3.1×10^{-4}	3.4×10^{-5}	3.1×10^{-8}	--	3.8×10^{-7}
Sr-90	8.8×10^{-6}	9.7×10^{-7}	8.8×10^{-10}	--	1.4×10^{-8}
Y-91	5.6×10^{-5}	6.2×10^{-6}	5.6×10^{-9}	--	7.4×10^{-8}
Zr-95	5.3×10^{-5}	5.8×10^{-6}	5.3×10^{-9}	2.3×10^{-6}	6.7×10^{-8}
Nb-95	4.4×10^{-5}	4.8×10^{-6}	4.4×10^{-9}	3.2×10^{-6}	6.6×10^{-8}
Mo-99	7.6×10^{-2}	8.4×10^{-3}	7.6×10^{-6}	--	1.1×10^{-5}
Ru-103	3.9×10^{-5}	4.3×10^{-6}	3.9×10^{-9}	2.3×10^{-7}	4.5×10^{-8}
Ru-106	8.8×10^{-6}	9.7×10^{-7}	8.8×10^{-10}	3.9×10^{-6}	1.4×10^{-8}
Te-125m	2.5×10^{-5}	2.8×10^{-6}	2.5×10^{-9}	--	3.0×10^{-8}
Te-127m	2.5×10^{-4}	2.8×10^{-5}	2.5×10^{-8}	--	3.5×10^{-7}
Te-129m	1.7×10^{-3}	1.9×10^{-4}	1.7×10^{-7}	--	1.8×10^{-6}
Te-131m	2.3×10^{-3}	2.5×10^{-4}	2.3×10^{-7}	--	1.4×10^{-7}
Te-132	2.4×10^{-2}	2.6×10^{-3}	2.4×10^{-6}	--	4.1×10^{-6}
I-131	2.4×10^{-1}	2.6×10^{-2}	2.4×10^{-4}	9.7×10^{-7}	8.9×10^{-3}
I-133	3.7×10^{-1}	4.1×10^{-2}	3.7×10^{-4}	--	1.5×10^{-3}
Cs-134	2.2×10^{-2}	2.4×10^{-3}	2.2×10^{-6}	2.1×10^{-5}	2.2×10^{-5}
Cs-136	1.2×10^{-2}	1.3×10^{-3}	1.2×10^{-6}	--	5.0×10^{-7}
Cs-137	1.6×10^{-2}	1.8×10^{-3}	1.6×10^{-6}	3.9×10^{-5}	1.7×10^{-5}
Ce-141	6.1×10^{-5}	6.7×10^{-6}	6.1×10^{-9}	--	6.4×10^{-8}
Pr-143	4.4×10^{-5}	4.4×10^{-6}	4.4×10^{-9}	--	3.0×10^{-8}
Ce-144	2.9×10^{-5}	3.2×10^{-6}	2.9×10^{-9}	8.1×10^{-6}	4.4×10^{-8}
Cr-51	1.7×10^{-3}	1.9×10^{-4}	1.7×10^{-7}	--	1.7×10^{-6}
Mn-54	2.7×10^{-4}	3.0×10^{-5}	2.7×10^{-8}	1.6×10^{-6}	4.2×10^{-7}
Fe-55	1.4×10^{-3}	1.5×10^{-4}	1.4×10^{-7}	--	--
Fe-59	8.8×10^{-4}	9.7×10^{-5}	8.8×10^{-8}	--	1.0×10^{-6}
Co-58	1.4×10^{-2}	1.5×10^{-3}	1.4×10^{-6}	6.4×10^{-6}	1.7×10^{-5}
Co-60	1.8×10^{-3}	2.0×10^{-4}	1.8×10^{-7}	1.4×10^{-5}	2.8×10^{-6}

TABLE 11.2-4.2

RADIONUCLIDE INVENTORY OF LWPS TANKS/UNIT
(Design Basis)

Nuclide	WHT/RCDT (μCi/g)	FDT (μCi/g)	WMT/WECT (μCi/g)	LHST (μCi/g)	CPRWCT (μCi/g)
H-3	3.5	.385	3.5	--	--
Rb-86	2.0×10^{-2}	2.2×10^{-3}	2.0×10^{-6}	--	1.0×10^{-5}
Sr-89	3.7×10^{-3}	4.1×10^{-4}	3.7×10^{-7}	--	4.4×10^{-6}
Sr-90	1.1×10^{-4}	1.2×10^{-5}	1.1×10^{-8}	--	1.7×10^{-7}
Y-91	4.9×10^{-4}	5.4×10^{-5}	4.9×10^{-8}	--	6.5×10^{-7}
Zr-95	5.6×10^{-4}	6.2×10^{-5}	5.6×10^{-8}	2.4×10^{-5}	7.1×10^{-7}
Nb-95	5.6×10^{-4}	6.2×10^{-5}	5.6×10^{-8}	4.1×10^{-5}	8.4×10^{-7}
Mo-99	.66	7.3×10^{-2}	6.6×10^{-5}	--	9.9×10^{-5}
Ru-103	5.0×10^{-4}	5.5×10^{-5}	5.0×10^{-8}	2.9×10^{-6}	5.7×10^{-7}
Ru-106	1.2×10^{-4}	1.3×10^{-5}	1.2×10^{-8}	5.3×10^{-5}	1.9×10^{-7}
Te-125m	2.5×10^{-4}	2.7×10^{-5}	2.5×10^{-8}	--	3.0×10^{-7}
Te-127m	2.6×10^{-3}	2.8×10^{-4}	2.6×10^{-7}	--	3.6×10^{-6}
Te-129m	1.6×10^{-2}	1.7×10^{-3}	1.6×10^{-6}	--	1.7×10^{-5}
Te-131m	2.3×10^{-2}	2.5×10^{-3}	2.3×10^{-6}	--	1.4×10^{-6}
Te-132	.26	2.8×10^{-2}	2.6×10^{-5}	--	4.4×10^{-5}
I-131	2.4	.26	2.4×10^{-3}	9.7×10^{-6}	8.9×10^{-2}
I-133	3.8	.41	3.8×10^{-3}	--	1.5×10^{-2}
Cs-134	2.0	.22	2.0×10^{-4}	2×10^{-3}	2.0×10^{-3}
Cs-136	2.9	.32	2.9×10^{-4}	--	1.2×10^{-5}
Cs-137	1.3	.14	1.3×10^{-4}	--	1.4×10^{-3}
Ce-141	5.5×10^{-4}	6.1×10^{-5}	5.5×10^{-8}	3.2×10^{-3}	5.8×10^{-7}
Pr-143	5.5×10^{-4}	6.1×10^{-5}	5.5×10^{-8}	--	3.8×10^{-7}
Ce-144	3.4×10^{-4}	3.7×10^{-5}	3.4×10^{-8}	7.3×10^{-5}	5.1×10^{-7}
Cr-51	5.0×10^{-3}	5.5×10^{-4}	5.0×10^{-7}	--	5.0×10^{-6}
Mn-54	3.9×10^{-4}	4.3×10^{-5}	3.9×10^{-8}	2.2×10^{-6}	5.9×10^{-7}
Fe-55	2.1×10^{-3}	2.3×10^{-4}	2.1×10^{-7}	--	--
Fe-59	5.1×10^{-4}	5.6×10^{-4}	5.1×10^{-7}	--	5.9×10^{-7}
Co-58	1.2×10^{-2}	1.3×10^{-3}	1.2×10^{-6}	5.8×10^{-6}	1.5×10^{-5}
Co-60	1.4×10^{-3}	1.5×10^{-4}	1.4×10^{-7}	1.1×10^{-5}	2.2×10^{-6}

TABLE 11.2-5

TANKS POTENTIALLY CONTAINING RADIOACTIVE LIQUID

Identification	Quantity Per Unit	Location	Volume (gal)	Water Level Monitored
Reactor Coolant Drain Tank	1	Containment	350	Yes
Waste Holdup Tank	1	MAB[1]	10,000	Yes
Waste Evaporator Condensate Tank	2	MAB	5,000	Yes
Condensate Polishing Regeneration Waste Collection Tank	1	MAB	22,800	Yes
Concentrates Storage Tank	1	MAB	5,000	Yes
Spent Resin Storage Tank	1	MAB	5,000[2]	Yes
Low Activity Spent Resin Storage Tank	1	MAB	6,000[3]	Yes
Laundry & Hot Shower Tank	1	MAB	10,000	Yes
Floor Drain Tank	1	MAB	33,000	Yes
Waste Monitor Tanks A & B	2	MAB	5,000	Yes
Waste Monitor Tank C	1	MAB	10,000	Yes
Waste Monitor Tanks D, E, F	3	Outdoors	20,000	Yes
Surge Tank	2	FHB[4]	23,000	Yes
Radwaste Mixing Tank	1	MAB	935	Yes
Component Cooling Water Surge Tank	1	MAB	5,000	Yes
Reactor Makeup Water Storage Tank	1	MAB	160,000	Yes
Boron Recycle System Recycle Holdup Tank	2	MAB	85,000	Yes
Boric Acid Tank	2	MAB	33,500	Yes
Refueling Water Storage Tank	1	MAB	530,000	Yes
Cation Low Total Dissolved Solids Tank	1	Outdoors	50,000	Yes
Mixed Bed Low Total Dissolved Solids Tank	1	Outdoors	60,000	Yes
Cation High Total Dissolved Solids Tank	1	Outdoors	18,000	Yes
Mixed Bed High Total Dissolved Solids Tank	2	Outdoors	18,000	Yes

1. MAB – Mechanical Auxiliary Building
2. SRST, 700 ft^3
3. LASRST, 800 ft^3
4. FHB – Fuel Handling Building

TABLE 11.2-5A

LWPS TANK MONITORING PROVISIONS

Tank	Location	Monitoring Provisions	Alarms	Overflow Collection
Waste Holdup Tank	MAB El. 10 ft	Level Transmitter (1, 2)	High Level Low-Low Level	Note 3
Waste Evaporator Condensate Tanks A & B	MAB El. 10 ft	Level Transmitter (1, 2)	High Level Low-Low Level	Note 3
Laundry and Hot Shower Tank	MAB El. 10 ft	Level Transmitter (1, 2)	High Level Low-Low Level	Note 3
Condensate Polishing Regeneration Waste Collection Tank	MAB El. 10 ft	Level Transmitter (1, 2)	High Level Low-Low Level	Note 3
Floor Drain Tank	MAB El. 10 ft	Level Transmitter (1, 2)	High Level Low-Low Level	Note 4
Waste Monitor Tanks A, B, & C	MAB El. 10 ft	Level Transmitter (1, 2)	High Level Low-Low Level	Note 3
Waste Monitor Tanks D, E, & F	Outdoors	Level Transmitter (1, 2)	High Level Low-Low Level	Note 5
Surge Tanks A & B	FHB El. 4 ft	Level Transmitter (1, 2)	High Level Low-Low Level	Note 3

1. Level transmitter with high and low-low level alarm switches.

2. Alarm point on LWPS Control Panel in Radwaste Control Room.

3. Overflow directed to sump; pumped to FDT.

4. Overflow directed to sump; cubicle is water tight; sump pump is automatically operated.

5. Overflow directed to the internal WMT Sump. The WMTs are provided with a protective basin which drains to the external WMT sump. Both sumps are pumped by the sump emptying pump to the storm drain system or to the LWPS depending upon activity levels.

TABLE 11.2-7.1

ASSUMPTIONS USED FOR ESTIMATING ACTIVITY RELEASES

1. Reactor core thermal power: 3800 MWt

2. Plant capacity factor: 0.8

3. Source terms: Primary and secondary concentrations are taken from Table 11.1-7

4. Primary

   - Mass of primary coolant: 5.73×10^5 lb

   - Primary letdown flow rate: 100 gal/min

   - Primary letdown flow rate through cation bed: 20 gal/min

5. Secondary

   - Total steam flow rate: 1.69×10^7 lb/hr

   - Mass of steam in each steam generator: 1.3×10^4 lb

   - Mass of liquid in each steam generator: 1.23×10^5 lb

   - Total secondary coolant: 3.77×10^6 lb

   - Steam generator blowdown is treated prior to being recycled to the condensate system.

   - Steam generator blowdown flow rate: 1.68×10^5 lb/hr

   - Condensate regeneration time: 21 days

   - Fraction of feedwater through the condensate polishing demineralizer: 0.54

   - Primary to secondary break leak: 100 lb/day

6. LWPS

   a. Shim bleed: Except for tritium releases, no release is assumed

   b. Equipment and floor drains

      - Inlet floor: 6,900 gal/day

      - Fraction of primary coolant: 0.11

TABLE 11.2-7.1 (Continued)

ASSUMPTIONS USED FOR ESTIMATING ACTIVITY RELEASES

- DFs, iodine: 10^3
- DFs, all others: 10^4
- Collection time: 1.9 days
- Processing and discharge time: 0.332 days
- Fraction released: 1.0

c. Waste Holdup Tank

- Inlet flow: 530 gal/day
- Primary coolant fraction: 1.0
- DFs, iodine: 10^3
- DFs, all others: 10^4
- Collection time: 7.6 days
- Processing and discharge time: 0.115 days
- Fraction released: 1.0

d. Condensate Polishing Regeneration Waste Collection Tank

- Inlet flow: 4,650 gal/day
- DFs, iodine: 10^5
- DFs, Cs and Rb: 2×10^4
- DFs, others: 10^6
- Collection time: 1.96 days
- Processing and discharge time: 0.211
- Fraction released: 1.0

TABLE 11.2-7.1 (Continued)

ASSUMPTIONS USED FOR ESTIMATING ACTIVITY RELEASES

e. Steam Generator Blowdown

- DFs, Cs and Rb: 100
- DFs, others: 10^3
- Fraction released: 0.0

f. Dilution Method

- Reservoir dilution: See section 5.3.1 of STPEGS Environmental Report
- Reservoir release: Based upon 21,125 acre-ft/yr released from the reservoir
- Total annual release based upon reservoir release and concentrations given in Table 11.2-7.2

TABLE 11.2-7.2

EXPECTED SITE RADIONUCLIDE RELEASES AND CONCENTRATIONS

Nuclide	Reactor Release (Ci/yr)	Reservoir[a] Concentration (μCi/cm^3)	MPC[b] (μCi/cm^3)	EC[c] (μCi/cm^3)	Nuclide	Reactor Release (Ci/yr)	Reservoir[a] Concentration (μCi/cm^3)	MPC[b] (μCi/cm^3)	EC[c] (μCi/cm^3)
Rb-86	3.8(-3)[d]	1.1(-12)	1(-7)	7(-6)	Te-132	3.7(-2)	2.0(-13)	2(-5)	9(-6)
Sr-89	7.6(-4)	6.3(-13)	3(-6)	8(-6)	I-133	1.1	1.2(-16)	1(-6)	7(-6)
Sr-90	2.0(-5)	6.4(-13)	3(-7)	5(-7)	Cs-134	.414	4.6(-9)	9(-6)	9(-7)
Sr-91	1.7(-4)	8.9(-28)	5(-5)	2(-5)	I-135	.15	3.9(-31)	4(-6)	3(-5)
Y-91	1.1(-4)	1.1(-13)	3(-5)	8(-6)	Cs-136	5.4(-2)	8.8(-12)	6(-5)	6(-6)
Y-93	8.8(-6)	1.7(-28)	3(-5)	2(-5)	Cs-137	3.1(-1)	1.0(-8)	2(-5)	1(-6)
Zr-95	3.0(-3)	3.5(-12)	6(-5)	2(-5)	Ba-140	6.2(-4)	9.8(-14)	2(-5)	8(-6)
Nb-95	4.2(-3)	2.6(-12)	1(-4)	3(-5)	La-140	4.2(-4)	5.1(-17)	2(-5)	9(-6)
Mo-99	9.6(-2)	2.5(-13)	4(-5)	2(-5)	Ce-141	1.1(-4)	6.1(-14)	9(-5)	3(-5)
Tc-99m	8.6(-2)	5.7(-34)	3(-5)	1(-3)	Ce-143	3.6(-5)	7.5(-19)	4(-5)	2(-5)
Ru-103	3.6(-4)	2.5(-13)	8(-5)	3(-5)	Pr-143	9.0(-5)	1.6(-14)	5(-5)	2(-5)
Ru-106	4.8(-3)	3.1(-11)	1(-5)	3(-6)	Ce-144	1.0(-2)	5.1(-11)	1(-5)	3(-6)
Te-125m	4.0(-5)	4.3(-14)	1(-4)	2(-5)	Cr-51	.24	1.1(-10)	2(-3)	5(-4)
Te-127m	5.4(-4)	1.1(-12)	5(-5)	7(-6)	Mn-54	2.2(-2)	1.2(-10)	1(-4)	3(-5)
Te-127	7.6(-4)	1.1(-27)	2(-4)	1(-4)	Fe-55	5.8(-4)	7.7(-12)	8(-4)	1(-4)
Te-129m	3.3(-3)	1.9(-12)	2(-4)	7(-6)	Fe-59	2.4(-2)	2.0(-11)	5(-5)	1(-5)
I-130	3.3(-3)	1.3(-23)	1(-7)	2(-5)	Co-58	5.9(-1)	8.0(-10)	9(-5)	2(-5)
Te-131m	2.0(-3)	1.8(-17)	4(-5)	8(-6)	Co-60	9.0(-2)	1.8(-9)	3(-5)	3(-5)
I-131	3.24	2.2(-10)	3(-7)	1(-6)	Np-239	2.6(-4)	3.3(-16)	1(-4)	2(-5)
					H-3	1806	2.1(-5)	3(-3)	1(-3)

Total annual release from the site boundary = 0.47 Ci/yr (except H-3)

MPC Fraction = 1.86×10^{-3}

EC Fraction = 3.68×10^{-2}

a. The reservoir concentration is the concentration that is released to the Colorado River, and includes released activity from both units.
b. Non-occupational Maximum Permissible Concentration limit from 10CFR20 in effect prior to January 1, 1994
c. Effluent concentration limit from 10CFR20 in effect beginning January 1, 1994
d. 3.8(-3) = $3.8 \times 10^{-}$

11.3 GASEOUS WASTE MANAGEMENT SYSTEM

11.3.1 Design Bases

The design objectives of the Gaseous Waste Management System (GWMS) are twofold. The first objective is to process and control the release of gaseous radioactive effluents to the site environs in order to meet the requirements of 10CFR20 and the dose design objectives specified in 10CFR50, Appendix I. The second objective is to remove fission product gases from the reactor coolant and process these gases before they are released. These objectives are achieved when the input sources are as specified in Table 11.1-2 (design basis source terms). The GWMS is designed so that radiation exposure to personnel will be as low as is reasonably achievable (ALARA).

The effect of the V5H fuel upgrade on the radioactivity concentrations in the fluid systems was reviewed and it was determined that the original reactor coolant activity listed in Table 11.1-2 is bounding. Therefore, the FSAR analyses based on this activity are not adversely impacted by the fuel upgrade. The corresponding reactor core activity for the V5H upgrade is shown in Table 15.A-1A.

The impact of operating at a feedwater temperature as low as 390˚F on the radiological source terms has been evaluated. It was determined that operation under this scenario would have a negligible impact on the isotopic inventory of the liquid waste processing system and the radiological consequences of a GWPS failure, as described in Chapter 15.7.1

Various gas treatment systems are employed for the control of noble gases and iodine. The process vents and the building ventilation air filtration systems are described in detail in Section 9.4 and are only briefly described in this section for completeness. The Gaseous Waste Processing System (GWPS) removes and processes fission product gases from the Reactor Coolant System (RCS) and other miscellaneous sources of fission product gases. Table 11.3-1.1 lists the expected activity releases. During refueling the Reactor Coolant Vacuum Degassing System (RCVDS) may be used, if necessary, to remove fission product gases from the RCS free space and to reduce the time between draindown and reactor head removal.

The design bases for the GWMS are as follows:

1. The GWMS is designed to limit routine station activity releases to a small fraction of the limits specified in l0CFR20, and to minimize doses to ALARA in accordance with 10CFR50, Appendix I.

2. The GWMS furnishes protection against inadvertent release of significant quantities of gaseous and particulate radioactive material to the environs by providing:

   a. Design redundancy when required.

   b. Instrumentation for detection and alarm of abnormal conditions.

   c. Procedural controls and/or provisions for automatically halting the discharge of gaseous waste effluents if their activity exceeds preset limits.

d. Continuous monitoring of the various holdup and process systems. Integral control and monitoring instruments in the process lines preclude uncontrolled release of radioactive material to the environment.

e. Adequate time for operator decision and action when the monitors indicate the development of abnormal conditions.

3. The seismic classification and safety class information for the GWPS and RCVDS are given in Section 3.2.

4. The design requirements specified in Section 11.2.2.2.1, items 2, 3, and 4, are applied to the GWPS.

5. For the GWPS, the following additional design bases apply:

a. Aerated gases with the oxygen concentration above the oxygen analyzer setpoint shall not be processed by the GWPS.

b. The GWPS provides for long-term holdup for decay, and then controlled release to the environment, of noble gases stripped from the primary coolant. The minimum delay time is 3.65 days for krypton and 67.5 days for xenon.

An evaluation is contained in Appendix 11.A which shows that the GWMS is capable of controlling releases of radioactive materials within the dose design objectives of Appendix I to 10CFR50.

The GWPS and RCVDS component design parameters are given in Table 11.3-3 and instrumentation and control parameters are specified in Table 11.3-6. Design features to reduce maintenance, equipment downtime, leakage, and gaseous releases are incorporated in the GWPS and RCVDS and are discussed in Section 11.3.2.

The design and expected inventories of individual radionuclides (curies) in system components are given in Tables 11.3-5.1 and 11.3-5.2. The geometry and layout of equipment are described in Section 12.3. The design provisions to control release of radioactive materials in gaseous effluents as a result of equipment malfunction or operator error are discussed in Section 11.3.2.

The design objectives of the plant ventilation systems for normal and emergency operation are included in Section 9.4.

The GWPS is designed to prevent oxygen from entering the system. The process stream is continuously monitored for oxygen concentration at the inlet header. When a preset high oxygen concentration is attained, an alarm is activated and the GWPS is automatically shut down. The isolation valves are then opened by the operator and nitrogen is manually introduced into the GWPS inlet header at a controlled rate so that the oxygen concentration will be reduced to below alarm levels. In addition, the appropriate GWPS cubicles are monitored for hydrogen. Upon detection of a high hydrogen concentration, which indicates a leak from the process stream, an alarm is activated and the GWPS is shut down automatically.

In addition to the precautions taken to prevent entry of oxygen into the system, the GWPS is designed to withstand a hydrogen explosion without the release of radioactive material. The design conditions are listed in Table 11.3-3.

11.3.2 System Description

11.3.2.1 Radioactive Gas Sources. The primary sources of radioactive gas in the plant are:

1. Turbine Generator Building (TGB) process vents, i.e., main condenser mechanical vacuum pump exhaust, gland seal condenser exhaust, and deaerator vent. The auxiliary feedwater (AFW) pump turbine exhaust, which is vented directly to the atmosphere through the isolation valve cubicle process vent, is included in this group.

2. Reactor Containment Building (RCB) ventilation

3. Mechanical Auxiliary Building (MAB) and TGB ventilation

4. Fuel Handling Building (FHB) ventilation

5. Reactor coolant gaseous waste

The details of these sources are described in the following sections. Design provisions for radioactivity monitoring of these sources are discussed in Section 11.5. Figure 11.3-1 illustrates the GWMS associated with these sources.

11.3.2.2 Turbine Generator Building and Isolation Valve Cubicle Process Vents. Table 11.3-1.1 lists the expected radioactive gaseous release from the TGB sources.

