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DRAWINGS CITED IN THIS CHAPTER*

*The listed drawings are included as "General References" only; i.e., refer to the drawings to obtain additional detail or to obtain background information. These drawings are not part of the UFSAR. They are controlled by the Controlled Documents Program.

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11.1 SOURCE TERMS

Radioactive source terms are explained in this section. Radioactive source terms are used in: shielding design, assuring adequacy of ventilation, design of radioactive systems, calculation of expected gaseous and liquid releases from the station, and accident analysis. Source terms are dependent on a number of assumptions; the assumptions depend on the particular application under consideration. To avoid confusion, clear distinction is made between the design-basis shielding source term, the expected source term, and the accident source term. Operating limits are given in the Technical Specifications and other documents.

The releases of radioactivity and their resulting doses included in this chapter were calculated during plant licensing from assumed values for many parameters. These included coolant activity, iodine partitioning, amount of failed fuel, filter efficiencies, system flow rates, component leak rates, and associated activity for all potentially radioactive water and steam systems. Estimates were made for many individual contributors and then summed to obtain estimates for total annual dose. These values were then compared to appropriate regulatory limits, such as 10 CFR 20 and Appendix I to 10 CFR 50, to show that the plant could be operated, if granted a license, in compliance with these regulations. The NRC reviewed these estimated values and confirmed that the plant could be operated and meet the regulations in their safety evaluation report.

After the NRC issues an operating license, the requirement to meet the applicable radiological dose regulations is demonstrated in the stations annual radiological effluent release report. The values for the report are calculated using the measured total radioactivity releases from all sources and equations and data included in the Offsite Dose Calculation Manual. Only the total values are calculated; there is no requirement to calculate the dose from each of the individual sources listed in this section. The information on release estimates and offsite doses is maintained in the UFSAR for historical reference and is not intended to be used to establish current operating limits.

The impact of a core power uprate on the radiation source terms at B&B Nuclear Stations is discussed in Section 11.1.8. The original licensed power level was 3411 MWt. The original source term, effluent and shielding analyses were performed at a power level of 3565 MWt. Core power has been uprated twice, first to 3586.6 MWt, then to the Measurement Uncertainty Recapture power uprate core power level of 3645 MWt.

11.1.1 Definition of Radioactive Source Terms

11.1.1.1 Design-Basis Shielding Source Terms

Design-basis shielding source terms or conservative source terms are those source terms used for the design of bulk shielding, for determining in-plant airborne concentrations and the subsequent ventilation adequacy, for determining 40-year integrated doses for the specifications of station equipment, and for determining that the design of the station is such that doses to personnel do not exceed the limits specified in 10 CFR 20 and are as low as reasonably achievable (ALARA). These source terms are described in Subsection 12.2.1.

11.1.1.2 Realistic Source Terms

Realistic or operating-basis source terms are those terms which are used for describing the releases from the station to the environment on an average annual basis. Site boundary doses due to releases from the station stack, discharges to the blowdown stream for liquid discharges, and offsite shipment of solid radioactive material are examples of calculations which use these source terms. Realistic source terms are based on realistic models for reactor coolant activity as represented in Tables 11.1-3 and 11.1-4. Calculations pertaining to releases described in Appendix I of 10 CFR 50 follow the source assumptions of Regulatory Guide 1.112, Revision 0, April 1976 and NUREG-0017, April 1976.

11.1.1.3 Accident Sources

Accident sources are those sources used in the determination of doses to plant operating personnel and the public during one of the postulated accidents described in the regulatory guides. The design-basis accidents are discussed in Chapter 15.0. The analyses determine that the doses to the population do not exceed the limits specified in 10 CFR 100 for accidents analyzed using TID-14844 and 10 CFR 50.67 for accidents analyzed using alternative source term methodology. Some of the bulk shielding calculations use accident sources. These include the shielding of the control room and the shielding of piping and components which process radioactive fluids which contain sources from one of the design-basis accidents. These include the components of the RHR, safety injection, and containment spray systems. The accident design conditions for these components are clearly defined in Table 12.3-2. The postulated accidents described in Chapter 15.0 include component failure in which there is a release of contained radionuclides to the environment. The sources for these accidents are referred to as component failure sources and will be referenced in this chapter.

11.1.2 Basis for Radioactive Source Terms

Two source term models (a design-basis model and an operational basis realistic model) are presented for shielding design and effluent release analysis. Source terms for shielding design and component failure are based on the same design-basis model for reactor coolant activity but on different assumptions with respect to the operating characteristics of the Waste Processing Systems. The source terms for the effluent release analysis are based on the realistic model for reactor coolant activity as formulated in the draft standard N237 (Reference 1).

Tritium production and fuel operating experience are fully addressed in References 2 (Sections 3 and 4.12) and 3, respectively.

Source terms and models used in the design and evaluation of the Waste Processing Systems are compared to operating plant data where available (Reference 2).

11.1.2.1 Conservative Model for Reactor Coolant Activity

Fission Products

The parameters used in the calculation of the reactor coolant fission product concentrations for original plant design are summarized in Table 11.1-1 and the concentrations are presented in Table 11.1-2.

The fission products concentrations are computed using the following differential equations:

For parent nuclides in the coolant:

$$\frac{dN_{wi}}{dt} = D\upsilon_i N_{c_i} - \left(\lambda_i + R\eta_i + \frac{B'}{B_o - tB'}\right) N_{wi} \qquad (11.1\text{-}1)$$

For daughter nuclides in the coolant:

$$\frac{dN_{wi}}{dt} = D\upsilon_j N_{c_j} - \left(\lambda_j + R\eta_j + \frac{B'}{B_o - tB'}\right) N_{wj} + \lambda_i N_{wi} \qquad (11.1\text{-}2)$$

Where

N	=	population of nuclides, atoms
t	=	time (sec),
D	=	cladding defects, as a fraction of rated core thermal power being generated by rods with cladding defects,
R	=	purification flow, coolant system volumes per second,
B_o	=	initial boron concentration (ppm),
B'	=	boron concentration reduction rate by feed and bleed, (ppm/sec),
η	=	removal efficiency of purification cycle for nuclide,
λ	=	radioactive decay constant (sec^{-1}), and
υ	=	escape rate coefficient for diffusion into coolant (sec^{-1}).

Subscripts:

C	=	refers to core
W	=	refers to coolant
i	=	refers to parent nuclide
j	=	refers to daughter nuclide.

The fission products are removed by decay, by cleanup in the chemical volume and control system, and by letdown to the boron recycle system.

Corrosion Products

The corrosion product activities, which are independent of fuel defect level, are based on measurements at operating reactors (Reference 2). The corrosion product concentrations are given in Table 11.1-2.

11.1.2.2 Realistic Model for Reactor Coolant Activity

The range of plant design and operating parameters covered by the referenced standard N237 (Reference 1), together with the corresponding specific plant related parameters, are given in Table 11.1-3. Corrections are made whenever a parameter falls outside the given range as recommended in Reference 1. The Gaseous Waste Processing System is assumed to strip fission gases from the volume control tank. The overall y parameter, as given in Reference 1 is interpreted as being equivalent to the stripping fractions. A separate value of the stripping fraction for each noble gas isotope is used as indicated in Table 11.1-1. A stripping efficiency of 40% is used for conservatism. Using this low stripping or separation efficiency in the volume control tank results in a conservative estimation of the reactor coolant system radioactivity.

The amounts of fission gases removed from the reactor coolant in the volume control tank and collected by the gaseous waste processing system are related by the following equations:

$$SE = \frac{C_R - C_L}{C_R - C_{L_{eq}}} \qquad (11.1\text{-}3)$$

$$SF = \frac{C_R - C_L}{C_R} \qquad (11.1\text{-}4)$$

where

SE = stripping efficiency,

SF = stripping fraction,

C_R = gas concentration in the liquid phase entering volume control tank,

C_L = gas concentration in the liquid phase leaving the volume control tank, and

C_{Leq} = gas concentration in the liquid phase leaving the volume control tank, assuming the ratio of the gas concentration in the vapor and liquid phases in the volume control tank follows Henry's Law.

Specific activities in the primary coolant, based on the realistic model, are given in Table 11.1-4.

11.1.3 Source Terms for Shielding Design Basis

Liquid Waste Processing System

Shielding source terms are supplied for components of the liquid waste processing systems (inside and outside the containment). These sources are based upon the design-basis coolant activity given in Subsection 11.1.1.1. Source terms for shielding design are given in Subsection 12.2.1.

Gaseous Waste Processing System

The gaseous waste processing system consists of two waste-gas compressor packages, six gas decay tanks, and the associated piping, valves and instrumentation. The equipment serves both units. The system is shown in Drawing M-69.

The reactor coolant activities in Table 11.1-2 are used. A stripping efficiency of 100% is assumed. The resulting source terms are given in Table 12.2-28.

11.1.4 Source Terms for Component Failure

Liquid Waste Processing System

The tanks with the highest isotopic inventories, the recycle holdup tank and the spent resin storage tank, were selected for accident analysis. The inventory used for accident analysis is also the inventory used for shielding design basis for these tanks, thus the sources are found in Subsection 12.2.1. The accident analyses for these tanks are discussed in Subsections 2.3.4, 2.3.5, 2.4.12, 2.4.13.3, and 15.7.3.

Gaseous Waste Processing System

The isotopic inventories in one gas decay tank to be used for the gas decay tank rupture accident are given in Table 11.1-5. The inventories are based on the reactor coolant activity in Table 11.1-2 and 100% stripping efficiency in the volume control tank. The activity is further based on 40 years inventory taking credit for radioactive decay results in equilibrium levels of Kr-85 and all other isotopes within the volume control tank. It is assumed two units are operating simultaneously and decay tanks are switched every 24 hours.

11.1.5 Source Terms for Radwaste System Components

Realistic reactor coolant activities presented in Table 11.1-4 are used as a basis for the expected isotopic inventories of radwaste components for the estimate of average annual curies of radioactive wastes to be shipped offsite. The radioactive inventories are presented in Tables 11.1-6 through 11.1-11. The flow rates and operating times used in the calculation of these inventories are the design-basis parameters for the radwaste system as described in Sections 11.2 and 11.4.

11.1.6 Sources of In-Plant Airborne Radioactivity

Sources of in-plant airborne radioactivity for the purpose of evaluating the ventilation systems are discussed in Subsection 12.2.2. Leakage rates are discussed there, and Tables 12.2-46 through 12.2-48 present total liquid iodine concentrations, number of leakage sources, exhaust air flow rates, and fractions of maximum permissible concentrations for iodine (10 CFR 20 Appendix B). Previous experience of gaseous radioactive in-plant concentrations are cited in Reference 2 for the Robert E. Ginna Plant. Special design features which minimize the possibility of airborne contamination of occupied areas are proper venting of equipment, discussed in Subsection 12.3.1.5, and proper location of valves and instruments, discussed in Subsection 12.3.1.8.

11.1.7 Sources of Radioactive Releases to the Environment

11.1.7.1 Gaseous Releases

Gaseous radioactive releases are discussed in Subsection 11.3.3.3. Estimates of the gaseous releases from the plant, which includes gas stripping, blowdown ventilation off-gas, and air ejector exhaust, are presented in Table 11.3-6.

11.1.7.2 Liquid Releases

Liquid radioactive releases are discussed in Subsection 11.2.1.3. Expected annual average releases of radionuclides in liquid effluents are presented in Table 11.2-1. Parameters used in the calculation are presented in Table 11.2-2.

11.1.8 Impact of Uprate on Normal Operation Radiation Source Terms

The original licensed power level was 3411 MWt. The original source term, effluent and shielding data/analyses presented in the UFSAR represent a power level of 3565 MWt. As a result of a reactor core power uprate to 3586.6 MWt, the design basis reactor coolant activity was re-calculated at a core power level of 3658.3 MWt which includes a 2% margin for uncertainty. A core power level of 3658.3 MWt bounds the Measurement Uncertainty Recapture power uprate core power level of 3645 MWt including margin for uncertainty. The parameters used in the calculation of the original as well as the uprated reactor coolant concentrations are summarized in Table 11.1-1. The design basis reactor coolant concentrations for the uprated core are presented in Table 11.1-13.

The uprated design basis reactor coolant concentrations are comparable to the original design basis reactor coolant concentrations given to Table 11.1-2. Consequently, the normal operation radiation source terms for downstream process systems described in prior sections, including liquid and gaseous radwaste, remain valid for uprate.

Based on a comparison of original vs power uprate GALE-PWR computer program input parameters presented in Table 11.2-2, and the methodology outlined in NUREG 0017, the maximum expected increase in the realistic reactor coolant source term is limited to the percentage of the uprate relative to the power level used in the original analyses, i.e.; 0.6%. Considering the accuracy and error bounds of the operational data utilized in NUREG 0017 as shown in Table 11.1-3, this small percentage is well within the uncertainty of the existing NUREG 0017 based realistic reactor coolant isotopic inventory. Consequently, the realistic reactor coolant source terms presented in Table 11.1-4, as well as all of the downstream realistic source terms, remain valid for uprate.

11.1.9 References

1. American National Standard Source Term Specification, N237, March 9, 1976.

2. Source Term Data for Westinghouse Pressurized Water Reactors, WCAP-8253, Amendment 1, July 1975.

3. Operational Experience with Westinghouse Cores, WCAP-8183, June 1, 1977.

TABLE 11.1-1

PARAMETERS USED IN THE CALCULATION OF DESIGN BASIS

PRIMARY COOLANT ACTIVITIES – ORIGINAL & UPRATED(***)

1.	Ultimate core thermal power, MWt	3565 (3658.3)
2.	Cladding defects, as a percent of rated core thermal power being generated by rods with clad defects	1.0
3.	Reactor coolant liquid mass, gms	2.42E8 (2.477E8)
4.	Reactor coolant full power average temperature,°F	586.2
5.	Purification flow rate (normal) *gpm	118.3
6.	Effective cation demineralizer flow, *gpm	7.5
7.	Volume control tank volumes (stripping efficiency 40%, purge rated rate at which purge gas is introduced in the volume control tank, 0.7 scfm)	
	a. Vapor, ft^3	200
	b. Liquid, ft^3	200
8.	Fission product escape rate coefficients:**	
	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}

* At reference condition, 130°F and 2300 psig, 1 gpm = 497.3 lb/hr.

** Escape rate coefficients are based on fuel defect tests performed at the Saxton reactor. Recent experience at plants operating with fuel rod defects has verified the listed escape rate coefficients.

***Parameters that changed due to uprate are presented in ().

TABLE 11.1-1 (Cont'd)

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 — 10.0

10. Cation bed demineralized decontamination factor for Cs-134, 137, Y-90, 91 — 10.0

11a. Volume control tank noble gas stripping fractions

Isotope	Stripping Fraction
Kr-85	2.3×10^{-5}
Kr-85m	2.7×10^{-1}
Kr-87	6.0×10^{-1}
Kr-88	4.3×10^{-1}
Xe-131m	1.0×10^{-2}
Xe-133	1.6×10^{-2}
Xe-133m	3.7×10^{-2}
Xe-135	1.8×10^{-1}
Xe-135m	8.0×10^{-1}
Xe-138	1.0

11b. Partition factor* for iodine in the volume control tank — 100.0

12. Boron Concentration and Reduction Rates

   a. B_o (initial cycle beginning of life, full power, and with equilibrium xenon), ppm — 805

   b. B_o (equilibrium cycle), ppm — 1080

TABLE 11.1-1 (Cont'd)

13.	Pressurizer Volumes	
	a. Vapor, ft^3	720
	b. Liquid, ft^3	1080
14.	Spray line flow*, gpm	1.0
15.	Pressurizer Stripping fractions	
	a. Noble gases	1.0
	b. All other elements	0

* At reference conditions 130 °F and 2300 psig,
1 gpm = 497.3 lb/hr.

TABLE 11.1-2

DESIGN-BASIS REACTOR COOLANT FISSION AND CORROSION PRODUCT ACTIVITY (ORIGINAL DESIGN)

ISOTOPE	ACTIVITY* (μCi/gram)	ISOTOPE	ACTIVITY* (μCi/gram)
H-3	3.5 (maximum)	Cs-136	2.8
Br-84	4.3×10^{-2}	Cs-137	1.5
Rb-88	3.7	Cs-138	0.98
Rb-89	2.1×10^{-1}	Ba-140	4.3×10^{-3}
Sr-89	3.3×10^{-3}	La-140	1.5×10^{-3}
Sr-90	1.7×10^{-4}	Ce-144	3.4×10^{-4}
Sr-91	1.9×10^{-3}	Pr-144	3.4×10^{-4}
Sr-92	7.4×10^{-4}	Kr-85	8.8 (peak)
Y-90	2.0×10^{-4}	Kr-85m	2.1
Y-91	6.1×10^{-3}	Kr-87	1.2
Y-92	7.2×10^{-4}	Kr-88	3.7
Zr-95	7.0×10^{-4}	Xe-131m	1.9
Nb-95	6.9×10^{-4}	Xe-133	2.81×10^{2}
Mo-99	5.3	Xe-133m	18.8
I-131	2.5	Xe-135	6.3
I-132	2.8	Xe-135m	0.4
I-133	4.0	Xe-138	0.7
I-134	0.6	Mn-54**	7.9×10^{-4}
I-135	2.2	Mn-56**	3.0×10^{-2}
Te-132	0.26	Co-58**	2.6×10^{-2}
Te-134	2.9×10^{-2}	Co-60**	1.0×10^{-3}
Cs-134	2.3	Fe-59**	1.1×10^{-3}
		Cr-51**	9.5×10^{-4}

* Parameters used in primary coolant activity calculation are listed in Table 11.1-1, at operating temperature.

** Corrosion product activities are based on activity levels measured at operating reactors.

TABLE 11.1-3

PARAMETERS USED IN THE CALCULATION OF

REALISTIC, OPERATIONAL BASIS

PRIMARY COOLANT ACTIVITIES

PARAMETER	UNITS	NOMINAL VALUE	RANGE MAXIMUM	RANGE MINIMUM	BYRON/ BRAIDWOOD*
Thermal power	MWT	3400	3800	3000	3558
Steam flow rate	lbs/hr	1.5E+07	1.7E+07	1.3E+07	1.5E+07
Weight of water in reactor coolant system	lbs	5.5E+05	6.0E+05	5.0E+05	5.3E+05
Weight of water in all steam gen. (full load)	lbs	4.5E+05	5.0E+05	4.0E+05	3.84E+05
Reactor coolant let-down flow (purification)	lbs/hr	3.7E+04	4.2E+04	3.2E+04	3.7E+04
Reactor coolant let-down flow (yearly average for boron control)	lbs/hr	500	1000	250	130
Steam generator blow-down flow (total)	lbs/hr	9000	10,000	8,000	3.0E+04

TABLE 11.1-3 (Cont'd)

PARAMETER	UNITS	NOMINAL VALUE	RANGE MAXIMUM	RANGE MINIMUM	BYRON/ BRAIDWOOD*
Fraction of radioactivity in blowdown stream which is not returned to the secondary coolant system	-	1.0	1.0	0.9	1.0
Flow through the purification system cation demineralizer	lbs/hr	3700	7500	0.0	3.7E+03
Ratio of condensate demineralizer flow rate to the total steam flow rate	-	0.0	0.01	0.0	0.0
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)	-	0.0	0.01	0.0	1.0 for Kr-83m, Kr-89, Xe-137. See Table 11.1-1 for other isotopes.

*Corrections are made whenever a parameter falls outside the given range as recommended in Reference 2.3

TABLE 11.1-4

REALISTIC, OPERATIONAL BASIS REACTOR COOLANT FISSION AND

CORROSION PRODUCT ACTIVITIES

ISOTOPE	REACTOR COOLANT ACTIVITY (μCi/gram)	ISOTOPE	REACTOR COOLANT ACTIVITY (μCi/gram)
GROUP I - NOBLE GASES		GROUP III - CS, RB	
Kr-83m	2.06E-02	Rb-86	8.87E-05
Kr-85m	9.81E-02	Rb-88	2.17E-01
Kr-85	7.56E-01		
Kr-87	6.09E-02	Cs-134	2.60E-02
Kr-88	1.88E-01	Cs-136	1.36E-02
Kr-89	5.60E-03	Cs-137	1.87E-02
Xe-131m	1.13E-01		
Xe-133m	1.87E-01	GROUP IV - N - 16	
Xe-133	1.63E+01	N-16	4.00E+1
Xe-135m	1.43E-02		
Xe-135	3.07E-01		
Xe-137	1.01E-02	GROUP V - TRITIUM	
Xe-138	4.84E-02	H-3	1.00E+00
GROUP II - HALOGENS			
Br-83	5.17E-03		
Br-84	2.82E-03		
Br-85	3.25E-04		
I-130	2.23E-03		
I-131	2.81E-03		
I-132	1.08E-01		
I-133	4.00E-01		
I-134	5.08E-01		
I-135	2.03E-01		

TABLE 11.1-4 (Cont'd)

ISOTOPE	REACTOR COOLANT ACTIVITY (μCi/gram)	ISOTOPE	REACTOR COOLANT ACTIVITY (μCi/gram)
GROUP IV - OTHER ISOTOPES		GROUP VI - OTHER ISOTOPES (Cont'd)	
Cr-51	1.95E-03	Te-129m	1.44E-03
Mn-54	3.18E-04	Te-129	1.73E-03
Fe-55	1.64E-03	Te-131m	2.61E-03
Fe-59	1.03E-03	Te-131	1.19E-03
Co-58	1.64E-02	Te-132	2.79E-02
Co-60	2.05E-03	Ba-137m	1.74E-02
Sr-89	3.60E-04	Ba-140	2.26E-04
Sr-90	1.03E-05	La-140	1.56E-04
Sr-91	6.88E-04	Ce-141	7.19E-05
Y-90	1.24E-06	Ce-143	4.17E-05
Y-91m	3.89E-04	Ce-144	3.39E-05
Y-91	6.57E-05	Pr-143	5.14E-05
Y-93	3.59E-05	Pr-144	3.58E-05
Zr-95	6.16E-05	Np-239	1.24E-03
Nb-95	5.14E-05		
Mo-99	8.69E-02		
Tc-99m	5.11E-02		
Ru-103	4.62E-05		
Ru-106	1.03E-05		
Rh-103m	4.86E-05		
Rh-106	1.09E-05		
Te-125m	2.98E-05		
Te-127m	2.88E-04		
Te-127	8.99E-04		

TABLE 11.1-5

MAXIMUM REALISTIC, OPERATIONAL BASIS WASTE GAS DECAY TANK ACTIVITY FOR GAS DECAY TANK RUPTURE*

ISOTOPE	ACTIVITIES (Curies)
Kr-85	1140.0
Kr-85m	23.6
Kr-87	14.6
Kr-88	45.2
Xe-131m	27.9
Xe-133	5760.0
Xe-133m	45.0
Xe-135	73.9
Xe-135m	3.4
Xe-138	11.6

* Based on reactor coolant activities from Reference 2.

TABLE 11.1-6

REALISTIC SOURCE TERMS FOR STEAM GENERATOR BLOWDOWN AND RADIOACTIVE SOURCE STREAMS

ISOTOPE	STEAM GENERATOR BLOWDOWN (μCi/ml)	TURBINE BLDG. FLOOR DRAINS (μCi/ml)	TURBINE BLDG. EQUIPMENT DRAINS (μCi/ml)	CHEMICAL DRAINS (μCi/ml)	REGENERA-TION WASTE DRAINS WITH SGBD LEAK (μCi/ml)	REGENERATION WASTE DRAINS WITHOUT SGBD LEAK (μCi/ml)	AUXILIARY BLDG. EQUIPMENT DRAINS (μCi/ml)	AUXILIARY BLDG. FLOOR DRAINS (μCi/ml)	LAUNDRY DRAINS (μCi/ml)
H-3	7.400-03	9.915-06	2.000-05	8.000-03	1.190+00	6.346-03	5.000-03	2.007-03	4.000-04
Cr-51	1.443-05	1.893-08	3.900-08	1.560-05	2.272-03	1.212-05	9.750-06	3.871-06	7.800-07
Mn-54	2.353-06	3.147-09	6.360-09	2.544-06	3.777-04	2.014-06	1.590-06	6.375-07	1.272-07
Mn-56	1.214-05	1.481-09	3.280-08	1.312-05	1.778-04	9.481-07	8.200-06	5.903-07	6.560-07
Co-58	1.214-04	1.613-07	3.280-07	1.312-04	1.936-02	1.032-04	8.200-05	3.277-05	6.560-06
Fe-59	7.622-06	1.008-08	2.060-08	8.240-06	1.210-03	6.452-06	5.150-06	2.053-06	4.120-07
Co-60	1.517-05	2.032-08	4.100-08	1.640-05	2.439-03	1.301-05	1.025-05	4.113-06	8.200-07
Br-83	3.826-05	4.363-09	1.034-07	4.136-05	5.236-04	2.792-06	2.585-05	1.741-06	2.068-06
Br-84	2.087-05	5.245-10	5.640-08	2.256-05	6.294-05	3.357-07	1.410-05	2.098-07	1.128-06
Br-85	2.405-06	5.707-12	6.500-09	2.600-06	6.848-07	3.652-09	1.625-06	2.283-09	1.300-07
Rb-88	1.606-03	2.257-08	4.340-06	1.736-03	2.709-03	1.445-05	1.085-03	9.030-06	8.680-05
Rb-89	8.066-08	9.812-13	2.180-10	8.720-08	1.177-07	6.280-10	5.450-08	3.925-10	4.360-09
Sr-89	2.664-06	3.530-09	7.200-09	2.880-06	4.236-04	2.259-06	1.800-06	7.183-07	1.440-07
Y-89m	0.000	3.529-13	0.000	0.000	4.235-08	2.259-10	0.000	7.181-11	0.000
Sr-90	7.622-08	1.021-10	2.060-10	8.240-08	1.226-05	6.537-08	5.150-08	2.067-08	4.120-09
Y-90	9.176-09	2.952-11	2.480-11	9.920-09	3.543-06	1.890-08	5.200-09	4.379-09	4.960-10
Sr-91	5.091-06	2.209-09	1.376-08	5.504-06	2.650-04	1.414-06	3.440-06	7.209-07	2.752-07
Y-91m	0.000	1.290-09	0.000	0.000	1.547-04	8.253-07	0.000	4.114-07	0.000
Y-91	4.862-07	6.757-10	1.314-09	5.256-07	8.108-05	4.324-07	3.285-07	1.354-07	2.628-08
Sr-92	2.879-06	3.699-10	7.780-09	3.112-06	4.439-05	2.367-07	1.945-06	1.472-07	1.556-07
Y-92	2.657-07	4.139-10	7.180-10	2.872-07	4.966-05	2.649-07	1.795-07	1.568-07	1.436-08
Zr-95	4.558-07	6.054-10	1.232-09	4.928-07	7.264-05	3.874-07	3.080-07	1.230-07	2.464-08
Nb-95m	0.000	1.723-12	0.000	0.000	2.068-07	1.103-09	0.000	1.860-10	0.000
Nb-95	3.804-07	5.112-10	1.028-09	4.112-07	6.134-05	3.271-07	2.570-07	1.033-07	2.056-08
Mo-99	6.431-04	7.030-07	1.738-06	6.952-04	8.436-02	4.499-04	4.345-04	1.570-04	3.476-05
Tc-99m	3.781-04	6.075-07	1.022-06	4.088-04	7.289-02	3.888-04	2.555-04	1.260-04	2.044-05

TABLE 11.1-6 (Cont'd)

ISOTOPE	STEAM GENERATOR BLOWDOWN (μCi/ml)	TURBINE BLDG. FLOOR DRAINS (μCi/ml)	TURBINE BLDG. EQUIPMENT DRAINS (μCi/ml)	CHEMICAL DRAINS (μCi/ml)	REGENERA-TION WASTE DRAINS WITH SGBD LEAK (μCi/ml)	REGENERATION WASTE DRAINS WITHOUT SGBD LEAK (μCi/ml)	AUXILIARY BLDG. EQUIPMENT DRAINS (μCi/ml)	AUXILIARY BLDG. FLOOR DRAINS (μCi/ml)	LAUNDRY DRAINS (μCi/ml)
Tc-99	0.000	5.419-15	0.000	0.000	6.503-10	3.468-12	0.000	5.521-13	0.000
Ru-103	3.419-07	4.514-10	9.240-10	3.696-07	5.417-05	2.889-07	2.310-07	9.201-08	1.848-08
Rh-103m	3.596-07	4.526-10	9.720-10	3.888-07	5.431-05	2.897-07	2.430-07	9.242-08	1.944-08
Ru-106	7.622-08	1.020-10	2.060-10	8.240-08	1.224-05	6.527-08	5.150-08	2.065-08	4.120-09
Rh-106	0.000	1.019-10	0.000	0.000	1.223-05	6.525-08	0.000	2.064-08	0.000
Te-125m	2.205-07	2.925-10	5.960-10	2.384-07	3.510-05	1.872-07	1.490-07	5.949-08	1.192-08
Te-127m	2.131-06	2.841-09	5.760-09	2.304-06	3.409-04	1.818-06	1.440-06	5.763-07	1.152-07
Te-127	6.653-06	4.749-09	1.798-08	7.192-06	5.699-04	3.039-06	4.495-06	1.205-06	3.596-07
Te-129m	1.066-05	1.404-08	2.880-08	1.152-05	1.684-03	8.983-06	7.200-06	2.864-06	5.760-07
Te-129	1.280-05	9.321-09	3.450-08	1.384-05	1.118-03	5.965-06	8.650-06	1.966-06	5.920-07
I-129	0.000	1.398-18	0.000	0.000	1.677-13	8.945-16	0.000	1.493-16	0.000
I-130	1.650-05	8.717-09	4.460-08	1.784-05	1.046-03	5.579-06	1.115-05	2.657-06	8.920-07
Te-131m	1.931-05	1.676-08	5.220-08	2.088-05	2.011-03	1.072-05	1.305-05	4.165-06	1.044-06
Te-131	8.806-06	3.163-09	2.380-08	9.520-06	3.796-04	2.024-06	5.950-06	8.020-07	4.760-07
I-131	2.079-05	2.729-08	5.620-08	2.248-05	3.274-03	1.746-05	1.405-05	5.601-06	1.124-06
Te-132	2.065-04	2.321-07	5.580-07	2.232-04	2.785-02	1.486-04	1.395-04	5.116-05	1.116-05
I-132	7.992-04	3.031-07	2.160-06	8.640-04	3.637-02	1.940-04	5.400-04	7.823-05	4.320-05
I-133	2.960-03	2.180-06	8.000-06	3.200-03	2.617-01	1.395-03	2.000-03	5.822-04	1.600-04
I-134	3.759-03	1.545-07	1.016-05	4.064-03	1.854-02	9.888-05	2.540-03	6.180-05	2.032-04
Cs-134	1.924-04	2.576-07	5.200-07	2.080-04	3.092-02	1.649-04	1.300-04	5.215-05	1.040-05
I-135	1.502-03	4.705-07	4.060-06	1.624-03	5.646-02	3.011-04	1.015-03	1.684-04	8.120-05
Cs-136	1.006-04	1.289-07	2.720-07	1.088-04	1.547-02	8.251-05	6.800-05	2.667-05	5.440-06
Cs-137	1.384-04	1.854-07	3.740-07	1.496-04	2.225-02	1.187-04	9.350-05	3.752-05	7.480-06
Ba-137m	1.288-04	1.734-07	3.480-07	1.392-04	2.081-02	1.110-04	8.700-05	3.509-05	6.960-06
Ba-140	1.672-06	2.141-09	4.520-09	1.808-06	2.569-04	1.370-06	1.130-06	4.431-07	9.040-08
La-140	1.154-06	1.723-09	3.120-09	1.248-06	2.067-04	1.103-06	7.800-07	3.342-07	6.240-08
Ce-141	5.321-07	7.004-10	1.438-09	5.752-07	8.405-05	4.483-07	3.595-07	1.430-07	2.876-08
Ce-143	3.086-07	2.788-10	8.340-10	3.336-07	3.334-05	1.778-07	2.085-07	6.791-08	1.668-08

TABLE 11.1-6 (Cont'd)

ISOTOPE	STEAM GENERATOR BLOWDOWN (μCi/ml)	TURBINE BLDG. FLOOR DRAINS (μCi/ml)	TURBINE BLDG. EQUIPMENT DRAINS (μCi/ml)	CHEMICAL DRAINS (μCi/ml)	REGENERA-TION WASTE DRAINS WITH SGBD LEAK (μCi/ml)	REGENERATION WASTE DRAINS WITHOUT SGBD LEAK (μCi/ml)	AUXILIARY BLDG. EQUIPMENT DRAINS (μCi/ml)	AUXILIARY BLDG. FLOOR DRAINS (μCi/ml)	LAUNDRY DRAINS (μCi/ml)
Pr-143	3.804-07	5.016-10	1.028-09	4.112-07	6.019-05	3.210-07	2.570-07	1.025-07	2.056-08
Ce-144	2.509-07	3.355-10	6.780-10	2.712-07	4.026-05	2.147-07	1.695-07	6.795-08	1.356-08
Pr-144	2.649-07	3.357-10	7.160-10	2.864-07	4.028-05	2.148-07	1.790-07	6.803-08	1.432-08
Np-239	9.176-06	9.673-09	2.480-08	9.920-06	1.161-03	6.191-06	6.200-06	2.198-06	4.960-07
TOTAL	2.017-02	1.567-05	5.452-05	2.181-02	1.880+00	1.003-02	1.363-02	3.464-03	1.090-03

TABLE 11.1-6 (Cont'd)

ASSUMPTIONS

GENERAL: SOURCE TERMS ARE BASED ON THE REALISTIC SOURCE TERMS FROM ANSI N-237 (Table 11.1-4).

1. Steam generator blowdown
   a. Assume a 1-gpm primary-to-secondary leak.
   b. Assuming blowdown from the leaking steam generator is 90 gpm and the other steam generators are operating at the normal 15-gpm blowdown, the total blowdown is 135 gpm from the leaking unit.
   c. From the above assumptions, the activity in the steam generator blowdown is 1/135 of PCA or 7.4×10^{-3} PCA.

2. Turbine building floor drains
   a. Assume activity is 1×10^{-5} PCA (based on NUREG/CR-0715, In-Plant Source Term Measurements at Zion Station).

3. Turbine building equipment drains
   a. Assume activity is 2×10^{-5} PCA (based on NUREG/CR-0715, In-Plant Source Term Measurements at Zion Station).

4. Chemical drains
   a. Assume activity is 8×10^{-3} PCA (based on NUREG/CR-0715, In-Plant Source Term Measurement at Zion Station).

5. Regeneration waste drains
   a. Assume activity is 6×10^{-3} PCA under operating conditions other than a steam generator primary to secondary leak condition.
   b. Assume activity is 1.2 PCA during a steam generator primary to secondary leak condition.
   c. The above assumptions are calculated from flow and source data in this document and equipment parameters by an iterative means.

6. Auxiliary building equipment drains
   a. Assume activity is 5×10^{-3} PCA (based on NUREG/CR-0715, In-Plant Source Term Measurement at Zion Station).

7. Auxiliary building floor drains
   a. Assume activity is 2×10^{-3} PCA (based on NUREG/CR-0715, In-Plant Source Term Measurement at Zion Station).

8. Laundry drains
   a. Assume activity is 4×10^{-4} PCA (based on NUREG/CR-0715, In-Plant Source Term Measurement at Zion Station).

TABLE 11.1-7

REALISTIC SOURCE TERMS FOR BALANCE OF PLANT
(1-Year Accumulation as Shipped for 2 Units)

ISOTOPE	BLOWDOWN DEMINERALIZER PREFILTER (Ci)	BLOWDOWN DEMINERALIZER AFTERFILTER (Ci)	TURBINE BUILDING EQUIPMENT DRAIN FILTER (Ci)	TURBINE BUILDING EQUIPMENT DRAIN DEMINERALIZER AFTERFILTER (Ci)	TURBINE BUILDING FLOOR DRAIN FILTER (Ci)	BLOWDOWN DEMINER-ALIZER (Ci)	TURBINE BUILDING EQUIPMENT DRAIN DEMINERALIZER (Ci)
H-3	2.802-05	2.802-05	9.010-07	1.802-06	4.505-07	2.802-05	1.502-07
Cr-51	1.926-01	1.926-03	1.374-04	2.748-06	6.869-05	6.754-02	8.648-06
Mn-54	4.228-02	4.228-04	3.135-05	6.269-07	1.567-05	1.191-02	1.571-06
Mn-56	1.245-03	1.245-05	7.894-08	1.579-09	3.947-08	1.370-03	1.447-08
Co-58	1.970+00	1.970-02	1.441-03	2.882-05	7.206-04	5.984-01	7.818-05
Fe-59	1.148-01	1.148-03	8.319-05	1.664-06	4.160-05	3.686-02	4.779-06
Co-60	2.800-01	2.800-03	2.083-04	4.166-06	1.041-04	7.728-02	1.022-05
Br-83	1.449-07	1.449-09	3.965-10	7.930-12	1.982-10	4.034-03	3.982-08
Br-84	7.901-08	7.901-10	4.766-11	9.533-13	2.383-11	4.849-04	1.061-09
Br-85	9.106-09	9.106-11	5.186-13	1.037-14	2.593-13	5.285-06	1.168-12
Rb-88	6.080-06	6.080-07	2.051-09	2.051-09	1.026-09	1.898-02	1.315-08
Rb-89	3.054-10	3.054-11	8.917-14	8.917-14	4.458-14	8.249-07	4.965-13
Sr-89	1.009-08	1.009-10	3.208-10	6.415-12	1.604-10	1.297-02	1.687-06
Y-89m	0.000	0.000	3.207-14	6.415-16	1.604-14	1.297-06	1.687-10
Sr-90	2.886-10	2.886-12	9.281-12	1.856-13	4.641-12	3.887-04	5.144-08
Y-90	3.474-11	3.474-13	2.683-12	5.366-14	1.342-12	2.313-04	3.606-08
Sr-91	1.928-08	1.928-10	2.007-10	4.014-12	1.004-10	2.158-03	8.093-08
Y-91m	0.000	0.000	1.172-10	2.344-12	5.859-11	1.267-03	5.158-08
Y-91	1.841-09	1.841-11	6.140-11	1.228-12	3.070-11	2.537-03	3.320-07
Sr-92	1.090-08	1.090-10	3.361-11	6.723-13	1.681-11	3.420-04	3.803-09
Y-92	1.006-09	1.006-11	3.761-11	7.522-13	1.880-11	3.831-04	9.339-09
Zr-95	7.309-03	7.309-05	5.338-06	1.068-07	2.669-06	2.241-03	2.923-07
Nb-95m	1.207-04	1.207-06	9.272-08	1.854-09	4.636-08	1.987-05	3.279-09
Nb-95	7.181-03	7.181-05	5.342-06	1.068-07	2.671-06	1.960-03	2.602-07
Mo-99	1.714+00	1.714-02	9.719-04	1.944-05	4.860-04	1.555+00	1.538-04
Tc-99m	1.498+00	1.498-02	8.494-04	1.699-05	4.247-04	1.430+00	1.461-04

TABLE 11.1-7 (Cont'd)

ISOTOPE	BLOWDOWN DEMINERALIZER PREFILTER (Ci)	BLOWDOWN DEMINERALIZER AFTERFILTER (Ci)	TURBINE BUILDING EQUIPMENT DRAIN FILTER (Ci)	TURBINE BUILDING EQUIPMENT DRAIN DEMINERALIZER AFTERFILTER (Ci)	TURBINE BUILDING FLOOR DRAIN FILTER (Ci)	BLOWDOWN DEMINER-ALIZER (Ci)	TURBINE BUILDING EQUIPMENT DRAIN DEMINERALIZER (Ci)
Tc-99	3.648-07	3.648-09	2.242-10	4.484-12	1.121-10	6.403-08	1.050-11
Ru-103	1.294-09	1.294-11	4.102-11	8.204-13	2.051-11	1.641-03	2.122-07
Rh-103m	1.362-09	1.362-11	4.113-11	8.226-13	2.057-11	1.643-03	2.124-07
Ru-106	2.886-10	2.886-12	9.267-12	1.853-13	4.634-12	3.862-04	5.099-08
Rh-106	0.000	0.000	9.264-12	1.853-13	4.632-12	3.862-04	5.099-08
Te-125m	8.350-12	8.350-12	2.658-11	5.317-13	1.329-11	1.079-03	1.406-07
Te-127m	8.070-09	8.070-11	2.581-10	5.163-12	1.291-10	1.063-02	1.395-06
Te-127	2.519-08	2.519-10	4.316-10	8.632-12	2.158-10	1.245-02	1.458-06
Te-129m	4.035-08	4.035-10	1.275-09	2.551-11	6.377-10	5.066-02	6.525-06
Te-129	4.847-08	4.847-10	8.470-10	1.694-11	4.235-10	3.277-02	4.183-06
I-129	0.000	0.000	1.270-19	2.540-21	6.351-20	2.048-11	3.696-15
I-130	6.248-08	6.248-10	7.921-10	1.584-11	3.961-10	8.979-03	4.100-07
Te-131m	7.313-08	7.313-10	1.523-09	3.046-11	7.614-10	2.485-02	1.880-06
Te-131	3.334-08	3.334-10	2.874-10	5.749-12	1.437-10	4.633-03	3.434-07
I-131	7.873-08	7.873-10	2.480-09	4.959-11	1.240-09	8.878-02	1.072-05
Te-132	7.817-07	7.817-09	2.109-08	4.219-10	1.055-08	5.473-01	5.615-05
I-132	3.026-06	3.026-08	2.754-08	5.509-10	1.377-08	6.231-01	5.811-05
I-133	1.121-05	1.121-07	1.981-07	3.963-09	9.907-08	2.715+00	1.732-04
I-134	1.423-05	1.423-07	1.404-08	2.808-10	7.020-09	1.428-01	5.096-07
Cs-134	7.285-07	7.285-08	2.341-08	2.341-08	1.171-08	8.893-01	6.531-05
I-135	5.688-06	5.688-08	4.276-08	8.551-10	2.138-08	4.415-01	1.196-05
Cs-136	3.811-07	3.811-08	1.172-08	1.172-08	5.858-09	3.894-01	2.670-05
Cs-137	5.240-07	5.240-08	1.685-08	1.685-08	8.425-09	6.416-01	4.717-05
Ba-137m	4.875-07	4.875-09	1.576-08	3.151-10	7.878-09	5.999-01	4.412-05
Ba-140	6.332-09	6.332-11	1.946-10	3.891-12	9.728-11	7.100-03	8.754-07
La-140	4.371-09	4.371-11	1.566-10	3.131-12	7.828-11	6.888-03	8.986-07
Ce-141	2.015-09	2.015-11	6.365-11	1.273-12	3.183-11	2.524-03	3.248-07
Ce-143	1.168-09	1.168-11	2.525-11	5.049-13	1.262-11	4.333-04	2.412-08