11.3.2.2.1 Main Condenser Mechanical Vacuum Pump: The waste gases in the Main Steam (MS) and Condensate Systems are removed by the main condenser mechanical vacuum pumps, as described in Section 10.4.2 and illustrated on Figure 11.3-1. Generally, these gases consist of main condenser air inleakage and contain no radioactivity. However, in the event of operation with steam generator (SG) tube leaks, the effluents to the Main Condenser Evacuation System may contain radioactive gases. As discussed in Section 10.4.2, the main condenser offgas is discharged directly to the unit vent.

11.3.2.2.2 Turbine Gland Seal Condenser Exhaust: A small fraction of the MS is processed through the turbine gland seals and condensed in the gland seal condenser. Generally, the noncondensable gases exhausting from this condenser are not radioactive. However, in the event of operation with SG tube leaks, the effluents from this condenser may contain radioactive gases. As discussed in Section 10.4.3 and illustrated on Figure 11.3-1, the noncondensable gases from the gland seal condenser are vented to the atmosphere via redundant exhaust blowers without filtration.

11.3.2.2.3 Isolation Valve Cubicle Process Vent: The exhaust from the AFW pump turbine is vented directly to the atmosphere without filtration, as illustrated on Figure 11.3-1. Generally, the exhausted steam flow does not contain radioactive gases. However, in the event of operation with SG tube leaks, the exhaust flow may contain radioactive gases.

11.3.2.2.4 Deaerator Vent: Steam and noncondensible gases are vented from the deaerator to the main condenser off gas header as illustrated in Figure 11.3-1.

11.3.2.3 Containment Ventilation. Radioactive gases evolve from the reactor coolant leakage to the Containment. The radioactivity level in the Containment depends upon the leakage rate of the reactor coolant, half-lives of the isotopes, filter removal rate, and building purge intervals. The Containment atmosphere can be purged. The purge systems are described in Section 9.4.5 and illustrated on Figure 11.3-1. The estimated annual releases are given in Table 11.3-1.1 using the assumptions given in Table 11.3-2 for reactor coolant leakage, partition factors, filter efficiencies, and number of purges per year.

11.3.2.4 Mechanical Auxiliary Building Ventilation. The radioactive gases released to the MAB are the result of leakage from systems containing reactor coolant which mixes with the air in the building and finally reaches the environment through the MAB Ventilation System. Included in this discharge is the effluent from the GWPS. The MAB Ventilation System is described in detail in Section 9.4.3 and illustrated on Figure 11.3-1. The anticipated annual releases are estimated in Table 11.3-1.1 using the assumptions given in Table 11.3-2.

11.3.2.5 Turbine Generator Building Ventilation Systems. Radioactive gases released to the TGB are the result of steam leakage into the TGB while operating with SG tube leaks. As described in detail in Section 9.4.4 and illustrated on Figure 11.3-1, the TGB Ventilation System discharges these gases to the atmosphere. The contribution from this source is included in the TGB releases on Table 11.3-1.1.

11.3.2.6 Fuel Handling Building Ventilation System. As described in detail in Section 9.4.2, the FHB Ventilation System mixes and dilutes the tritiated water vapor and discharges it directly to the atmosphere. Table 11.3-1.1 lists the total annual airborne tritium released from all sources and is based on the assumptions listed in Table 11.3-2.

11.3.2.7 Gaseous Waste Processing System. The waste gases originating in the reactor coolant consist mainly of hydrogen with trace amounts of noble gases and halogens. These gases are stripped from the coolant by the volume control tank (VCT) hydrogen purge (the principal source), and from the hydrogen or nitrogen gases vented off the boron recycle holdup tanks, boron recycle evaporator, reactor coolant drain tank (RCDT), Liquid Waste Processing System (LWPS) waste evaporator (when processing the contents of the Boron Recycle System [BRS] recycle holdup tank [RHT] only), pressurizer relief tank (PRT) vent, and the RCVDS storage tanks. CN-3001

During normal operation, the hydrogen gas containing trace quantities of fission gases from the above sources is processed through a moisture removal skid, a charcoal guard bed, two charcoal delay tanks, and a high-efficiency particulate air (HEPA) filter before being released with the MAB exhaust. The minimum time delay provided by the charcoal for xenon is 67.5 days, with 3.65 days for krypton. The estimated annual releases are listed in Table 11.3-1.1 using the assumptions listed in Table 11.3-2.

The piping and instrumentation diagram (P&ID) for the GWPS is shown on Figure 11.3-2. This system is described in the following paragraphs and is designed to accommodate the modes of operation described below.

11.3.2.7.1 Operating Modes:

11.3.2.7.1.1 Normal Operation - Hydrogen gas with trace quantities of noble gases and halogens is letdown from the VCT, boron recycle evaporator, liquid waste evaporator (only when processing the contents of the BRS RHT), PRT vent, and RCDT into the GWPS, which operates at 1 to 2 psig. The main source is the reactor coolant in the VCT from which the fission product gases are stripped by 0.7 scfm hydrogen purge. An inlet header water removal skid removes (to a dewpoint of 40°F) water and heat from the gas stream prior to processing the stream through charcoal beds. The gases are then delayed as the gas stream progresses through the charcoal beds. The discharge gas stream is filtered by HEPA filters to remove charcoal dust prior to release to the atmosphere via the plant vent header. CN-3001

The 0.7 scfm flow rate from the Volume Control Tank (VCT) to the Gaseous Waste Processing System (GWPS) may be increased proportionally as the reactor coolant system isotopic inventory (presented on Table 11.1-7) decreases. This will allow operation at a higher flow rate while preserving the activity flow rate (curies/min) into the GWPS. The isotopic releases, component activities, and GWPS inlet activity in Section 11.3 and the projected offsite releases and doses presented in Section 11.A will remain bounding.

Venting of the BRS RHT is accomplished by starting the bellows compressor at a maximum rate of 1 scfm. Venting of the BRS recycle holdup tank is required for approximately 6 hours every month.

11.3.2.7.1.2 Reactor Shutdown Operations - The RCVDS P&ID is shown on Figure 11.3-3. Prior to reactor shutdown, the VCT letdown and purge flow rates are increased to aid in lowering the fission gas concentration in the reactor coolant. At shutdown, the VCT hydrogen purge is switched to a 5 scfm nitrogen purge to strip the hydrogen from the reactor coolant. The gas mixture from the VCT flows to the GWPS for processing. At the start of reactor coolant draindown, the RCS is vented with nitrogen to prevent oxygenation of the reactor coolant and permit continued operation of the VCT.

Following draindown, the RCVDS may be used, if necessary, to remove radioactive gases released into the RCS free space from the primary coolant, prior to reactor head removal for refueling operations. The RCVDS utilizes a vacuum pump in tandem with a compressor to evacuate and compress the fission gases removed from the RCS through a connection in the 14-in. pressurizer safety and relief valve discharge line near the PRT. The nitrogen in the RCS free space is used as the carrier gas for the degassing operations. The nitrogen and fission gas mixture is compressed and stored in the two 600-ft^3 gas storage tanks at 120 psig. The gas mixture is then vented through the GWPS when the activity has been reduced to acceptable levels. The GWPS may be bypassed to upstream of the HEPA filter provided the releases are below acceptable limits.

11.3.2.8 System Component Design. The GWPS and RCVDS component capacities, design pressures and temperatures, process parameters and materials of construction are given in Table 11.3-3. The following sections provide information regarding seismic and quality classification, safety evaluation, and component operation.

11.3.2.8.1 Seismic and Quality Group Classification: The GWPS and the RCVDS are classified as non-nuclear safety (NNS). All components of the GWPS and RCVDS are designed to meet the seismic requirements of BTP ETSB 11-1, Rev. 1.

11.3.2.8.2 Safety Evaluation: The GWPS and RCVDS process only nonaerated gases.

In addition, to ensure that air inleakage to the GWPS system is prevented, the entire GWPS (except one small section of the BRS RHT vent line) is above atmospheric pressure; sample bottles are purged with nitrogen prior to being placed in service. Even though air inleakage into the GWPS is not considered possible, if it should occur, a resulting hydrogen-oxygen ignition is not considered credible for the following reasons:

1. The gas in process is continuously monitored for oxygen content at the inlet header. An alarm is activated and the isolation valve of the GWPS is automatically closed if the oxygen content reaches the high level setpoint. When this occurs, the GWPS isolation valve is opened by the operator. Nitrogen is introduced manually at the inlet header until the source of oxygen is located and stopped, and oxygen concentration is brought down to acceptable levels.

2. The minimum ignition temperature for a hydrogen-oxygen mixture is in the range of 1076°F to 1094°F at one atmosphere pressure.

3. The heat-generating components of the GWPS are the guard bed and the charcoal adsorbers. The maximum operating temperature of these vessels is well below the ignition temperature of the charcoal (approximately 600°F). Therefore, ignition of the charcoal, which may cause a hydrogen-oxygen detonation, is not possible.

4. There are no spark-generating items within the GWPS.

Since excessive hydrogen leakage from the GWPS into the surrounding air spaces could lead to a hazardous condition, i.e., an explosive hydrogen-air mixture within the building, the following features are employed to prevent leakage, provide early detection, and ensure adequate dilution:

1. The GWPS consists of welded piping to the greatest extent practicable. Flanged joints are kept to a minimum.

2. All manual process valves are of the packless metal diaphragm (PMD) type.

3. Hydrogen monitors are employed to survey the appropriate GWPS cubicles for hydrogen leakage. The GWPS is automatically shut down if hydrogen leakage is detected. An alarm is also activated upon reaching the high level setpoint.

4. The MAB Ventilation System provides continuous cooling air which is circulated through the charcoal bed vaults and GWPS spaces, removing heat and potentially hazardous gases from the area.

In addition to all the above precautions taken to prevent a hydrogen explosion, the GWPS is designed to withstand a hydrogen explosion without releasing any radioactive material.

The reactor coolant is purged with nitrogen prior to using the RCVDS, and therefore the gases handled by the RCVDS will not contain significant concentrations of hydrogen or oxygen.

11.3.2.9 Shielding and Field Run Piping. The design philosophy for component shielding and field run piping is delineated in Sections 12.1.2.1 through 12.1.2.2.

11.3.2.10 Component Description. A discussion of the major components is provided in the following sections. These components are conservatively designed with additional capacity to process waste gas in the event of equipment outages.

11.3.2.10.1 Inlet Header Water Removal Skid: This skid consists of an inlet header receiving all inputs to the GWPS, a glycol chiller tank, a bellows compressor, a moisture separator, a moisture separator drain tank, and associated piping, valves, and instrumentation. A description of these major skid components is given below. Design parameters are given in Table 11.3-3.

11.3.2.10.1.1 Inlet Header - The inlet header receives process gas from each individual input stream to the GWPS. The header includes an oxygen monitor, pressure transmitter, and isolation valve. Each individual input stream to the GWPS contains necessary isolation valves, control valves, and associated instrumentation to regulate flow to the inlet header. The inlet header pipes the process stream into the cooling coils submerged in the glycol chiller tank. The inlet header operates at a maximum pressure of 2 psig.

Nitrogen can also be introduced into the GWPS inlet header through a pressure control valve for system purge or dilution when the oxygen content of the gas in the inlet header reaches a high limit.

11.3.2.10.1.2 Glycol Chiller Tank - The glycol chiller tank contains a glycol water solution that is cooled by one of two refrigeration coils immersed in the solution. The gaseous waste process stream passes through coils submerged in the chilled glycol water solution. The gas stream is chilled to a dew point of 40°F. Due to the large quantity of glycol water solution, the system has a "thermal inertia". Thus, in the unlikely event of a loss of both refrigerators, the GWPS can still operate up to 4 hours while repairs are in progress.

11.3.2.10.1.3 Moisture Separator - The moisture separator is also immersed inside the glycol chiller tank solution. Condensation is removed, and the dry gas stream passes out of the tank to the guard bed. The condensation drains to the moisture separator drain tank.

11.3.2.10.1.4 Moisture Separator Drain Tank - The moisture separator drain tank can hold up to 19 gallons of condensation, or water from approximately two weeks of GWPS operation. The tank is manually drained when a high level is indicated in the tank. The operator drains the tank until low level is indicated.

11.3.2.10.1.5 Bellows Compressor - A metal bellows compressor is provided on the skid to compress the BRS RHT vent input from atmospheric pressure up to 2 psig before entering the inlet header. This occurs approximately 6 hours/month at a flow rate of 1 scfm. This compressor is a double bellows design so that if the inner bellows should rupture, the secondary bellows would prevent release of radioactive material.

11.3.2.10.2 Guard Bed and Charcoal Delay Tanks - A guard bed and two charcoal tanks containing a total of 22,300 pounds of charcoal are employed for xenon and krypton delay. These tanks are located in shielded vaults maintained at a temperature not to exceed 85°F by the MAB Heating, Ventilating and Air-Conditioning (HVAC) System. All tanks have the provision to replace charcoal. The amount of charcoal contained in these tanks is sufficient to meet the design bases of the system, as noted in Section 11.3.1, including anticipated operational occurrences.

The guard bed offers protection to the large charcoal beds. In the unlikely event of contamination or flooding, the guard bed charcoal can be dried with heated nitrogen or replaced if necessary.
The relationship used to predict xenon and krypton delay was investigated in depth by Browning, Adams, and Ackley (Ref. 11.3-1). The delay time depends on gas flow rate, mass of charcoal, and a gas unique coefficient referred to as the dynamic adsorption coefficient (Ref. 11.3-2).
The dynamic adsorption coefficients (K_j) for xenon and krypton applied to evaluate the system are those values published by the Nuclear Regulatory Commission (NRC) in Reference 11.3-2 and are shown below.

K_{xe} = 330 (77°F/45°F dewpoint)

K_{kr} = 18.5 (77°F/45°F dewpoint)

Based on the above data, the minimum delay times for xenon and krypton were calculated and are 3.65 days for krypton and 67.5 days for xenon.

Table 11.3-5.1 predicts the worst-case equilibrium isotopic curie content contained within the guard bed and the charcoal beds for operation with an assumed 1 percent failed fuel. The charcoal adsorbers are designed so the maximum operating temperature of 200°F is well below the ignition temperature of the charcoal.

The charcoal adsorbers are located in shielded vaults maintained at a temperature not to exceed 85°F. Since the maximum heat load is estimated to be less than 400 Btu/hr, and because of the large thermal capacitance of the charcoal system, there is sufficient time to restore ventilation supply air in case of failure of the air supply system to ensure continued operation. In the unlikely event of longer ventilation system outage, the charcoal adsorbers can be isolated.

Suitable piping connections make it possible to bypass either charcoal bed. In addition, heated nitrogen can be introduced to each charcoal adsorber independently in order to flush or dry the charcoal.

Since the normal flow rate is small and the ratio of charcoal bed diameter to particle diameter is very large, flow channeling is not considered credible.

11.3.2.10.3 Refrigeration Package: Redundant freon refrigeration units are used to cool a solution of water-glycol in the glycol chiller tank. Each refrigeration unit has its own coil immersed in the glycol chiller tank.

11.3.2.10.4 RCVDS Gas Decay Tanks: Two carbon steel, vertical, cylindrical-type decay tanks are provided to receive the reactor coolant gases vented during refueling following draindown and prior to reactor head removal.

11.3.2.10.5 RCVDS Vacuum Pump and Compressor: A vacuum pump, in tandem with a compressor, evacuates the reactor coolant free space during refueling. The compressor discharges these gases into the two gas storage tanks for decay.

11.3.2.10.6 Valves: Valve leakage to the atmosphere is minimized by employing, where practicable, packless metal diaphragm (PMD) valves. Air-operated isolation valves are diaphragm valves. Manual valves within the gas process stream or process liquid stream are PMD valves. Pressure-regulating valves are pneumatic control valves with controllers.

11.3.2.10.7 Iodine Removal: Iodine entering the GWPS is small by virtue of the ion exchangers and retention properties in the reactor coolant. However, all the iodine which does enter the GWPS is essentially removed by the charcoal.

11.3.2.10.8 Instrumentation: The GWPS instrumentation is shown on the system P&ID, Figure 11.3-2. The instrumentation of the RCVDS is shown on Figure 11.3-3. Instrumentation associated with HVAC Systems is discussed in Section 9.4. Operating parameter readouts are provided on the GWPS and RCVDS panels in the radwaste control room located in the MAB. All alarms are annunciated separately on the GWPS and RCVDS panels.

The PRT vent, VCT, and RCVDS decay tank inputs to the GWPS are provided with pressure controllers that reduce the input pressure for these three inputs to 2 psig. The BRS RHT vent input to the GWPS is provided with a compressor to increase the input pressure. The compressor controls are self-contained and receive input from a pressure switch on the compressor and from the GWPS control logic.

Oxygen concentration and pressure, are measured on the GWPS system inlet header. High oxygen and/or pressure signals send inputs to the system control logic. A temperature measurement on the glycol chiller tank is used to control the two refrigerators. A local pressure gauge is located on the discharge of each refrigerator. The moisture separator drain tank is provided with a level indicator and high- and low-level alarms.

Temperature, moisture, pressure, and radiation are measured on the discharge of the moisture separator. High moisture, high and low temperature, and high radiation activate alarms.

The temperature in the guard bed is indicated on the GWPS panel. When the high temperature setpoint is reached, an alarm is activated. A high-pressure alarm is provided on the discharge of the first charcoal tank. A local differential pressure indicator is provided on the HEPA filter.

Flow and radiation are measured on the discharge of the GWPS. High flow and high radiation signals are provided as input into the system control logic.

Hydrogen leakage detection is provided in the appropriate GWPS cubicles, and a high hydrogen signal inputs to the system control logic.

The system control logic closes the inlet and outlet valves and stops the BRS RHT vent compressor whenever there is high inlet oxygen, high inlet pressure, high outlet flow, high outlet radiation, or high hydrogen concentration in the GWPS cubicles.

In the RCVDS, pressure is monitored at the inlet to the vacuum pump package, compressor package, and gas storage tank 1A. Pressure and water level are also monitored for each gas storage tank. Pressure indicators are provided on the RCVDS control panel. High pressure at the vacuum pump inlet and high water level and pressure for the gas storage tanks are alarmed at the RCVDS control panel.

11.3.2.10.9 Component Isotopic Activity: Tables 11.3-5.1 and 11.3-5.2 provide an estimate of the component activities for design basis and realistic basis source terms. Maximum and realistic GWPS inlet and discharge activities are shown in Table 11.3-5.3.

11.3.3 Radioactive Releases

Table 11.3-1.1 lists expected annual activity releases from normal operation and anticipated operational occurrences from gaseous sources, based upon the reactor operating with expected primary and secondary coolant concentrations. Table 11.3-2 lists the bases for Table 11.3-1.1.

11.3.3.1 Release Points. Gaseous releases, except certain TGB process and HVAC vents and the Isolation Valve Cubicle vent, are vented to the atmosphere through a single main plant vent duct for each unit. This vent duct is located adjacent to the RCB.

The main plant ventilation duct is divided into three compartments up to the tornado damper, after which these are combined into one duct up to the discharge point. The minimum velocity of the gases flowing through the single discharge point is approximately 487 ft/min and the maximum velocity is 3,822 ft/min. The total flow rate varies from 37,000 ft^3/min to 290,500 ft^3/min. The discharge temperature is 120°F.

The TGB process vents, except for the Condenser Air Removal pumps discharge, release associated gases directly to the atmosphere through separate vents, all penetrating above the top deck of the TGB. The Condenser Air Removal pumps, discharge through the unit vent.

11.3.3.2 Dilution Factors. Dilution factors are discussed in Appendix 11.A.

11.3.3.3 Estimated Doses. Doses are discussed in Appendix 11.A

REFERENCES

Section 11.3:

11.3-1 Browning, W.E., et al., "Removal of Fission Product Gases from Reactor Off-Gas Streams by Adsorption", ORNL Central Files No. 59-6-47, June 11, 1959.

11.3-2 U.S. Nuclear Regulatory Commission, Office of Standards Development, "Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from Pressurized Water Reactors (PWR-GALE Code)", NUREG-0017, April 1976.

TABLE 11.3-1.1

EXPECTED ANNUAL ACTIVITY RELEASED PER UNIT (CURIES/YEAR)

Isotope	Half-life	Containment Release	Auxiliary Building (MAB and FHB) Release	TGB Releases	Reactor Coolant Gaseous Release	Total Releases
Kr-83m	1.86 hr	3.0	(a)	(a)	(a)	3.0
Kr-85	10.76 yr	5.0	(a)	(a)	3.2(+2)	3.3(+2)
Kr-85m	4.5 hr	2.8(+1)[(b)]	2.0	1.0	(a)	3.1(+1)
Kr-87	78 min	6.0	1.0	(a)	(a)	7.0
Kr-88	2.8 hr	3.8(+1)	4.0	3.0	(a)	4.5(+1)
Xe-131m	11.8 day	1.2(+1)	(a)	(a)	1.5(+1)	2.7(+1)
Xe-133m	2.26 day	6.2(+1)	2.0	1.0	(a)	6.5(+1)
Xe-133	5.27 day	3.2(+3)	9.6(+1)	6.0	3.0(+1)	3.3(+3)
Xe-135	9.19 hr	1.2(+2)	6.0	4.0	(a)	1.3(+2)
Xe-138	17.0 min	1.0	(a)	(a)	(a)	1.0
I-131	8.05 day	1.6(-1)	3.6(-2)	2.3(-2)	(a)	2.2(-1)
I-133	20.9 hr	1.9(-1)	5.5(-2)	3.4(-2)	(a)	2.7(-1)
H-3	12.26 yr	-	-	-	-	9.0(+2)
Mn-54	312.5 day	2.2(-2)	1.8(-2)	(a)	4.5(-3)	4.5(-2)
Fe-59	44.6 day	7.4(-3)	6.0(-3)	(a)	1.5(-3)	1.5(-2)
Co-58	70.8 day	7.4(-2)	6.0(-2)	(a)	1.5(-2)	1.5(-l)
Co-60	5.27 day	3.4(-2)	2.7(-2)	(a)	7.0(-3)	6.8(-2)
Sr-89	50.52 day	1.7(-3)	1.3(-3)	(a)	3.3(-4)	3.3(-3)
Sr-90	29 yr	3.0(-4)	2.4(-4)	(a)	6.0(-5)	6.0(-4)
Cs-134	2.062 yr	2.2(-2)	l.8(-2)	(a)	4.5(-3)	4.4(-2)
Cs-137	30.17 yr	3.7(-2)	3.0(-2)	(a)	7.5(-3)	7.4(-2)

a. Zero or negligible
b. $2.8(+1) = 2.8 \times 10^1$

TABLE 11.3-2

ASSUMPTIONS USED FOR ESTIMATING ACTIVITY RELEASES FOR TABLE 11.3-1.1

1. Reactor core thermal power: 3,800 MWt

2. Plant capacity factor: 0.8

3. Primary coolant isotopic activity is based on the realistic values in Table 11.1-7.

4. Secondary coolant isotopic activities are those values listed in Table 11.1-7 for the realistic cases.

5. Containment Purge Releases

    - Four purges/yr (two maintenance and two refueling) at 40,000 ft^3/min and continuous purging during operation at 5,000 ft^3/min were conservatively assumed
    - One 16-hour, 20,000-ft^3/min internal charcoal filter Containment cleanup prior to initiation of Containment purge for maintenance
    - Primary coolant leakage into Containment is 1 percent per day for noble gases and 0.001 percent per day for iodines. Leakage is only assumed to stop during purge for refueling and maintenance outages (i.e., 40,000 ft^3/min purge)
    - Iodine removal efficiency is 90 percent for charcoal filters in the Containment Cleanup System
    - Containment free volume: 3.58×10^6 ft^3
    - Volumetric mixing efficiency during internal cleanup: 70 percent
    - All remaining iodines after internal cleanup are directly released to the atmosphere during the Containment purge for maintenance or refueling
    - No decay is assumed during purge

6. Auxiliary Building Releases (MAB and FHB)

    - Primary coolant leakage is 160 lb/day
    - All noble gas contained in released coolant escapes
    - Fraction of iodine which becomes airborne is 0.0075

TABLE 11.3-2 (Continued)

ASSUMPTIONS USED FOR ESTIMATING ACTIVITY RELEASES
FOR TABLE 11.3-1.1

7. Secondary Coolant Releases

- Secondary coolant isotopic activity is listed in Table 11.1-7 for the realistic basis
- SG iodine carryover: 0.01 x liquid activity
- Steam leakage: 1,700 lb/hr
- Iodine released by steam leakage: 100 percent of steam activity
- Turbine condenser steam inlet flow rate: 1.7×10^7 lb/hr
- Full-flow condensate demineralizers with an iodine DF of 10 process all the turbine condenser liquid condensate
- There is no charcoal filtration of the condenser off-gas

8. GWPS

- There is 0.7 scfm purge of the VCT.

  Note: The 0.7 scfm flow rate from the VCT to the GWPS may be increased proportionally as the reactor coolant system isotopic inventory (presented on Table 11.1-7) decreases. This will allow operation at a higher flow rate while preserving the activity flow rate (curies/min) into the GWPS. The isotopic releases, component activities, and GWPS inlet activity in Section 11.3 and the projected offsite releases and doses presented in Section 11.A will remain bounding. CN-3001

- Delay time for krypton and xenon are 3.65 days and 67.5 days, respectively
- Two primary coolant degassing operations per year release 100 percent of noble gases
- Iodine adsorption in charcoal delay tanks: 100 percent

9. Tritium Releases

- The total tritium production is assumed to be equal to the equilibrium cycle production in Table 11.1.8
- Fifty percent of the total tritium generation is released as water vapor from the site

TABLE 11.3-3

GASEOUS WASTE PROCESSING SYSTEM

COMPONENT DESIGN PARAMETERS

Charcoal Beds

Type	Vertical
Code	ASME VIII
Quantity	2
Volume	343 ft^3
Charcoal/per bed	10,750 lbs
Design/operating temperature	200°F/60-104°F
Design/operating pressure	350 psig/1 psig
Charcoal ignition temperature	600°F minimum
Seismic category	BTP ETSB 11-1, Rev. 1
Material of construction	Carbon steel SA 516 Gr. 70

Guard Bed

Type	Vertical
Code	ASME VIII
Quantity	1
Volume	25 ft^3
Design/operating pressure	500 psig/1 psig
Charcoal	800 lb
Design/operating temperature	200°F/60-104°F
Charcoal ignition temperature	600°F minimum
Seismic category	BTP ETSB 11-1, Rev. 1
Material of construction	Stainless steel SA 240, SA 358 Type 304L

Refrigeration Package

Type	Self-contained
Refrigerant	Freon-12
Quantity Required	1
Number of Freon compressors	2
Number of Freon/air HXs	2
Number of cooling coils	2
Design heat load	4,250 Btu/hr

Gas Compressors

	BRS Recycle Holdup Tank Vent	RCS Vacuum Degassing
Type	Metal Bellows	Nash Liquid Ring
Quantity	1	1
Design/operating pressure	50 psig/2 psig	150 psig/120 psig max. discharge

TABLE 11.3-3 (Continued)

GASEOUS WASTE PROCESSING SYSTEM
COMPONENT DESIGN PARAMETERS

Gas Compressors (Continued)

	BRS Recycle Holdup Tank Vent	RCS Vacuum Degassing
Design/operating temperature	104°F/ambient	200°F/100°F max. discharge
Design flow	1 scfm	40 ft^3/min actual
Materials	Inconel 625	Stainless steel A351 CF3M

RCVDS Gas Decay Tanks

Type	Vertical
Code	ASME VIII
Quantity	2
Design/operating pressure	150 psig/120 psig
Design/operating temperature	200°F/100°F
Volume (each)	600 ft^3
Material of construction	Carbon steel SA 516 Gr. 70

RCVDS Vacuum Pump

Type	Nash Liquid Ring
Quantity	1
Design/operating pressure	50 psig/17.7 psia max. discharge
Design/operating temperature	200°F/120°F max. discharge
Design flow	127 ft^3/min actual
Material of construction	Stainless steel A351 CF3M

Drain Tank

Type	Horizontal
Code	ASME VIII, Div. 1
Quantity	1
Design/operating pressure	250 psig/2 psig
Design/operating temperature	200°F/40°F
Volume	19 gal
Material of construction	Stainless steel SA240 Type 304L, SA 182

TABLE 11.3-3 (Continued)

GASEOUS WASTE PROCESSING SYSTEM
COMPONENT DESIGN PARAMETERS

Glycol Chiller Tank

Type	Vertical
Code	API 650
Quantity	1
Design/operating pressure	3 psig/liquid head
Design/operating temperature	200°F/35°F
Volume	26.3 ft^3
Material of construction	Carbon steel SA 285

Gas Discharge Filter Assembly

Type	HEPA
Code	ASME VIII
Quantity	1
Design/operating temperature	200°F/ambient
Design/operating pressure	425 psig/0 psig
Design flow	5 scfm
Material of construction	Stainless steel SA 182 F304, SA 312 Type 304

TABLE 11.3-5.1

ESTIMATE OF MAXIMUM COMPONENT ACTIVITY – DESIGN BASIS

(Steady-State Accumulations [Curies])

Isotopes	Guard Bed	First Charcoal Bed	Second Charcoal Bed
Kr-85m	4.4(+1)	6.2(-1)[a]	(b)
Kr-85	5.7(+2)	7.5(+3)	7.5(+3)
Kr-87	3.3	(b)	(b)
Kr-88	4.7(+1)	1.3(-2)	(b)
Xe-131m	1.7(+3)	3.7(+3)	9.3(+2)
Xe-133m	7.5(+3)	4.7	3.0(-3)
Xe-133	1.8(+5)	2.5(+4)	1.1(+3)
Xe-135	7.1(+1)	(b)	(b)
I-131	1.2(+2)	1.2(+1)	1.2
I-132	1.6	1.6(-1)	2.0(-2)
I-133	2.0(+1)	2	2.0(-1)
I-134	1.3(-1)	1.3(-2)	1.0(-3)
I-135	3.7	3.7(-1)	4.0(-2)

a. 6.2(-1) = 6.2×10^{-1}

b. Zero or Negligible

TABLE 11.3-5.2

ESTIMATE OF MAXIMUM COMPONENT ACTIVITY – REALISTIC BASIS

(Steady-State Accumulations [Curies])

Isotopes	Guard Bed	First Charcoal Bed	Second Charcoal Bed
Kr-85m	2.2	3.1	(b)
Kr-85	4.0(-1)[a]	5.3	5.3
Kr-87	1.7(-1)	(b)	(b)
Kr-88	2.4	6.5(-4)	(b)
Xe-131m	1.2(+1)	2.6(-1)	6.5
Xe-133m	3.7(+1)	2.4(-2)	1.4(-5)
Xe-133	3.6(+3)	5.0(+2)	2.2(+1)
Xe-135	2.8	(b)	(b)
I-131	1.1(+1)	1.1	1.1(-1)
I-132	6.5(-2)	6.5(-3)	6.5(-4)
I-133	1.8	1.8(-1)	2.0(-2)
I-134	1.0(-2)	1.0(-3)	1.0(-4)
I-135	3.3(-1)	3(-2)	3.0(-3)

a. $4.0(-1) = 4.0 \times 10^{-1}$

b. Zero or Negligible

TABLE 11.3-5.3

MAXIMUM AND REALISTIC GWPS INLET ACTIVITY (Ci/min)

Isotopes	Realistic Inlet	Maximum Inlet
Kr-85m	2.0(-2)*	4.0(-1)
Kr-85	2.1(-3)	3.0
Kr-87	5.0(-3)	1.0(-1)
Kr-88	2.5(-2)	5.0(-1)
Xe-131m	4.2(-3)	6.0(-1)
Xe-133m	2.3(-2)	4.6
Xe-133	1.4	7.2(+1)
Xe-135m	4.2(-3)	1.4(-1)
Xe-135	6.8(-2)	1.7
Xe-138	8.0(-4)	1.0(-2)
I-131	6.5(-4)	7.2(-3)
I-132	4.0(-4)	1.0(-2)
I-133	9.0(-5)	1.0(-2)
I-134	1.8(-4)	2.0(-3)
I-135	5.8(-4)	6.4(-3)

* 2.0(-2) = 2.0×10^{-2}

TABLE 11.3-6

GASEOUS WASTE PROCESSING SYSTEM INSTRUMENTATION

A. PRESSURE INSTRUMENTATION

1. Recycle Holdup Tank Venting

Instrument	Purpose	Range or Setpoint
PT-4650	Monitor pressure in vent line	-50" wg to +50" wg
PI-4650	Indicate pressure	-50" wg to +50" wg
PSL-4650	Alarm low-pressure	-35" wg

2. Bellows Compression Leak Detection

Instrument	Purpose	Range or Setpoint
PSH-4651	Detect pressure behind bellows indicating leak	-8"Hg

Remarks: No leak pressure 0 in. wg
PSH-4651 also shuts down compressor

3. GWPS System Inlet Pressure

Instrument	Purpose	Range or Setpoint
PT-4656	Monitor and transmit GWPS inlet pressure	-
PI-4656	Indicate pressure	0 – 3 psig
PSH-4656	Initiate high pressure alarm	2.2 psig
PSL-4656	Initiate low pressure alarm	0.2 psig
PSH-4656A	System shutdown	2.5 psig

Remarks: Normal pressure: 2.0 psig

TABLE 11.3-6 (Continued)

GASEOUS WASTE PROCESSING SYSTEM INSTRUMENTATION

4. Moisture Separator Outlet Pressure

Instrument	Purpose	Range or Setpoint
PT-4663	Monitor pressure	-
PI-4663	Indicate pressure	0 – 3 psig

Remarks: Normal pressure: 1.7 psig

5. Adsorber Tank Pressure

Instrument	Purpose	Range or Setpoint
PSH-4669	Initiate alarm when pressure in tanks reaches setpoint	5 psig

6. Pressurizer Relief Tank

Instrument	Purpose	Range or Setpoint
PIC-4652	Control pressure	2 psig

7. Volume Control Tank

Instrument	Purpose	Range or Setpoint
PIC-4653	Control pressure	2 psig

B. FLOW INSTRUMENTATION

1. Pressurizer Relief Tank (PRT) Vent

Instrument	Purpose	Range or Setpoint
FE-4652	Monitor flow from PRT	-
FI-4652	Indicate flow	0 – 10 scfm

Remarks: Normal flow: 1-5 scfm

TABLE 11.3-6 (Continued)

GASEOUS WASTE PROCESSING SYSTEM
INSTRUMENTATION

2. Volume Control Tank (Inlet Flow to GWPS)

Instrument	Purpose	Range or Setpoint
FE-4653	Monitor flow in inlet of GWPS	-
FIT-4653	Indicate flow	0 – 10 scfm
FSH-4653	Initiate high flow alarm	1.2 scfm
FIC-4653	Indicate/control FV4653	1.0 scfm
FY-4653	Operate control valve FV4653	-
FIT-4658*	Indicate Flow	0-10scfm
FE-4658*	Monitor flow out outlet of Glycol Chiller Tank	-
HS-4653*	Switch Flow Element to Control FV-4653	-

* Alternate control of valve FV-4653 – intended use during system start-up.

Remarks: Normal flow: 0.7 to 1.0 scfm
The normal flow rate from the VCT to the GWPS, and the associated instrument ranges and setpoints, may be increased proportionally as the reactor coolant system isotopic inventory (presented on Table 11.1-7) decreases. This will allow operation at a higher flow rate while preserving the activity flow rate (curies/min) into the GWPS. The isotopic releases, component activities, and GWPS inlet activity in Section 11.3 and the projected offsite releases and doses presented in Section 11.A will remain bounding.

3. Reactor Coolant Vacuum Degassing System (RCVDS) Inlet Flow

Instrument	Purpose	Range or Setpoint
FE-4654	Monitor flow from RCVDS	-
FI-4654	Indicate flow	0-10 scfm

Remarks: Normal flow: 5.0 scfm

TABLE 11.3-6 (Continued)

GASEOUS WASTE PROCESSING SYSTEM INSTRUMENTATION

4. Deleted

5. GWPS System Exhaust Flow

Instrument	Purpose	Range or Setpoint
FE-4671	Monitor GWPS exhaust flow	-
FIT-4671	Indicate flow	0-10 scfm
FSH-4671	System shutdown	5.8 scfm
FSL-4671	Initiate low flow alarm	0.2 scfm
FY-4671	Provide signal to Radiation Monitoring System	-

C. LEVEL INSTRUMENTATION

1. Moisture Separator Drain Tank

Instrument	Purpose	Range or Setpoint
LT-4662	Monitor drain tank level	-
LI-4662	Indicate level	0-10 in.
LSH-4662	Initiate high level alarm	8 in.
LSL-4662	Initiate low level alarm	2 in.

D. TEMPERATURE MEASURING INSTRUMENTATION

1. Glycol Chiller Tank

Instrument	Purpose	Range or Setpoint
TE-4660	Monitor glycol tank temperature	-
TT-4660	Transmit temperature	30-50°F
TSH-4660	Start chiller unit	35°F
TSL-4660	Stop chiller unit	33°F

TABLE 11.3-6 (Continued)

GASEOUS WASTE PROCESSING SYSTEM
INSTRUMENTATION

B. Guard Bed Tank

Instrument	Purpose	Range or Setpoint
TE-4666	Monitor guard bed temperature	-
TT-4666	Transmit temperature	-
TI-4666	Indicate temperature	50-150°F

Remarks: Normal temperature: 70°F

3. Moisture Separator (MS) Outlet

Instrument	Purpose	Range or Setpoint
TE-4664	Monitor outlet flow temperature from MS	-
TT-4664	Transmit temperature	-
TI-4664	Indicate temperature	30-80°F
TSH-4664	Indicate high temperature alarm	60°F
TSL-4664	Indicate low temperature alarm	33°F

E. MOISTURE MEASURING INSTRUMENTATION

SEE GASEOUS WASTE PROCESSING SYSTEM P&ID 7R319FO5055

TABLE 11.3-6 (Continued)

GASEOUS WASTE PROCESSING SYSTEM INSTRUMENTATION

F. OXYGEN CONTENT INSTRUMENTATION

Instrument	Purpose	Range or Setpoint
AE-4655	Monitor O_2 content in inlet header	-
AT-4655	Transmit O_2 level	-
ASH-4655A	Initiate alarm, shut down GWPS	1%
ASH-4655	Shut down GWPS	1%
AI-4655	Indicate O_2 Level	0-5%

G. HYDROGEN CONTENT INSTRUMENTATION

Instrument	Purpose	Range or Setpoint
AE-4661A	Monitor H_2 level in room	0-LFL*
AE-4661B	Monitor H_2 level in room	0-LFL*
AE-4661C	Monitor H_2 level in room	0-LFL*
AE-4661D	Monitor H_2 level in room	0-LFL*
AIT-4661	Indicate H_2 Level	-
ASH-4661A	Initiate high H_2 alarm	60% LFL*
ASH-4661	Shut down GWPS	87.5% LFL*

Remarks: Probes AE-4661A-D are located in cubicles where H_2 gas may be present.

H. RADIATION MONITORING INSTRUMENTATION

See Section 11.5

* Lower Flammable Limit

11.4 SOLID WASTE MANAGEMENT SYSTEM

This section describes the Solid Waste Processing System (SWPS) and its processing capabilities.

11.4.1 Design Bases

11.4.1.1 Design Objectives. The SWPS is designed to meet the following objectives.

1. To provide for the collection, processing, packaging, temporary storage, and preparation for shipment of evaporator concentrates, spent ion exchange resins, expended liquid filter cartridges, and other miscellaneous solid and liquid wastes generated during plant operations and maintenance while maintaining operator radiation exposure as low as is reasonably achievable (ALARA), consistent with the recommendations of Regulatory Guide (RG) 8.8 and within the dose limits of 10CFR20 and 10CFR50.

2. Packaging and transport of waste will be in conformance with 10CFR71 and 10CFR61. Packaged waste will be shipped in conformance with 49CFR170-179.

3. Wet waste stabilization is performed either onsite or offsite using a system from a qualified vendor. The selected vendor possesses an approved Process Control Program. Should future evaluations or plant operations provide justification for a permanent SWPS, such a system could be installed.

11.4.1.2 Design Criteria. To meet the stated objectives, the SWPS is designed, fabricated, and installed in accordance with the following design criteria. These criteria apply to the permanently installed portion of the SWPS and any future installation of additional permanent SWPS equipment. The vendor waste stabilization system will have either an NRC approved Vendor Topical Report or be described in a Process Control Program approved by the waste disposal (burial) site.

1. Design Features

    a. System components and piping that convey waste are provided with provisions for draining and flushing.

    b. Tanks containing waste have cone-shaped bottoms and are provided with mechanical mixers.

    c. Tanks containing waste are provided with vents sized to prevent overpressure or vacuum and are connected to the plant vent header for monitoring prior to release in accordance with 10CFR50 Appendix A, General Design Criteria (GDC) 60 and 64.

    d. Process connections to tanks and piping carrying radioactive waste are butt-welded, to the maximum extent practicable to minimize crud traps.

    e. Valves in contact with waste streams are of a design that minimizes pockets or crud traps. Remote-operated valves are used, where necessary, in high radiation areas.

f. Piping is designed to provide a clean, free-flowing path. Bend radius is a minimum of five pipe diameters for all resin slurry piping. All resin slurry piping is provided with means for backflushing and is sloped, where possible, to prevent settling in the pipes.

g. Waste tanks have provisions for monitoring level and alarming potential overflow conditions.

h. Mixing and handling equipment is provided with redundant drives or with means for manual operation, where necessary, from low-radiation areas in the event of drive failures.

i. Remote control of the system and process is used to the maximum extent practicable. Control of the system is accomplished from a central control station.

j. Internal parts in contact with the waste streams are designed to withstand an integrated radiation exposure of 10^7 rads over the 40-year design life.

k. Provisions for operator surveillance during movement of waste containers are provided by use of closed-circuit television cameras and monitors.

l. In accordance with 10CFR50 Appendix A, GDC 63, radiation monitors are provided in the SWPS control area. (See Section 12.3 for further details.)

2. Types of Waste

The SWPS is designed to process these types of waste by stabilization or packaging:

a. Expended bead-type ion exchanger resins/and or media

b. Evaporator concentrates containing optimum operational levels as specified in the Process Control Program

c. Miscellaneous liquids resulting from decontamination, laboratory wastes, and system cleaning

d. Expended liquid and air filter elements

e. Miscellaneous dry wastes including plant equipment and/or parts thereof

3. Quality Group Classification

The SWPS is classified as non-nuclear safety (NNS) and meets the requirements of Branch Technical Position (BTP) ETSB 11-1, Rev. 1.

4. Seismic Classification

The SWPS meets the seismic requirements of BTP ETSB 11-1, Rev. 1, where applicable. It is located within and supported by the Mechanical Electrical Auxiliaries Building (MEAB) which is a seismic Category I structure (Section 3.2). The vendor-provided portion of the SWPS will be located in the truck bay. The truck bay is a nonseismic Category I structure.

5. Fabrication Codes

All components of the SWPS in contact with the waste stream are designed, fabricated, and tested in accordance with the codes and standards of BTP ETSB 11-1 as listed in Table 11.4-1.

6. Waste Volumes and Activity

The SWPS is designed to process the maximum volume of waste per reactor unit tabulated in Table 11.4-4. The maximum and expected activities of the principal nuclides input to the SWPS are tabulated in Tables 11.4-5 and 11.4-6, respectively. Activities of the solid waste are based upon the reactor coolant activities tabulated in Tables 11.1-2 and 11.1-7, and the volumes of waste as tabulated in Table 11.4-4.

The effect of the V5H fuel upgrade on the radioactivity concentrations in the fluid systems was reviewed and it was determined that the original reactor coolant activity listed in Table 11.1-2 is bounding. Therefore, the FSAR analyses based on this activity are not adversely impacted by the fuel upgrade. The corresponding reactor core activity for the V5H upgrade is shown in Table 15.A-1A.

11.4.2 System Description

The SWPS consists of the following equipment:

Permanently Installed

1. Concentrate Storage Tank and Transfer Subsystem (not currently in use)
2. Spent Resin Transfer Subsystem
3. Expended Cartridge Filter Transfer Subsystem
4. Overhead Crane Subsystem
5. Dry Active Waste Subsystem (not currently in use)
6. Chemical Addition Subsystem

Typical Vendor-Supplied (Mobile System)

1. Batching tank
2. Solidification agent storage tank and metering pump
3. Additive (catalyst) storage tank and metering pump
4. Dewatering pump
5. Mixing and filling station (Fill Head)

6. Control panel

7. Portable shielding

8. Solid waste container

9. Remote viewing

11.4.2.1 Permanently Installed Portion of SWPS. The permanently installed portion of the SWPS is located within the MEAB, a seismic Category I structure. The general arrangement of the SWPS area and the location of the major components are shown on the general arrangement drawings listed as Figures 1.2-28 and 1.2-29 in Table 1.2-1.

The piping and instrument diagrams (P&IDS) are shown on Figures 11.4-1 and 11.4-2. A simplified process flow diagram is shown on Figures 11.4-3.

Identical systems containing the following major subsystems are provided for each unit of the South Texas Project Electric Generating Station (STPEGS).

11.4.2.1.1 Concentrate Storage Tank and Transfer Subsystem: This subsystem includes a 5,000 gallon, Incolloy 825, conical bottom, concentrate storage tank. The tank is equipped with a mixer, heat tracing, and necessary level controls to prevent overflows and to provide the operator with continuous level indication.

The concentrates transfer pump is located in the cubicle below the concentrate storage tank. This pump along with the internal tank mixer, is used to recirculate the tank contents to provide a homogeneous mixture. This system is not currently being used.

11.4.2.1.2 Spent Resin Transfer Subsystem: The spent resin from the spent resin storage tank (SRST) or low activity spent resin storage tank (LASRST) can be transferred, as a slurry, to the vendor-supplied portion of the Solid Waste Processing System (SWPS).

11.4.2.1.3 Expended Cartridge Filter Transfer Subsystem: This subsystem provides for the handling of liquid filter cartridges. It consists of a filter transfer shield, a working shield plug, shielded drums, long-handled tools, a Tri-Nuc type filter cask (or equivalent), a monorail, controls and various other components. The expended liquid filter is transferred utilizing approved plant procedures designed to keep exposure to personnel ALARA.

11.4.2.1.4 Overhead Crane Subsystem: A 7-1/2-ton overhead bridge crane with automatic grapples is provided to move containers from the storage areas to the truck loading area for transportation. The crane may be remotely operated from a local control panel. Movement is observed by the operator by use of closed-circuit television cameras and monitors. The crane is provided with redundant drive motors to allow movement to an area designated for repair and maintenance.

11.4.2.1.5 Dry Active Waste Area: This area provides for the sorting and packaging of dry active waste produced during normal operating and maintenance activities. Dry Active Waste is typically bulk packaged and shipped to an offsite vendor for volume reduction processing prior to disposal.