TABLE 11.1-7 (Cont'd)

ISOTOPE	BLOWDOWN DEMINERALIZER PREFILTER (Ci)	BLOWDOWN DEMINERALIZER AFTERFILTER (Ci)	TURBINE BUILDING EQUIPMENT DRAIN FILTER (Ci)	TURBINE BUILDING EQUIPMENT DRAIN DEMINERALIZER AFTERFILTER (Ci)	TURBINE BUILDING FLOOR DRAIN FILTER (Ci)	BLOWDOWN DEMINER-ALIZER (Ci)	TURBINE BUILDING EQUIPMENT DRAIN DEMINERALIZER (Ci)
Pr-143	1.440-09	1.440-11	4.558-11	9.116-13	2.279-11	1.732-03	2.166-07
Ce-144	9.499-10	9.499-12	3.049-11	6.097-13	1.524-11	1.269-03	1.674-07
Pr-144	1.003-09	1.003-11	3.050-11	6.101-13	1.525-11	1.269-03	1.674-07
Np-239	3.474-08	3.474-10	8.790-10	1.758-11	4.395-10	1.981-02	1.872-06
TOTAL	5.828+00	5.830-02	3.735-03	7.654-05	1.867-03	1.110+01	9.221-04

TABLE 11.1-7 (Cont'd)

ASSUMPTIONS

1. Blowdown demineralizer prefilter.

    a. Assume steam generator leakage.
    b. Assume two 14-day leakage periods, one per unit per year.
    c. The total run time for the prefilter to be contaminated is 28 days per year.
    d. DFs given in Table 11.2-7.

2. Blowdown demineralizer afterfilter.
    a. As blowdown demineralizer prefilter.

3. Turbine building equipment drain filter.
    a. As blowdown demineralizer prefilter.

4. Turbine building equipment drain demineralizer afterfilter.
    a. As blowdown demineralizer prefilter.

5. Turbine building floor drain filter.

    a. As blowdown demineralizer prefilter.

6. Blowdown demineralizer.
    a. Assume 28 days of steam generator leakage per year.
    b. Assume that each demineralizer is regenerated every 6 days.
    c. DFs given in Table 11.2-7.

7. Turbine building equipment drain demineralizer.
    a. As blowdown demineralizer.

TABLE 11.1-8

REALISTIC SOURCE TERMS FOR RADWASTE SYSTEM FILTERS AND DEMINERALIZERS
(1-Year Accumulation as Shipped for 2 Units)

ISOTOPE	LAUNDRY DRAIN FILTER (Ci)	AUXILIARY BLDG. EQUIPMENT DRAIN FILTER (Ci)	AUXILIARY BLDG. FLOOR DRAIN FILTER (Ci)	RADWASTE DEMINERALIZER AFTERFILTER (Ci)	CHEMICAL DRAIN FILTER (Ci)	REGENERATION WASTE DRAIN FILTER (Ci)	RADWASTE DEMINERALIZER (Ci)
H-3	1.813-05	2.279-04	9.117-05	1.239-03	3.604-04	2.572-06	2.748-05
Cr-51	9.212-04	4.682-02	1.873-02	9.554-06	2.748-02	5.393-01	1.974-06
Mn-54	2.102-04	1.058-02	4.233-03	2.153-06	6.269-03	1.295-01	3.841-07
Mn-56	5.281-07	5.240-05	2.096-05	6.306-09	1.581-05	1.269-05	2.724-10
Co-58	9.664-03	4.880-01	1.952-01	9.943-05	2.882-01	5.856+00	1.868-05
Fe-59	5.579-04	2.824-02	1.130-02	5.758-06	1.664-02	3.338-01	1.122-06
Co-60	1.397-03	7.026-02	2.810-02	1.429-05	4.166-02	8.641-01	2.514-06
Br-83	7.930-09	1.977-07	7.909-08	7.411-12	1.586-07	1.061-07	7.267-09
Br-84	9.533-10	2.383-08	9.533-09	8.914-13	1.907-08	2.499-09	1.244-10
Br-85	1.037-11	2.593-10	1.037-10	9.699-15	2.074-10	8.689-13	1.136-12
Rb-88	4.103-08	1.026-06	4.103-07	3.837-11	8.206-07	4.877-08	2.782-09
Rb-89	1.783-12	4.458-11	1.783-11	1.668-15	3.567-11	1.764-12	1.034-13
Sr-89	6.453-09	8.159-08	3.264-08	5.354-12	1.283-07	2.444-06	3.987-06
Y-89m	6.452-13	8.157-12	3.263-12	5.353-16	1.283-11	2.444-10	3.988-10
Sr-90	1.867-10	2.348-09	9.391-10	1.548-13	3.713-09	7.373-08	1.266-07
Y-90	5.414-11	4.975-10	1.990-10	4.328-14	1.073-09	4.860-08	1.080-07
Sr-91	4.018-09	8.188-08	3.275-08	3.602-12	8.028-08	1.927-07	3.049-08
Y-91m	2.346-09	4.673-08	1.869-08	2.094-12	4.687-08	1.228-07	1.953-08
Y-91	1.235-09	1.538-08	6.154-09	1.023-12	2.456-08	4.799-07	7.896-07
Sr-92	6.723-10	1.672-08	6.689-09	6.280-13	1.345-08	1.017-08	7.333-10
Y-92	7.522-10	1.782-08	7.127-09	6.952-13	1.504-08	2.502-08	2.387-09
Zr-95	3.580-05	1.808-03	7.234-04	3.685-07	1.068-03	2.164-02	6.966-08
Nb-95m	6.218-07	3.090-05	1.236-05	6.338-09	1.854-05	4.051-04	1.041-09
Nb-95	3.582-05	1.802-03	7.206-04	3.666-07	1.068-03	2.217-02	6.441-08
Mo-99	6.511-03	3.618-01	1.447-01	7.027-05	1.944-01	2.217+00	1.996-05
Tc-99m	5.690-03	3.162-01	1.265-01	6.141-05	1.699-01	1.937+00	3.661-05
Tc-99	1.502-09	8.347-08	3.339-08	1.548-11	4.484-08	4.719-07	2.491-11

TABLE 11.1-8 (Cont'd)

ISOTOPE	LAUNDRY DRAIN FILTER (Ci)	AUXILIARY BLDG. EQUIPMENT DRAIN FILTER (Ci)	AUXILIARY BLDG. FLOOR DRAIN FILTER (Ci)	RADWASTE DEMINERALIZER AFTERFILTER (Ci)	CHEMICAL DRAIN FILTER (Ci)	REGENERATION WASTE DRAIN FILTER (Ci)	RADWASTE DEMINERALIZER (Ci)
Ru-103	8.251-10	1.045-08	4.181-09	6.848-13	1.641-08	3.085-07	4.952-07
Rh-103m	8.274-10	1.050-08	4.199-09	6.868-13	1.645-08	3.088-07	4.958-07
Ru-106	1.864-10	2.346-09	9.384-10	1.546-13	3.707-09	7.319-08	1.248-07
Rh-106	1.864-10	2.345-09	9.378-10	1.545-13	3.706-09	7.319-08	1.248-07
Te-125m	5.348-10	6.758-09	2.703-09	4.436-13	1.063-08	2.035-07	3.337-07
Te-127m	5.193-09	6.547-08	2.619-08	4.307-12	1.033-07	2.011-06	3.369-06
Te-127	8.665-09	1.369-07	5.477-08	7.425-12	1.726-07	2.166-06	3.380-06
Te-129m	2.566-08	3.254-07	1.301-07	2.130-11	5.102-07	9.509-06	1.510-05
Te-129	1.703-08	2.233-07	8.933-08	1.420-11	3.388-07	6.098-06	9.678-06
I-129	2.569-18	1.696-17	6.783-18	1.655-20	5.081-17	4.466-15	1.444-14
I-130	1.587-08	3.018-07	1.207-07	1.194-10	3.168-07	9.440-07	1.813-07
Te-131m	3.056-08	4.731-07	1.893-07	2.612-11	6.091-07	3.597-06	1.474-06
Te-131	5.769-09	9.110-08	3.644-08	4.944-12	1.150-07	6.571-07	2.692-07
I-131	4.987-08	6.362-07	2.545-07	3.482-10	9.918-07	1.686-05	2.164-05
Te-132	4.239-07	5.811-06	2.324-06	3.557-10	8.438-06	9.327-05	7.866-05
I-132	5.530-07	8.886-06	3.555-06	4.019-09	1.102-05	9.761-05	8.114-05
I-133	3.974-06	6.614-05	2.645-05	2.910-08	7.926-05	3.611-04	1.082-04
I-134	2.808-07	7.020-06	2.808-06	2.254-09	5.616-06	1.278-06	6.581-08
Cs-134	4.710-07	5.924-06	2.370-06	7.249-09	9.365-06	2.166-04	3.694+00
I-135	8.554-07	1.913-05	7.650-06	6.677-09	1.710-05	1.183-04	3.710-06
Cs-136	2.356-07	3.030-06	1.212-06	3.628-09	4.688-06	5.201-03	1.273+00
Cs-137	3.390-07	4.262-06	1.705-06	5.218-09	6.740-06	9.430-03	2.676+00
Ba-137m	3.170-07	3.986-06	1.594-06	2.628-10	6.303-06	8.817-03	2.501+00
Ba-140	3.913-09	5.033-08	2.013-08	3.254-12	7.783-08	3.359-06	1.836-06
La-140	3.151-09	3.796-08	1.518-08	2.597-12	6.262-08	3.443-06	2.008-06
Ce-141	1.280-09	1.624-08	6.497-09	1.063-12	2.546-08	1.243-06	7.504-07
Ce-143	5.068-10	7.714-09	3.086-09	4.319-13	1.010-08	1.321-07	2.860-08
Pr-143	9.168-10	1.164-08	4.657-09	7.611-13	1.823-08	8.308-07	4.632-07
Ce-144	6.133-10	7.719-09	3.088-09	5.086-13	1.219-08	6.396-07	4.090-07

TABLE 11.1-8 (Cont'd)

ISOTOPE	LAUNDRY DRAIN FILTER (Ci)	AUXILIARY BLDG. EQUIPMENT DRAIN FILTER (Ci)	AUXILIARY BLDG. FLOOR DRAIN FILTER (Ci)	RADWASTE DEMINERALIZER AFTERFILTER (Ci)	CHEMICAL DRAIN FILTER (Ci)	REGENERATION WASTE DRAIN FILTER (Ci)	RADWASTE DEMINERALIZER (Ci)
Pr-144	6.137-10	7.728-09	3.091-09	5.088-13	1.220-08	6.398-07	4.091-07
Np-239	1.766-08	2.497-07	9.987-08	1.488-11	3.516-07	7.257-06	2.210-06
TOTAL	2.505-02	1.326+00	5.304-01	1.503-03	7.473-01	1.189+01	1.014+01

TABLE 11.1-8 (Cont'd)

ASSUMPTIONS

1. Laundry drain filter.
   a. Assume 12 replacements per year based on N. S. Brooks and E. R. Chow, "Cartridge Filtration in Pressurized Water Reactors."
   b. DFs are given in Table 11.2-7.

2. Auxiliary building equipment drain filter.
   a. As laundry drain filter.

3. Auxiliary building floor drain filter.
   a. As laundry drain filter.

4. Radwaste demineralizer afterfilter.
   a. As laundry drain filter.

5. Chemical drain filter.
   a. As laundry drain filter.

6. Regeneration waste drain filter.
   a. As laundry drain filter.

7. Radwaste demineralizer.
   a. Assume each demineralizer is regenerated every 8 days.
   b. DFs are given in Table 11.2-7.

TABLE 11.1-9

REALISTIC SOURCE TERMS FOR NSSS FILTERS

ISOTOPE	REACTOR COOLANT (Ci)	SEAL WATER INJECTION (Ci)	SEAL WATER RETURN (Ci)	BRS CONCENTRATES (Ci)	BRS FEED (Ci)	BRS CONDENSATE (Ci)	SPENT FUEL PIT (Ci)	SPENT FUEL PIT SKIMMER (Ci)
I 131	4.2	1.8	8.3(-1)	1.2(-1)	2.1(-2)	7.0(-4)	-	-
I 133	7.1(-1)	2.8(-1)	1.3(-1)	1.9(-2)	3.3(-3)	1.4(-4)	-	-
RB 86	2.1(-3)	9.1(-4)	4.4(-4)	5.0(-5)	2.9(-5)	-	-	-
CS134	2.2	1.0	4.4(-1)	6.0(-2)	1.0(-1)	-	-	-
CS136	2.1(-1)	1.1(-1)	4.4(-2)	5.0(-3)	3.1(-3)	-	-	-
CS137	1.7	7.4(-1)	3.3(-1)	4.5(-2)	8.3(-2)	-	-	-
CR 51	1.1(-1)	4.5(-2)	2.2(-2)	2.9(-3)	5.1(-4)	-	2.3(-1)	5.5(-2)
MN 54	3.5(-2)	1.7(-2)	6.5(-3)	1.0(-3)	5.1(-4)	-	4.6(-1)	1.1(-1)
FE 55	2.5(-1)	1.1(-2)	4.4(-2)	7.0(-3)	3.4(-3)	-	-	-
FE 59	7.1(-2)	2.8(-2)	1.3(-2)	1.9(-3)	4.2(-4)	-	2.2(-2)	5.5(-3)
CO 58	1.5	6.8(-1)	3.1(-1)	4.0(-2)	1.0(-2)	-	4.6(-1)	1.1(-1)
CO 60	3.2(-1)	1.1(-1)	6.6(-2)	9.0(-3)	4.5(-3)	-	6.6(-2)	1.7(-2)
SR 87	2.8(-2)	1.1(-2)	6.6(-3)	8.0(-4)	1.7(-4)	-	-	-
SR 90	1.4(-3)	5.7(-4)	2.2(-4)	3.8(-5)	2.4(-5)	-	-	-
BA137M	1.6	6.8(-1)	3.1(-1)	4.2(-2)	7.9(-2)	-	-	-
BA140	7.1(-1)	2.8(-3)	1.3(-3)	1.9(-4)	2.7(-5)	-	-	-

TABLE 11.1-9 (Cont'd)

ASSUMPTIONS

1. ANSI Standard N-237 source terms for reactor coolant are used for the analysis.

2. All isotopes with half-lives less than 1 day are ignored.

3. The filter changeout frequencies are as follows:

FILTER	VOLUME PER FILTER (cm^3)	CHANGES PER YEAR*
A. Reactor coolant	1.11×10^4	3
B. Seal water return	1.11×10^4	1
C. Spent fuel pit	1.11×10^4	1
D. Spent fuel pit skimmer	1.11×10^4	1
E. Seal water injection	1.74×10^3	3
F. Recycle evaporator feed	1.11×10^4	1
G. Recycle evaporator concentrates	1.53×10^3	1
H. Recycle evaporator condensate	1.53×10^3	1

4. For filters following demineralizers, the isotopic. activities are based on 1% of the upstream demineralizer activity distributed on the filter as resin fines.

5. For filters where data exists, the measured contact dose rates are used to estimate the activities. The N-237 activities are scaled to meet the measured dose rate.

6. Primary water filters: reactor coolant, seal water injection, seal water return, and BRS concentrates filters are based on measured contact dose rates.

*Based on plant data.

TABLE 11.1-9 (Cont'd)

7. Spent fuel pit filters: only the isotopes listed have been measured at plants. Fission products are cleaned up before lifting the head, but corrosion products are released from the spent fuel. The skimmer filter is based on the ratio of measured contact dose rates for the skimmer and spent fuel pit filters.

TABLE 11.1-10

REALISTIC SOURCE TERMS FOR NSSS DEMINERALIZERS*

ISOTOPE	MIXED BED ($\mu Ci/cm^3$)	CATION BED ($\mu Ci/cm^3$)	BRS FEED ($\mu Ci/cm^3$)	BRS CONDENSATE ($\mu Ci/cm^3$)	BTRS ($\mu Ci/cm^3$)	SPENT FUEL PIT ($\mu Ci/cm^3$)
I 131	1390.0	-	2.4	1.2(-1)	12.7	-
I 133	218.0	-	3.7(-1)	2.4(-2)	2.0	-
RB 86	0.6	0.80	3.3(-3)	-	-	-
CS134	1050.0	142.00	11.2	-	-	-
CS136	61.0	8.00	3.5(-1)	-	-	-
CS137	818.0	117.00	9.4	-	-	-
CR 51	33.0	-	5.7(-2)	-	-	2.70
MN 54	20.0	-	5.8(-2)	-	-	54.0
FE 55	120.0	-	3.8(-1)	-	-	-
FE 59	27.0	-	4.8(-2)	-	-	3.0
CO 58	600.0	-	1.2	-	-	54.0
CO 60	155.0	-	5.1(-1)	-	-	8.0
SR 89	10.0	2.00	1.9(-2)	-	-	-
SR 90	0.8	0.01	2.7(-3)	-	-	-
Y 90	-	-	-	-	-	-
Y 91	-	-	-	-	-	-
ZR 95	-	-	-	-	-	-
NB 95	-	-	-	-	-	-
MO 99	-	-	-	-	-	-
TO 99M	-	-	-	-	-	-
RU103	-	-	-	-	-	-
RU106	-	-	-	-	-	-
BA137M	774.0	105.00	8.8	-	-	-
BA140	2.0	0.30	3.0(-3)			
	30.0	30.0	30.0	20.0	70.0	30.0

Value in ft^3

*Multiplier for Ci:

20 - 5.7×10^5
30 - 8.5×10^5
70 - 2.0×10^6

TABLE 11.1-10

REALISTIC SOURCE TERMS FOR NSSS DEMINERALIZERS*

ISOTOPE	MIXED BED ($\mu Ci/cm^3$)	CATION BED ($\mu Ci/cm^3$)	BRS FEED ($\mu Ci/cm^3$)	BRS CONDENSATE ($\mu Ci/cm^3$)	BTRS ($\mu Ci/cm^3$)	SPENT FUEL PIT ($\mu Ci/cm^3$)
I 131	1390.0	-	2.4	1.2(-1)	12.7	-
I 133	218.0	-	3.7(-1)	2.4(-2)	2.0	-
RB 86	0.6	0.80	3.3(-3)	-	-	-
CS134	1050.0	142.00	11.2	-	-	-
CS136	61.0	8.00	3.5(-1)	-	-	-
CS137	818.0	117.00	9.4	-	-	-
CR 51	33.0	-	5.7(-2)	-	-	2.70
MN 54	20.0	-	5.8(-2)	-	-	54.0
FE 55	120.0	-	3.8(-1)	-	-	-
FE 59	27.0	-	4.8(-2)	-	-	3.0
CO 58	600.0	-	1.2	-	-	54.0
CO 60	155.0	-	5.1(-1)	-	-	8.0
SR 89	10.0	2.00	1.9(-2)	-	-	-
SR 90	0.8	0.01	2.7(-3)	-	-	-
Y 90	-	-	-	-	-	-
Y 91	-	-	-	-	-	-
ZR 95	-	-	-	-	-	-
NB 95	-	-	-	-	-	-
MO 99	-	-	-	-	-	-
TO 99M	-	-	-	-	-	-
RU103	-	-	-	-	-	-
RU106	-	-	-	-	-	-
BA137M	774.0	105.00	8.8	-	-	-
BA140	2.0	0.30	3.0(-3)			
	35.0	30.0	30.0	20.0	70.0	30.0

Value in ft^3

*Multiplier for Ci:

20 - 5.7×10^5
30 - 8.5×10^5
70 - 2.0×10^6

TABLE 11.1-10 (Cont'd)

ASSUMPTIONS

1. ANSI Standard N-237 source terms are used for the analysis.

2. All isotopes with half-lives less than 1 day are ignored.

3. The resin changeout frequency is as follows:

DEMINERALIZER	VOLUME (ft^3 per bed)	CHANGES PER YEAR*
A. Mixed bed	30	2
B. Cation bed	20	1
C. Boron thermal regeneration	70	1
D. Boron recycle evaporator feed	30	1
E. Boron recycle condensate	20	1
F. Spent fuel pit	30	1

4. Mixed bed and cation bed demineralizers: the mixed-bed activities are based on continuous flow through the bed at the nominal letdown rate. The flow through the cation bed is 0.1 of the mixed-bed flow.

5. Boron thermal regeneration demineralizers: the BTR demineralizer activity is based on the estimated flow through 5 BTR beds during continuous load follow operation.

6. Boron recycle system demineralizers: the BRS feed demineralizer activities are based on the estimated volume of primary water processed for boron control. Credit is taken for the mixed-bed demineralizer. The BRS condensate demineralizer activity is based on processing this water at the maximum processing rate.

7. Spent fuel pool demineralizers: only those isotopes that have been measured at plants are listed.

*Based on plant data.

TABLE 11.1-10 (Cont'd)

ASSUMPTIONS

1. ANSI Standard N-237 source terms are used for the analysis.

2. All isotopes with half-lives less than 1 day are ignored.

3. The resin changeout frequency is as follows:

DEMINERALIZER	VOLUME (ft^3 per bed)	CHANGES PER YEAR*
A. Mixed bed	35	2
B. Cation bed	20	1
C. Boron thermal regeneration	70	1
D. Boron recycle evaporator feed	30	1
E. Boron recycle condensate	20	1
F. Spent fuel pit	30	1

4. Mixed bed and cation bed demineralizers: the mixed-bed activities are based on continuous flow through the bed at the nominal letdown rate. The flow through the cation bed is 0.1 of the mixed-bed flow.

5. Boron thermal regeneration demineralizers: the BTR demineralizer activity is based on the estimated flow through 5 BTR beds during continuous load follow operation.

6. Boron recycle system demineralizers: the BRS feed demineralizer activities are based on the estimated volume of primary water processed for boron control. Credit is taken for the mixed-bed demineralizer. The BRS condensate demineralizer activity is based on processing this water at the maximum processing rate.

7. Spent fuel pool demineralizers: only those isotopes that have been measured at plants are listed.

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*Based on plant data.

TABLE 11.1-11

REALISTIC SOURCE TERMS FOR

CONCENTRATES AND SPENT RESIN TANKS

ISOTOPE	CONCENTRATES HOLDING TANK ACTIVITY* (Ci/tank)	SPENT RESIN TANK (Ci/tank)
Cr-51	3.01×10^{-2}	55.29
Mn-54	5.02×10^{-3}	55.97
Fe-55	2.48×10^{-2}	143.02
Mn-56	7.18×10^{-9}	4.80×10^{-4}
Co-58	2.56×10^{-1}	748.50
Fe-59	1.57×10^{-2}	33.89
Co-60	3.19×10^{-2}	189.47
Br-83	1.84×10^{-7}	1.41×10^{-3}
Br-84	1.08×10^{-9}	1.70×10^{-4}
Br-85	1.05×10^{-13}	1.85×10^{-6}
Rb-86	2.60×10^{-4}	1.03
Rb-88	1.46×10^{-8}	6.65×10^{-3}
Rb-89	4.75×10^{-13}	2.89×10^{-7}
Sr-89	2.07×10^{-3}	12.67
Y-89m	1.52×10^{-7}	4.55×10^{-7}
Sr-90	7.50×10^{-5}	$9.59 \mathrm{X} 10^{-1}$
Y-90	1.17×10^{-4}	8.09×10^{-5}
Sr-91	1.26×10^{-6}	7.56×10^{-4}
Y-91m	8.11×10^{-7}	4.45×10^{-4}
Y-91	3.38×10^{-3}	8.89×10^{-4}
Sr-92	1.97×10^{-8}	1.20×10^{-4}
Y-92	8.12×10^{-8}	1.34×10^{-4}
Zr-95	2.86×10^{-3}	7.84×10^{-4}
Nb-95m	5.55×10^{-7}	6.97×10^{-6}
Nb-95	2.66×10^{-3}	6.86×10^{-4}
Mo-99	4.13×10^{0}	5.46×10^{-1}
Tc-99m	2.48×10^{0}	5.01×10^{-1}
Tc-99	7.82×10^{-9}	2.24×10^{-8}
Ru-103	2.30×10^{-3}	5.74×10^{-4}
Rh-103m	1.78×10^{-4}	5.74×10^{-4}
Ru-106	1.75×10^{-4}	1.35×10^{-4}
Rh-106	5.71×10^{-5}	1.35×10^{-4}
Te-125m	1.55×10^{-3}	3.75×10^{-3}
Te-127m	1.44×10^{-2}	3.71×10^{-3}
Te-127	4.51×10^{-2}	4.34×10^{-3}
Te-129m	7.13×10^{-2}	1.77×10^{-2}
Te-129	8.83×10^{-2}	1.15×10^{-2}
I-129	1.84×10^{-11}	7.18×10^{-12}
I-130	8.71×10^{-6}	3.14×10^{-3}
Te-131m	1.18×10^{-1}	8.68×10^{-3}
Te-131	5.66×10^{-2}	1.62×10^{-3}

TABLE 11.1-11 (Cont'd)

ISOTOPE	CONCENTRATES HOLDING TANK ACTIVITY* (Ci/tank)	SPENT RESIN TANK (Ci/tank)
I-131	4.32×10^{-1}	1672.22
Te-132	1.31	1.91×10^{-1}
I-132	$6.31 \text{ X } 10^{-3}$	2.18×10^{-1}
I-133	6.20×10^{-1}	263.21
I-134	8.52×10^{-7}	5.01×10^{-2}
Cs-134	9.72×10^{-2}	1313.35
I-135	1.46×10^{-4}	1.55×10^{-1}
Cs-136	4.31×10^{-1}	76.46
Cs-137	7.06×10^{-2}	1023.65
Ba-137m	9.91×10^{-2}	968.36
Ba-140	1.45×10^{-3}	2.51
La-140	8.01×10^{-3}	2.41×10^{-3}
Ce-141	3.56×10^{-3}	8.82×10^{-4}
Ce-143	2.01×10^{-3}	1.52×10^{-4}
Pr-143	2.47×10^{-3}	6.06×10^{-4}
Ce-144	1.72×10^{-3}	4.45×10^{-4}
Pr-144	1.85×10^{-4}	4.45×10^{-3}
Np-239	5.91×10^{-2}	6.93×10^{-3}

*Tank has usable volume of 5200 gallons. Waste from radwaste evaporators is 726,000 gal/yr. Waste from boron recycle system is 8000 gal/yr.

TABLE 11.1-11

REALISTIC SOURCE TERMS FOR

HIGH AND LOW ACTIVITY SPENT RESIN TANKS

ISOTOPE	LOW ACTIVITY SPENT RESIN TANK (Ci/tank)	HIGH ACTIVITY SPENT RESIN TANK (Ci/tank)
Cr-51	4.29×10^{-2}	157.90
Mn-54	7.56×10^{-2}	159.90
Fe-55		408.64
Mn-56	8.70×10^{-4}	
Co-58	3.80×10^{-1}	2132.60
Fe-59	2.48×10^{-2}	96.78
Co-60	4.91×10^{-2}	541.26
Br-83	2.56×10^{-3}	
Br-84	3.08×10^{-4}	
Br-85	3.35×10^{-6}	
Rb-86		2.95
Rb-88	1.21×10^{-2}	
Rb-89	5.24×10^{-7}	
Sr-89	8.25×10^{-3}	36.20
Y-89m	8.25×10^{-7}	
Sr-90	2.47×10^{-4}	2.74
Y-90	1.47×10^{-4}	
Sr-91	1.37×10^{-3}	
Y-91m	8.06×10^{-4}	
Y-91	1.61×10^{-3}	
Sr-92	2.17×10^{-4}	
Y-92	2.43×10^{-4}	
Zr-95	1.42×10^{-3}	
Nb-95m	1.26×10^{-5}	
Nb-95	1.24×10^{-3}	
Mo-99	9.91×10^{-1}	
Tc-99m	9.08×10^{-1}	
Tc-99	4.06×10^{-8}	
Ru-103	1.04×10^{-3}	
Ru-103m	1.04×10^{-3}	
Ru-106	2.45×10^{-4}	
Rh-106	2.45×10^{-4}	
Te-125m	6.86×10^{-4}	
Te-127m	6.73×10^{-3}	
Te-127	7.87×10^{-3}	
Te-129m	3.22×10^{-2}	
Te-129	2.08×10^{-2}	
I-129	1.30×10^{-11}	
I-130	5.70×10^{-3}	
Te-131m	1.75×10^{-2}	
Te-131	2.94×10^{-3}	

TABLE 11.1-11 (Cont'd)

ISOTOPE	LOW ACTIVITY SPENT RESIN TANK (Ci/tank)	HIGH ACTIVITY SPENT RESIN TANK (Ci/tank)
I-131	5.64×10^{-2}	4777.69
Te-132	3.47×10^{-1}	
I-132	3.96×10^{-1}	
I-133	1.73	749.31
I-134	9.08×10^{-2}	
Cs-134	2.91	3747.84
I-135	2.81×10^{-1}	
Cs-136	1.05	216.80
Cs-137	2.11	2921.40
Ba-137m	1.97	2763.64
Ba-140	4.51×10^{-3}	7.15
La-140	4.37×10^{-3}	
Ce-141	1.60×10^{-3}	
Ce-143	2.75×10^{-4}	
Pr-143	1.10×10^{-3}	
Ce-144	8.06×10^{-4}	
Pr-144	8.06×10^{-4}	
Np-239	1.26×10^{-2}	

TABLE 11.1-12 HAS BEEN INTENTIONALLY DELETED.

TABLE 11.1-13

UPRATED DESIGN-BASIS REACTOR COOLANT FISSION
AND CORROSION PRODUCT ACTIVITY

Nuclide	Activity* (μCi/gram)	Nuclide	Activity* (μCi/gram)
H-3	3.50E-00 (maximum)	Y-90	3.01E-05
		Y-91m	2.42E-03
Kr-83m	4.39E-01	Y-91	3.44E-04
Kr-85m	1.80E-00	Y-92	8.95E-04
Kr-85	7.11E-00	Y-93	3.03E-04
Kr-87	1.15E-00	Zr-95	4.05E-04
Kr-88	3.35E-00	Nb-95	4.06E-04
Kr-89	9.58E-02	Mo-99	5.29E-01
Xe-131m	3.31E-00	Tc-99m	4.88E-01
Xe-133m	3.65E-00	Ru-103	3.61E-04
Xe-133	2.51E+02	Ru-106	1.22E-04
Xe-135m	4.88E-01	Rh-103m	3.57E-04
Xe-135	7.72E-00	Ag-110m	1.18E-03
Xe-137	1.85E-01	Te-125m	4.14E-04
Xe-138	6.63E-01	Te-127m	2.01E-03
		Te-127	9.77E-03
Br-83	8.74E-02	Te-129m	6.85E-03
Br-84	4.59E-02	Te-129	1.04E-02
Br-85	5.47E-03	Te-131m	1.73E-02
I-130	3.29E-02	Te-131	1.17E-02
I-131	1.84E-00	Te-132	1.98E-01
I-132	2.43E-00	Te-134	2.95E-02
I-133	3.35E-00	Ba-137m	1.19E-00
I-134	6.04E-01	Ba-140	2.62E-03
I-135	2.09E-00	La-140	7.66E-04
		Ce-141	3.99E-04
Rb-86	2.28E-02	Ce-143	3.65E-04
Rb-88	4.21E-00	Ce-144	2.92E-04
Rb-89	1.93E-01	Pr-143	3.84E-04
Cs-134	1.80E-00		
Cs-136	2.89E-00	Cr-51**	5.30E-03
Cs-137	1.26E-00	Mn-54**	4.00E-04
Cs-138	1.02E-00	Fe-55**	2.30E-03
Sr-89	2.75E-03	Fe-59**	5.80E-04
Sr-90	1.20E-04	Co-58**	1.50E-02
Sr-91	4.64E-03	Co-60**	1.90E-03
Sr-92	1.12E-03		

NOTES:

* Parameters used in primary coolnt activity calculation are listed in Table 11.1-1, at operating temperature.

** Corrosion product activities are based activity levels measured at operating reactors.

11.2 LIQUID WASTE MANAGEMENT SYSTEMS

In general, the liquid radwaste system collects, monitors, and recycles or releases, with or without treatment where appropriate, all potentially radioactive liquid wastes produced by the station during normal operation and maintenance, as well as transient conditions. The only exception is that effluent from the treated water system (Byron only), the condensate polisher sump and the turbine building fire and oil sump, because of minimal activity levels, is normally discharged without being processed through the liquid radwaste system. Effluent from these sumps is monitored by radiation monitors that will automatically terminate sump discharge if unacceptable activity is present in the sump effluent. Corrective action can then be initiated to reroute the sump effluents to the appropriate treatment system prior to release.

11.2.1 Design Bases

11.2.1.1 Safety Design Basis

The liquid radwaste system is designed so that liquid radwaste discharged from the site will have radioactive nuclide concentrations well within the limits specified in 10 CFR 20 and 10 CFR 50, Appendix I.

Each liquid radwaste processing stream terminates in a monitor tank (see Drawing M-48A). Since the liquid radwaste system operates on a batch basis, this arrangement allows each treated batch to be sampled to assure that the treatment was sufficient. If the sample indicates that the waste needs further processing, it is recycled either through the same subsystem or through another subsystem providing a different form of treatment. If the treated waste water is not needed for reuse, the water is sent to either release tank (OWX01T or OWX26T) for discharge. Each batch is sampled prior to discharge from the release tank to verify that its activity level is within limits for discharge. The actual discharge to the circulating water blowdown line requires manually opening a remotely operated valve with a keylocked switch. The key for the valve lock is controlled by administrative procedures.

11.2.1.2 Power Generation Design Basis

The liquid radwaste system is sized to handle maximum expected liquid waste inputs on the basis of both volume and activity as a result of normal operation, including anticipated abnormal occurrences for Units 1 and 2.

The liquid radwaste system is composed of the following two subsystems:

a. the steam generator blowdown subsystem, and

b. the nonblowdown radwaste subsystem.

These subsystems are extensively crosstied to provide a high degree of availability and reliability.

The purpose of the steam generator blowdown subsystem is to maintain the steam generator water chemistry within specified limits.

The liquid radwaste system is designed to permit recycling of plant water. The stations are designed to minimize noncontaminated inputs from leakage of service water, circulating water, and groundwater into the plant floor drain system.

A cost-benefit analysis is not required for the liquid radwaste system. This is because Commonwealth Edison has complied with the Guides on Design Objectives for Light-Water-Cooled Nuclear Power Reactors proposed in the concluding statement of the position of the regulatory staff in Docket RM-50-2 dated February 20, 1974, pp. 25-30.

11.2.1.3 Expected Radioactive Releases

Byron and Braidwood Nuclear stations have updated the core power level twice. First to a core power level of 3586.6 MWt, then to the Measurement Uncertainty Recapture uprate power level of 3645 MWt. The original licensed power level was 3411 MWt. The original expected liquid radwaste effluent data presented in the UFSAR is based on a power level of 3565 MWt.

Expected annual average releases of radionuclides from the liquid radwaste system are shown in Table 11.2-1. These releases were determined by using the NUREG 0017/PWR-GALE computer program (References 1 and 2). Both the original as well as the uprated parameters describing the expected normal operation of one unit of the station are listed in Table 11.2-2. These values were used as input to the computer code for the original analyses. The impact of core uprate on the effluent releases was evaluated based on an assessment of the changes in input parameters.

Core uprate results in a maximum potential increase of 0.6% in the liquid effluent release concentrations previously reported. Taking into consideration the accuracy and error bounds of the operational data utilized in NUREG 00017, this small percentage change is well within the uncertainty of the calculated results of the original NUREG 0017 based expected liquid effluent concentrations presented in Table 11.2-4 which remain valid for uprate.

For tables 11.2-1 and 11.2-4 (for Braidwood only), actual data has been used to determine the expected tritium (H-3) release and blowdown concentration values.

11.2.1.4 10 CFR 50 Comparison

Conservatively estimated annual average doses to individuals exposed to radioactive liquid effluents are given in Table 11.2-3. As can be seen from the total dose rates from the various exposure pathways, the numerical guidelines set forth in Appendix I to 10 CFR 50 are satisfied. As discussed in Section 11.2.1.3, this assessment and Table 11.2-3 remain valid for uprate.

For Braidwood only, dose calculations using actual release data and compiled in annual effluent release reports, in accordance with the ODCM, indicate that normal liquid effluents, including tritium, are typically within the estimates of Table 11.2-3 and within guidelines of 10 CFR 50 App.I.

11.2.1.5 10 CFR 20 Comparison

Table 11.2-4 compares expected liquid effluent concentrations with 10 CFR 20 limits. It can be seen that the expected effluent concentrations are significantly below the specified limits. As discussed in Section 11.2.1.3, this assessment and Table 11.2-4 remain valid for uprate.

For Braidwood only, actual liquid effluent release data compiled in annual effluent release reports, in accordance with the ODCM, indicate that effluents are maintained within the concentration and dose guidelines of 10 CFR 20.

11.2.1.6 Component Specifications

Table 11.2-5 gives the design parameters of various radwaste system components.

11.2.1.7 Seismic Design and Quality Group

The structures housing the liquid radwaste system are Safety Category I for the auxiliary building, and Safety Category II for the turbine building and radwaste building. All components (including tanks, pumps, valves, and piping) of the liquid radwaste system containing radioactive wastes are classified as Quality Group D, with the exception of the containment penetration piping out to and including the second isolation valve from the containment sump pump discharge, which is Quality Group B piping and valves (refer to Section 3.2).

11.2.1.8 Facility and Equipment Design

The liquid radwaste system is designed to minimize radiation exposure to operating personnel. Normal operations, maintenance, and nonroutine operations are discussed in the following.

11.2.1.8.1 Maintenance Operations

Wherever practicable, components of the liquid radwaste systems are segregated to the maximum extent practical. To reduce radiation exposure to maintenance personnel, components are arranged so that access to a low activity component does not necessitate passing near a high activity component. Instruments are located in low dose rate areas wherever practical to minimize the radiation exposure to maintenance personnel.

Valves, where practicable, are located outside of compartments to minimize radiation exposure from tanks or components during valve maintenance. Most radwaste pumps are equipped with mechanical seals to minimize maintenance.

In general, components which may require maintenance are capable of being flushed prior to maintenance.

11.2.1.8.2 Floor, Wall, and Ceiling Coatings

In rooms containing radioactive wastes, the floors, and as necessary, the walls and ceilings, are coated with a two-coat water base epoxy paint for ease of decontamination.

11.2.1.9 Tank Level Control

Provisions are made to preclude uncontrolled spills due to tank overflows. The following criteria apply to tanks outside the containment building which may contain radioactive fluids:

a. Tank level instrumentation is provided on most radwaste tanks with readout devices in the radwaste control room. A high-level condition on these tanks will be annunciated.

b. Some radwaste tanks overflow to an adjacent sump, as described in Table 11.2-9. Sumps are provided with duplex or triplex (redundant) pumps as appropriate. Sumps are level controlled and logic is provided to start and stop pumps automatically.

c. Provisions for tank level indication, level annunciation, and overflows are given in Table 11.2-9 for all tanks outside the containment building containing potentially radioactive liquids.

11.2.1.10 Prevention of Uncontrolled Releases

Based on operating experience during normal operations, it is expected that it will be necessary to make controlled releases of contaminated steam and condensate leakage to the environment. During normal operations, these releases of radioactive liquids to the environment are from the release tank after processing, as needed, by the liquid radwaste system.