11.4.2.1.6 Chemical Addition Subsystem: This subsystem provides chemical adjustment of liquids upstream or the SWPS. It consists of a chemical storage tank and metering pump. The system is capable of feeding sodium hydroxide or other chemicals to the laundry and hot shower tank, condensate polishing regeneration waste collection tank, floor drain tank (FDT), and waste holdup tank (WHT) in order to maintain pH control.

11.4.2.2 Vendor-Supplied Onsite Portion of SWPS. The onsite vendor-supplied portion of the SWPS is set up in or adjacent to the Radwaste Truck Bay and typically consists of control panels, dewatering pumps, fill/dewatering heads, etc. Appropriate level control and monitoring systems are provided to prevent inadvertent spillage during transfers to the system.

Spent resin/media is sluiced to the system, sampled and dewatered in accordance with applicable STP or vendor implementing procedures. Resin/media destined for shipment directly to a burial site shall be dewatered (stabilized) in accordance with the STP Process Control Program. Resin/media destined for shipment to an offsite vendor for processing/stabilization is dewatered to meet applicable shipping and transport requirements.

Evaporator concentrates are mixed and sampled on a batch basis and subsequently transferred to the vendor-supplied system. The concentrates are then stabilized using appropriate media and additives in accordance with the Process Control Program.

11.4.2.3 Storage of Waste. Spent resins from demineralizers which are normally higher in activity are stored in the SRST prior to processing. The SRST is capable of storing at least 60 days' spent resin at normal generation rates. Spent resins from demineralizers which are normally lower in activity are stored in the LASRST prior to processing. The LASRST is capable of storing at least 30 days' spent resin at normal generation rates. (For a detailed discussion of these tanks see Section 11.2.)

When used, evaporator concentrates are collected in the concentrate storage tank before processing. Holdup time prior to processing is dependent upon waste production and evaporator processing rates.

Waste containers maybe stored onsite prior to shipment. This storage can be in any one or a combination of the following three areas.

11.4.2.3.1 Storage in the Mechanical Electrical Auxiliary Building: A storage area is provided in the SWPS area on El. 41 ft for the storage of Dry Active Waste. The storage area is provided with sufficient shielding to reduce the operator's radiation exposure from stored waste containers consistent with ALARA practices. The storage area is divided into high activity and low activity storage areas. Separation of the high activity storage area from the building exterior by the low activity area provides for a reduction in radiation levels in the truck loading area.

This storage capacity provides storage of at least 30 days' normal operations (not including noncompactible waste) for the waste generated at the maximum rate identified in Table 11.4-4.

11.4.2.3.2 Onsite Staging Facility: Radioactive Waste produced at STPEGS will normally be shipped to a licensed facility for disposal. However, should disposal circumstances change, two Onsite Staging Facilities (OSF), located outside of the Protected Area are available to provide staging areas for the waste generated for up to five years operation of both reactors. One OSF is located just West of STPEGS Unit 2 and the other is located East of STPEGS Unit 1. The OSF design is based upon outdoor storage of process wastes in High Integrity Containers (HICs) (e.g., spent filter cartridges and dewatered resins) in modular concrete shields and a building for storage of dry active wastes (DAW) (e.g., compactable trash, surface contaminated objects) and also, dewatered resins and cartridge filters from secondary treatment systems (e.g., condensate polishing and steam generator blowdown processing). CN-3070 Supplement 1

Waste containers are handled using standard lifting equipment/machinery suitable for the container weights.

Safety Design Basis: There is no requirement for a reactor safety design basis for the OSF.

Power Generation Design Basis: The following lists the power generation design basis for the OSF.

1. Storage Capacity: The OSF is designed to receive the estimated quantity of wastes generated during five years of normal operation of both units considering actual historical generation rates, anticipated events, processing and volume reduction techniques and minimization programs.

2. Containers: The OSF is designed to locate HICs containing process wastes in modular concrete shields outdoors and DAW and secondary system process waste in an enclosed structure. All waste containers shall be suitable for future transportation. CN-3070 Supplement 1

3. Container Handling: Containers are handled using standard lifting equipment/machinery suited for these types of containers.

4. Building: The HIC and DAW storage areas are non-safety related, non-seismic Category I structures. The wastes are located such that water does not enter these areas during the 10-year storm at the site. The containers in the DAW area are held down to the floor using suitable restraints attached to plates or padeyes.

5. Decontamination and Repackaging: No decontamination or repackaging capability is provided in the OSF as only packages suitable for disposal will be stored. Packages failing during storage will be contained and returned to the plant for repackaging and the cause of failure will be determined.

6. Other Items: The OSF may also be used to temporarily store/stage materials other than wastes (e.g., tools, contaminated components, scaffolding, etc.) The control, use, and placement of materials, including wastes, stored at the OSF will be by Health Physics in accordance with approved procedures.

7. Shielding:

   a. The OSF is designed so that the annual dose to the public is a small fraction of the 25 mrem/yr allowed from all sources of the uranium fuel cycle as per 40 CFR190.

b. Radiation exposure to individuals shall be controlled in accordance with 10CFR20.

c. The OSF is designed such that the outer boundary meets the Radiation Zone 1 (0.5 mrem/h) design target.

8. Releases: No releases of radioactive effluents are anticipated from the OSF.

9. Water Intrusion: Curbing provided around stored DAW containers will confine intruded water. Waste containers are raised off of the floor to minimize possible degradation from accumulated water. The source of any liquid discovered within a curbed area will be investigated. Accumulated water will be sampled for radioactivity and if contaminated, returned to the either Unit 1 or 2 for processing. Any nonradioactive accumulated water will be removed to prevent corrosion degradation of stored containers.

10. Ventilation and Atmospheric Control: HICs are stored outdoors and require no ventilation. Ventilation air only is provided for the DAW storage area.

11 Security: Both the outside area for the HICs and the DAW storage area in the building are surrounded by security fences with locked gates to preclude unauthorized entry. The doors of the building for DAW storage have locks consistent with the STPEGS security requirements. CN-3070 Supplement 1

12. Surveillances: Periodic visual inspections and radiological surveys and sampling are performed to verify container integrity and inventory and to ensure compliance with applicable regulations, license conditions, and plant Technical Specifications.

13. Fire Protection: A wet-pipe sprinkler system, manual hose stations, and manual fire extinguishers are provided in the DAW storage area. A water flow alarm is given at the West Gatehouse. The outdoor area for the concrete containers for the HICs does not require any fire protection features.

14. Lighting: Fixed lights are provided in the DAW storage area.

15. Transportation: Both storage areas are located outside the Protected Area fence but within the Owner Controlled Area. Transport routes used to reach the storage areas will not involve travel on public highways. CN-3070 Supplement 1

16. Monitoring Equipment:

a. Area radiation monitors will not normally be employed as these areas are not intended for continuous occupancy. Instead, access controls and Health Physics surveillances and surveys during and following placement or rearrangement of materials in storage will verify and document compliance with applicable design requirements.

b. Air Monitoring - A portable continuous air monitor and/or sampling device will be available for use in the DAW storage area. Grab sampling capability will be provided for both the DAW storage area and the outdoor HIC storage area. However, no airborne releases are expected since transferable contamination levels on container and building surfaces will normally be maintained below the level for packages offered for shipment per Department of Transportation regulations.

11.4.2.3.3 Temporary Outdoor Storage: Packaged radioactive waste containers, or incompletely loaded DAW containers (e.g., sea-land vans), may be stored outdoors in designated locations. As necessary, containers will be provided with sufficient protection against the external environmental conditions in order to maintain container integrity (e.g., elevated platforms, tarpaulins) and to ensure stability during high wind conditions (e.g., hold down system/nets).

Sufficient area around the storage area will be barricaded such that doses to individuals will be maintained below applicable limits. Periodic surveys will be performed to ensure compliance.

Loading and unloading of the waste containers from the storage area will be by the use of standard lifting equipment/machinery suitable for the container weights.

11.4.2.3.4 Old Steam Generator Storage Facility: The Old Steam Generator Storage Facility (OSGSF) provides long-term on-site storage of large contaminated components (Original Steam Generators) removed from the Reactor Containment Buildings during Steam Generator Replacement Outages in 2000 (Unit 1) and 2002 (Unit 2). The OSGSF is designed to safely store the eight Old Steam Generators for Unit 1 and 2.

The OSGSF is designed as a storage facility until such time as the old steam generators are shipped offsite. Therefore, it is not designed to accumulate or process waste materials. As a long-term storage facility of items containing radioactive materials, the mechanical design basis for this facility warrants a brief presentation below.

The design features for storage of radioactive materials in the OSGSF related to source and shielding considerations are further described in Sections 12.2.1.2 and 12.3.2.2.2.9 and Tables 12.2.1-11 and 12.2.1-12. CN-3072

Design Basis:

1. Storage Capacity: The OSGSF is designed to hold eight Westinghouse Model E old steam generators (OSG) in two parallel 2x2 configurations.
2. Building: The building was constructed in Phase I for the Unit 1 steam generators and Phase II for the Unit 2 steam generators. Both phases are identical in size, shape, and design, with a final dimension of approximately 162'x124.5'. The building is classified as a non-Category I, non-power generating structure, and is designed as a non-seismic structure. This building is designed to withstand minimum design loads per ASCE 7-95. The external walls and foundation are designed to withstand design basis probable maximum precipitation without flooding.

3. Shielding: The OSGSF was designed to provide shielding for the general public such that the dose rate outside the facility was within the limits of 10CFR20 and 40CFR190 at the time that the steam generators were loaded into the facility. The shielding was conservatively calculated assuming all of the steam generator external radiation was from the most intense gamma ray emitter (Co-60).
4. Releases: The steam generators were conservatively evaluated for airborne release during transport, and for a flood release inside the building. The airborne release was a small fraction of 10CFRlOO limits, and the flood release was within 10CFR20 limits.
5. Security: Access to the OSGSF is restricted administratively to prevent unauthorized access to the stored OSGs.
6. Surveillance: The OSGSF is periodically checked for dose and contamination levels.
7. Lighting: The facility lighting and electrical controls are located in the entry vestibule. The vestibule is designed as a Radiation Zone 1 area.
8. Monitoring Equipment: The facility is not intended for continuous occupancy, and is therefore not continuously monitored. As a Zone 5 radiation area, Radiation Work Permits (RWPs) are required prior to accessing the interior of this facility. These RWPs establish monitoring and access controls as necessary for entry into the OSGSF interior.

CN-3072

11.4.2.4 Waste Containers. Containers used for packaging of radioactive material shall meet the requirements of 49CFR178, "Shipping Container Specification". In addition, packaging shall meet the applicable sections of 49CFR171-178 as well as 10CFR71, "Packaging of Radioactive Materials Under Certain Conditions". STPEGS does not fabricate NRC-certified shipping casks; consequently NRC certification is done under the vendor's QA program.

11.4.2.5 Operating History of Components Used. The major components used in the processing of solid waste have been utilized in operating nuclear plants and chemical processing plants with satisfactory results.

The pumps used for transfer of waste are the progressing cavity type. These pumps are used extensively in nuclear facilities for transfer of radioactive waste slurries.

Equipment provided by vendors for stabilization of waste at STPEGS will be similar in design to equipment used at other operating nuclear power plants. The vendor selected to provide equipment for STPEGS will have previous operating experience with the equipment at operating nuclear plants.

11.4.2.6 This section is not used.

11.4.2.7 This section is not used.

11.4.2.8 Provisions for Packaging Dry Waste. Potentially radioactive dry wastes are collected at appropriate locations throughout the plant. Bagged wastes are transported to the SWPS for short-term storage in a low activity area pending shipment offsite to a licensed disposal facility or a vendor for volume reduction processing prior to disposal.

Large waste materials and equipment (e.g., high-efficiency particulate air filters [HEPA] and charcoal filters) that have been contaminated or activated during reactor operation are collected and packaged in accordance with 49CFR173 for shipment to offsite disposal facilities.

CN-3070 Supplement 1

STPEGS's packaging program does not include fabrication of NRC-certified shipping casks. (See Sec. 11.4.2.4)

11.4.2.9 ALARA Design Features. The SWPS is designed so that radiation exposures during operation, maintenance, and repair are ALARA (as per RG 8.8). To provide this, the following features are included.

1. Separation of components is used to reduce exposure during maintenance and repair. Pumps are separated from tanks so that the sources of radiation within the tanks do not interfere with pump repair and maintenance.

2. The storage area is separated from operating and process areas by shield walls and is divided into high activity and low activity areas.

3. Provisions are included for maintenance of the bridge crane while it is parked.

4. Provisions are included for the remote removal and transfer of expended liquid filter elements in shielded casks to reduce operator exposure while changing filter elements.

5. The mobile system will be installed inside the truck bay.

6. A curb is provided in the truck bay for the mobile solidification equipment to prevent the spread of contamination in case of a spill and to contain the volume of liquid in the tank in case of an overflow/failure. The permanently installed equipment in the MEAB is located in cubicles. The floors in the cubicles are pitched to flow to drains located at low points to facilitate drainage to a radioactive sump. These drains can then be transferred to LWPS for processing.

7. Provisions are incorporated in the layout of the system to allow for periodic inspection and monitoring. Equipment is arranged and shielded to permit operating, inspecting, and maintenance with ALARA personnel exposure. Tanks and processing equipment which contain large quantities of radwaste are shielded and air flows are from low activity areas to higher activity areas.

11.4.2.10 Radiation Monitoring. The Area Radiation Monitoring System provides an area monitor in the control area for the SWPS. This system is described in Section 12.3.4.

11.4.2.11 Assurance of Stabilization: To provide assurance that the waste meets disposal facility criteria, the system will be operated within the prescribed limits set forth in reviews and approved process program implementing procedures of the vendor or STPEGS, and applicable regulatory requirements.

11.4.2.12 Volume and Activity of Waste. The maximum volumes of waste to be processed and shipped offsite to licensed disposal facilities are tabulated in Table 11.4-4.

The maximum activity of solid waste is estimated for operations with design basis fuel defects. Source terms are listed in Table 11.1-2.

The expected activity of solid waste is estimated for operation with realistic activity as listed in Table 11.1-7.

The maximum and expected activities of principal nuclides input to the SWPS are tabulated in Tables 11.4-5 and 11.4-6, respectively.

Tables 11.4-7 and 11.4-8 show estimated maximum and expected annual activities in shipped radwaste.

Experience in the industry indicates that actual annual generation rates may deviate significantly from the design basis depending on fuel integrity outage schedule and processing efficiency. Annual summary reports contain information on actual waste disposal.

TABLE 11.4-1

SOLID WASTE PROCESSING SYSTEM FABRICATION CODES

Equipment	Design Code	Material Code	Welding Code	Inspection & Testing Code
Pressure Vessels	ASME Sec. VIII Div. 1	ASME Sec. II	ASME Sec. IX	ASME Sec. VIII Div. 1
Atmospheric Tanks	API 650 API 620	ASME Sec. II	ASME Sec. IX	API 620 API 650
Piping and Valves	ANSI B31.1	ASTM or ASME Sec. II	ASME Sec. IX	ANSI B31.1
Pumps	Manufacturers Standards	ASME Sec. II	ASME Sec. IX as required	Hydraulic Institute
Structural Members	Industry Standards	ASTM	AWS D1.1	Industry Standards

TABLE 11.4-4

ESTIMATED MAXIMUM ANNUAL QUANTITIES OF SOLID RADWASTE FOR ONE UNIT

Source	Influent Volume to the SWPS (ft^3)	Solidified/Compacted Waste Volume (ft^3)
Spent Resin	2,850	5,888 (2,850)*
Evaporator Concentrate	6,000	10,965
Cartridge Filters	646	646
Compactible Waste	28,500	4,750
Noncompactible Waste	4,750	4,750
Total		26,999 (24,149)*

* Numbers in parentheses reflect volumes based upon dewatering resins and placing in high integrity containers or other containers as required for shipment, rather than solidifying.

TABLE 11.4-5

ESTIMATED MAXIMUM ANNUAL ACTIVITIES OF THE INPUTS TO THE SOLID WASTE PROCESSING SYSTEM (Ci/yr unit)

Isotope	Spent Resins	Evaporator Concentrates	Cartridge Filters	Dry and Compacted Waste
I-129	4.30(-5)*	2.52(-4)	---	---
I-130	1.48(-1)	1.06(+2)	---	---
I-131	3.69(+4)	1.41(+4)	---	---
I-132	5.95(+2)	1.56(+4)	---	---
I-133	5.24(+2)	2.14(+4)	---	---
I-134	1.09(-1)	3.17(+3)	---	---
I-135	1.30(+3)	1.17(+4)	---	---
Cs-134	5.04(+4)	1.25(+4)	---	---
Cs-135	8.37(-7)	1.37(-6)	---	---
Cs-136	5.98(+3)	1.82(+4)	---	---
Cs-137	3.77(+4)	8.15(+3)	---	---
Cs-138	6.37(+1)	6.03(+3)	---	---
Rb-86	7.66(+0)	1.24(+2)	---	---
Rb-88	1.68(+2)	2.98(+4)	---	---
Rb-89	1.07(-2)	1.36(+3)	---	---
Cr-51	4.20(+1)	3.10(+1)	---	---
Mn-54	8.19(+0)	2.42(+0)	8.70(+1)	---
Mn-56	1.98(-2)	8.68(+1)	---	---
Fe-55	7.35(-1)	1.30(+1)	---	---
Fe-59	4.31(+0)	3.17(+0)	8.70(+1)	---
Co-58	8.83(+1)	7.45(+1)	1.74(+3)	---
Co-60	3.81(+2)	8.69(+0)	1.74(+2)	---
Br-83	1.08(-1)	5.78(+2)	---	---
Br-84	1.79(+0)	2.93(+2)	---	---
Br-85	3.39(-3)	3.72(+1)	---	---
Sr-89	3.17(+0)	2.29(+1)	---	---
Sr-90	1.72(-1)	6.83(-1)	---	---
Sr-91	4.30(-2)	3.60(+1)	---	---
Sr-92	1.83(-3)	7.44(+0)	---	---
Y-90	1.67(-1)	1.81(-1)	---	---
Y-91m	2.56(-2)	2.23(+1)	---	---
Y-91	4.77(-1)	3.05(+0)	---	---
Y-92	4.25(-3)	6.82(+0)	---	---
Y-93	3.00(-3)	2.17(+0)	---	---
Zr-95	4.44(+0)	3.47(+0)	---	---
Nb-95m	4.62(-3)	3.68(-5)	---	---
Nb-95	7.09(-1)	3.48(+0)	---	---
Mo-99	4.22(+1)	4.13(+3)	---	---
Tc-99m	3.91(+1)	3.75(+3)	---	---
Tc-99	3.64(-5)	2.16(-7)	---	---
Ru-103	4.28(+0)	3.10(+0)	---	---
Ru-106	1.68(-1)	7.45(-1)	---	---
Rh-103m	3.68(-1)	3.45(-3)	---	---

* 4.30(-5) = 4.30×10^{-5}

TABLE 11.4-5 (Continued)

ESTIMATED MAXIMUM ANNUAL ACTIVITIES OF THE INPUTS TO THE SOLID WASTE PROCESSING SYSTEM (Ci/yr unit)

Isotope	Spent Resins	Evaporator Concentrates	Cartridge Filters	Dry and Compacted Waste
Rh-106	1.68(-1)	1.16(-3)	---	---
Ag-110m	1.77(+0)	8.07(+0)	---	---
Ag-110	2.67(-2)	1.81(-4)	---	---
Te-125m	2.28(-1)	1.55(+0)	---	---
Te-127m	2.95(+0)	1.61(+1)	---	---
Te-127	2.95(+0)	6.82(+1)	---	---
Te-129m	1.11(+1)	9.93(+1)	---	---
Te-129	6.96(+0)	9.93(+1)	---	---
Te-131m	6.25(-1)	1.44(+2)	---	---
Te-131	1.40(-1)	7.44(+1)	---	---
Te-132	5.22(+0)	1.62(+3)	---	---
Te-134	7.02(-3)	1.86(+2)	---	---
Ba-136m	1.29(+2)	1.94(-1)	---	---
Ba-137m	3.78(+4)	7.53(+3)	---	---
Ba-140	1.03(+0)	2.23(+1)	---	---
La-140	8.27(+1)	7.45(+0)	---	---
Ce-141	3.59(-1)	3.42(+0)	---	---
Ce-143	2.82(-1)	2.80(+0)	---	---
Ce-144	4.85(-1)	2.11(+0)	---	---
Pr-143	4.20(-1)	3.42(+0)	---	---
Pr-144m	6.91(-3)	4.69(-5)	---	---
Pr-144	4.58(-1)	2.11(+0)	---	---
TOTAL	1.72(+5)	1.61(+5)	2.09(+3)	5.23(+1)

* 4.30(-5) = 4.30 x 10^{-5}

TABLE 11.4-6

ESTIMATED EXPECTED ANNUAL ACTIVITIES OF THE INPUTS TO THE SOLID WASTE PROCESSING SYSTEM (Ci/yr unit)

Isotope	Spent Resins	Evaporator Concentrates	Cartridge Filters	Dry and Compacted Waste
I-129	4.30(-5)*	2.52(-4)	---	---
I-130	1.48(-2)	1.06(+1)	---	---
I-131	3.38(+3)	1.29(+3)	---	---
I-132	2.12(+1)	5.57(+2)	---	---
I-133	4.69(+1)	1.92(+3)	---	---
I-134	9.37(-3)	2.73(+2)	---	---
I-135	1.11(+2)	1.00(+3)	---	---
Cs-134	5.29(+2)	1.31(+2)	---	---
Cs-135	8.37(-7)	1.37(-6)	---	---
Cs-136	2.27(+1)	6.92(+1)	---	---
Cs-137	4.34(+2)	9.37(+1)	---	---
Cs-138	6.37(+1)	6.03(+3)	---	---
Rb-86	2.76(-2)	4.46(-1)	---	---
Rb-88	7.36(+0)	1.31(+3)	---	---
Rb-89	1.07(-2)	1.36(+3)	---	---
Cr-51	1.34(+1)	9.92(+0)	---	---
Mn-54	5.25(+0)	1.55(+0)	5.58(+1)	---
Mn-56	1.98(-2)	8.68(+1)	---	---
Fe-55	4.55(-1)	8.05(+0)	---	---
Fe-59	4.31(+0)	3.17(+0)	8.70(+1)	---
Co-58	8.83(+1)	7.45(+1)	1.74(+3)	---
Co-60	3.81(+2)	8.69(+0)	1.74(+2)	---
Br-83	5.69(-3)	3.05(+1)	---	---
Br-84	1.03 (-1)	1.68(+1)	---	---
Br-85	1.81(-4)	1.98(+0)	---	---
Sr-89	2.38(-1)	1.72(+0)	---	---
Sr-90	1.27(-2)	5.03(-2)	---	---
Sr-91	4.52(-3)	3.78(+0)	---	---
Sr-92	1.83(-3)	7.44(+0)	---	---
Y-90	5.76(-3)	6.24(-3)	---	---
Y-91m	2.71(-3)	2.36(+0)	---	---
Y-91	5.06(-2)	3.23(-1)	---	---
Y-92	4.25(-3)	6.82(+0)	---	---
Y-93	2.74(-4)	1.98(-1)	---	---
Zr-95	3.89(-1)	3.04(-1)	---	---
Nb-95m	4.62(-3)	3.68(-5)	---	---
Nb-95	5.19(-2)	2.55(-1)	---	---
Mo-99	4.56(+0)	4.46(+2)	---	---
Tc-99m	3.00(+0)	2.88(+2)	---	---
Tc-99	3.64(-5)	2.16(-7)	---	---
Ru-103	3.17(-1)	2.29(-1)	---	---
Ru-106	1.54(-2)	6.83(-2)	---	---
Rh-103m	3.46(-2)	3.24(-4)	---	---
Rh-106	1.54(-2)	1.06(-4)	---	---