As a batch of waste is processed, the effluent is transferred to an appropriate monitor tank (e.g., blowdown monitor tanks, boric acid monitor tanks, and radwaste monitor tanks) for sampling prior to being transferred to the release tanks or being reprocessed. In the release tanks, the liquid is mixed and sampled for activity prior to discharge. The release tanks discharge must pass through either one of two remotely controlled keylocked valves (0WX353 and 0WX896 on Drawing M-48-1) to be released from the station. Limit switches supply status information on the valve position to the operator at the radwaste control panel. A radiation monitor is provided to automatically close the valves on a high radiation signal.

In addition, effluents from the treated water system, the condensate polisher sump and the turbine building fire and oil sump are released to the environment. While normally considered non-radioactive, these effluents can potentially become contaminated, and the sump effluents are monitored by radiation monitors which will halt sump pump operation if unacceptable activity levels are present in sump effluent.

11.2.1.11 ETSB-BTP 11-1 Comparison

The liquid radwaste system is designed to meet the design criteria of the former Effluent Treatment Systems Branch (ETSB), Branch Technical Position BTP 11-1, Revision 1, and meets the criteria of Regulatory Guide 1.143, as described in Appendix A.

11.2.2 System Description

The liquid radwaste system is shared by both units. Unit 1 and Unit 2, however, have separate equipment and floor drain collection sump systems. Process flow diagrams are shown in Drawing M-48A. The systems are depicted in Drawings M-48-1 through M-48-40.

Inputs to the system are separated according to origin and/or concentrations of radioactivity and chemical impurity. Separate collection tanks are provided for each input stream. The waste is routed from the collection tanks to the appropriate processing paths. The system processes the radioactive liquid waste by various combinations of filtration, evaporation (Braidwood only), and/or demineralization. At Braidwood, vendor radwaste processing systems may utilize filtration, demineralization, chemical and ultraviolet treatment, and/or reverse osmosis to assist in radioactive liquid waste processing and recycling.

Provisions are made to bypass any processing device. The release tanks cannot be bypassed.

After being processed through the various equipment items, the purified effluent can be reused as secondary cycle makeup at Byron, primary cycle makeup at Braidwood, or released to the environment via the circulating water blowdown line.

The liquid radwaste system is designed to handle wastes generated during design-basis operational occurrences. This is accomplished by providing sufficient process capacity within the subsystems and collection and monitor tanks of adequate size.

The liquid radwaste system consists of two crosstied subsystems:

a. steam generator blowdown subsystem, and

b. non-blowdown radwaste subsystem which treats the following waste streams:

   1. auxiliary building equipment drains,

   2. auxiliary building floor drains,

   3. chemical waste drains,

   4. regeneration waste drains,

   5. laundry (detergent) drains,

   6. turbine building equipment and floor drains when contaminated, and

   7. condensate polisher sump when unacceptably contaminated.

Expected concentrations of radioactive nuclides in the various input waste streams to the radwaste subsystems are listed in Table 11.1-6. Expected inventories of radioactive nuclides in major components of the liquid waste system are tabulated in Tables 11.1-7 through 11.1-12. Table 11.2-6 lists the annual average and maximum expected daily flows of each waste stream. The expected activities in Table 11.1-1 correspond to the annual average daily flows. The activities for the maximum daily flows vary significantly. Actual release data are available in the effluent release reports, which are prepared in accordance with the ODCM.

Table 11.2-7 lists the design-basis decontamination factors for the processing components used in the analysis of the systems.

The original steam generator blowdown prefilters were replaced with larger prefilter units. However, the expected average and maximum waste stream flows and the design basis decontamination factors for the steam generator blowdown prefilters were not revised to account for the larger prefilter volume.

11.2.2.1 Steam Generator Blowdown Subsystem

The function of the steam generator blowdown subsystem is to maintain steam generator shell side water chemistry within the specified limits. Continuous blowdown constantly removes impurities from the steam generator. The flow rate is varied as required to maintain the steam generator water chemistry within the required limits.

At Byron, steam generator blowdown may be sent to the condensate polisher sump to improve secondary chemistry when excessive impurities are present that would quickly exhaust steam generator blowdown demineralizers.

For a further description of the steam generator blowdown subsystem, see Subsections 10.4.8 and 10.4.9.3.1.

The components of the steam generator blowdown treatment subsystem include four blowdown prefilters; four blowdown mixed bed demineralizers; four blowdown demineralizer after filters; three blowdown monitor tanks; and associated pumps, valves, and instrumentation.

11.2.2.1.1 Normal Operation

Steam generator blowdown is operated in a normal range of 15 to 90 gpm per steam generator, depending on steam generator chemistry requirements. During normal operation, blowdown is pumped from the steam generator blowdown condenser hotwells through the blowdown prefilters, the blowdown mixed-bed demineralizers, and the blowdown after filters to the condensate storage tanks or respective unit hotwell. In the event of high radioactive material in the purified effluent leaving the blowdown mixed-bed demineralizers, the effluent is diverted to the monitoring tanks. Unit 1 and Unit 2 blowdown is normally segregated, as the Unit 1 and Unit 2 condensate storage tanks are normally segregated.

Blowdown from each steam generator is sampled and analyzed at periodic intervals to determine:

a. If the blowdown flow rate requires adjustment to maintain the steam generator water chemistry limits.

b. If leakage condition exists, either at the main condenser or primary to secondary leakage within one or more steam generators so that remedial action can be taken.

c. If the method of processing the blowdown should be changed.

The time interval between samples of the blowdown from each steam generator depends upon operating experience.

The effluent from each blowdown mixed bed demineralizer is directed through a blowdown afterfilter to a header which is valved so that Unit 1 effluent is normally separated from Unit 2 effluent. Conductivity of each effluent stream from the blowdown mixed bed demineralizers is monitored. The processed liquid can be routed to either Unit 1 or Unit 2 condensate storage tanks as described above or to a monitor tank. The water in the blowdown monitor tanks is normally drained to the turbine building floor drain system. The water may also be used to sluice blowdown demineralizers or to backwash blowdown demineralizer strainers.

In addition to processing steam generator blowdown, the blowdown mixed bed demineralizers can be used for processing turbine building equipment drains, turbine building floor drains, and for the further processing of the purified effluent from the radwaste subsystems via the radwaste and blowdown monitor tanks. This practice is not recommended for normal operation.

Effluent from the blowdown prefilters of each unit can be diverted to each of the three radwaste evaporators, but normally this flowpath is blocked by a spectacle blank flange (Braidwood only).

11.2.2.1.2 Circulating Water to Secondary System Leakage

In the event of condenser tube or tube sheet leakage, the blowdown rate may be increased to 360 gpm (180,000 lbs/hr) total per unit to keep the steam generator shell side chemistry within operating limits. The blowdown rate from the four steam generators would be approximately 90 gpm for each steam generator.

11.2.2.1.3 Primary-to-Secondary-Leakage Concurrent with Failed Fuel

The radioisotope concentration in the steam generator blowdown is given in Table 12.2-30 and Table 11.1-6. If primary to secondary leakage occurs in only one steam generator, the blowdown rate from nonleaking steam generators remains high enough to maintain chemistry specifications while the blowdown rate from the leaking steam generator may be increased to the design rate of 90 gpm.

11.2.2.1.4 Primary-to-Secondary Leakage Not Concurrent with Failed Fuel

The steam generator blowdown during primary-to-secondary leakage not concurrent with failed fuel will be processed as discussed in Subsection 11.2.2.1.3 during transient operating conditions.

11.2.2.1.5 Transient Operating Conditions

Increased blowdown may be used to keep the steam generator water chemistry within specifications.

11.2.2.2 Nonblowdown Liquid Radwaste Subsystem

This processing train collects and treats liquid radwastes from sources other than steam generator blowdown. The mode of operation is batchwise. The nonblowdown liquid radwaste subsystem includes the following input sources:

a. auxiliary building equipment drain,

b. auxiliary building floor drain,

c. chemical waste drain,

d. regeneration waste drain,

e. laundry (detergent) drain,

f. turbine building equipment and floor drain (when contaminated),

g. turbine building fire and oil sump (when contaminated) (Byron only),

h. condensate polisher sump when unacceptably contaminated, and

i. waste treatment system (when contaminated) (Byron only).

Each drain system except the chemical waste, regeneration waste, and laundry drains, has two drain collection tanks. The chemical waste and regeneration waste drains utilize one tank each plus a shared dual purpose chemical/regeneration waste drain tank. Waste is usually collected in one of two drain tanks. The contents of the other tank may be sampled or processed. Chemical additions to adjust the wastewater pH or filter aids may be added to improve waste processing efficiency.

Oil separators are provided in those sumps that could potentially have oil in the water. A filter is installed downstream of each drain tank pump discharge header, or drain tank effluent is sent to vendor-installed equipment for filtration as needed.

The radwaste evaporator inlet header receives liquid wastes from the previously mentioned drain tanks. The liquid wastes entering the radwaste evaporator inlet header normally bypass the evaporators and are processed by the radwaste demineralizers or by the vendor demineralizers.

At Byron, nonessential service water to the radwaste evaporator skids has been isolated permanently. Blank plates have also been installed in the inlets to the evaporators to prevent liquid wastes from entering.

The radwaste monitor tanks collect radwaste demineralizer effluent. The tanks' contents will be mixed and sampled prior to being transferred to the release tank.

Wastewater may be routed from the radwaste monitor tanks to vendor taps in the radwaste building for additional processing, as needed, and returned to the installed radwaste system for monitored discharge.

Based on this sample and station water balance considerations, the water may be reprocessed or discharged via the release tanks.

See Table 11.2-6 for the design-basis average and maximum waste stream flows for the various inputs that are discussed in the following. Also refer to Table 11.1-6 for the realistic source terms for these inputs.

At Byron, effluent from the condensate polisher sump, from the turbine building floor and equipment drains (collected in the turbine building fire and oil sump) and from the waste treatment system is processed by the radwaste system if the contamination exceeds effluent limits for the sumps. The sump effluent is monitored by radiation monitors to ensure that ODCM limits are maintained.

At Braidwood, effluent from the condensate polisher sump and from the turbine building floor and equipment drains is processed by the radwaste system if contamination levels exceed effluent limits. The turbine building fire and oil sump effluent is monitored by a radiation monitor to ensure that ODCM limits are maintained.

At Braidwood, a Radwaste Storage Tank (RST) is used to store and manage the release of radioactive liquid waste containing elevated concentrations of tritium. Based on waste water tritium concentration, influenced by the time period of the fuel cycle of each unit, discharge of the waste water may be delayed and the waste water stored in the RST. The tank’s contents are sampled to determine the degree of processing required prior to transferring the contents to the liquid radwaste release tanks for discharge.

11.2.2.2.1 Auxiliary Building Equipment Drain

Input sources to the auxiliary building equipment drain tanks include the following:

a. auxiliary building equipment drain collection sumps,

b. reactor coolant drain tank, and

c. spent resin tank drains (Braidwood only).

The waste is normally processed through demineralizers.

11.2.2.2.2 Auxiliary Building Floor Drain

Input sources to the floor drain tanks include leakage from pump seals and stuffing boxes, valve stem packing, equipment overflows, and spills. Oil separators are provided in the subsystem's sumps.

Input sources to the auxiliary building floor drain tanks include the following:

a. reactor cavity sumps,

b. containment floor drain sumps,

c. auxiliary building floor drain sumps,

d. fuel handling building floor drain sumps, and

e. radwaste building sump.

The two tanks are sized to accommodate the maximum accumulation of wastes expected in 1 day. The processing flow paths are the same as in the auxiliary building equipment drain.

11.2.2.2.3 Chemical Waste Drain

Input sources to the chemical drain tank and the dual purpose chemical/regeneration drain tank include the following:

a. laboratory drains,

b. fuel handling building decontamination sump,

c. samples containing tritiated water and chemicals required for analysis,

d. drumming station sumps,

e. boric acid processing system,

f. primary water storage tank, and

g. any other high-conductivity radioactive drains.

One tank is provided solely for the chemical drains. A second tank is used as a dual purpose chemical/regeneration waste drain tank. These wastes are processed through a demineralizer.

11.2.2.2.4 Regeneration Waste Drain

Input sources to the regeneration waste drain tank and the dual purpose chemical/regeneration waste drain tank include the following:

a. spent resin sluicing drain header,

b. drumming station decanting tank overflows (Byron only),

c. release tanks (regeneration waste drain tank only), and

d. tendon tunnel sumps (when determined to be a source of radiation contamination into the fire and oil sump).

The blowdown and radwaste mixed bed demineralizers are replaced as often as is required to maintain the demineralizers effluent water quality.

11.2.2.2.5 Laundry Drain

The laundry drain tank collects detergent wastes from the radioactive laundry (Braidwood only), personnel decontamination shower and the TSC drains and showers. These waste streams are sent to the release tanks for release or a radwaste demineralizer for further treatment.

11.2.2.2.6 Turbine Building Equipment Drain

Secondary system drains are divided into turbine building equipment drain and turbine building floor drain. The turbine building equipment drain system can recover a large amount of condensate grade water for station reuse.

Two turbine building equipment drain tanks receive water from the turbine building equipment drain sumps. Since this drain water is from the secondary system, the water in the turbine building equipment drains are normally uncontaminated or only very slightly contaminated. The water is normally treated in the wastewater treatment plant for discharge. There are also flowpaths from the turbine building equipment drain system to the radwaste demineralizers and to the liquid release tank.

At Byron, in the event of excessive leakage of the primary coolant into the secondary system, the water may be processed in the waste treatment plant and returned to the release tank for discharge. At Braidwood, in the event of excessive leakage of the primary coolant into the secondary system, the contaminated water may be processed through the coalescer/carbon filters and through additional filtration as needed and discharged via the release tanks, but normally this flowpath is blocked by a spectacle blank flange.

11.2.2.2.7 Turbine Building Floor Drain

The two turbine building floor drain tanks collect water from the turbine building floor drain sumps, condensate pit sumps, and essential service water sumps. These wastes are normally nonradioactive, except for tritium, and are released to the environment after filtration via the wastewater treatment (TR) system.

11.2.2.2.8 Turbine Building Fire and Oil Sump

Turbine building waste water collected in the fire and oil sump, including equipment and floor drain water, is monitored by a radiation monitor. Water from this sump is normally discharged to the waste treatment system for removal of oil and solids and then released to the environment via the circulating water system and blowdown line. However, if unacceptable radioactive contamination is detected, the sump pumps are automatically stopped and the water may be sent to the liquid radwaste treatment system, via the waste treatment system (Byron only). If the source of radioactive contamination is determined to be one of the tendon tunnel sumps, either tendon tunnel pump discharge can be sent to the regeneration waste drain tank for processing in the radwaste system. The water may be processed by the waste treatment plant and returned to the release tanks for discharge (Byron only).

11.2.2.2.9 Condensate Polisher Sump

Water in the condensate polisher sump is monitored by a radiation monitor on the sump discharge. Water from this sump discharge is normally directed to the circulating water system, and then released to the environment via the blowdown line. If a high radiation signal is detected, pump operation is automatically stopped and major condensate polisher inputs into the sump are automatically isolated. If samples confirm that the water is contaminated, the operator may manually change the valve lineup to send the water to the release tank for a monitored discharge.

11.2.2.2.10 Waste Treatment System

The input to the waste treatment system is the Turbine Building Fire and Oil Sump (see 11.2.2.2.8). Water processed by the waste treatment system is normally released to the environment via the circulating water system and blowdown line. If the radiation monitor on the Turbine Building Fire and Oil Sump should fail, an alarm will be annunciated in the radwaste control room, and the contents of the treated water system would be sampled. If the sample contains radioactive contamination, the system's contents would be pumped to the liquid radwaste system.

11.2.2.3 Operating Procedures

If the contents of a monitor tank are to be released, the required radioactivity analysis is performed prior to transferring the material to the release tank. The liquid is then pumped to a release tank where a sample is again taken and the required analysis is performed. Based on this analysis, the discharge rate is determined so that, when mixed with cooling water blowdown discharges, the water leaving the plant has a radioactivity level less than the applicable effluent concentration as stated in the Technical Specifications. A remotely operated valve with a keylocked switch may then be manually opened so that water can be discharged. The key for the valve lock is controlled by administrative procedures. As a further backup, a radiation detector monitors the liquid in the discharge line prior to the point where the liquid is mixed with the cooling water blowdown to the river. Upon detecting an abnormal level of radiation, a valve on the release tank line immediately upstream of the mixing point closes and an alarm signal is relayed to the control room. A composite sample of the cooling water blowdown is analyzed to verify that radioactive releases conform with the requirements of the Technical Specifications. Records are maintained of radioactive wastes discharged to the environment.

11.2.2.4 Performance Tests

Liquid wastes may be monitored before and after each processing step on a batch basis. The equipment is therefore subjected to continuous performance testing.

Data on specific isotope decontamination factors are not conclusive. This system was designed using conservative overall decontamination factors. These decontamination factors are based on guidelines from References 2, 4, and 5.

Through system cross-ties, redundancy of equipment, and excess storage capacity, ample provision has been made for equipment maintenance and for reprocessing treated effluents if required.

11.2.2.5 Control and Instrumentation

A large portion of the liquid radwaste system is controlled and monitored from the liquid radwaste control panel (LRCP) located in the radwaste control room. Radwaste and blowdown demineralizers and radwaste evaporator control panels and the liquid/solid radwaste interface are also located in the radwaste control room. The solid radwaste handling system control panel is located in the radwaste building.

Some subsystem operations are controlled by automatic sequencers. Instrumentation on radwaste system tanks includes, as a minimum, a high level detector for LRCP annunciation, a low level detector for pump cutoff, and LRCP level recording. The system instrumentation is shown in detail on Drawings M-48-1 through M-48-40.

11.2.3 Radioactive Releases

11.2.3.1 Release Points

All liquid radwaste system effluent paths for radioactive nuclides to the environment are suitably processed, monitored, and recycled or discharged via the release tanks in accordance with procedures outlined in Subsection 11.2.2.3. The radioactive waste release line joins the circulating water blowdown line. Water from the turbine building fire and oil sump, the condensate polisher sump and the treated water system (Subsections 11.2.2.2.8, 11.2.2.2.9 and 11.2.2.2.10), if not unacceptably contaminated, is discharged after suitable treatment into the circulating water flume, and released via the blowdown line.

11.2.3.2 Dilution Factors

At 100% capacity factor and design-basis ambient air conditions, blowdown from the circulating water system serving the two units is approximately 23,000 gpm. On an average annual basis, the circulating water blowdown is expected to be approximately 13,000 gpm, or 2.6×10^{13} cm^3 per year. The annual radionuclide release and the concentration in the cooling tower blowdown line are given in Table 11.2-4.

Circulating water blowdown enters the Rock River approximately 50 yards downstream of the intake structure, so releases do not become entrained in makeup water. The circulating water blowdown warming line to the river screen house is isolated during releases to prevent entraining radionuclides in the circulating water and essential service water makeup lines.

11.2.3.3 Estimated Annual Average Doses

The estimated total annual release of radionuclides in liquid effluents is given in Table 11.2-1. Using an annual dilution volume of 2.6×10^{13} cm^3, the concentration of each nuclide in the cooling tower blowdown line can be determined. This is shown in Table 11.2-4.

Estimated annual average doses to individuals exposed to radioactive liquid effluents were calculated using the methodology of Regulatory Guide 1.109 (Reference 3). Fish consumption, drinking water, and recreational exposure pathways were considered. Annual use factors for these pathways are given in Table 11.2-8.

In order to obtain a conservative estimate of the radiation doses, no radioactive decay or dilution by river water was taken into consideration.

Estimates of doses to the whole body and to different organs are summarized in Table 11.2-3. As explained in Subsection 11.2.1.4, these estimated doses are all within Appendix I to 10 CFR 50 guidelines. Actual release data are available in the effluent release reports, which are prepared in accordance with the ODCM.

11.2.3 Radioactive Releases

11.2.3.1 Release Points

All controlled liquid radwaste system effluent releases of radioactive nuclides to the environment are suitably processed, monitored, and recycled or discharged via the release tanks in accordance with procedures outlined in Subsection 11.2.2.3. The radioactive waste release line joins the cooling pond blowdown line as indicated in Drawing M-48-1. Water from the fire and oil sump, and condensate polisher sump (Subsections 11.2.2.2.8 and 11.2.2.2.9), if not unacceptably contaminated, is discharged, after suitable treatment, into the cooling pond at the circulating water discharge canal, where it mixes with circulating water prior to release via the blowdown line.

Temporary groundwater remediation activities, where contaminated water from the Exelon Pond and surrounding groundwater is pumped into the circulating water blowdown line at Vacuum Breakers 1 and 2, contribute to the inventory of radioactive nuclides released to the environment via the blowdown line. Periodic sampling of the water is used to monitor the radioactivity of the water that is discharged into the blowdown line.

11.2.3.2 Dilution Factors

At 100% capacity factor, blowdown from the cooling lake is expected to be 25,000 gpm on an annual average basis, or 4.98×10^{13} cm^3 per year. The annual radionuclide release and the concentration in the cooling pond blowdown line are given in Table 11.2-4. Blowdown isotope concentrations were calculated using cooling pond blowdown flow of 12,000 gpm, which is the normally expected blowdown flow rate without the use of blowdown booster pumps.

Cooling pond blowdown enters the Kankakee River approximately 50 yards downstream of the intake structure, so that releases do not become entrained in makeup water.

11.2.3.3 Estimated Annual Average Doses

The estimated total annual release of radionuclides in liquid effluents is given in Table 11.2-1. Using an annual dilution volume of 2.4×10^{13} cm^3, the concentration of each nuclide in the discharge canal can be determined. This is shown in Table 11.2-4.

Estimated annual average doses to individuals exposed to radioactive liquid effluents were calculated using the methodology of Regulatory Guide 1.109 (Reference 3). Fish consumption, drinking water, and recreational exposure pathways were considered. Annual use factors for these pathways are given in Table 11.2-8.

In order to obtain a conservative estimate of the radiation doses, no radioactive decay or dilution by river water was taken into consideration.

Estimates of doses to the whole body and to different organs are submitted in Table 11.2-3. As explained in Subsection 11.2.1.4, these estimated doses are all within Appendix I to 10 CFR 50 guidelines. Actual release data are available in the effluent release reports, which are prepared in accordance with the ODCM.

11.2.4 References

1. Regulatory Guide 1.112, "Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from Light Water-Cooled Power Reactors," U.S. Nuclear Regulatory Commission, April 1976.

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

3. Regulatory Guide 1.109, "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I," U.S. Nuclear Regulatory Commission, Revision 1, October 1977.

4. ANSI Standard N199, "Liquid Radioactive Waste Processing System for Pressurized Water Reactor Plants," American National Standards Institute, Inc., 1976.

5. WASH-1258, "Numerical Guides for Design Objectives and Limiting Conditions for Operation to Meet the Criteria 'Low as Practicable' for Radioactive Material in Light-Water-Cooled Nuclear Power Reactor Effluents," U.S. Atomic Energy Commission, 1973.

TABLE 11.2-1

EXPECTED ANNUAL AVERAGE RELEASES OF RADIONUCLIDES IN LIQUID EFFLUENTS

ANNUAL RELEASES TO DISCHARGE CANAL

NUCLIDE	HALF-LIFE (DAYS)	COOLANT CONCENTRATIONS PRIMARY (MICRO CI/ML)	SECONDARY (MICRO CI/ML)	BORON RS (CURIES)	MISC. WASTES (CURIES)	SECONDARY (CURIES)	TURB BLDG (CURIES)	TOTAL LWS (CURIES)	ADJUSTED TOTAL (CI/YR)	DETERGENT WASTES (CI/YR)	TOTAL (CI/YR)
CORROSION AND ACTIVATION PRODUCTS											
CR 51	2.78+01	1.90-03	2.51-07	5.36-06	6.13-09	0.00	2.48-06	7.85-06	6.16-05	0.00	6.16-05
MN 54	3.03+02	3.10-04	6.08-08	9.21-07	1.05-09	0.00	6.05-07	1.53-06	1.20-05	1.00-03	1.01-03
FE 55	9.50+02	1.60-03	2.12-07	4.77-06	5.44-09	0.00	2.11-06	6.89-06	5.40-05	0.00	5.40-05
FE 59	4.50+01	1.00-03	1.55-07	2.88-06	3.29-09	0.00	1.54-06	4.42-06	3.47-05	0.00	3.47-05
CO 58	7.13+01	1.60-02	2.15-06	4.67-05	5.34-08	0.00	2.14-05	6.81-05	5.35-04	4.00-03	4.53-03
CO 60	1.92+03	2.00-03	2.73-07	5.97-06	6.81-09	0.00	2.72-06	8.69-06	6.82-05	8.70-03	8.77-03
ZR 95	6.50+01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.40-03	1.40-03
NB 95	3.50+01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00.03	2.00-03
NP 239	2.35+00	1.20-03	1.23-07	1.82-06	2.32-09	0.00	1.14-06	2.96-06	2.32-05	0.00	2.32-05
FISSION PRODUCTS											
BR 83	1.00-01	4.80-03	1.26-07	2.11-09	2.69-09	0.00	2.24-06	2.24-06	1.76-05	0.00	1.76-05
RB 86	1.87+01	8.50-05	1.40-08	5.83-06	1.34-08	0.00	1.38-07	5.98-06	4.69-05	0.00	4.69-05
SR 89	5.20+01	3.50-04	6.17-08	1.01-06	1.16-09	0.00	6.13-07	1.63-06	1.28-05	0.00	1.28-05
MO 99	2.79+00	8.40-02	1.19-05	1.42-04	1.76-07	0.00	1.11-04	2.53-04	1.98-03	0.00	1.98-03
TC 99M	2.50-01	4.80-02	2.18-05	1.35-04	1.65-07	0.00	1.58-04	2.94-04	2.31-03	0.00	2.31-03
RU 103	3.96+01	4.50-05	6.21-09	1.29-07	1.48-10	0.00	6.16-08	1.91-07	1.50-06	1.40-04	1.41-04
RU 106	3.67+02	1.00-05	1.52-09	2.97-08	3.39-11	0.00	1.51-08	4.49-08	3.52-07	2.40-03	2.40-03
AG 110M	2.53+02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.40-04	4.40-04
TE 127	3.92-01	8.50-04	1.31-07	8.46-07	1.24-09	0.00	9.37-07	1.78-06	1.40-05	0.00	1.40-05
TE 129M	3.40+01	1.40-03	1.87-07	3.99-06	4.56-09	0.00	1.85-06	5.85-06	4.59-05	0.00	4.59-05
TE 129	4.79-02	1.60-03	5.39-07	2.56-06	2.94-09	0.00	1.30-06	3.86-06	3.03-05	0.00	3.03-05
I 130	5.17-01	2.10-03	1.53-07	2.95-06	1.18-08	0.00	1.09-05	1.38-05	1.09-04	0.00	1.09-04
TE 131M	1.25+00	2.50-03	2.39-07	2.10-06	3.24-09	0.00	2.07-06	4.17-06	3.27-05	0.00	3.27-05
I 131	8.05+00	2.70-01	3.72-05	6.62-03	7.69-06	0.00	3.63-03	1.03-02	8.04-02	6.20-05	8.05-02
TE 132	3.25+00	2.70-02	3.07-06	4.94-05	6.02-08	0.00	2.90-05	7.85-05	6.16-04	0.00	6.16-04
I 132	9.58-02	1.00-01	9.32-06	5.11-05	3.47-07	0.00	1.77-04	2.28-04	1.79-03	0.00	1.79-03
I 133	8.75-01	3.80-01	3.43-05	1.85-03	3.65-06	0.00	2.80-03	4.66-03	3.66-02	0.00	3.66-02
CS 134	7.49+02	2.50-02	4.01-06	1.86-03	4.25-06	0.00	3.99-05	1.91-03	1.50-02	1.30-02	2.80-02
I 135	2.79-01	1.90-01	9.96-06	2.10-05	5.10-07	0.00	5.33-04	5.54-04	4.35-03	0.00	4.35-03
CS 136	1.30+01	1.30-02	1.78-06	8.59-04	1.98-06	0.00	1.75-05	8.79-04	6.89-03	0.00	6.89-03
CS 137	1.10+04	1.80-02	2.67-06	1.34-03	3.06-06	0.00	2.65-05	1.37-03	1.08-02	2.40-02	3.48-02
BA 137M	1.77-03	1.60-02	7.67-06	1.26-03	2.87-06	0.00	2.48-05	1.29-03	1.01-02	0.00	1.01-02
CE 144	2.84+02	3.30-05	6.08-09	9.80-08	1.12-10	0.00	6.05-08	1.59-07	1.24-06	5.20-03	5.20-03
ALL OTHERS		2.53-01	2.02-06	3.69-06	7.27-09	0.00	2.84-06	6.54-06	5.13-05	0.0	5.13-05
TOTAL (EXCEPT TRITIUM)		1.46+00	1.50-04	1.43-02	2.49-05	0.00	7.60-03	2.19-02	1.72-01	6.23-02	2.34-01

TRITIUM RELEASE 300 CURIES PER YEAR (BYRON), 750 CURIES PER YEAR (BRAIDWOOD)

TABLE 11.2-2

PARAMETERS USED IN THE GALE-PWR COMPUTER PROGRAM
(ORIGINAL & UPRATED) - NOTE 1

1)	Reactor type	PWR
2)	Thermal power level (MWt)	3565.0 (3586.6)
3)	Mass of coolant in the primary system (10^6 gms)	242 (247.7)
4)	Primary system letdown rate (gpm)	75.0
5)	Letdown cation demineralizer flow (gpm)	7.5
6)	Number of steam generators	4.0
7)	Total steam flow (10^6 lb/hr)	15.0 (16.04)
8)	Mass of steam in each steam generator (10^3 lb)	9.1 (6.039)
9)	Mass of liquid in each steam generator (10^3 lb)	117.0 (114.465)
10)	Total mass of secondary coolant (10^3 lb)	2023.0
11)	Steam generator blowdown rate (10^3 lb/hr)	30.0
	The steam generator blowdown is recycled to the condensate system after treatment in the blowdown system. Condensate demineralizers are not used.	
12)	Condensate demineralizer regeneration time (days)	0.0
13)	Fraction of feedwater through the condensate demineralizers	0.0
14)	Annual average liquid radwaste dilution flow (10^3 gpm)	
	Cooling tower blowdown, Byron	13.0
	Cooling lake blowdown, Braidwood	12.0*
15)	Shim bleed rate (gpd)	2160.0
16)	Decontamination Factors for the shim bleed system:	
	Iodine - 10^3, Cesium - 2 x 10^3, Others - 10^4	

TABLE 11.2-2 (Cont'd)

17)	Shim bleed system - Collection time (days)	0.60
	Processing time (days)	2.00
	Fraction discharged	0.10
18)	Equipment drains input (gpd)	2800.0
	Fraction of primary coolant activity	0.005
19)	Decontamination Factors for Equipment Drains Processing:	
	Iodine - 10^5, Cesium - 2 x 10^4, Others - 10^6	
20)	Equipment drains - Collection time (days)	2.30
	Processing time (days)	0.15
	Fraction discharged	0.10
21)	Clean waste input (gpd)	2800.0
	Fraction of primary coolant activity	0.002
22)	Decontamination Factors for Clean Waste Processing:	
	Iodine - 10^5, Cesium - 2 x 10^4, Others - 10^6	
23)	Clean waste - Collection time (days)	2.30
	Processing time (days)	0.15
	Fraction discharged	0.10
24)	Dirty wastes input (gpd)	2800.0
	Fraction of primary coolant activity	0.0068
25)	Decontamination Factors for Dirty Waste Processing:	
	Iodine - 10^5, Cesium - 2 x 10^4, Others - 10^6	
26)	Dirty wastes - Collection time (days)	4.60
	Processing time (days)	0.11
	Fraction discharged	0.10
27)	Blowdown fraction processed	1.00
28)	Decontamination Factors for Blowdown Processing:	
	Iodine - 10^2, Cesium - 10, Others - 10^2	
29)	Blowdown - Collection time (days)	0.03
	Processing time (days)	0.03
	Fraction discharged	0.10

TABLE 11.2-2 (Cont'd)

30)	Condensate demineralizer regenerant flow (gpd)	0.00
31)	Decontamination Factors for Regenerant Processing: Iodine - 1.0, Cesium - 1.0, Others - 1.0	
32)	Regenerant - Collection time (days)	0.00
	Processing time (days)	0.00
	Fraction discharged	0.00
33)	There is not continuous stripping of full letdown flow.	
34)	Holdup time for xenon (days)	45.0
35)	Holdup time for krypton (days)	45.0
36)	Fill time for gas decay tanks (days)	43.0
37)	The waste gas system does not have a HEPA filter.	
38)	The auxiliary building vent system does have a HEPA filter, but it does not have a charcoal filter.	
39)	Containment volume (10^6 ft^3)	2.9
40)	Containment atmosphere cleanup rate (10^3 cfm)	16.0
41)	The containment shutdown purge line has a HEPA filter, but it does not have a charcoal filter.	
42)	There is no continuous low volume purge of the containment.	
43)	There is no blowdown tank vent.	
44)	Fraction of iodine released from the main condenser air ejector **	1.00**
45)	Reciprocal of the detergent waste processing decontamination factor	1.00

TABLE 11.2-2 (Cont'd)

___

* Original design and without the use of CW blowdown booster pumps installed at Braidwood.

** The Off-Gas filter unit does not provide an Iodine removal mechanism. The iodine removal capability of the Off-Gas system has been evaluated for this condition and the off gas flow bypassing charcoal filter found acceptable, per calculation BRW-99-0468-M (Braidwood) / BYR16-012 (Byron).

Note 1: Parameters that changed due to uprate are presented in ().

TABLE 11.2-3

PATHWAYS DOSES FROM LIQUID EFFLUENTS

(BYRON)

EXPOSURE PATHWAY	ORGAN	DOSE (mrem/yr/unit)[1]
Drinking Water		
	Whole Body	7.36×10^{-1}
	GI-LLI	6.87×10^{-1}
	Thyroid	$3.49 \times 10^{+0}$
	Bone	7.03×10^{-2}
Fish Consumption		
	Whole Body	4.54×10^{-1}
	GI-LLI	7.43×10^{-2}
	Thyroid	1.03×10^{-1}
	Bone	3.4×10^{-1}
Shoreline Recreation		
	Skin	9.15×10^{-3}
	Whole Body	7.83×10^{-3}
Swimming & Boating		
	Skin	3.38×10^{-4}
	Whole Body	2.56×10^{-4}

[1]All activities are assumed to take place in the discharge canal. No credit is taken for dilution of effluents in the Rock River.

TABLE 11.2-3

PATHWAYS DOSES FROM LIQUID EFFLUENTS

(BRAIDWOOD)

EXPOSURE PATHWAY	ORGAN	DOSE (mrem/yr/unit)[2]
Drinking Water		
	Whole Body	9.88×10^{-1}
	GI-LLI	9.22×10^{-1}
	Thyroid	$4.69 \times 10^{+0}$
	Bone	9.44×10^{-2}
Fish Consumption		
	Whole Body	6.09×10^{-1}
	GI-LLI	9.97×10^{-2}
	Thyroid	1.38×10^{-1}
	Bone	4.67×10^{-1}
Shoreline Recreation		
	Skin	1.23×10^{-2}
	Whole Body	1.05×10^{-2}
Swimming and Boating		
	Skin	4.53×10^{-4}
	Whole Body	3.42×10^{-4}

[2] All activities are assumed to take place in the discharge canal. No credit is taken for dilution of effluents in the Kankakee River.

TABLE 11.2-4

COMPARISON OF EXPECTED LIQUID EFFLUENT CONCENTRATIONS TO 10 CFR 20 LIMITS

ISOTOPE	EXPECTED* RELEASE (Ci/yr/unit)	BLOWDOWN** CONCENTRATION (μci/ml)	10 CFR 20 LIMIT*** (μCi/ml)
H 3	3.00+02	1.16-05	3.00-03
Cr 51	6.20-05	2.39-12	2.00-03
Mn 54	1.00-03	3.86-11	1.00-04
Fe 55	5.40-05	2.08-12	8.00-04
Fe 59	3.50-05	1.35-12	5.00-05
Co 58	4.50-03	1.74-10	9.00-05
Co 60	8.80-03	3.40-10	3.00-05
Br 83	1.80-05	6.59-13	3.00-06
Rb 86	4.70-05	1.81-12	2.00-05
Sr 89	1.30-05	5.02-13	3.00-06
Zr 95	1.40-03	5.40-11	6.00-05
Nb 95	2.00-03	7.72-11	1.00-04
Mo 99	2.00-03	7.72-11	4.00-05
Tc 99m	2.30-03	8.88-11	3.00-03
Ru 103	1.40-04	5.40-12	8.00-05
Ru 106	2.40-03	9.26-11	1.00-05
Ag 110m	4.40-04	1.70-11	3.00-05
Te 127	1.40-05	5.40-13	2.00-04
Te 129m	4.60-05	1.78-12	2.00-05
Te 129	3.00-05	1.16-12	8.00-04
Te 131m	3.30-05	1.27-12	4.00-05
Te 132	6.20-04	2.39-11	2.00-05
I 130	1.10-04	4.24-12	3.00-06
I 131	8.00-02	3.09-09	3.00-07
I 132	1.80-03	6.95-11	8.00-06
I 133	3.70-02	1.43-09	1.00-06
I 135	4.30-03	1.66-10	4.00-06
Cs 134	2.80-02	1.08-09	9.00-06
Cs 136	6.90-03	2.66-10	9.00-05
Cs 137	3.50-02	1.35-09	2.00-05
Ce 144	5.20-03	2.01-10	1.00-05
Np 239	2.30-05	8.88-13	1.00-04

* Calculated using the PWR-GALE computer program described in NUREG-0017. The actual data are available in the effluent release reports, which are prepared in accordance with the ODCM.

** Annual average cooling tower blowdown = 29.0 cfs.

*** Limits used in the comparison are those that were in effect at the time of the analysis.

TABLE 11.2-4

COMPARISON OF EXPECTED LIQUID EFFLUENT CONCENTRATIONS TO 10 CFR 20 LIMITS

ISOTOPE	EXPECTED* RELEASE (Ci/yr/unit)	BLOWDOWN** CONCENTRATION (μCi/ml)	10 CFR 20 LIMIT*** (μCi/ml)
H 3	7.50+02	3.88-05	3.00-03
Cr 51	6.20-05	3.21-12	2.00-03
Mn 54	1.00-03	5.18-11	1.00-04
Fe 55	5.40-05	2.80-12	8.00-04
Fe 59	3.50-05	1.81-12	5.00-05
Co 58	4.50-03	2.33-10	9.00-05
Co 60	8.80-03	4.56-10	3.00-05
Br 83	1.80-05	9.33-13	3.00-06
Rb 86	4.70-05	2.44-12	2.00-05
Sr 89	1.30-05	6.74-13	3.00-06
Zr 95	1.40-03	7.25-11	6.00-05
Nb 95	2.00-03	1.04-10	1.00-04
Mo 99	2.00-03	1.04-10	4.00-05
Tc 99m	2.30-03	1.19-10	3.00-03
Ru 103	1.40-04	7.25-12	8.00-05
Ru 106	2.40-03	1.24-10	1.00-05
Ag 110m	4.40-04	2.28-11	3.00-05
Te 127	1.40-05	7.25-13	2.00-04
Te 129m	4.60-05	2.38-12	2.00-05
Te 129	3.00-05	1.55-12	8.00-04
Te 131m	3.30-05	1.71-12	4.00-05
Te 132	6.20-04	3.21-11	2.00-05
I 130	1.10-04	5.70-12	3.00-06
I 131	8.00-02	4.14-09	3.00-07
I 132	1.80-03	9.33-11	8.00-06
I 133	3.70-02	1.92-09	1.00-06
I 135	4.30-03	2.23-10	4.00-06
Cs 134	2.80-02	1.45-09	9.00-06
Cs 136	6.90-03	3.57-10	9.00-05
Cs 137	3.50-02	1.81-09	2.00-05
Ce 144	5.20-03	2.69-10	1.00-05
Np 239	2.30-05	1.19-12	1.00-04

* Calculated using the PWR-GALE computer program described in NUREG-0017 (Except H-3. Tritium value is based on actual data.) The actual data are available in the effluent release reports, which are prepared in accordance with the ODCM.

** Annual average cooling lake blowdown = 13.4 cfs per unit. Original design and without the use of CW blowdown booster pumps installed at Braidwood.

*** Limits used in the comparison are those that were in effect at the time of the analysis.

TABLE 11.2-5

LIQUID RADWASTE SYSTEM COMPONENTS AND DESIGN PARAMETERS PER STATION

	EQUIPMENT	DESIGN PRESSURE (psig)	DESIGN TEMP (°F)	CAPACITY	NUMBER	MATERIALS OF CONSTRUCTION
I.	Blowdown mixed bed demineralizers	150	110	283 gpm*	4	316-SS
II.	Radwaste mixed bed demineralizers	150	110	45 gpm	3	316-SS
III.	Cartridge filters:					
	1. Chemical drain	150	140	130 gpm	1	316-SS
	2. Regeneration waste drain	150	140	130 gpm	1	316-SS

* Hydraulic limit. The kinetic limit will vary based on resin types and water chemistry.