* 4.30(-5) = 4.30×10^{-5}

TABLE 11.4-6 (Continued)

ESTIMATED EXPECTED ANNUAL ACTIVITIES OF THE INPUTS TO THE SOLID WASTE PROCESSING SYSTEM (Ci/yr unit)

Isotope	Spent Resins	Evaporator Concentrates	Cartridge Filters	Dry and Compacted Waste
Ag-110m	1.77(+0)	8.07(+0)	---	---
Ag-110	2.67(-2)	1.81(-4)	---	---
Te-125m	2.19(-2)	1.49(-1)	---	---
Te-127m	2.61(-1)	1.42(+0)	---	---
Te-127	2.14(-1)	4.96(+0)	---	---
Te-129m	8.33(-1)	7.45(+0)	---	---
Te-129	7.38(-1)	1.05(+1)	---	---
Te-131m	5.98(-2)	1.38(+1)	---	---
Te-131	1.40(-2)	7.44(+0)	---	---
Te-132	4.62(-1)	1.43(+2)	---	---
Te-134	7.02(-3)	1.86(+2)	---	---
Ba-136m	1.29(+2)	1.94(-1)	---	---
Ba-137m	4.42(+2)	8.81(+1)	---	---
Ba-140	5.15(-2)	1.12(+0)	---	---
La-140	8.93(+0)	8.05(-1)	---	---
Ce-141	3.73(-2)	3.56(-1)	---	---
Ce-143	2.19(-2)	2.18(-1)	---	---
Ce-144	3.85(-2)	1.68(-1)	---	---
Pr-143	3.13(-2)	2.55(-1)	---	---
Pr-144m	6.91(-3)	4.69(-5)	---	---
Pr-144	4.72(-2)	2.17(-1)	---	---
TOTAL	5.70(+3)	1.55(+4)	2.06(+3)	5.23(+1)

---

* 4.30(-5) = 4.30 x 10^{-5}

TABLE 11.4-7

ESTIMATED MAXIMUM ANNUAL ACTIVITIES IN SHIPPED RADWASTE (Ci/yr unit)

Isotope	Spent Resins[(a)]	Evaporator Concentrates[(b)]	Cartridge Filters[(c)]	Dry and Compacted Waste[(c)]
I-129	4.30(-5)[(d)]	2.52(-4)	---	---
I-130	---	---	---	---
I-131	2.10(+2)	1.06(+3)	---	---
I-132	---	---	---	---
I-133	---	8.28(-7)	---	---
I-134	---	---	---	---
I-135	---	---	---	---
Cs-134	4.77(+4)	1.22(+4)	---	---
Cs-135	8.37(-7)	1.37(-6)	---	---
Cs-136	2.39(+2)	3.66(+3)	---	---
Cs-137	3.77(+4)	8.15(+3)	---	---
Cs-138	---	---	---	---
Rb-86	8.20(-1)	4.05(+1)	---	---
Rb-88	---	---	---	---
Rb-89	---	---	---	---
Cr-51	9.32(+0)	1.46(+1)	---	---
Mn-54	7.17(+0)	2.27(+0)	8.70(+1)	---
Mn-56	---	---	---	---
Fe-55	7.05(-1)	1.27(+1)	---	---
Fe-59	1.69(+0)	1.99(+0)	8.70(+1)	---
Co-58	4.92(+1)	5.56(+1)	1.74(+3)	---
Co-60	3.73(+2)	8.59(+0)	1.74(+2)	---
Br-83	---	---	---	---
Br-84	---	---	---	---
Br-85	---	---	---	---
Sr-89	1.39(+0)	1.55(+1)	---	---
Sr-90	1.71(-1)	6.82(-1)	---	---
Sr-91	---	---	---	---
Sr-92	---	---	---	---
Y-90	2.79(-8)	7.40(-5)	---	---
Y-91m	---	---	---	---
Y-91	2.35(-1)	2.14(+0)	---	---
Y-92	---	---	---	---
Y-93	---	---	---	---
Zr-95	1.59(-3)	2.53(+0)	---	---
Nb-95m	4.62(-8)	1.10(-7)	---	---
Nb-95	2.16(-1)	1.92(+0)	---	---
Mo-99	1.19(-5)	2.19(+0)	---	---
Tc-99m	---	---	---	---
Tc-99	3.64(-5)	2.16(-7)	---	---
Ru-103	1.49(+0)	1.83(+0)	---	---
Ru-106	1.50(-1)	7.04(-1)	---	---
Rh-103m	---	---	---	---

TABLE 11.4-7 (Continued)

ESTIMATED MAXIMUM ANNUAL ACTIVITIES IN SHIPPED RADWASTE (Ci/yr unit)

Isotope	Spent Resins[(a)]	Evaporator Concentrates[(b)]	Cartridge Filters[(c)]	Dry and Compacted Waste[(c)]
Rh-106	---	---	---	---
Ag-110m	1.50(+0)	7.43(+0)	---	---
Ag-110	---	---	---	---
Te-125m	1.11(-1)	1.08(+0)	---	---
Te-127m	2.01(+0)	1.33(+1)	---	---
Te-127	---	---	---	---
Te-129m	3.20(+0)	5.33(+1)	---	---
Te-129	---	---	---	---
Te-131m	---	8.54(-6)	---	---
Te-131	---	---	---	---
Te-132	1.44(-5)	2.69(+0)	---	---
Te-134	---	---	---	---
Ba-136m	---	---	---	---
Ba-137m	3.78(+4)	7.53(+3)	---	---
Ba-140	4.02(-2)	4.42(+0)	---	---
La-140	1.43(-9)	3.10(-5)	---	---
Ce-141	9.98(-2)	1.80(+0)	---	---
Ce-143	---	7.87(-7)	---	---
Ce-144	4.19(-1)	1.96(+0)	---	---
Pr-143	1.93(-2)	7.39(-1)	---	---
Pr-144m	---	---	---	---
Pr-144	---	---	---	---
TOTAL	1.24(+5)	3.28(+4)	2.09(+3)	5.23(+1)

a. A holdup time of 60 days is assumed for spent resins.
b. A holdup time of 30 days is assumed for concentrates.
c. No holdup time is assumed for the cartridge filters and the dry and compacted waste.
d. 4.3(-5) = 4.3 x 10^{-5}

TABLE 11.4-8

ESTIMATED EXPECTED ANNUAL ACTIVITIES IN SHIPPED RADWASTE (Ci/yr unit)

Isotope	Spent Resins[a]	Evaporator Concentrates[b]	Cartridge Filters[c]	Dry and Compacted Waste[c]
I-129	4.30(-5)[d]	2.52(-4)	---	---
I-130	---	---	---	---
I-131	1.93(+1)	9.72(+1)	---	---
I-132	---	---	---	---
I-133	---	7.41(-8)	---	---
I-134	---	---	---	---
I-135	---	---	---	---
Cs-134	5.01(+2)	1.28(+2)	---	---
Cs-135	8.37(-7)	1.37(-6)	---	---
Cs-136	9.08(-1)	1.39(+1)	---	---
Cs-137	4.34(+2)	9.37(+1)	---	---
Cs-138	---	---	---	---
Rb-86	2.95(-3)	1.46(-1)	---	---
Rb-88	---	---	---	---
Rb-89	---	---	---	---
Cr-51	2.98(+0)	4.67(+0)	---	---
Mn-54	4.60(+0)	1.46(+0)	5.58(+1)	---
Mn-56	---	---	---	---
Fe-55	4.36(-1)	7.86(+0)	---	---
Fe-59	1.69(+0)	1.99(+0)	8.70(+1)	---
Co-58	4.92(+1)	5.56(+1)	1.74(+3)	---
Co-60	3.73(+2)	8.59(+0)	1.74(+2)	---
Br-83	---	---	---	---
Br-84	---	---	---	---
Br-85	---	---	---	---
Sr-89	1.04 (-1)	1.16(+0)	---	---
Sr-90	1.26(-2)	5.02(-2)	---	---
Sr-91	---	---	---	---
Sr-92	---	---	---	---
Y-90	9.63(-10)	2.55(-6)	---	---
Y-91m	---	---	---	---
Y-91	2.49(-2)	2.27(-1)	---	---
Y-92	---	---	---	---
Y-93	---	---	---	---
Zr-95	1.39(-4)	2.21(-1)	---	---
Nb-95m	4.62(-8)	1.10(-7)	---	---
Nb-95	1.58(-2)	1.41(-1)	---	---
Mo-99	1.29(-6)	2.37-1)	---	---
Tc-99m	---	---	---	---
Tc-99	3.64(-5)	2.16(-7)	---	---
Ru-103	1.10(-1)	1.35(-1)	---	---
Ru-106	1.38(-2)	6.46(-2)	---	---
Rh-103m	---	---	---	---

TABLE 11.4-8 (Continued)

ESTIMATED EXPECTED ANNUAL ACTIVITIES IN SHIPPED RADWASTE (Ci/yr unit)

Isotope	Spent Resins[a]	Evaporator Concentrates[b]	Cartridge Filters[c]	Dry and Compacted Waste[c]
Rh-106	---	---	---	---
Ag-110m	1.50(+0)	7.43(+0)	---	---
Ag-110	---	---	---	---
Te-125m	1.07(-2)	1.04(-1)	---	---
Te-127m	1.78(-1)	1.18(+0)	---	---
Te-127	---	---	---	---
Te-129m	2.40(-1)	4.00(+0)	---	---
Te-129	---	---	---	---
Te-131m	---	8.17(-7)	---	---
Te-131	---	---	---	---
Te-132	1.27(-6)	2.38(-1)	---	---
Te-134	---	---	---	---
Ba-136m	---	---	---	---
Ba-137m	4.42(+2)	8.81(+1)	---	---
Ba-140	2.01(-3)	2.21(-1)	---	---
La-140	1.54(-10)	3.35(-6)	---	---
Ce-141	1.04(-2)	1.87(-1)	---	---
Ce-143	---	6.12(-8)	---	---
Ce-144	3.33(-2)	1.56(-1)	---	---
Pr-143	1.44(-3)	5.51(-2)	---	---
Pr-144m	---	---	---	---
Pr-144	---	---	---	---
TOTAL	1.39(+3)	5.17(+2)	2.06(+3)	5.23(+1)

a. A holdup time of 60 days is assumed for spent resins.
b. A holdup time of 30 days is assumed for concentrates.
c. No holdup time is assumed for the cartridge filters and the dry and compacted waste.
d. 4.3(-5) = 4.3×10^{-5}

11.5 PROCESS AND EFFLUENT RADIOLOGICAL MONITORING AND SAMPLING SYSTEMS

The function of the process and effluent radiological monitoring system is to monitor, record, and control the release of radioactive materials that may be generated during normal operation, anticipated operational occurrences, and postulated accidents.

The Process and Effluent Radiation Monitoring System (PERMS) furnishes information to operations personnel concerning radioactivity levels in principal plant process streams and atmospheres. The monitoring system indicates and alarms excessive radioactivity levels. It initiates operation of standby treatment systems (as required), provides input to the ventilation and liquid discharge isolation systems, and records the rate of release of radioactive materials to the environs.

The PERMS is provided and designed to meet the requirements of General Design Criteria (GDC) 60, 63, and 64 of 10CFR50 Appendix A, 10CFR20, and Regulatory Guide (RG) 1.21.

The PERMS is a part of the Radiation Monitoring System provided for South Texas Project Electric Generating Station (STPEGS). The Radiation Monitoring System (RMS) consists of the following equipment:

1. Monitors used for process monitoring (see this section)

2. Monitors used for effluent monitoring (see this section)

3. Monitors used for area monitoring (see Section 12.3.4)

4. Monitors used for airborne monitoring (see Section 12.3.4)

5. Electronic equipment used in system communications, operator interface, report generation, etc. (for example computers, printer, keyboards, cathode ray tubes [CRTs])

The integrated digital RMS and its overall operation will be described in this section; information about specific monitoring functions is given in other sections as noted above.

The RMS is designed to perform its functions continuously during normal operation, including anticipated operational occurrences, and as required during accident conditions.

Sampling capabilities for the plant are described in Section 9.3.2.

Compliance with RG 1.97 is discussed in Table 7.5-1.

11.5.1 Design Bases

11.5.1.1 Design Objectives.

The design objectives for the RMS are discussed below:

1. The Control Room/Electrical Auxiliary Building (CR/EAB) ventilation monitors, the Reactor Containment Building (RCB) purge isolation monitors and the spent fuel pool exhaust (SFPE)

monitors are designed to actuate Engineered Safety Features (ESF) systems in the event airborne radioactivity in excess of allowable limits exists. Additional design bases are stated in the following sections:

a. Containment ventilation and isolation systems: Section 7.3.1 and 9.4.5.

b. Fuel Handling Building (FHB) exhaust system: Sections 7.3.3 and 9.4.2.

c. CR ventilation actuation: Sections 6.4, 7.3.2, and 9.4.1.

These radiation monitors are protection system elements and are designed in accordance with Institute of Electrical and Electronics Engineers (IEEE) 279-1971.

The safety evaluation of these systems is discussed in the above-referenced sections and in Chapter 15.

2. The effluent radiation monitors operate continuously during discharges of potentially radioactive plant effluents, in compliance with RG 1.21. Data from the monitors are used to demonstrate that the released effluents are low enough that 10CFR50 Appendix I dose guidelines are not exceeded at the site boundary. The monitors provide sufficient radioactivity release data to prepare the reports required by RG 1.21.

3. The effluent radiation monitors alarm and automatically terminate the release of effluents when radionuclide concentrations exceed the limits specified, thus meeting GDC 60. Where termination of releases is not feasible, the monitors provide continuous indication of the magnitude of the activity released.

4. The radwaste process system monitors measure radioactivity in process streams (and perform certain control functions as required) to aid personnel in the treatment of radioactive fluids prior to recycle or discharge, thus meeting GDC 63.

5. The process and effluent radiation monitors monitor the Containment atmosphere and effluent discharge paths for radioactivity that may be released during normal operations, including anticipated operational occurrences, and during postulated accidents, in accordance with GDC 64.

6. The process and effluent monitors indicate the existence of and, to the extent possible, the magnitude of reactor coolant and auxiliary systems leakage to the Containment atmosphere, cooling water systems, or the secondary side of the steam generators (SGs).

7. A process radiation monitor located on the Chemical and Volume Control System (CVCS) provides alarm and gross indication of the extent of any failed fuel within the primary system.

11.5.1.2 Design Criteria. The following design criteria are employed in the design of the PERMS (and RMS, as applicable):

1. Monitors and detectors have sensitivities and ranges compatible with radiation levels anticipated at specific detector locations.

2. PERMS monitors incorporate alert, high, and malfunction alarms and provisions for recording and continuous indication of radiation levels. Access to alarm setpoints is under administrative control.

3. The readings of the PERMS monitors are indicated in the CR and Health Physics office.

4. Control room annunciation is provided for computer failures. Radiation monitors in alarm and/or radiation monitor failures are alarmed via the RMS Control Room CRT.

5. The proper operation of each detector is checked as required with a built-in check source or check current actuated locally at the monitor or from the control room console.

6. Local alarms and indication are provided as required on local panels.

7. Environmental conditions for the components are considered in the design. Safety-related components are seismically and environmentally qualified as described in Sections 3.10 and 3.11, respectively, to ensure that they will function before, during, and after design basis events.

8. Monitors are accessible for maintenance and inspection in accordance with governing as low as is reasonably achievable (ALARA) design considerations.

9. Sufficient lead-shielding against ambient background radiation is provided to achieve adequate sensitivity.

10. The design of air stream sampling is based upon the guidance of American National Standards Institute (ANSI) N13.1-1969.

11. Radiation monitors are of a nonsaturating design, registering full-scale if exposed to radiation levels in excess of full-scale indication.

12. Safety-related monitors are redundant, to meet the single failure criterion, and have the required capacity and reliability to perform their intended safety functions.

13. Independence of redundant monitors is maintained by providing adequate separation of detectors, signal cabling, power supplies, and actuation circuits to meet IEEE 279-1971 criteria.

    Monitoring redundancy is provided for:

    a. RCB purge isolation

    b. FHB ventilation actuation

    c. CR/EAB ventilation actuation

    d. Containment high range area monitors (discussed in Section 12.3.4)

14. Monitors and their detectors are designed to function at the maximum temperature and pressure normally expected to occur at the sampling point. Where required, sampling conditioning equipment is provided.

15. RMS equipment is designed and located so that radiation effects to electrical insulation and other materials will not affect the equipment usefulness over the life of the plant.

16. All microprocessors are located in areas where the background radiation is 2.5 mR/hr or less during normal operations.

17. The RMS is designed so it can be checked on a daily basis, tested periodically, and recalibrated during refueling shutdowns or as system operation requires.

18. Radiation monitors are designed for stand-alone operation. In the event of a communication link failure, the monitor continues to function and store data. No failure in one monitor will cause a loss of operating function of more than that one monitor.

19. Detectors are designed to minimize crud buildup. Purge or flush capabilities are provided where required and sample chambers are removable for decontamination. Flow rates for liquid monitors are selected to minimize particulate settlement.

20. Post-accident monitoring detectors meet the shielding requirements of RG 1.97 and NUREG-0737.

21. Radiation monitors which perform an automatic isolation function are designed and qualified to the same criteria consistent with those of the actuated system.

11.5.2 System Description

11.5.2.1 General Description. The RMS is comprised of the following:

1. The area radiation monitors, which continually monitor radiation fields in various representative regions within the plant. These monitors are described in Section 12.3.4.

2. The process and effluent radiation monitors, which provide a means for assessing radioactivity levels in plant process and effluent streams, and control plant and effluent streams including the handling and processing of radioactive waste.

3. Airborne monitors, which continually monitor airborne radioactivity in selected ventilation streams in the plant to assist in determining habitability. Functional requirements for these monitors are discussed in Section 12.3.4.

4. Associated electronics for system communications, data processing and storage, and operator interface.

The following monitors are provided in the RMS for process and effluent monitoring:

a. RCB atmosphere monitor

b. Unit vent monitor

c. CR/EAB ventilation monitors (2)

d. Condenser vacuum pump monitor

e. SFPE monitors (2)

f. RCB purge isolation monitors (2)

g. SG blowdown liquid monitor

h. Liquid Waste Processing System (LWPS) monitors (2)

i. Component Cooling Water (CCW) monitor

j. Boron Recycle System (BRS) monitor

k. Turbine Generator Building (TGB) drains monitor

l. Failed fuel monitor

m. Condensate Polishing System monitor

n. Gaseous Waste Processing System (GWPS) inlet monitor

o. GWPS discharge monitor

p. Main steam (MS) line monitors (4)

q. SG blowdown monitors (4)

r. Main Steam Line High Energy Gamma (N-16) Monitors (4)

11.5.2.1.1 Detector Location Selection: In accordance with RG 1.21, detectors are located at the major and potentially significant paths for release of radioactive material during normal operation, including anticipated operational occurrences. Detectors are also provided for process and ventilation lines as required to determine process malfunction or approach to unsafe conditions and provide isolation signals where required for personnel safety or accident mitigation. The monitors are thus located in the following:

1. Process streams that normally discharge low level activity directly to the environment.

2. Process streams that discharge directly to the environment but do not normally carry radioactive material. Such monitoring indicates if any radioactive leaks into these process lines have occurred.

3. Process lines which contain radioactivity but do not normally discharge to the environment. Such monitoring indicates if process malfunctions have occurred.

4. MS lines, to assist in determination of releases from the MS safety and relief valves.

5. Ventilation lines which supply the CR and Technical Support Center (TSC) and require isolation upon high radiation for personnel protection.

6. Ventilation lines which may contain radioactivity due to fuel handling accidents.

7. Ventilation lines that discharge to the environment and normally carry radioactive material.

Detector locations and sample line routes from sampling point to detector are chosen to minimize sample line length, and the number of direction changes are chosen to minimize transport losses.

11.5.2.1.2 Detector Type, Sensitivity and Range: The range of each detector, along with other pertinent information such as detector type, reference nuclide, and minimum detectable concentration, are summarized in Table 11.5-1.

Bases for the ranges listed in Table 11.5-1 are as follows:

1. For process monitors, the ranges include:

    a. Maximum calculated concentrations during normal operations and anticipated operational occurrences.

    b. The highest sensitivity commercially available when purchased, for early detection of process system leakage and airborne contamination.

2. For effluent monitors, the ranges include:

    a. Maximum calculated concentrations for normal operations, anticipated operational occurrences, and postulated accidents.

    b. Minimum concentrations that must be detected in order to allow automatic and/or operator actions to avoid exceeding Technical Specifications for the release of radioactivity.

11.5.2.1.3 Setpoints: Setpoints for effluent monitors are established to meet plant Technical Specification limits, which are governed by 10CFR Parts 20 and 50 Appendix I objectives. Setpoints for process monitors are established to meet plant Technical Specifications and to provide timely warning of increased system activity requiring corrective action for maintenance of safe operating conditions.

Two independently adjustable radiation setpoints are provided, alert and high. The alert activates an alarm, while the high actuates an alarm and also initiates control action where appropriate. The alert setpoint may be set as close to the background as feasible to provide early warning without generating statistically nonsignificant alarms. The setpoints are listed in Table 11.5-1.

11.5.2.1.4 Annunciators and Alarms: Radiation monitors alarm at the RMS operator consoles in the CR, Health Physics office, and the Technical Support Center (TSC). The individual detector microprocessor initiates alarm messages when setpoints are exceeded. Monitor failure or malfunctions also initiate alarm messages.

Each new alarm condition is logged at a console printer, upon operator request.

11.5.2.1.5 Maintenance and Calibration: The channel detector and electronics are serviced and maintained in accordance with manufacturers' recommendations to ensure reliable operations. Such maintenance includes component cleaning, replacement, or adjustment required after performing a test or calibration check. If any work is performed which could affect the calibration, a recalibration is performed upon completion of the work.

The initial calibration of each complete monitoring system is performed by the manufacturer at the factory. Primary calibration is performed in accordance with ANSI N13.10. After installation, the equipment is rechecked by obtaining the response to portable calibration sources. Calibration of detectors is performed based upon a known correlation between the detector responses and a secondary standard. The source-detector geometry during primary calibration is identical to the sample-detector geometry in actual use. Portable field calibration sources are supplied for each type of detector. These are in addition to the monitor's built-in check source or current. The calibration source radionuclides, which are traceable to the National Institute of Standards and Technology (NIST), have a half-life of greater than 10 years.

Each monitor has a solenoid-operated check source or current to check detector response. For gamma detectors a Cs-137 source is used and for beta detectors a Cl-36 source is used. Each detector is checked periodically using its built-in check source or current.

A channel calibration is performed on each monitor at least every 18 months during plant operation or during the refueling outage. If the detector is not readily accessible then calibration is performed using the secondary radionuclide standard which is periodically confirmed using calibration sources traceable to NIST standards. A calibration can also be performed by using liquid or gaseous radionuclide standards traceable to NIST.

11.5.2.1.6 Power Sources: Class 1E power is supplied to the safety-related monitors by the 120V Vital AC Instrumentation and Control busses. Monitors listed in Table 7.5-1, which satisfy a RG 1.97 requirement, receive diesel-backed power from the 120 V AC-regulated power bus.