TABLE 11.2-5 (Cont'd)

	EQUIPMENT	DESIGN PRESSURE (psig)	DESIGN TEMP (°F)	CAPACITY	NUMBER	MATERIALS OF CONSTRUCTION
3.	Blowdown prefilters (Byron)	250	120	360 gpm	4	Housing shell - 304-SS internal components - 316-SS
	Blowdown prefilters (Braidwood)	150	250	250 gpm	4	Housing shell - carbon steel internal components - 304-SS
4.	Blowdown after-filters	150	140	250 gpm	4	304-SS
5.	Auxiliary Bldg. floor drains	150	180	250 gpm	1	304-SS
6.	Auxiliary Bldg. equipment drain	150	180	250 gpm	1	304-SS
7.	Turbine Bldg. floor drains	150	140	130 gpm	1	304-SS
8.	Turbine Bldg. equipment drains	150	180	130 gpm	1	304-SS
9.	Laundry drain	150	180	130 gpm	1	304-SS
10.	Radwaste deminer-alizer afterfilter	150	180	250 gpm	3	304-SS

TABLE 11.2-5 (Cont'd)

	EQUIPMENT	DESIGN PRESSURE (psig)	DESIGN TEMP (°F)	CAPACITY	NUMBER	MATERIALS OF CONSTRUCTION
VI.	Tanks:					
1.	Chemical drain	Atmos.	200	6,000 gal	1	304-SS
2.	Dual Purpose Chemical/Regeneration waste Drain	Atmos.	200	10,000 gal	1	304-SS

TABLE 11.2-5 (Cont'd)

	EQUIPMENT	DESIGN PRESSURE (psig)	DESIGN TEMP (°F)	CAPACITY	NUMBER	MATERIALS OF CONSTRUCTION
3.	Regeneration waste Drain	Atmos.	200	30,000 gal (Byron) 20,000 gal (Braidwood)	1	304-SS
4.	Auxiliary Bldg. equipment drain	50	200	8,000 gal	2	304-SS
5.	Auxiliary Bldg. floor drain	Atmos.	150	8,000 gal	2	304-SS
6.	Turbine Bldg. equipment drain	Atmos.	130	12,000 gal	2	C.S.
7.	Turbine Bldg. floor drain	Atmos.	150	12,000 gal	2	C.S.
8.	Laundry drain	Atmos.	200	4,000 gal	1	C.S.
9.	Laundry drain storage	Atmos.	130	2,000 gal	2	C.S.
10.	Blowdown monitor	Atmos.	150	20,000 gal	3	304-SS
11.	Radwaste monitor	Atmos.	150	20,000 gal	2	304-SS
12.	Release	Atmos.	150	30,000 gal	2	304-SS

TABLE 11.2-5 (Cont'd)

	EQUIPMENT	DESIGN PRESSURE (psig)	DESIGN TEMP (°F)	CAPACITY	NUMBER	MATERIALS OF CONSTRUCTION
13.	Concentrates (Byron) holding	Atmos.	250	6,400 gal	1	316L-SS
14.	Spent Resin (Byron)	125	120	5,000 gal	1	304-SS
15.	Low Activity Spent Resin (Braidwood)	15	120	6,400 gal	1	316L-SS
16.	High Activity Spent Resin (Braidwood)	125	120	5,000 gal	1	304-SS
17.	Radwaste Storage Tank (Braidwood)	Atmos.	120	500,000 gal	1	304L-SS

TABLE 11.2-5 (Cont'd)

	EQUIPMENT	CAPACITY	DISCHARGE HEAD (ft)	NUMBER	MATERIALS OF CONSTRUCTION
VII.	Pumps:				
1.	Chemical drain tank	60 gpm	235	2	316-SS
2.	Dual purpose chemical/ Regeneration waste drain tank	60 gpm	235	2	316-SS
3.	Regeneration waste drain tank	60 gpm	235	2	316-SS
4.	Auxiliary Bldg. equip. drain tank	60 gpm	235	2	304-SS
5.	Auxiliary Bldg. floor drain tank	60 gpm	235	2	304-SS
6.	Turbine Bldg. equip. drain tank	90 gpm	235	2	304-SS
7.	Turbine Bldg. floor drain tank	90 gpm	235	2	304-SS
8.	Laundry drain tank	30 gpm	200	1	C.S.
9.	Laundry drain storage tank	25 gpm	150	2	C.S.
10.	Blowdown monitor tank	350 gpm	175	3	304-SS
11.	Radwaste monitor tank	350 gpm	175	2	304-SS

TABLE 11.2-5 (Cont'd)

	EQUIPMENT	CAPACITY	DISCHARGE HEAD (ft)	NUMBER	MATERIALS OF CONSTRUCTION
12.	Release tank	500 gpm	100	2	304-SS
13.	Blowdown condenser	180 gpm	1050	4	304-SS
14.	Spent resin (Byron)	120 gpm	115	2	ACI CD4MCu-SS
15.	Spent resin (Braidwood)	65 gpm	175	2	BUNA N, 316-SS
16.	Radwaste Storage Recirculating Pump (Braidwood)	150 gpm	65	1	316-SS
17.	Brine Tank Transfer Pump (Braidwood)	200 gpm	100	1	316-SS

NOTE: Radwaste Evaporator Components have been intentionally deleted from this table. Braidwood and Byron stations do not intend to use this equipment.

TABLE 11.2-6

DESIGN-BASIS ANNUAL AVERAGE AND MAXIMUM WASTE STREAM FLOWS

(Two Units)

WASTE INPUT SOURCES	AVERAGE DAILY FLOW (gpd)	MAXIMUM DAILY FLOW (gpd)
Steam generator blowdown	259,200*	604,800**
Auxiliary building equipment drain	5,600	16,000
Auxiliary building floor drain	5,600	16,000
Chemical waste drain	2,100	6,000
Laundry drain	1,400	4,000
Turbine building equipment drain	4,200	12,000
Turbine building floor drain	4,200	12,000
Condensate polisher	25,300	90,700
Turbine building fire and oil sump	62,000	150,000
Waste treatment system	36,300	56,900

* Based on average of 28 days primary to secondary leakage (1956 gpm/two units), 28 days condenser to secondary leakage (420 gpm/two units) and 309 days of normal operation (120 gpm/two units).

** Based on condenser to secondary leakage of 420 gpm/two units.

TABLE 11.2-7

DESIGN-BASIS PROCESS DECONTAMINATION FACTORS

ELEMENT	FILTERS		CLEAN WASTE DEMINERALIZERS	BLOWDOWN DEMINERALIZERS	EVAPORATORS	EVAPORATORS DISTILLATE DEMINERALIZERS
	(A)	(B)				
H	1	1	1	1	1	1
Cr	10	1	100	100	10^4	10
Mn	10	1	100	100	10^4	10
Fe	10	1	100	100	10^4	10
Co	10	1	100	100	10^4	10
Br	1.0	1	100	100	10^4	10
Kr	1	1	1	1	1	1
Rb	1.0	1	2	10	10^4	10
Sr	1.0	1	100	100	10^4	10
Y	1.0	1	100	100	10^4	10
Zr	10	1	100	100	10^4	10
Nb	10	1	100	100	10^4	10
Mo*	10	1	100	100	10^4	10
Tc*	1.0	1	100	100	10^4	10
Ru	1.0	1	100	100	10^4	10
Rh	1.0	1	100	100	10^4	10
Te	1.0	1	100	100	10^4	10
I	1.0	1	100	100	10^3	10
Xe	1	1	1	1	1	1
Cs	1.0	1	2	10	10^4	10
Ba	1.0	1	100	100	10^4	10

TABLE 11.2-7 (Cont'd)

ELEMENT	FILTERS (A)	FILTERS (B)	CLEAN WASTE DEMINER-ALIZERS	BLOWDOWN DEMINER-ALIZERS	EVAPORATORS	EVAPORATORS DISTILLATE DEMINER-ALIZERS
La	1.0	1	100	100	10^4	10
Ce	1.0	1	100	100	10^4	10
Pr	1.0	1	100	100	10^4	10
Np	1.0	1	100	100	10^4	10

Basis for Decontamination Factors:

1. Filters:
   (A) Is used for filter source term calculations only.
   (B) Is used for other calculations. (Table 1-3, NUREG-0017, PWR GALE)
2. (A) Radwaste Demineralizers:
   (Table 1-3, NUREG-0017, PWR GALE and Table 1 ANSI N199-1976)
   (B) Blowdown Demineralizers
   (Table 1-3, NUREG-0017, PWR GALE)
3. Evaporators:
   (Table 1-3, NUREG-0017, PWR GALE and Table 1 ANSI N199-1976)
4. Evaporator Distillate Demineralizers:
   (Table 1-3, NUREG-0017, PWR GALE)

TABLE 11.2-8

CONSUMPTION FACTORS FOR THE MAXIMUM EXPOSED INDIVIDUAL

PATHWAY	CHILD	TEEN	ADULT	UNITS
Fruits, vegetables and grains*	520.0	630.0	520.0	kg/yr
Leafy vegetables**	26	42	64	kg/yr
Milk**	330	400	310	l/yr
Meat and poultry**	41	65	110	kg/yr
Sport fish**	6.9	15.8	21	kg/yr
Drinking water**	508	508	728	l/yr
Shoreline activities***	-	-	15.0	hr/yr
Boating/swimming***	-	-	29.0/6.0	hr/yr
Inhalation*,**	3700.0	8000.0	8000.0	m^3/yr

1400.0 (Infant)

* From Regulatory Guide 1.109, Table E-5 (Reference 3).

** From Offsite Dose Calculation Manual, Revision 1.2, Table D-10.

*** From HERMES as used in Zion Station annual and semiannual reports on station radioactive waste, environmental monitoring, and occupational personnel radiation exposure.

TABLE 11.2-9

SUMMARY OF TANK LEVEL INDICATION, ANNUNCIATORS, AND OVERFLOWS
FOR TANKS OUTSIDE OF CONTAINMENT POTENTIALLY CONTAINING RADIOACTIVE LIQUIDS

TANK	LEVEL INDICATOR AND/OR RECORDER LOCATION	ANNUNCIATOR	OVERFLOW TO
Primary Water Storage	Main Control Room* Radwaste Control Panel	AL, AH, AHH None	Turbine Building Equipment Drains Sump
Condensate Storage	Main Control Room* Radwaste Control Panel Makeup Demineralizer Panel	AL, AH None AL, AH	Turbine Building Equipment Drains Sump
Turbine Building Equipment Drain	Radwaste Control Panel	AL, AH	None
Turbine Building Floor Drain	Radwaste Control Panel	AL, AH	None
Chemical Drain	Radwaste Control Panel	AL, AH	None
Chemical/Regeneration Waste Drain	Radwaste Control Panel	AL, AH	None
Regeneration Waste Drain	Radwaste Control Panel	AL, AH	Auxiliary Building Floor Drain System*
Auxiliary Building Equipment Drain	Radwaste Control Panel	AL, AH	None
Auxiliary Building Floor Drain	Radwaste Control Panel	AL, AH	None

TABLE 11.2-9 (Cont'd)

TANK	LEVEL INDICATOR AND/OR RECORDER LOCATION	ANNUNCIATOR	OVERFLOW TO
Laundry Drain	Radwaste Control Panel	AL, AH	None
Laundry Waste Storage	Radwaste Control Panel	AL, AH	Auxiliary Building Equipment Drains Sump
Blowdown Monitor	Radwaste Control Panel	AL, AH	Turbine Building Equipment Drains Sump
Radwaste Monitor	Radwaste Control Panel	AL, AH	Auxiliary Building Equipment Drains Sump
Release	Radwaste Control Panel	AL, AH	Regeneration Waste Drain Tank or Auxiliary Building Floor Drain System*
Concentrates Holding (Byron)	Radwaste Control Panel	AL, AH	None
Spent Resin (Byron)	Radwaste Control Panel	AL, AH	None
Decant (Byron)	Solid Radwaste Panel	AL, AH	Regeneration Waste Drain Tank
Vacuum Deaerator Catch	Radwaste Control Panel	AL, AH	None
High Activity Spent Resin (Braidwood)	Radwaste Control Panel	AHH	None

TABLE 11.2-9 (Cont'd)

TANK	LEVEL INDICATOR AND/OR RECORDER LOCATION	ANNUNCIATOR	OVERFLOW TO
Low Activity Spent Resin (Braidwood)	Radwaste Control Panel	AHH	None
Auxiliary Building Borated Equipment Drain	Radwaste Control Panel	AL, AH	None
Auxiliary Building Waste Oil Collection	Local	AH (Radwaste Panel)	None
Refueling Water Storage	Main Control Room*	AH, AL, ALL, ALLL	Recycle Holdup Tank
Volume Control	Main Control Room* Local	AH, AL None	None
Recycle Holdup	Main Recycle Panel Local	AH, AL None	None
Boric Acid	Main Control Room* Local	AH, AL None	Auxiliary Building Equipment Drains
Boric Acid Batching	Local	AH, AL (Main Control Room)	Recycle Holdup Tank
Radwaste Storage (Braidwood)	Radwaste Control Panel	AL, ALL, AH, AHH	3000 gal overflow tank

TABLE 11.2-9 (Cont'd)

TANK	LEVEL INDICATOR AND/OR RECORDER LOCATION	ANNUNCIATOR	OVERFLOW TO
Boric Acid Monitor	Boron Recovery Panel Local	AH, AL None	Auxiliary Building Equipment Drains

NOTES:

AL - Alarm Low
ALL - Alarm Low Low
ALLL - Alarm Low Low Low

AH - Alarm High
AHH - Alarm High High
*General Services Panel

11.3 GASEOUS WASTE MANAGEMENT SYSTEMS

This section describes the capabilities of the plant to collect, process, store, and dispose of gaseous radioactive wastes generated as a result of normal operation including anticipated operation occurrences. Total gaseous releases from the plant for normal operation, including anticipated operational occurrences, and the resulting offsite doses are also included. Design and operating features of the gaseous waste processing system (GWPS) are presented. Appropriate chapters for other systems which may handle radioactive gases are referenced.

11.3.1 Design Bases

Radioactive gaseous treatment systems are designed to ensure that the total plant gaseous release is as low as reasonably achievable and meet the requirements of Appendix I of 10 CFR 50. The systems have adequate capacity and redundancy to meet discharge concentration limits of 10 CFR 20 during periods of design-basis fuel leakage. In compliance with General Design Criterion 64 all gaseous effluent discharge paths are monitored for radioactivity.

The GWPS meets the requirements of General Design Criterion 60 by providing long-term holdup capacity, thus precluding the release of radioactive effluents during unfavorable environmental conditions. (See Section 3.1 for a discussion of General Design Criteria.) Component design parameters for the GWPS are given in Tables 11.3-1 and 11.3-2. Design codes and seismic design requirements are also supplied in Chapter 3.0. The protection of plant personnel is considered in component design and system layout. The GWPS is not designed explosion-proof but rather is supplied with instrumentation, particularly hydrogen and oxygen monitors, to preclude the buildup of an explosive mixture.

The gaseous radwaste system meets all of the code criteria specified in Regulatory Guide 1.143. Additional design bases for plant ventilation systems and condenser evacuation system are given in Sections 9.4 and 10.4, respectively.

11.3.2 System Description

11.3.2.1 System Design

The gaseous waste processing system (GWPS) processes hydrogen stripped from the reactor coolant and nitrogen from the closed cover gas system. The components connected to the GWPS are limited to those which contain no air or aerated liquids in order to prevent accumulation of oxygen in the system. Further, the GWPS is maintained at a pressure above atmospheric to avoid intrusion of air. The system is not designed for the addition of oxygen in order to recombine oxygen and hydrogen; therefore, no control functions are associated with the oxygen monitor. Hence, the GWPS will normally not contain oxygen and special design precautions are taken in order to avoid unintentional intrusion of oxygen.

The GWPS has two independent gas analyzing systems. One is a sequencing hydrogen and oxygen monitoring loop (At Byron, the system has a manual switch to select the sample points) which can sample the gas decay tanks and/or the components connected to the GWPS. The other gas analyzing system is an oxygen monitor that samples the waste gas compressor discharge to the inservice gas decay tank. Both gas analyzing systems have independent high oxygen concentration alarms at 2%, which annunciate at the local panel, as well as in the radwaste control room. In addition, each gas analyzing system provides locations at which manual grab samples may be taken.

During normal GWPS operation, the gas analyzers monitor the contents of the inservice gas decay tank and the waste gas compressor discharge for hydrogen and oxygen concentrations. Any high oxygen concentration entering the GWPS will be sensed by the compressor discharge analyzer which will alarm so that corrective actions can be taken before the contents of the gas decay tank exceed the limits for explosive gas mixtures. The sequencing analyzer system can be utilized (At Byron, the selector switch allows selection of sample point) to determine the source of the high oxygen and hydrogen concentrations.

Based on the above, the two analyzer system provides adequate prevention of explosive gas mixtures in the GWPS.

The gaseous waste processing system consists of two waste-gas compressor packages, six gas decay tanks, and the associated piping, valves and instrumentation. The equipment serves both units. The system is shown on the piping and instrumentation diagram Drawing M-69 and the process flow diagram Figure 11.3-2.

Table 11.3-3 gives process parameters for key locations in the system.

The bases used for estimating the process parameters are given in Table 11.3-4.

Gaseous wastes are received from the following: degassing of the reactor coolant and purging of the volume control tank prior to a cold shutdown; displacing of cover gases caused by liquid accumulation in the tanks connected to the vent header; purging of some equipment; sampling and gas analyzer operation; and operating the boron recycle system.

Auxiliary Services

The auxiliary services portion of the gaseous waste processing system consists of an automatic gas analyzer and its instrumentation, valves, and tubing; and a nitrogen and a hydrogen supply manifold with the necessary instrumentation, valves, and piping.

The automatic (At Byron, the waste) gas analyzer may be used to determine the quantity of oxygen and hydrogen in the volume control tanks, pressurizer relief tanks, boron recycle holdup tanks, boron recycle evaporators, gas decay tanks, reactor coolant drain tanks, and spent resin storage tank, and provides an alarm on high oxygen concentration.

The nitrogen and hydrogen supply packages are designed to provide a supply of gas to the nuclear steam supply system. Two headers are provided for nitrogen supply: one low pressure for normal operation, which is supplied by a bulk liquid nitrogen tank, and one high pressure consisting of 36 high pressure cylinders for backup. When the operating header is exhausted, an alarm alerts the operator and the backup high pressure header is valved in through a pressure regulator to supply gas.

Low pressure nitrogen is supplied to the following components: spent resin storage tank, pressurizer relief tank, volume control tank, spray additive tanks, gas decay tanks, radwaste evaporators, hydrogen recombiners, reactor coolant drain tank, recycle holdup tank, and containment electrical penetrations. At Byron, low pressure nitrogen is also supplied to the primary water storage tanks. Makeup nitrogen for the safety injection accumulators during normal operation is supplied from the high pressure backup header.

In addition, there is a truck fill connection in the nitrogen supply header for the direct filling of the safety injection accumulators and the high pressure cylinder backup manifold.

Hydrogen is supplied at pressures between 100 and 125 psig for the volume control tank. The hydrogen system is described in Chapter 10.

The design and material of valves and manifolds are the same as for the main GWPS.

Plant Ventilation Systems

Plant ventilation systems are described in Chapter 9.0.

Steam and Power Conversion Systems

The main condenser evacuation system and the turbine gland sealing system may be potential sources of gaseous radioactive effluents. These systems are described in Section 10.4.

11.3.2.2 Component Design

GWPS equipment parameters are given in Table 11.3-2. Component ASME Code, seismic design and quality assurance requirements for all components in the GWPS are shown in Table 3.2-1. These design and quality assurance requirements meet the NRC Branch Technical Position ETSB11-1. Source terms for component shielding and failure are provided in Section 11.1. Westinghouse experiences, general practices, and recommendations with respect to controlling occupational radiation exposure are given in Reference 1.

Waste Gas Compressors

The two waste gas compressors are provided for the removal of gases discharging to the vent header. One unit is supplied for normal operation and is capable of handling the gas from a holdup tank which is receiving letdown flow at the maximum rate. The second unit is provided for backup during peak load conditions, such as when degassing the reactor coolant, or for service when the first unit is down for maintenance.

The compressors are of the liquid seal rotary type and are provided with mechanical seals.

Gas Decay Tanks

Six tanks are provided to hold radioactive waste gases for decay.

The tanks are the vertical cylindrical type and are constructed of carbon steel.

Valves

The valves handling gases are carbon steel, Saunders-patent diaphragm type, which minimize stem leakage.

Piping

The piping for gaseous waste is carbon steel; all piping joints are welded except where flanged connections are necessary for maintenance.