11.5.2.2 Digital System Description.

11.5.2.2.1 General: The RMS is a distributed microprocessor-based digital monitoring system. System communication connections require two twisted-shielded pairs of low-voltage cable (Figure 11.5-1). The operator consoles provide CRT displays and recording on printers. The monitor detector locations have control, data processing, data storage, and multilevel alarming features.

The RMS is comprised of the following components:

1. Dual RM-11 computers

2. Three operator consoles for the RM-11s, one each in the CR, Health Physics office, and the TSC. Each console consists of a computer, color CRT, keyboard, and printer.

3. A Dose Assessment and Report Generation Computer System.

4. A CR cabinet, which houses the remote control unit (RCU) for each Class 1E radiation monitor and the seismically qualified indicator for the RCB atmosphere monitor.

The system utilizes a distributed data base with each individual monitor microprocessor maintaining its own data base and stored data. The microcomputers contain the communications links to the monitor process loops and the necessary memory and programming to provide overall system status. These microcomputers are interconnected to provide alternate communications paths, thus tolerating a single communications cable fault or monitor malfunction without loss of function in the system. In addition to the display requests from the keyboard, other control functions such as check-source readings, pump motor control, and purge control, are provided.

11.5.2.2.2 Monitor Local Control Unit: At each monitor, the local microprocessor performs control, data processing, data storage, and multilevel alarming independent from the rest of the system. Each monitor microprocessor has a data base which includes calibration count rate, conversion factors, high alarm limit, alert alarm limit, check-source count rate, and where monitored, flow rate. Processed data are averaged and stored in memory for historical trends. The historical file of detector data consists of 24 ten-minute averages, 24 one-hour averages, and 28 one-day averages. Locally stored data is battery-backed to preclude loss of data in the event of a loss of power.

Depending upon the application, each microprocessor receives input from up to four detectors. Liquid and noble gas monitors have one detector, while the airborne monitors have up to three detectors each (particulate, iodine, noble gas). The MS line and SG blowdown monitors have two detector channels each. Up to four detectors are handled by one area microprocessor.

11.5.2.2.3 Operator Consoles: The operator consoles are dedicated to radiation monitoring duties only and function independently of any other computer systems.

The consoles each have a computer, color CRT display, a keyboard, and a printer. The consoles give operators consolidated and fully processed information on the RMS throughout the plant. The basic displays on the CRT console are the status grid displays, wherein each monitor is represented by a colored rectangle with six superimposed characters. The characters identify the monitor, and the background color indicates monitor status.

All displayed data and plots on the CRT displays are updated at regular intervals or after an alarm message is received from that monitor.

11.5.2.2.4 Dose Assessment and Report Generation Computer: The Dose Assessment and Report Generation Computer System performs as follows:

1. Collects radioactivity level information from effluent radiation monitors throughout the plant

2. Collects and displays meteorological data from the meteorological towers

3. Calculates meteorological dispersion factors and generates reports for compliance with RG 1.23

4. Generates radioactive effluent reports for compliance with RG 1.21

5. Calculates offsite dose consequences from normal plant operation releases

The Dose Assessment and Report Generation Computer System consists of Integrated Computer System (ICS), Emergency Response Facilities Data Acquisition and Display System (ERFDADS), Local Area Network (LAN) and ORACLE, and Plant Information (PI) software and the interfaces are shown on Figure 11.5-1.

Laboratory isotopic data needed for RG 1.21 reports can be entered manually at the CRT keyboard or communicated from the counting room multichannel analyzer. Alternate means for dose assessment, consistent with the methodology in the Offsite Dose Calculation Manual and/or regulatory guidance for accident assessment, are available for use in lieu of the RM-21A as appropriate.

11.5.2.2.5 Remote Control Unit and Special Considerations for Class 1E Monitors: Each Class 1E radiation monitor includes an environmentally and seismically qualified RCU mounted in the RMS CR cabinet.

The microprocessor-based RCU provides control and indication of the Class 1E radiation monitor, independent of the RMS computer system. The RM-11 computer system can, through communication isolation devices, display on the operator console CRT the data and alarm status of the Class 1E radiation monitors. However, only the RCU provides remote control of the monitor functions (check source actuation, purge initiation, etc.) and loading or changing of the monitor's data base.

11.5.2.3 Airborne Radioactivity Monitoring System. Fixed monitors are provided for continuous detection and measurement of airborne radioactivity for ventilation systems and for plant gaseous effluents. The design parameters for these monitors are summarized in Table 11.5-1. Design requirements for building ventilation monitors are given in Section 12.3.4. The following criteria for air sampling are met:

1. Detectors are located as close to sampler intakes as feasible.

2. Design of sample nozzles and lines is based on applicable sections of ANSI N13.1-1969 to ensure representative sampling and minimum settling and plateout losses of particulates during transport to the detector.

11.5.2.3.1 Sampling Devices: For each off-line monitor, a sample is drawn through a sample line and passed through a filter to collect particulates. The filters used to collect particulates have a collection efficiency of at least 99 percent for 0.3 micron particles. The air stream then passes through a charcoal cartridge to collect iodine. The charcoal cartridges used to collect iodine have been shown to have a minimum efficiency of 95 percent for elemental and organic iodine. These filters and cartridges are replaced at periodic intervals, as needed and consistent with the sampling intervals provided in the Technical Specifications. The removed filters and cartridges are counted, and, if necessary, analyzed in the counting room for particulate and iodine activity.

The air stream is then routed by a pump to a shielded, internally polished stainless steel chamber where the sampled air is monitored for radioactive noble gases by a beta scintillation detector. The air is finally returned to the system for which it was extracted, except the Condenser Vacuum Pump radiation monitor RT-8027.

Each sample pump is capable of drawing an appropriate air sample through the monitor. Each monitor has a low sample flow alarm.

The location of sample probes and off-line monitors has been chosen to minimize sample plateout. Unavoidable bends are made with radii not less than five times the tubing diameter. Stainless steel lines and appropriate sampling valves are used.

A sample conditioning skid, provided as part of the unit vent monitor, provides sampling capability of plant effluents in compliance with NUREG-0737, Item II.F.1.

11.5.2.3.2 Reactor Containment Building Atmosphere Monitor: This monitor is provided to monitor Containment air for particulate, iodine, and noble gas activities. The monitor continuously samples from the Containment atmosphere, which is drawn outside the Containment in a closed system. The detectors and associated equipment are mounted on a single skid. The sample air passes through a moving (nominal 1 in./hr) filter tape at an appropriate rate depositing airborne particules on the paper, which is continuously monitored by a beta-sensitive scintillation detector. The detector assembly is in a completely enclosed, shielded housing. The detector is a hermetically sealed photomultiplier tube, thin-plastic scintillator combination. Four-pi lead shielding is provided to reduce ambient background radiation to a level that provides adequate detector sensitivity.

The sample then passes through a closed system to a charcoal cartridge to collect iodine. The cartridge is monitored by a shielded gamma-sensitive scintillation detector.

When the sample air leaves the charcoal cartridge, it is drawn through a closed system to a shielded stainless steel gas sampling chamber monitored by a beta-sensitive scintillation detector. The sampled air is finally returned to the Containment atmosphere.

The particulate channel is used as part of the Reactor Coolant Pressure Boundary (RCPB) leakage detection system. The sensitivity and response time of this part of the leakage detection system, which is used for monitoring unidentified leakage to the Containment, are sufficient to detect an increase in leakage rate of the equivalent of one gal/min within one hour. Elements of this monitor, including the indicator mounted in the RMS CR cabinet, are designed and qualified to remain functional following a Safe Shutdown Earthquake (SSE), in compliance with RG 1.45. Further information on the RCPB leakage detection system is presented in Section 5.2.5.

11.5.2.3.3 Unit Vent Monitor: The unit vent monitor samples the plant vent stack prior to discharge to the environment and monitor for particulates, iodine, and noble gases.

The unit vent particulate and iodine monitor draws representative air samples from the plant vent stack via isokinetic nozzles in the stack, and directs them through a moving filter paper monitored by a shielded beta-sensitive scintillation detector. The sample stream then passes through a charcoal collector, where collected iodine is monitored by a shielded gamma-sensitive scintillation detector. The sample is then returned to the vent stack.

A separate wide-range gas monitor is provided for the unit vent. The monitor has two isokinetic nozzles for sampling during both normal and accident conditions. The stack samples pass first through a sample conditioning unit which filters particulates and iodine and may be used to take grab samples. The samples then pass through the shielded detector assembly, which uses three detectors to cover the complete range required. The low range detector uses a beta-sensitive plastic scintillator-photomultiplier (PM) tube. The mid-range and high-range detectors use cadmium telluride (CdTe), chlorine-doped, solid-state sensors. This wide-range gas monitor satisfies the requirements of NUREG-0737, Item II.F.1 for provisions for sampling plant effluents for iodines and particulates and for noble gas effluents from the plant vent.

11.5.2.3.4 Control Room Electrical Auxiliary Building Ventilation Monitors: The CR/EAB ventilation monitors are Class 1E monitors which continuously assess the intake air to the CR for indication of abnormal airborne radioactivity concentration. Each monitor assembly is powered from a separate electrical power source. In the event of high radiation CR emergency ventilation operation is initiated (Section 7.3.2). Failure of a monitor is alarmed in the CR.

Each monitor assembly is comprised of a recirculation pump, beta-sensitive scintillation detector, four-pi lead shielding, check source, stainless steel sample gas receiving chamber, and associated electronics.

11.5.2.3.5 Condenser Vacuum Pump Monitor: Gaseous samples are drawn through an off-line system by a pump from the discharge of the vacuum pump exhaust header of the condenser. This channel monitors the gaseous sample for radioactivity which would be indicative of an SG tube leak, allowing reactor coolant to enter the secondary side fluid; this monitor complements the SGBD monitors in indication of a SG tube leak. The gaseous radioactivity levels are monitored by a single detector in a manner similar to the unit vent wide range gas monitor.

11.5.2.3.6 Spent Fuel Pool Exhaust Monitors: The SFPE monitors are Class 1E and are identical to the CR/EAB ventilation monitors described in Section 11.5.2.3.4 except that they sample the exhaust from the FHB. In the event of high radiation the monitors initiate emergency operation of the FHB HVAC, causing the exhaust air to be filtered prior to release (Section 7.3.3). Failure of a monitor is alarmed in the CR.

11.5.2.3.7 RCB Purge Isolation Monitors: The RCB/purge isolation monitors are Class 1E monitors that sample the Containment Normal Purge System or the Supplementary Purge System and are identical to the CR/EAB ventilation monitors described in Section 11.5.2.3.4. In the event of high radiation the monitors send signals to the Solid-State Protection System (SSPS) for containment ventilation isolation (Section 7.3.1). Failure of a monitor is alarmed in the CR.

11.5.2.4 Liquid Monitors. Fixed, off-line monitors are provided for continuous detection and measurement of radioactivity for liquid process streams. The design parameters for these monitors are summarized in Table 11.5-1. Each monitor is provided with demineralized water for flushing.

11.5.2.4.1 Sampling Devices: For each monitor, a sample is drawn from the process line, passed through a shielded sample chamber, through the sample pump and then returned to the system. Each sample pump is capable of drawing at least one gal/min of liquid through the monitor. The sample flow rate is controlled by means of a manual valve.

Each monitor has a low-sample-flow alarm.

The monitor inlet and outlet lines have compression fittings. The sample piping has isolation valves so that the monitor skid can be isolated and the sample chamber dissembled for decontamination.

11.5.2.4.2 Detector Unit: Each detector is a NaI(Tl) gamma-sensitive scintillation detector. The detectors are designed to remain fully operational over a wide range of temperatures. If they are exposed to high radiation transients exceeding the channel range, the channel maintains its operation and returns to normal functioning when the transients have subsided. Since gamma detectors are used, comparison of monitor readout with the results of grab samples is possible. The grab samples are counted in the plant multichannel gamma pulse height spectrometer to check for proper monitor operation. Solenoid-operated check sources are provided to check detector response.

11.5.2.4.3 Steam Generator Blowdown Liquid Monitor: The SG blowdown liquid monitor samples the liquid from either the SG blowdown flash tank or demineralizer. The sample is continuously monitored by a shielded gamma-sensitive detector. Detection of high radiation by this monitor alerts the operator to the possibility of primary-to-secondary leakage.

In the event of activity above the high alarm setpoint or monitor failure, the monitor initiates the automatic closure of FV-5019, the SG blowdown discharge to neutralization basin isolation valve.

11.5.2.4.4 Liquid Waste Processing System Monitors: LWPS monitor no. 1 detects activity present in the liquid waste effluent being discharged from the waste monitor tanks in the LWPS. The monitor is located upstream of the LWPS diversion valve, FV-4077. Upon initiation of a high radiation or monitor failure alarm, the monitor causes the valve to automatically divert the effluent back to the waste monitor tanks.

Prior to discharge, the liquid in the monitor tank to be released is sampled and analyzed in the laboratory for radioactivity. Based upon this analysis, a discharge permit is issued specifying the release rate and the dilution rate. The release rate and dilution rate are used to determine the alarm setpoints for the monitor.

LWPS monitor no. 2 detects activity present in the liquid waste effluent being discharged to the waste monitoring tanks outside the Mechanical Auxiliary Building.

11.5.2.4.5 Component Cooling Water Monitor: This monitor samples the discharge of the CCW pumps. The monitor can sample from any of the three CCW pumps in the system, as selected by the operator.

The sample is drawn from the CCW pump discharge line downstream of the CCW heat exchanger, monitored, and then returned to the CCW surge tank.

11.5.2.4.6 Boron Recycle System Monitor: This monitor is located in the BRS evaporator condensate line downstream of the recycle evaporator condensate filter.

Upon initiation of a high radiation or monitor failure alarm, the monitor initiates changeover of the BRS diversion valve, RCV-4202, causing the BRS condensate to be diverted from the Reactor Makeup Water Storage Tank (RMWST) back to the BRS recycle evaporator feed demineralizers.

11.5.2.4.7 Turbine Generator Building Drain Monitor: This monitor monitors the water in TGB drain sump no. 1. Upon detection of high radiation level or monitor failure, the monitor automatically stops the sump pumps and alarms the condition.

11.5.2.4.8 Failed Fuel Monitor: This monitor takes a sample downstream of the letdown heat exchanger (HX) of the CVCS and acts as a gross-failed fuel detector. The radiation alarms alert the operator to an abnormal increase in gross gamma activity in the CVCS letdown system possibly indicative of fuel cladding failure. Determination of the cause can be made by laboratory analysis. The sample location provides a letdown sample point prior to filtration and demineralization.

11.5.2.4.9 Condensate Polishing System Monitor: This monitor is located on the discharge of the Condensate Polishing System to the neutralization basin. Upon detection of high radiation or monitor failure, the monitor sends a signal to automatically close FV-5804 to terminate discharge to the basin.

11.5.2.5 Adjacent-to-Line Monitors. Adjacent-to-line (ATL) monitors are used to monitor:

1. GWPS

2. MS System

3. Steam Generator Blowdown System (SGBS)

These monitors are mounted adjacent to the process line and do not require a sample stream to monitor for radioactivity.

11.5.2.5.1 Gaseous Waste Processing System Inlet Monitor: The GWPS inlet monitor employs a gamma (NaI crystal) scintillator/photomultiplier tube combination to measure the radioactivity level of the waste gases entering the GWPS. The monitor is used in conjunction with the GWPS discharge monitor to measure overall effectiveness of the GWPS.

11.5.2.5.2 GWPS Discharge Monitor: This monitor is similar to the GWPS inlet monitor and is installed upstream of the GWPS discharge valve. Upon detection of high radioactivity or monitor failure, the GWPS discharge valve, FV-4671, is automatically closed.

11.5.2.5.3 Main Steam Line Monitors: Each MS line is monitored by an ATL monitor consisting of a Geiger Mueller (GM) tube detector and an ion chamber detector with overlapping ranges. The detectors are shielded by 3 in. of lead.

The monitors are designed to monitor gross gamma activity in the steam line and provide a basis for determining possible atmospheric releases from the MS power-operated relief valve (PORV), SG safety valves, and/or auxiliary feedwater pump turbine.

The monitors provide a dose rate range equivalent to 10^{-1} to 10^{3} $\mu Ci/cm^3$ xenon-133. Based upon core inventory, the ratio of xenon-133 to other nuclides in the fuel can be detemined. In order to obtain the above concentrations of xenon-133 in the main steam line, a large primary-to-secondary leak must be present coincident with a large amount of fuel failure. The presence of xenon-133 indicates other radioactive isotopes are present.

Using the relative ratios of isotopes present in the MS line, a computer model for determination of dose rates from these isotopes, detector response curves, the thickness of the MS line, and the geometry of the MS line relative to the detector, the dose rate equivalent to MS line concentration is obtained. The quantity of radioactive effluents released is obtained by multiplying the xenon-133 equivalent MS line concentrations by the isotope ratio times the steam release rate.

These detectors are safety-related Class 1E and meet the requirements of RG 1.97 and NUREG-0737.

11.5.2.5.4 Steam Generator Blowdown Monitors: These monitors are identical to the MS line monitors and are adjacent to the SG blowdown lines in the Isolation Valve Cubicle (IVC).

The monitors are used as an aid in determining the source of SG blowdown radioactivity due to SG tube rupture or a large primary-to-secondary leak.

These detectors are safety-related Class 1E and meet the requirements of RG 1.97.

11.5.2.5.5 Main Steam Line High Energy Gamma (N-16) Monitors: Each main steam line is monitored by an ATL NaI scintillation detector. These detectors were installed to monitor the status of steam generator primary to secondary tube leaks and to provide a diagnostic tool for all individuals concerned with steam generator condition. These detectors are designed to detect high energy gamma activity in the 6 to 7.2 MEV energy range. High energy gamma activity in the main steam lines indicates the presence of N-16. The level of N-16 in the main steam lines is used to calculate the primary to secondary leak rate. This information is then input to the plant computer through the I/O subsystem.

11.5.2.6 Safety Evaluation. Samples for radiation monitors are not removed from the RCB for monitoring, except the RCB atmosphere monitor, which is shown on Figure 9.4.5-1. In the unlikely event of an accident, the lines providing the sample to the monitor and returning the sample to the RCB would be automatically isolated by the valves inside and outside the RCB. As discussed in Section 6.2.4 and shown on Figure 6.2.4-1, Sheet 83, the inside and outside valves receive power from separate Class 1E power sources and close upon receipt of a Containment ventilation isolation signal.

The monitors of the RMS, which are safety-related in function, are seismic Category I supported and Class 1E qualified and powered, and are the following:

1. RCB Purge Isolation Monitors

2. CR/EAB ventilation monitors

3. SFPE monitors

4. RCB high range area monitors

5. MS monitors

6. SG blowdown monitors

A failure modes and effects analysis for these monitors is given in Table 11.5-2.

11.5.3 Effluent Monitoring and Sampling

Effluent sampling of all potentially radioactive liquid and gaseous effluent paths is conducted on a regular basis. This verifies the adequacy of effluent processing for compliance with the discharge limits to unrestricted areas. This effluent sampling program is of a comprehensive nature and provides the information for the effluent measuring and reporting programs required by 10CFR50.36a in reports to the Nuclear Regulatory Commission (NRC).

The requirement of GDC 64 for the monitoring of effluent discharge paths is implemented by providing continuous radiation detection and periodic sampling. This monitoring and sampling is provided for all liquid and gaseous effluent paths from which detectable quantities of radioactivity can be released from the plant during normal operation, including anticipated operational occurrences, and from postulated accidents.

These effluent monitors are as follows:

1. LWPS Monitor No. 1 (provides automatic isolation)

2. Unit Vent Monitor

3. MS line Monitors (post-accident)

11.5.4 Process Monitoring and Sampling

Potentially radioactive systems which lead to effluent discharge paths are equipped with a control system to automatically isolate the discharge upon indication of a high radioactivity level. These include: the Containment Normal and Supplementary Purge Systems, TGB drain sump, Condensate Polishing System, SG blowdown, and the gaseous and liquid radwaste systems. Batch releases are sampled and analyzed prior to discharge, in addition to the continuous effluent monitoring.

By means of the continuous radiation monitors mentioned above their associated control valves, and due to the extensive sampling program described in the Environmental Report, GDC 60, and the Radiological Effluent Technical Specifications are met with regard to the control of releases of radioactivity to the environment.

Process monitoring is accomplished by continuous radiation monitors. By means of these monitors, GDC 63 is met with regard to monitoring radioactivity levels in the radioactive waste processing systems.

TABLE 11.5-1

PROCESS AND EFFLUENT RADIATION MONITORING SYSTEM

Service	Sample Location	Detector Number	Detector Type	Analysis Performed	Range (9) (μCi/cm^3)	MDC (1) (μCi/cm^3)	Controlling Isotope	Alert Alarm (10) (μCi/cm^3)	High Alarm (10) (μCi/cm^3)	Control Function
Reactor Containment Building Atmosphere	Containment Atmosphere	Re-8011A Particulate (P)	(2)	Gross Beta	1.6(-11)* to 1.6(-5)	8.6(-12)	Cs-137	8.4(-7)	1.0(-6)	None
		RE-8011B Iodine (I)	(3)	Gross Gamma	3.3(-12) to 1.2(-5)	3.3(-12)	I-131	8.6(-8)	2.0(-7)	
		RE-8011C Noble Gas (NG)	(2)	Gross Beta	5.4(-7) to 5.4(-1)	4.1(-7)	Xe-133	5.8(-3)	5.8(-3)	
Unit Vent Particulate and Iodine	Unit Vent Stack, MAB Roof	RE-8010A(P)	(2)	Gross Beta	1.6(-11) to 1.6(-5)	8.6(-12)	Cs-137	3.6(-9)	7.1(-9)	None
		RE-8010B (I)	(3)	Gross Gamma	3.3(-12) to 1.2(-5)	3.3(-12)	I-131	5.1(-10)	9.6(-10)	
Unit Vent Wide Range Gas	Unit Vent Stack, MAB Roof	RE-8010C (NG) Low Range	(2)	Gross Beta	3.4(-7) to 3.4(-1)	6.5(-8)	Xe-133	N/A	N/A	None
		RE-8010D (NG) Mid-Range	(5)		7.0(-4) to 7.0(+2)	3.8(-5)	Xe-133	N/A	N/A	
		RE-8010E (NG) High Range	(5)		2.0(-1) to 2.0(+5)	1.0(-2)	Xe-133	N/A	N/A	
		Effluent	N/A	N/A	N/A	N/A	Xe-133	4.8(4)**	9.6(4) **	
Control Room/ Electrical Auxiliary Building Air Intake	EAB Intake Air	RE-8033 (NG)	(2)	Gross Beta	3.4(-7) to 3.4(-1)	1.3(-7)	Xe-133	(8)	(8)	Initiates Control Room Emergency Ventilation (Section 9.4.1)
Control Room/ Electrical Auxiliary Building Air Intake	EAB Intake Air	RE-8034 (NG)	(2)	Gross Beta	3.4(-7) to 3.4(-1)	1.3(-7)	Xe-133	(8)	(8)	Initiates Control Room Emergency Ventilation (Section 9.4.1)

TABLE 11.5-1 (Continued)

PROCESS AND EFFLUENT RADIATION MONITORING SYSTEM

Service	Sample Location	Detector Number	Detector Type	Analysis Performed	Range (9) ($\mu Ci/cm^3$)	MDC (1) ($\mu Ci/cm^3$)	Controlling Isotope	Alert Alarm (10) ($\mu Ci/cm^3$)	High Alarm (10) ($\mu Ci/cm^3$)	Control Function
Condenser Vacuum Pump (CVP)	CVP Exhaust Pipe, TGB	Re-8027A (NG) Low Range	(2)	Gross Beta	3.4(-7) to 3.4(-1)	6.0(-8)	Xe-133	N/A	N/A	None
Spent Fuel Pool Exhaust	Fuel Handling Building Ventilation Exhaust	RE-8035 (NG)	(2)	Gross Beta	3.4(-7) to 3.4(-1)	2.7(-7)	Xe-133	(8)	(8)	Initiates Fuel Handling Building Exhaust Filtration (Section 9.4.2)
Spent Fuel Pool Exhaust	Fuel Handling Building Ventilation Exhaust	RE-8036 (NG)	(2)	Gross Beta	3.4(-7) to 3.4(-1)	2.7(-7)	Xe-133	(8)	(8)	Initiates Fuel Handling Building Exhaust Filtration (Section 9.4.2)
Reactor Containment Building (RCB) Purge Isolation	RCB Normal and Supplementary Purge Systems Exhaust	RE-8012 (NG)	(2)	Gross Beta	3.4(-7) to 3.4(-1)	2.7(-7)	Xe-133	(8)	(8)	Sends signal to SSPS for Containment Ventilation Isolation (Section 9.4.5)
RCB Purge Isolation	RCB Normal and Supplementary Purge Systems Exhaust	RE-8013 (NG)	(2)	Gross Beta	3.4(-7) to 3.4(-1)	2.7(-7)	Xe-133	(8)	(8)	Sends signal to SSPS for Containment Ventilation Isolation (Section 9.4.5)
Steam Generator Blowdown (SGBD) Liquid	SGBD Flash Tank Outlet, Demineralizer Outlet	RE-8043 Liquid (L)	(4)	Gross Gamma	7.8(-8) to 7.8(-2)	3.9(-8)	Cs-137	4.9(-6)	1.2(-5)	Closes SG Blowbown Discharge to Neutralization Basin Isolation Valve, FV-5019

TABLE 11.5-1 (Continued)

PROCESS AND EFFLUENT RADIATION MONITORING SYSTEM

Service	Sample Location	Detector Number	Detector Type	Analysis Performed	Range (9) (μCi/cm^3)	MDC (1) (μCi/cm^3)	Controlling Isotope	Alert Alarm (10) (μCi/cm^3)	High Alarm (10) (μCi/cm^3)	Control Function
Liquid Waste Processing System	Upstream of LWPS Diversion Valve FV-4077	Re-8038 (L) Effluent	(4) N/A	Gross Gamma N/A	7.8(-8) to 7.8(-2) N/A	7.9(-8) N/A	Cs-137 Cs-137	4.8(-6) 8.9(-2)**	9.0(-6) 1.7(-1)**	Positions Diversion Valve FV-4077 to divert effluent back to Waste Monitor Tanks (Section 11.2)
Liquid Waste Processing System	Upstream of LWPS Diversion Valve FV-5050	RE-8045 (L)	(4)	Gross Gamma	7.8(-8) to 7.8(-2)	7.9(-8)	Cs-137	2.5(-5)	4.9(-5)	None
Component Cooling Water (CCW)	Discharge of CCW Pumps	RE-8040 (L)	(4)	Gross Gamma	7.8(-8) to 7.8(-2)	7.9(-8)	Cs-137	7.8(-7)	1.3(-6)	None
Boron Recycle System (BRS)	BRS Evaporator Condensate Line	RE-8037 (L)	(4)	Gross Gamma	7.8(-8) to 7.8(-2)	7.9(-8)	Cs-137	2.6(-6)	5.6(-6)	Positions Diversion Valve RCV-4202 to divert fluid back to BRS Evaporator Feed Demineralizers (Section 9.3.4.2)
Turbine Generator Building Drain	Discharge Sump Pumps Sump No. 1	RE-8041 (L)	(4)	Gross Gamma	7.8(-8) to 7.8(-2)	3.9(-8)	Cs-137	1.4(-6)	2.3(-6)	Stops TBG Sump No. 1 Sump Pump (Section 9.3.3)
Failed Fuel	Chemical and Volume Control System Letdown Line	RE-8039 (L)	(4)	Gross Gamma	8.7(-4) to 8.7(+2)	7.9(-8)	Cs-137	3.0(+1)	1.6(+2)	None
Condensate Polishing System (CPS)	Discharge of CPS to Neutralization Basin	RE-8042 (L)	(4)	Gross Gamma	7.8(-8) to 7.8(-2)	3.9(-8)	Cs-137	7.5 (-7)	9.5(-7)	Closes FV-5804, CPS Discharge to Neutralization Basin Valve (Section 10.4.6)
Gaseous Waste Processing System Inlet	Adjacent to Inlet Line to GWPS	RE-8031 Adjacent to line (ATL)	(4)	Gross Gamma	1.8(-4) to 1.8(2)	3.7(-4)	Xe-133	1.8(+2)	1.8(+2)	None

CN-3153

TABLE 11.5-1 (Continued)

PROCESS AND EFFLUENT RADIATION MONITORING SYSTEM

Service	Sample Location	Detector Number	Detector Type	Analysis Performed	Range (9) ($\mu Ci/cm^3$)	MDC (1) ($\mu Ci/cm^3$)	Controlling Isotope	Alert Alarm (10) ($\mu Ci/cm^3$)	High Alarm (10) ($\mu Ci/cm^3$)	Control Function
Gaseous Waste Processing System Discharge	Adjacent to Discharge Line, Upstream of GWPS Discharge Valve	RE-8032 (ATL)	(4)	Gross Gamma	3.7(-4) to 3.7(2)	1.4(-3)	Kr-85	9.1(+0)	1.8(+1)	Close GWPS Inlet and Outlet Valves, Stop BRS Vent Compressor (Section 11.3)
Main Steam Line A	IVC, Adjacent to Main Steam Line	RE-8046A (ATL)	(6)	Gross Gamma	1.0(-1) to 1.0(4) mR/hr	5.6(-3)	Xe-133	N/A	N/A	None
		RE-8046B (ATL)	(7)	(11)	1.0(2) to 1.0(7) mR/hr	N/A		N/A	N/A	
		µCi/cc channel	N/A	N/A	1.4(-2) to 1.4(6)	N/A	Xe-133	5.0(-2)	4.0(+0)	
		effluent	N/A	N/A	N/A		Xe-133	2.1(+6)**	3.6(+6)**	
Main Steam Line B	IVC, Adjacent to Main Steam Line	RE-8047A (ATL)	(6)	Gross Gamma	1.0(-1) to 1.0(4) mR/hr	5.6(-3)	Xe-133	N/A	N/A	None
		RE-8047B (ATL)	(7)	(11)	1.0(2) to 1.0(7) mR/hr	N/A		N/A	N/A	
		µCi/cc channel	N/A	N/A	1.4(-2) to 1.4(6)	N/A	Xe-133	5.0(-2)	4.0(+0)	
		effluent	N/A	N/A	N/A		Xe-133	2.1(+6)**	3.6(+6)**	
Main Steam Line C	IVC, Adjacent to Main Steam Line	RE-8048A (ATL)	(6)	Gross Gamma	1.0(-1) to 1.0(4) mR/hr	5.6(-3)	Xe-133	N/A	N/A	None
		RE-8048B (ATL)	(7)	(11)	1.0(2) to 1.0(7) mR/hr	N/A		N/A	N/A	
		µCi/cc channel	N/A	N/A	1.4(-2) to 1.4(6)	N/A	Xe-133	5.0(-2)	4.0(+0)	
		effluent	N/A	N/A	N/A		Xe-133	2.1(+6)**	3.6(+6)**	
Main Steam Line D	IVC, Adjacent to Main Steam Line	RE-8049A (ATL)	(6)	Gross Gamma	1.0(-1) to 1.0(4) mR/hr	5.6(-3)	Xe-133	N/A	N/A	None
		RE-8049B (ATL)	(7)	(11)	1.0(2) to 1.0(7) mR/hr			N/A	N/A	
		µCi/cc channel	N/A	N/A	1.4(-2) to 1.4(6)	N/A	Xe-133	5.0(-2)	4.0(+0)	
		effluent	N/A	N/A	N/A	N/A	Xe-133	2.1(+6)**	3.6(+6)**	

CN-3153

CN-3153

CN-3153

CN-3153

TABLE 11.5-1 (Continued)

PROCESS AND EFFLUENT RADIATION MONITORING SYSTEM

Service	Sample Location	Detector Number	Detector Type	Analysis Performed	Range (9) (μCi/cm^3)	MDC (1) (μCi/cm^3)	Controlling Isotope	Alert Alarm (10) (μCi/cm^3)	High Alarm (10) (μCi/cm^3)	Control Function
SGBD Steam Generator A	IVC, Adjacent to SGBD Line	RE-8022A (ATL)	(6)	Gross Gamma	1.0(-1) to 1.0(4) mR/hr	1.3(-4)	Cs-137	N/A	N/A	None
		RE-8022B (ATL)	(7)	(12)	1.0(2) to 1.0(7) mR/hr			N/A	N/A	
		μCi/cc channel	N/A	N/A	2.6(-4) to 2.6(4)	N/A	Cs-137	2.5(-3)	4.4(-3)	
SGBD Steam Generator B	IVC, Adjacent to SGBD Line	RE-8023A (ATL)	(6)	Gross Gamma	1.0(-1) to 1.0(4) mR/hr	1.3(-4)	Cs-137	N/A	N/A	None
		RE-8023B (ATL)	(7)	(12)	1.0(2) to 1.0(7) mR/hr			N/A	N/A	
		μCi/cc channel	N/A	N/A	2.6(-4) to 2.6(4)	N/A	Cs-137	2.5(-3)	4.4(-3)	
SGBD Steam Generator C	IVC, Adjacent to SGBD Line	RE-8024A (ATL)	(6)	Gross Gamma	1.0(-1) to 1.0(4) mR/hr	1.3(-4)	Cs-137	N/A	N/A	None
		RE-8024B (ATL)	(7)	(12)	1.0(2) to 1.0(7) mR/hr			N/A	N/A	
		μCi/cc channel	N/A	N/A	2.6(-4) to 2.6(4)	N/A	Cs-137	2.5(-3)	4.4(-3)	
SGBD Steam Generator D	IVC, Adjacent to SGBD Line	RE-8025A (ATL)	(6)	Gross Gamma	1.0(-1) to 1.0(4) mR/hr	1.3(-4)	Cs-137	N/A	N/A	None
		RE-8025B (ATL)	(7)	(12)	1.0(2) to 1.0(7) mR/hr			N/A	N/A	
		μCi/cc channel	N/A	N/A	2.6(-4) to 2.6(4)	N/A	Cs-137	2.5(-3)	4.4(-3)	

1. Minimum detectable concentration
2. Beta scintillation detector
3. Gamma scintillation detector
4. NaI(T1) gamma scintillation detector
5. CdTe, chlorine-doped, solid state sensor
6. GM tube
7. Ion chamber
8. Refer to Technical Specifications for high alarm. Alert alarm is one decade lower.
9. Range is based on microprocessor conversion factor and a detector signal which has a high degree of confidence. Conversion factor will vary dependent on the detector calibration. Exact ranges are found in plant instrument scaling manuals.
10. Setpoints are nominal values and may be adjusted as necessary depending on plant conditions.
11. Conversion Factor 1.4(-1) μCi/cm^3 Xe-133 per mR/hr for range on channel 3.
12. Conversion Factor 2.6(-3) μCi/cm^3 Cs-137 per mR/hr for range on channel 3.

* 1.56(-11) = 1.6 x 10^{-11}

** μCi/sec

TABLE 11.5-2

RADIATION MONITORING SYSTEM
FAILURE MODES AND EFFECTS ANALYSIS

Description of Component	Safety Function	Plant Operating Mode*	Failure Mode(s)	Method of Failure Detection	Failure Effect on System Safety Function Capability	General Remarks
Reactor Containment Building (RCB) Purge Isolation Monitors RE-8012, 8013 RT-8012, 8013 RI-8012A, 8013A RI-8012B, 8013B						See RCB HVAC FMEA Table 9.4-5.5
Control Room/Electrical Auxiliary Building (CR/EAB) Ventilation Monitors RE-8033, 8034 RT-8033, 8034 RI-8033A, 8034A RI-8033B, 8034B						See CR/EAB HVAC FMEA Table 9.4-5.1

* Plant Modes

1. Power Operation
2. Startup
3. Hot Standby
4. Hot Shutdown
5. Cold Shutdown
6. Refueling

TABLE 11.5-2 (Continued)

RADIATION MONITORING SYSTEM
FAILURE MODES AND EFFECTS ANALYSIS

Description of Component	Safety Function	Plant Operating Mode*	Failure Mode(s)	Method of Failure Detection	Failure Effect on System Safety Function Capability	General Remarks
Spent Fuel Pool Exhaust Monitors RE-8035, 8036 RT-8035, 8036 RI-8035A, 8036A RI-8035B, 8036B						See Fuel Handling Building HVAC FMEA Table 9.4-5.2
RCB High Range Area Monitors RE-8050, 8051 RT-8050, 8051 RI-8050A, 8051A RI-8050B, 8051B	Detect, monitor, indicate and alarm radiation level inside Containment	1-6	Signal loss (RE/RT) Fails to send signal (RT) Fails to receive signal (RI)	Green "operate" LED in CR off. Alarm and message at CRT. Alarm in CR. "Error" LED in CR on. Alarm in CR.	None – Additional containment radiation monitor available	Monitor is used to meet requirements of RG 1.97
Steam Generators A, B, C and D Blowdown Monitors RE-8022A, 8023A, 8024A, 8025A RE-8022B, 8023B, 8024B, 8025B RT-8022, 8023	Detect, monitor, indicate and alarm radiation level for steam generator blowdown	1-6	Signal loss (RE/RT) Fails to send signal (RT) Fails to receive signal (RI)	Green "operate" LED in CR off. Alarm and message at CRT. Alarm in CR. "Error" LED in CR on. Alarm in CR.	None – Functionally redundant main steam line monitors available	Monitor is used to meet requirements of RG 1.97

* Plant Modes

1. Power Operation
2. Startup
3. Hot Standby
4. Hot Shutdown
5. Cold Shutdown
6. Refueling

TABLE 11.5-2 (Continued)

RADIATION MONITORING SYSTEM
FAILURE MODES AND EFFECTS ANALYSIS

Description of Component	Safety Function	Plant Operating Mode*	Failure Mode(s)	Method of Failure Detection	Failure Effect on System Safety Function Capability	General Remarks
8024, 8025 RI-8022A, 8023A, 8024A, 8025A RI-8022B, 8023B, 8024B, 8025B						
Main Steam Lines A, B, C and D Monitors RE-8046A, 8047A, 8048A, 8049A RE-8046B, 8047B, 8048B, 8049B RT-8046, 8047, 8048, 8049 RI-8046A, 8047A, 8048A, 8049A RI-8046B, 8047B, 8048B, 8049B	Detect, monitor, indicate and alarm radiation level for main steam lines.	1-6	Signal loss (RE/RT) Fails to send signal (RT) Fails to receive signal (RI)	Green "operate" LED in CR off. Alarm and message at CRT. Alarm in CR. "Error" LED in CR on. Alarm in CR.	None – Functionally redundant steam generator blowdown monitors available	Monitor is used to meet requirements of RG 1.97

* Plant Modes

1. Power Operation
2. Startup
3. Hot Standby
4. Hot Shutdown
5. Cold Shutdown
6. Refueling

TABLE 11.5-2 (Continued)

RADIATION MONITORING SYSTEM
FAILURE MODES AND EFFECTS ANALYSIS

Description of Component	Safety Function	Plant Operating Mode*	Failure Mode(s)	Method of Failure Detection	Failure Effect on System Safety Function Capability	General Remarks
Channel I AC Power (Channel IV analogous	Provide 120 V AC power to Channel I components	1-6	Loss of AC power	Analog ERF point to monitor voltage at distribution panel	None-Functionally redundant channel available	

* Plant Modes

1. Power Operation
2. Startup
3. Hot Standby
4. Hot Shutdown
5. Cold Shutdown
6. Refueling

APPENDIX 11.A

OFFSITE RADIOLOGICAL IMPACT DUE TO EFFLUENTS RESULTING FROM OPERATION OF SOUTH TEXAS PROJECT ELECTRIC GENERATING STATION

11.A.1 INTRODUCTION

Doses to individuals in the environs of the plant from each of the potentially significant pathways of exposure of man to radioactive materials in liquid and gaseous effluents from the South Texas Project Electric Generating Station (STPEGS) have been calculated; methodology for and results of the calculations are discussed in the following sections.

Doses to individuals from liquid and gaseous pathways and doses to the population are discussed. All results presented in these sections were obtained using the calculational techniques prescribed in Regulatory Guide (RG) 1.109, Rev. 1. Except where noted in discussion of doses for specific pathways, all usage and consumption values, transport times, bioaccumulation factors, dose conversation factors, and other constants utilized were those suggested in RG 1.109.

Dilution factors for atmospheric and liquid pathways were calculated according to the methods of RGs 1.111 and 1.113, respectively, as discussed in Section 11.A.3.2 of this Appendix.

A comparison of site boundary concentrations, computed from expected releases to limits established in 10CFR20, Appendix B, is presented in Section 11.A.5. These releases were obtained using the methodologies described in NUREG-0017.

11.A.2 SUMMARY AND CONCLUSIONS

11.A.2.1 Maximum Individual Dose

The largest individual organ dose from gaseous pathways was calculated to be 3.39 mrem/yr to a child living at and consuming vegetables from the nearest garden 4.0 miles northwest of the plant. The largest total body dose from gaseous pathways was calculated to be 0.714 mrem/yr to an individual living at a residence 2.0 miles north of the plant; plume immersion, inhalation, and deposition were the exposure pathways contributing to this dose. Vegetable, milk, and meat production were not reported (Ref. 11.A-2) at this location and therefore did not contribute to the total body dose.

The maximum individual organ dose from liquid pathways was estimated to be 0.55 mrem/yr to a teen's liver from fish ingestion and recreational exposure. Maximum total body dose was calculated to be 0.39 mrem/yr to an adult from the same exposure pathway.

11.A.2.2 Population Dose

Calculated annual population doses from total body exposure were 2.95 and 0.456 man-rem for gaseous and liquid pathways, respectively. Annual population thyroid doses were estimated to be 1.81 and 0.11 thyroid-rem for gaseous and liquid pathways.

11.A.2.3 Conclusions

Results of the dose calculations indicate that the STPEGS design conforms to the requirements of 10CFR50, Appendix I, and that annual population doses can be expected to be a fraction of those to which the same population is exposed from natural radiation (Section 11.A.4 of this Appendix).

11.A.3 RADIOLOGICAL IMPACT ON MAN

11.A.3.1 Dose Pathways to Man

A schematic depicting generalized potential pathways of exposure of man to radionuclides in effluents from the plant is presented in Figure 11.A-1, which has been taken from Appendix H of RG 4.2, Rev. 2.

There are currently no points of drinking water withdrawal downstream of the site, and the tidal influence on the salinity of the Colorado River makes it very unlikely that any future withdrawal for consumption will be made. For these reasons, exposure of man from the drinking water pathway was not considered. Three valid permits for withdrawal of Colorado River water for irrigation are held by landowners downstream of the site. Because of salinity levels expected in the River, however, it is unlikely that these withdrawal rights will be exercised. With these exceptions, most of the pathways depicted are expected to provide a possibility for exposure from STPEGS.

The relative importance of the remaining potential pathways to man has been evaluated by calculating estimated doses from routine operation of STPEGS from each pathway. The assumptions, methodology, results, and conclusions of the evaluation are presented in the following sections.

11.A.3.2 Radioactivity in the Environment

11.A.3.2.1 Radioactivity in Surface Waters. Concentrations of radioactive effluents in waters affected by operation of the plant were calculated according to the methods set forth in RG 1.113. Based upon the analytic techniques therein and the predicted releases of radioactive materials in the plant liquid effluent, the estimated concentration of each radioisotope in the STPEGS Main Cooling Reservoir (MCR) was calculated. The release rates and the expected concentrations are listed in Table 11.A-1.

In addition, concentrations of radionuclides have been calculated at a point in the Colorado River near the plant spillway; these radionuclide concentrations include dilution by the average river flow and are also listed in Table 11.A-1.

11.A.3.2.2 Radioactivity in Air. Dilution factors (χ/Qs) and relative deposition utilized in evaluating the releases of gaseous effluents were calculated according to the methods set forth in RG 1.111, based upon four years of onsite meteorological data. All releases were assumed to be at ground level. A detailed discussion of the applicable methodology appears in Section 2.3.5; the results of the calculation of annual average dilution and deposition values are listed in Tables 2.3-27 and 2.3-28. Examination of those tables reveals that the highest offsite concentration of gaseous effluents will occur at the site boundary in the north-northwest sector, where a relative concentration of 1.1E-6 sec/m^3 was calculated.

Expected annual gaseous release rates were used in conjunction with this χ/Q value to estimate the total maximum site boundary expected radioisotope concentrations in air outside the site boundary. The release rates and expected maximum offsite concentrations are listed in Table 11.A-2, along with 10CFR20 Appendix B limits. The resulting air doses can be found in Table 11.A-6.

11.A.3.3 Radiation Dose from Gaseous Effluents

Maximum doses to individuals were calculated for cloud immersion, ground plane contamination, inhalation, vegetable, milk, and meat ingestion pathways. Assumptions, including point of exposure, are described for each pathway in the following sections; the calculated gaseous pathways doses are summarized in Table 11.A-3. All calculations were based upon the calculated gaseous releases given in Table 11.A-2. Each dose was calculated at the location of the highest dose offsite at which the pathway could be assumed to exist.

11.A.3.3.1 Estimated Gaseous Effluents. Estimated annual gaseous releases are listed in Table 11.A-2. The methodology for calculating the release values is discussed in Section 11.3.

11.A.3.3.2 External Doses from Gaseous Effluents.

1. Maximum Individual External Dose

   a. External Dose from the Radioactive Cloud

      Calculated exposure to an individual from immersion in a cloud containing radioactive effluents was found to be greatest at a residence located 2.0 miles north of the plant. The total body dose was calculated to be 0.0306 mrem/yr, while the skin dose was 0.084 mrem/yr.

   b. External Dose From Contaminated Land Surface

      External irradiation from activity deposited on the ground surfaces was evaluated at the same residence. These analyses indicate that a dose of 0.682 mrem/yr to the total body and 0.798 mrem/yr to the skin can be expected from this pathway.

2. External Population Dose

External population doses from gaseous effluents were calculated for cloud immersion and ground-plane contamination pathways. Dispersion factors (χ/Qs) and relative deposition were those discussed in Section 11.A.3.2 of this Appendix. The estimate of the population distribution projected for the year 2030 (Figure 2.1-11) was used.

Predicted doses to the population within 50 miles of STPEGS are listed in Table 11.A-5. Exposure to radioactive materials deposited on the ground and ingestion of staple crops exposed to radioactive particulates appear to be the major contributors to the whole body population dose.

11.A.3.3.3 Internal Dose from Gaseous Effluents (Radiohalogens, Radioparticulates, and Tritium). The maximum individual dose calculated from the air inhalation pathway was found in the north sector, 2.0 miles from the plant. The maximum dose to an organ of an individual at this location inhaling radioiodine and radioparticulates in the plant effluent was calculated to be 0.0915 mrem/yr to a child's thyroid. Maximum whole-body dose was calculated to be 1.4E-3 mrem/yr to an adult at the same location.

The calculated dose to an individual consuming vegetable grown in a garden adjacent to a nearby residence was also determined. Maximum calculated exposure from this pathway was 3.39 mrem/yr to a child's thyroid at a residence 4.0 miles north-northwest of the plant. Maximum total body dose was 0.293 mrem/yr to a child at the same residence.

Calculated doses from ingestion of milk from goats grazing year-round on land contaminated by radioparticulates deposited from the effluent plume were evaluated at the location of the nearest goat 5.4 miles east-northeast of the plant. The maximum organ dose from ingestion of milk from a goat grazing year-round at this location was 0.177 mrem/yr to an infant's thyroid. The adult is expected to receive the maximum total body dose of 4.49E-3 mem/yr. The consumption of contaminated cow's milk is at the location of the nearest milk cow (4.8 miles WNW) which results in an infant thyroid dose of 1.2 mrem/yr.

The maximum organ dose to an individual from ingestion of meat from a cow grazing year-round 0.93 miles north-northwest of the plant was 0.202 mrem/yr to the thyroid of a child. The maximum total body dose from the meat ingestion pathway was 5.47E-2 mrem/yr to an adult.

11.A.3.4 Radiation Dose from Liquid Effluents

11.A.3.4.1 Estimated Liquid Effluents and Concentrations. Estimated annual liquid releases from the South Texas Plant and MCR concentrations are listed in Table 11.A-1. The methodology for calculating the release values is discussed in Section 11.2.

11.A.3.4.2 Maximum Individual Radiation Dose from Liquid Effluents. Doses to individuals were calculated for fish and shellfish consumption, and recreational activity (swimming, boating, shoreline activity) pathways. Assumptions, including point of exposure, are described for each pathway in the following sections; the calculated liquid pathway doses are summarized in Table 11.A-4.

11.A.3.4.2.1 Internal Dose from Fish Ingestion: Doses to man from the fish consumption pathway were calculated for fish caught in Little Robbins Slough, Colorado River, and for those caught in the Matagorda Bay/Gulf area. Based upon the possibility that fishing could occur on Little Robbins Slough, this pathway was evaluated and found to result in the maximum fish ingestion dose. The radionuclide concentrations in the Little Robbins Slough were assumed to be the same as those found in the MCR, with the exception of cesium. Credit is taken for the reduction of the cesium during its transit through the soil. This results in a maximum predicted dose to a single organ from the fish consumption pathway of 0.54 mrem/yr to the teen liver and a maximum total body dose of 0.38 mrem/yr to an adult.

11.A.3.4.2.2 Internal Dose from Shellfish Ingestion: Exposure from ingestion of shellfish was estimated using the assumption that invertebrates are in equilibrium with waters containing plant effluents at the calculated Colorado River concentrations. Maximum dose predicted was 0.026 mrem/yr to an adult's gastrointestinal-tract. Maximum estimated total body dose was 0.01 mrem/yr to an adult.

11.A.3.4.2.3 External Dose from Recreational Activity: Exposure to an adult, teen, and child swimming in or boating on water bodies affected by the plant or engaging in recreational activity on the shore was evaluated. No credit for radioactive decay during transit from the plant outfall to the point of exposure was taken, and doses were based upon the Colorado River concentrations. The doses from recreational exposure are summarized in Table 11.A-4. Maximum predicted total dose to a single organ from recreation pathways was 0.024 mrem/yr to the skin of a teen. The maximum calculated total body dose was 0.021 mrem/yr to a teen.

11.A.3.4.2.4 Radiation Dose from Other Pathways: Doses from pasture irrigation were not evaluated because no significant watering of grazing land is conducted in the plant area.

Based upon the possibility that a cow grazing on the site might obtain drinking water from the reservoir, the meat ingestion pathway was evaluated. The largest dose to a single organ from meat ingestion was calculated to be 0.19 mrem/yr to the adult liver with a total body dose of 0.17 mrem/yr to an adult.

Since no milk cows drink from water influenced by STPEGS liquid effluents, the milk pathway was not considered.

11.A.3.4.3 Population Radiation Dose from Liquid Effluents. Population doses were based upon the ingestion of finfish and shellfish caught in the Colorado River (downstream of the plant) and the Matagorda Bay/Gulf area. The population doses are presented in Table 11.A-5. The doses were evaluated based upon the commercial and sport fishing activity in the Colorado River and Matagorda Bay/Gulf area (Ref. 11.A-2).

The major fishing activity in the Colorado River is sport fishing and consists almost entirely of finfish (2.3E+4 kg/yr). Commercial fishing activity is almost entirely due to shellfish with an annual catch of 4.5E+3 kg/yr.

The commercial and shellfish harvest is the major fishing activity in the Matagorda Bay/Gulf area with an annual catch of 1.84E+6 kg/yr. The sport fishing contribution consisted entirely of finfish and is about 2.3E+4 kg/yr.

Consumption of shellfish caught in the Matagorda Bay/Gulf area appears to be by far the most important contributor to the total body population dose, with finfish consumption accounting for considerably less of the liquid pathway man-rem figure.

11.A.4 DOSE TOTALS AND COMPARISON WITH FEDERAL REGULATIONS AND NATURAL BACKGROUND

11.A.4.1 Individual Doses

Maximum individual doses calculated as described above were used to evaluate the status of conformance of predicted liquid and gaseous effluents from STPEGS with the requirements of Appendix I to 10CFR50. The assumptions and results of this evaluation are summarized in Table 11.A-6. Beta and gamma doses in air were calculated according to the methods of RG 1.109. The calculated doses indicate that the plant design conforms to the criteria established in Appendix I.

11.A.4.2 Population Doses

In order to assess the relative radiological impact of the STPEGS on persons in the area, it is useful to compare the predicted population dose from the plant to the dose to be expected to the same population from natural background radiation. Data presented by the Environmental Protection Agency's Office of Radiation Programs (Ref. 11.A-1) indicate that the average total body dose to an individual living in Texas, from terrestrial and cosmic radiation, is about 100 mrem/yr. Exposure of each person within a 50-mile radius of the plant to this radiation level would result in a population dose of 5.28E+4 man-rem from natural background in the year 2030. The predicted total body population dose is about 3.41 man-rems from the operation of STPEGS, representing a minute fraction of the background dose. Radiological impact of the plant on the area population is, therefore, expected to be negligible.

11.A.5 COMPARISON OF SITE BOUNDARY CONCENTRATIONS (DESIGN BASIS RELEASES) TO 10CFR20 APPENDIX B

11.A.5.1 Liquid Effluent Concentrations

Concentrations of site radioactive materials in liquid effluents (expected releases) do not exceed the limits of 10CFR20 Appendix B at the site boundary. The liquid dispersion model (Environmental Report [ER] Appendix 5.3.A) demonstrates that the radioactive concentrations beyond the STPEGS site boundary are small fractions of the effluent concentration limits listed in 10CFR20 Appendix B (Table 11.A-7).

11.A.5.2 Gaseous Effluent Concentrations

Table 11.A-2 delineates annual isotopic releases, site boundary concentrations, and 10CFR20 Appendix B limits. The data are based on expected releases and annual average meteorological dispersion factors from Table 2.3-27. The site boundary concentrations from gaseous releases are small fractions of 10CFR20 Appendix B effluent concentration limits.

REFERENCES

Section 11.A:

11.A-1 Klement, A. W., Jr., et al. "Estimates of Ionizing Radiation Doses in the United States, 1960 – 2000", U. S. Environmental Protection Agency, Office of Radiation Programs of Criteria and Standards, Rockville, Maryland, August 1972, 171pp.

11.A-2 John A Molino et al. "Ingestion Pathway Data to Support Annual Dose Calculations for the South Texas Project Electric Generating Station", Wyle Research Report, WR 84-34, July 1984, 155 pp.

11.A-3 HL&P Letter to USNRC, M. R. Wisenburg to G. W. Knighton, ST-HL-AE-1327, dated August 23, 1985 which transmitted a copy of the Report titled "Wyle Research Report – WR 84-24, Ingestion Pathway Data to Support Annual Dose Calculations for the South Texas Project Electric Generating Station".

TABLE 11.A-1

CALCULATED CONCENTRATIONS OF RADIOACTIVE MATERIALS IN ENVIRONMENTAL MEDIA FROM LIQUID EFFLUENTS OF THE SOUTH TEXAS PROJECT ELECTRIC GENERATING STATION

Nuclide	Release to the MCR (Ci/yr)	Main Cooling Reservoir Concentration* (μCi/cm^3)	Colorado River Concentrations*** (μCi/cm^3)	Nuclide	Release to the MCR (Ci/yr)	Main Cooling Reservoir Concentration* (μCi/cm^3)	Colorado River Concentration (μCi/cm^3)
Rb-86	3.8(-3)**	1.1(-12)	5.0E-14	Te-132	3.7(-2)	2.0(-13)	9.1E-15
Sr-89	7.6(-4)	6.3(-13)	2.9E-14	I-133	1.1	1.2(-16)	5.5E-18
Sr-90	2.0(-5)	6.4(-13)	2.9E-14	Cs-134	.414	4.6(-9)	2.1E-10
Sr-91	1.7(-4)	8.9(-28)	4.0E-29	I-135	.15	3.9(-31)	1.8E-32
Y-91	1.1(-4)	1.1(-13)	5.0E-15	Cs-136	5.4(-2)	8.8(-12)	4.0E-13
Y-93	8.8(-6)	1.7(-28)	7.7E-30	Cs-137	3.1(-1)	1.0(-8)	4.5E-10
Zr-95	3.0(-3)	3.5(-12)	1.6E-13	Ba-140	6.2(-4)	9.8(-14)	4.5E-15
Nb-95	4.2(-3)	2.6(-12)	1.2E-13	La-140	4.2(-4)	5.1(-17)	2.3E-18
Mo-99	9.6(-2)	2.5(-13)	1.1E-14	Ce-141	1.1(-4)	6.1(-14)	2.8E-15
Tc-99m	8.6(-2)	5.7(-34)	2.6E-35	Ce-143	3.6(-5)	7.5(-19)	3.4E-20
Ru-103	3.6(-4)	2.5(-13)	1.1E-14	Pr-143	9.0(-5)	1.6(-14)	7.3E-16
Ru-106	4.8(-3)	3.1(-11)	1.4E-12	Ce-144	1.0(-2)	5.1(-11)	2.3E-12
Te-125m	4.0(-5)	4.3(-14)	2.0E-15	Cr-51	.24	1.1(-10)	5.0E-12
Te-127m	5.4(-4)	1.1(-12)	5.0E-14	Mn-54	2.2(-2)	1.2(-10)	5.5E-12
Te-127	7.6(-4)	1.1(-27)	5.0E-29	Fe-55	5.8(-4)	7.7(-12)	3.5E-13
Te-129m	3.3(-3)	1.9(-12)	8.6E-14	Fe-59	2.4(-2)	2.0(-11)	9.1E-13
I-130	3.3(-3)	1.3(-23)	5.9E-25	Co-58	5.9(-1)	8.0(-10)	3.6E-11
Te-131m	2.0(-3)	1.8(-17)	8.2E-19	Co-60	9.0(-2)	1.8(-9)	8.2E-11
I-131	3.24	2.2(-10)	1.0E-11	Np-239	2.6(-4)	3.3(-16)	1.5G-17
				H-3	1806	2.1(-5)	9.5E-7

Total annual release from the MCR to the Colorado River (offsite) = .47 Ci/yr (except H-3)

* The reservoir concentration is the concentration that is released to the Colorado River, and includes both units' release activity.

** 3.8(-3) = 3.8 x 10^{-3}

*** This value is based upon the MCR concentration being the input concentration to the Colorado River value.

Note: Concentrations in the Matagorda Bay/Gulf area are conservatively estimated as being 10 times lower than those of the Colorado River.

TABLE 11.A-2

MAXIMUM SITE BOUNDARY CONCENTRATION COMPARED TO 10CFR20 LIMITS

Radionuclide	Total Annual Release For Two Units (Ci/yr)	Maximum Site Boundary Ground Level Air Concentration (μCi/cm^3)*	MPC[a] Limit (μCi/cm^3)	EC[b] Limit (μCi/cm^3)
Kr-83m	6.0E+0	2.1E-13	**	5E-5
Kr-85m	6.2E+1	2.2E-12	1E-7	1E-7
Kr-85	6.6E+2	2.3E-11	3E-7	7E-7
Kr-87	1.4E+1	4.9E-13	2E-8	2E-8
Kr-88	9.0E+1	3.1E-12	2E-8	9E-9
Xe-131m	5.4E+1	1.9E-12	4E-7	2E-5
Xe-133m	1.3E+2	4.5E-12	3E-7	6E-7
Xe-133	6.8E+3	2.4E-10	3E-7	5E-7
Xe-135	2.6E+2	9.1E-12	1E-7	7E-8
Xe-138	2.0E+0	7.0E-14	**	2E-8
I-131	4.4E-1	1.5E-14	1E-10	2E-10
I-133	5.6E-1	2.0E-14	4E-10	1E-9
Mn-54	8.8E-2	3.1E-15	1E-9	1E-9
Fe-59	3.0E-2	1.0E-15	2E-9	5E-10
Co-58	3.0E-1	1.0E-14	2E-9	1E-9
Co-60	1.4E-1	4.7E-15	3E-10	5E-11
Sr-89	6.6E-3	2.3E-16	3E-10	2E-10
Sr-90	1.2E-3	4.2E-17	3E-11	6E-12
Cs-134	8.8E-2	3.1E-15	4E-10	2E-10
Cs-137	1.5E-1	5.2E-15	5E-10	2E-10

a. Non-occupational Maximum Permissible Concentration limit from 10CFR20 in effect prior to January 1, 1994.

b. Effluent concentration limit from 10CFR20 in effect beginning January 1, 1994.

* Maximum site boundary annual average χ/Q is 1.1E-6 sec/m^3 (1 mile NNW)

** Not reported

TABLE 11.A-3

SUMMARY OF CALCULATED GASEOUS PATHWAY DOSES
SOUTH TEXAS PROJECT ELECTRIC GENERATING STATION

Pathway	Location[1]	Organ Receiving Maximum Dose: Maximum Age Group	Organ Receiving Maximum Dose: Organ	Organ Receiving Maximum Dose: Dose (mrem/yr)	Total Body Dose (mrem/yr)
Cloud Immersion	Assumed Nearest Individual (2.0 mi N)	All	Skin	8.39E-2	3.06E-2 (All)
Ground Plane Contamination	Assumed Nearest Individual (2.0 mi N)	All	Skin	7.98E-1	6.82E-1 (All)
Inhalation	Assumed Nearest Individual (2.0 mi N)	Child	Thyroid	9.15E-2	1.39E-3 (Adult)
Vegetable Ingestion	Nearest Home Garden (4.0 mi NW)	Child	Thyroid	3.39	2.93E-1 (Child)
Goat Milk Ingestion	Nearest Assumed Milk Goat (5.4 mi ENE)	Infant	Thyroid	1.77E-1	4.49E-2 (Adult)
Cow Meat Ingestion	Nearest Cow (0.93 mi NNW)	Child	Thyroid	2.02E-1	5.47E-2 (Adult)
Cow Milk Ingestion	Nearest Milk Cow (4.8 mi WNW)	Infant	Thyroid	1.2	1.23E-2 (Adult)

1. Reference 11.A-3 provides the site specific information that was used in the analysis.

TABLE 11.A-4

SUMMARY OF CALCULATED LIQUIDS PATHWAY DOSES
SOUTH TEXAS PROJECT ELECTRIC GENERATING STATION

		Organ Receiving Maximum Dose			
Pathway	Location	Maximum Age Group	Organ	Dose (mrem/yr)	Total Body Dose (mrem/yr)
Fish Ingestion	Little Robbins Slough	Teen	Liver	5.4E-1	3.8E-1 (Adult)
Shellfish Ingestion	Colorado River	Adult	GI Tract*	2.6E-2	1.0E-2 (Adult)
Shoreline Exposure	Colorado River	Teen	Skin	2.4E-2	2.1E-2 (Teen)
Swimming	Colorado River	Teen	Skin	3.9E-4	9.1E-5 (Teen)
Boating	Colorado River	Adult/Teen	Skin	4.5E-5	4.5E-5 (Adult/ Teen)
Meat Ingestion	Little Robbins Slough	Adult	Liver	1.9E-1	1.7E-1 (Adult)

* Gastrointestinal

TABLE 11.A-5

PREDICTED DOSES TO THE POPULATION WITHIN 50 MILES OF THE SOUTH TEXAS PROJECT ELECTRIC GENERATING STATION

Pathway[1]	Total-Body Dose (man-rem)	Total-Body Dose Percent of Total	Thyroid Dose (thyroid-rem)	Thyroid Dose Percent of Total
Gaseous Effluents				
Plume Submersion	1.88E-1	6.4	1.88E-1	10.4
Ground Plane Contamination	7.95E-1	27	7.95E-1	44
Inhalation	8.39E-3	1	5.48E-1	30
Vegetable Ingestion	1.74	59	9.74E-8	<1
Cow Milk Ingestion	1.44E-3	1	1.67E-2	1
Meat Ingestion	2.13E-1	7.2	2.64E-1	14.6
Total, Gaseous Pathways	2.95	100	1.81	100
Liquid Effluents		13	5.4E-3	5
Fish Ingestion	6.0E-2			
Shellfish Ingestion	3.96E-1	87	1.1E-1	95
Total, Liquid Pathways	4.6E-1	100	1.1E-1	100
Total Population Dose	3.41		1.92	

1. Reference 11.A-3 provides the site specific information that was used in the analysis.

TABLE 11.A-6

APPENDIX I CONFORMANCE SUMMARY TABLE
SOUTH TEXAS PROJECT ELECTRIC GENERATING STATION

	Appendix I Criteria		SOUTH TEXAS PROJECT ELECTRIC GENERATING STATION	
Type of Dose	Design Objective(1)	Point of Dose Evaluation	Calculated Dose	Point of Dose Evaluation(7)
Liquid Effluents (8)				
Dose to total body from all pathways	5 mrem/yr per site	Location of the highest dose offsite(2)	3.9E-1 mrem/yr(5)	Little Robbins Slough
Dose to any organ from all pathways	5 mrem/yr per site	Same as above	5.5E-1 mrem/yr(5)	Little Robbins Slough
Gaseous Effluents(8)				
Gamma dose in air	10 mrad/yr per site	Location of the highest dose offsite(3)	0.16 mrad/yr	Location of highest annual average concentration at the site boundary (NNW at 0.89 mi)
Beta dose in air	20 mrad/yr per site	Same as above	0.35 mrad/yr	Same as above
Dose to total body	5 mrem/yr per site	Location of the highest dose offsite(2)	0.71 mrem/yr	Nearest residence (N at 2.0 miles)
Dose to skin of an individual	15 mrem/yr	Same as above	0.88 mrem/yr	Same as above
Radioiodines and Particulates Released to the Atmosphere				
Dose to any organ from all pathways	15 mrem/yr per site	Location of the highest dose offsite	3.4 mrem/yr(4)	Nearest assumed garden (NW at 4.0 miles)

TABLE 11.A-6 (Continued)

APPENDIX I CONFORMANCE SUMMARY TABLE
SOUTH TEXAS PROJECT ELECTRIC GENERATING STATION

Notes to Table 11.A-6

1. Design objectives as specified in the NRC's Appendix I Conformance Option, 40 FR 40816, September 4, 1975.

2. Evaluated at a location that is anticipated to be occupied during plant lifetime or evaluated with respect to such potential land and water usage and food pathways as could actually exist during the term of plant operation. (Reproduced from Regulatory Guide 1.109.)

3. Evaluated at a location that could be occupied during the term of plant operation.

4. Dose to an infant thyroid from air inhalation and vegetable ingestion.

5. Dose to adult's whole body and teen's liver from fish ingestion from Little Robbins Slough and shoreline exposure, swimming and boating in the Colorado River.

6. Fish in the Little Robbins Slough were assumed to be exposed to average radionuclide concentration, except cesium.

7. Points given correspond to points of dose evaluation under Appendix I heading.

8. Reference 11.A-3 provides the site-specific information that was used in the analysis.

TABLE 11.A-7

COMPARISON OF SITE BOUNDARY TO 10CFR20
APPENDIX B CONCENTRATION LIMITS (EXPECTED CONCENTRATIONS)

Nuclide	Reservoir Concentration* ($\mu Ci/cm^3$)	MPC[(a)] ($\mu Ci/cm^3$)	EC[(b)] ($\mu Ci/cm^3$)	Nuclide	Reservoir Concentration* ($\mu Ci/cm^3$)	MPC[(a)] ($\mu Ci/cm^3$)	EC[(b)] ($\mu Ci/cm^3$)
Rb-86	1.1(-12)**	1(-7)	7(-6)	Te-132	2.0(-13)	2(-5)	9(-6)
Sr-89	6.3(-13)	3(-6)	8(-6)	I-133	1.2(-16)	1(-6)	7(-6)
Sr-90	6.4(-13)	3(-7)	5(-7)	Cs-134	4.6(-9)	9(-6)	9(-7)
Sr-91	8.9(-28)	5(-5)	2(-5)	I-135	3.9(-31)	4(-6)	3(-5)
Y-91	1.1(-13)	3(-5)	8(-6)	Cs-136	8.8(-12)	6(-5)	6(-6)
Y-93	1.7(-28)	3(-5)	2(-5)	Cs-137	1.0(-8)	2(-5)	1(-6)
Zr-95	3.5(-12)	6(-5)	2(-5)	Ba-140	9.8(-14)	2(-5)	8(-6)
Nb-95	2.6(-12)	1(-4)	3(-5)	La-140	5.1(-17)	2(-5)	9(-6)
Mo-99	2.5(-13)	4(-5)	2(-5)	Ce-141	6.1(-14)	9(-5)	3(-5)
Tc-99m	5.7(-34)	3(-5)	1(-3)	Ce-143	7.5(-19)	4(-5)	2(-5)
Ru-103	2.5(-13)	8(-5)	3(-5)	Pr-143	1.6(-14)	5(-5)	2(-5)
Ru-106	3.1(-11)	1(-5)	3(-6)	Ce-144	5.1(-11)	1(-5)	3(-6)
Te-125m	4.3(-14)	1(-4)	2(-5)	Cr-51	1.1(-10)	2(-3)	5(-4)
Te-127m	1.1(-12)	5(-5)	7(-6)	Mn-54	1.2(-10)	1(-4)	3(-5)
Te-127	1.1(-27)	2(-4)	1(-4)	Fe-55	7.7(-12)	8(-4)	1(-4)
Te-129m	1.9(-12)	2(-4)	7(-6)	Fe-59	2.0(-11)	5(-5)	1(-5)
I-130	1.3(-23)	1(-7)	2(-5)	Co-58	8.0(-10)	9(-5)	2(-5)
Te-131m	1.8(-17)	4(-5)	8(-6)	Co-60	1.8(-9)	3(-5)	3(-5)
I-131	2.2(-10)	3(-7)	1(-6)	Np-239	3.3(-16)	1(-4)	2(-5)
				H-3	2.1(-5)	3(-3)	1(-3)

Total annual release from the site boundary = .47 Ci/yr (except H-3)

MPC Fraction = 1.86×10^{-3} EC Fraction = 3.68×10^{-2}

* The reservoir concentration is that released to the Colorado River, and includes both units' release activity

** 1.1 (-12) = 1.1×10^{-12}

a. Non occupational Maximum Permissible Concentration limit from 10CFR20 in effect prior to January 1, 1994.

b. Effluent concentration limit from 10CFR20 in effect beginning January 1, 1994.