11.3.2.3 Instrumentation Design

The main system instrumentation is described in Table 11.3-2 and shown on Drawing M-69.

The instrumentation readout is located mainly on the waste processing system (WPS) panel in the auxiliary building. Some instruments have local readout at the equipment location.

At Byron, alarms are shown separately on the WPS panel and key alarms are further relayed to one common WPS annunciator on the main control board of the plant. At Braidwood, all alarms are shown separately on the WPS panel and further relayed to one common WPS annunciator on the main control board of the plant.

A multipoint automatic gas analyzer (At Byron, a gas analyzer with manual selector switch) is provided to monitor hydrogen and oxygen concentrations in the GWPS. (At Byron, the sample points in the gaseous waste processing system are manually selected to monitor hydrogen and oxygen concentration in various samples in GWPS.) The analyzer records (At Byron, the analyzer monitors and indicates) the oxygen and hydrogen concentrations and alarms at high levels. In addition, a separate oxygen analyzer is provided between the compressors and the gas decay tanks. The two analyzers provide redundant capability for monitoring oxygen concentration in the gaseous waste processing system to assure that explosive levels of oxygen in hydrogen are avoided.

11.3.2.4 Operating Procedure

The equipment installed to reduce radioactive effluents to the minimum practicable level is maintained in good operating order and is operated in accordance with general power plant practices. In order to ensure that these conditions are met, administrative controls are exercised on overall operation of the system; preventive maintenance is performed in accordance with general power plant practices to maintain equipment in peak condition; and experience available from similar plants is used in planning for operation.

Administrative controls are exercised through the use of instructions covering such areas as valve alignment for various operations, equipment operating instructions, and other instructions pertinent to the proper operation of the processing equipment. Operating procedures ensure that proper valve alignments are made, and other operating conditions are satisfied before a release.

Operating procedures and administrative controls incorporate procedures and controls developed at operational PWR plants having similar waste management equipment.

11.3.2.5 Operations

Gaseous wastes consist primarily of hydrogen stripped from the reactor coolant during boron recycle and degassing operations and nitrogen from the nitrogen cover gas. The components connected to the vent header are limited to those which contain no air or aerated liquids to prevent the formation of a combustible mixture of hydrogen and oxygen.

Waste gases discharged to the vent header are pumped to a waste gas decay tank by one of the two waste gas compressors.

To compress gas into the gas decay tanks, the auxiliary control panel operator selects two tanks, one to receive gas and one for standby. When the tank in service is pressurized to the control setpoint, flow is automatically switched to the standby tank and an alarm alerts the operator to select a new standby tank.

The contents of the decay tank being filled is sampled automatically by the gas analyzer and an alarm alerts the operator to a high oxygen content. On high oxygen signal, the tank is isolated and operator action is taken to direct flow to the standby tank and to select a new standby tank.

If it should become necessary to transfer gas from one decay tank to another, the tank to be emptied is aligned to the holdup tank return line. The tank to receive gas is opened to the inlet header and the return line pressure regulator setpoint is raised to provide flow. The return line isolation valve is closed and the crossover between the return line and the compressor suction is opened. With this arrangement, gas is transferred by the compressor which is in service.

As the boron recycle systems holdup tanks' liquid is withdrawn for processing by the boric acid recycle system, gas from the gas decay tanks is returned to the holdup tanks. The gas decay tank selected to supply the returning cover gas is aligned with the return header by manually opening the appropriate valve.

Residence time is determined by the activity in the tank and need for volume in the system. A backup supply of gas for the holdup tanks is provided by the nitrogen header.

Before a gas decay tank is discharged to the atmosphere via the plant vent, a gas sample is taken to determine activity concentration of the gas and total activity inventory in the tank. The sample is taken by inserting a sample vessel into the gas analyzer's vent bypass line. Flow through the sample vessel is established by manually actuating the gas decay tank "manual select" sample station. When sufficient time has elapsed for a volume to be collected, the gas analyzer is returned to its normal alignment and the sample is removed for analysis. Total tank activity inventory is determined from the activity concentration and pressure in the tank.

To release the gas, the appropriate local manual stop valve is opened to the plant vent and the gas discharge modulating valve is opened by operating the valve control switch at the auxiliary control panel. The plant vent activity level is indicated on the panel to aid in setting the valve properly. If a high activity level is detected in the vent during release, the modulating valve closes.

11.3.2.6 Refueling

When preparing the plant for a cold shutdown prior to refueling, the reactor coolant is degassed to reduce the hydrogen concentrations. At the start of the degassing operation, the volume control tank gas space contains H_2 and traces of fission gases.

Operational procedures and controls direct the activities used to degas the reactor coolant system into the gaseous waste processing system.

Gas evolved from the volume control tank during this operation is pumped by the waste-gas compressors to the gas decay tanks.

Operation of the gaseous side of the gaseous waste processing system is the same during the actual refueling operation as during normal operation.

11.3.2.7 Auxiliary Services

During normal operation nitrogen and hydrogen are supplied to primary plant components from their respective systems. Separate headers are provided for each system. The nitrogen system is described in Subsection 11.3.2.1.

The hydrogen system is described in Chapter 10.

11.3.2.8 Performance Tests

Initial performance tests are performed to verify the operability of the components, instrumentation and control equipment. See

Chapter 14.0 on preoperational plant testing for further information.

During reactor operation, the system is normally in use at all times and is therefore under continuous surveillance.

11.3.3 Radioactive Releases

11.3.3.1 NRC Requirements

The following documents provide regulations and guidelines for radioactive releases:

a. 10 CFR 20, Standards for Protection Against Radiation.

b. Appendix I for 10 CFR 50.

11.3.3.2 Westinghouse PWR Experience Releases

Surveys have been performed of gaseous discharges from several Westinghouse PWR plants. The results are presented in Table 11.3-5.

11.3.3.3 Expected Gaseous Waste Processing System Releases

Gaseous wastes consist primarily of hydrogen stripped from coolant discharged to Boron Recycle System holdup tanks during boron dilution, nitrogen and hydrogen gases purged from the Chemical Volume Control System volume control tank when degassing the reactor coolant and nitrogen from the Nitrogen cover gas. The gas decay tank capacity permits sufficient decay time for waste gases to meet discharge limits.

The quantities and isotopic concentration of gases discharged from the gaseous waste processing system and from the volume reduction system have been estimated. The analysis is based on engineering judgment with respect to the operation of the plant and realistic estimations of the input sources to these two systems.

The associated releases in curies per year per nuclide are given in Table 11.3-6.

11.3.3.4 Estimated Total Releases

Byron and Braidwood Nuclear stations have uprated the core power level twice. First to a core power level of 3586.6 MWt, then to the Measurement Uncertainty Recapture uprate power level of 3645 MWt. The original licensed power level was 3411 MWt. The original expected gaseous radwaste effluent data presented in the UFSAR is based on a power level of 3565 MWt.

Estimated annual total releases of radioactive noble gases and particulates were determined by using NUREG 0017 methodology and computer program PWR-GALE. Both the original as well as the uprated parameters describing the normal operation of one unit of the station are listed in Table 11.2-2. These values were used as input to the computer code for the original analyses. The impact of core uprate on the effluent releases was evaluated based on an assessment of the changes in input parameters. Expected releases from routine and shutdown degassing of the primary coolant and from the building ventilation systems are shown in Table 11.3-6.

Core uprate results in a maximum potential increase of 0.6% for long lived isotopes such as Kr 85. Shorter lived isotopes will have reduced releases or only slight increases as compared to the 0.6% increase in power level. The impact of power uprate on iodine releases is limited to a maximum of 0.6%. The other components of gaseous releases (particulates via the building ventilation systems and water activation gases) are not impacted by uprate. All of the incremental tritium production due to power uprate is assumed to be released via the gaseous pathway resulting in an approximate 0.8% increase in tritium releases via the gaseous pathway.

Taking into consideration the accuracy and error bounds of the operational data utilized in NUREG 00017, these small percentage changes are well within the uncertainty of the calculated results of the original NUREG 0017 based maximum offsite airborne concentrations from gaseous radwaste effluents presented in Table 11.3-7.

Actual release data are available in the effluent release reports, which are prepared in accordance with the ODCM.

Expected releases from normal operation of the volume reduction system were determined using the estimated annual production of radioactive wastes and design flow rates and cleanup parameters for this system. Calculated routine releases for the volume reduction system are also included in Table 11.3-6.

11.3.3.5 Effluent Concentrations and Dilution Factors

A comparison of maximum offsite (at site boundary) airborne gaseous effluent concentration with 10 CFR 20 limits is given in Table 11.3-7. The atmospheric dilution factors used for these calculations are given in Table 11.3-8. As discussed in Section 11.3.3.4 above, this comparison and Table 11.3-7 remains valid for uprate.

11.3.3.6 Release Points of Dilution Factors

Gaseous radioactive wastes are released to the atmosphere through the two ventilation stacks. Each stack is rectangular and is 13.3 feet by 5.0 feet at the exit point, giving an effective diameter of 9.2 feet per stack. The top of the stack is at elevation 600 feet, and the base elevation is 401 feet. The next tallest structures are the tops of the containments, which are at elevation 599 feet. This qualifies the exhaust vent stacks as mixed-mode release points, since they are 1 foot higher than any surrounding structures.

Effluent Velocity Data

Unit Stack	Case 1 (Refueling) Except Mini-Flow Purge		Case 2 (Normal Plant Operation) Except Normal Purge	
	Air Flow (cfm)	Exit Velocity (fpm)	Air Flow (cfm)	Exit Velocity (fpm)
1 (Byron)	194,310	2932	151,842	2283
2 (Byron)	189,510	2854	147,042	2204
1 (Braidwood)	192,910	2893	150,442	2263
2 (Braidwood)	189,510	2854	147,042	2204

The expected temperature range of this exhaust gas is from 40°F to (in a few cases) 122°F. Table 11.3-10 gives a detailed breakdown of the exhaust airflows into each plant vent stack for Cases 1 and 2.

11.3.3.7 Estimated Doses from Gaseous Releases

Estimated annual average doses from radionuclides released from the waste gas processing system are given in Table 11.3-9. These doses were calculated using the methodology of Regulatory Guide 1.109 (Reference 3). Site meteorological data and the partially elevated release model were used to calculate the atmospheric dispersion of the effluents. Various exposure pathways were examined. Consumption factors for the ingestion pathways are given in Table 11.2-8. Note that all of these doses are well within the guidelines of Appendix I to 10 CFR 50. As discussed in Section 11.3.3.4 above, this assessment and Table 11.3-9 remain valid for uprate.

11.3.4 References

1. R. J. Lutz, "Design, Inspection, Operation, and Maintenance Aspects of the W NSSS to Maintain Occupational Radiation Exposures," WCAP-8872, April 1977.

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

3. Regulatory Guide 1.109, "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I," U.S. Nuclear Regulatory Commission, October 1977.

TABLE 11.3-1

GASEOUS WASTE PROCESSING SYSTEM COMPONENT DATA

WASTE GAS COMPRESSORS	
Number	2
Type	Liquid seal rotary type
Design Flow rate, N_2 (at 140° F, 2 psig), cfm	40
Design pressure, psig	150
Design temperature, °F	180
Normal operating pressure, psig	
Suction	0.5 - 2.0
Discharge	0 - 110
Normal operating temperature, °F	60 - 140
GAS DECAY TANKS	
Number	6
Volume, each, ft^3	600
Design pressure, psig	150
Design temperature, °F	180
Normal operating pressure, psig	0 - 125
Normal operating temperature, °F	50 - 140
Material of construction	Carbon steel

TABLE 11.3-2

GASEOUS WASTE PROCESSING SYSTEM INSTRUMENTATION DESIGN PARAMETERS

INSTRUMENT NUMBER	LOCATION OF PRIMARY SENSOR	DESIGN PRESSURE (psig)	DESIGN TEMP. (°F)	RANGE	ALARM SETPOINT	CONTROL SETPOINT	LOCATION OF READOUT
	TEMPERATURE INSTRUMENTATION						
TI-1029	Seal water, compressor No. 1 (Dial Thermometer)	150	300	30-300°F	NA	NA	At Waste Gas Compressor
TI-1034	Seal water, compressor No. 2 (Dial Thermometer)	150	300	30-300°F	NA	NA	At Waste Gas Compressor
	PRESSURE INSTRUMENTATION						
PICA-1025	Vent header	100	180	0 - 5 psig	Hi, 2.5 psig (BR) 2.0 psig (BY) Lo	3.0 psig (BR) 2.0 psig (BY) 2.0 psig (BR) 0.5 psig (BY)	WPS panel
PC-1028 (AB)	Compressor No. 1	150	180	0 - 150 psig	Hi, 100 psig Lo, 30 psig	100 psig	WPS panel
PC-1035 (AB)	Compressor No. 2	150	180	0 - 150 psig	Hi, 100 psig Lo, 30 psig	100 psig	WPS panel
PICA-1036	Waste gas decay tank No. 1	150	180	0 - 150 psig	Hi, 95 psig (BR) 100 psig (BY)	95 psig	WPS panel

F - Flow　　R - Radiation
P - Pressure　　I - Indication
L - Level　　C - Control
T - Temperature　　A - Alarm

TABLE 11.3-2 (Cont'd)

INSTRUMENT NUMBER	LOCATION OF PRIMARY SENSOR	DESIGN PRESSURE (psig)	DESIGN TEMP. (°F)	RANGE	ALARM SETPOINT	CONTROL SETPOINT	LOCATION OF READOUT
PICA-1037	Waste gas decay tank No. 2	150	180	0 - 150 psig	Hi, 95 psig (BR)	95 psig	WPS panel
PICA-1038	Waste gas decay tank No. 3	150	180	0 - 150 psig	Hi, 95 psig (BR) 100 psig (BY)	95 psig	WPS panel
PICA-1039	Waste gas decay tank No. 4	150	180	0 - 150 psig	Hi, 95 psig (BR) 100 psig (BY)	95 psig	WPS panel
PI-1047	Nitrogen header	150	180	0 - 25 psig	NA	NA	Local
PICA-1052	Waste gas decay tank No. 5	150	180	0 - 150 psig	Hi, 95 psig (BR) 100 psig (BY)	95 psig	WPS panel
PICA-1053	Waste gas decay tank No. 6	150	180	0 - 150 psig	Hi, 95 psig (BR) 100 psig (BY)	95 psig	WPS panel
PIA-1065	Hydrogen header	150	180	50 - 150 psig	Hi, 130 psig Lo, 90 psig	NA	WPS panel
PIA-1066	Nitrogen header	150	180	50 - 150 psig	Hi, 110 psig Lo, 90 psig	NA	WPS panel

TABLE 11.3-2 (Cont'd)

INSTRUMENT NUMBER	LOCATION OF PRIMARY SENSOR	DESIGN PRESSURE (psig)	DESIGN TEMP. (°F)	RANGE	ALARM SETPOINT	CONTROL SETPOINT	LOCATION OF READOUT
	LEVEL INSTRUMENTATION						
LICA-1030	Waste gas compressor No. 1	150	180	0 - 28 in.	Hi, 15 in. (BR) 21 in. (BY) Lo, 1 in.	Inches: 15, 13 10, 7, 1 (BR) 21, 15 7, 4, 1 (BY)	WPS panel
LICA-1032	Waste gas compressor No. 2	150	180	0 - 28 in.	Hi, 15 in. (BR) 21 in. (BY) Lo, 1 in.	Inches: 15, 13 10, 7, 1 (BR) 21, 15 7, 4, 1 (BY)	WPS panel
	RADIATION INSTRUMENTATION						
RICA-014	Plant vent			See Section 11.5			
	GAS ANALYZER						
	Located in separate cubicle in Aux. Bldg.						
ØAIT-GW8003 (Byron)/ ØAT-GW8003 (Braidwood)	Oxygen	300	212	0-19.99%	2% (Byron)	none	Local
ØAR-GW8003 (Braidwood)	Oxygen	300	212	0-5%	2%	none	Local
ØAIT-GW004	Oxygen	300	212	0-5%	2%	none	Local
ØAIT-GW8000 (Byron)/ ØAT-GW8000 (Braidwood)	Hydrogen	25	130	0-100%	-	none	Local
ØAR-GW8000 (Braidwood)	Hydrogen	25	130	0-100%	-	none	Local

TABLE 11.3-3

PROCESS PARAMETERS AND REALISTIC, OPERATION BASIS ACTIVITIES IN GASEOUS WASTE SYSTEM[1]

(CONCENTRATIONS IN $\mu C/cm^3$)

POS NO.[2]	LOCATION	PRESSURE (psig)	TEMP. (°F)	FLOW RATE (cm^3/day)	KR83M[4]	KR85M[4]	KR85	KR87	KR88
1	Unit 1 RCDT Vent	1.5	170 max.	1.14E+6	6.6E-04	1.9E-06	1.0E-04	1.0E-05	1.6E-05
2	Unit 2 RCDT Vent	1.5	170 max.	1.14E+6	6.6E-04	1.9E-06	1.0E-04	1.0E-05	1.6E-05
3	Sampling System VCT Vent Unit 1	1.5	115	0	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
4	Sampling System VCT Vent Unit 2	1.5	115	0	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
5	Vent Boron Recycle Holdup Tank Vent	-	-	2.18E+7	1.2E-05	2.9E-08	9.5E-05	4.7E-07	3.2E-07
6	Gas Analyzer	3.5	VAR	0	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
7	Waste Disposal System SRST Vent	-	-	0	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
8	BRS Evaporator Unit 1 Vent[3]	1.5	155	3.82E+5	8.1E-04	1.9E-06	1.9E-02	3.2E-05	2.1E-05
9	BRS Evaporator Unit 2 Vent[3]	1.5	155	3.82E+5	8.1E-04	1.9E-06	1.9E-02	3.2E-05	2.1E-05
10	CVCS VCT Vent Unit 1	1.5	115	0	1.0E-01	8.8E-01	1.6E+01	2.2E-01	1.3E+00
11	CVCS VCT Vent Unit 2	1.5	115	0	1.0E-01	8.8E-01	1.6E+01	2.2E-01	1.3E+00
12	Combination of Normal Letdown GWPS[5]	1.5	VAR	2.48E+7	4.5E-04	1.1E-06	7.8E-03	1.5E-05	1.2E-05
13	Compressor Recirculation Line	1.5	140	0	4.5E-04	1.1E-06	7.8E-03	1.5E-05	1.2E-05

TABLE 11.3-3 (Cont'd)

POS NO.[2]	LOCATION	PRESSURE (psig)	TEMP. (°F)	FLOW RATE (cm^3/day)	KR89	XE131M[4]	XE144M[4]	XE133	XE135M[4]
14	Compressor Inlet	1.5	VAR	2.48E+7	4.5E-04	1.1E-06	7.8E-03	1.5E-05	1.2E-05
15	Compressor Inlet	0.5	VAR	2.48E+7	4.5E-04	1.1E-06	7.8E-03	1.5E-05	1.2E-05
16	Downstream of Compressor	110 max.	140	2.48E+7	4.5E-04	1.1E-06	7.8E-03	1.5E-05	1.2E-05
17	Compressor Outlet to Gas Decay Tanks	-	-	0	4.5E-04	1.1E-06	7.8E-03	1.5E-05	1.2E-05
18	Inlet to Filling Gas Decay Tanks	110 max.	140	2.48E+7	4.5E-04	1.1E-06	7.8E-03	1.5E-05	1.2E-05
19	Line to Gas Decay Tank Header	110	AMB	VAR	5.4E-06	3.0E-09	7.8E-03	1.2E-06	2.0E-07
20	Discharge Line	20	AMB	VAR	0.0E+00	0.0E+00	7.7E-03	0.0E+00	0.0E+00
21	Discharge Line	1	AMB	VAR	0.0E+00	0.0E+00	7.7E-03	0.0E+00	0.0E+00
22	Gas Analyzer	3.5	VAR	0	0.0E+00	0.0E+00	0.0E-00	0.0E+00	0.0E+00
23	From Gas Decay Tanks to Compressor Inlet	110	AMB	1.64E+8	5.4E-06	3.0E-09	7.8E-03	1.2E-06	2.0E-07
24	From Gas Decay Tanks to BRS HTs[6]	3	AMB	1.64E+8	5.4E-06	3.0E-09	7.8E-03	1.2E-06	2.0E-07

AMB - Ambient
VAR - Variable

TABLE 11.3-3 (Cont'd)

POS NO.[2]	LOCATION	PRESSURE (psig)	TEMP. (°F)	FLOW RATE (cm^3/day)	KR89	XE131M[4]	XE133M[4]	XE133	XE135M[4]
1	Unit 1 RCDT Vent	1.5	170 max.	1.14E+6	6.4E-06	2.1E-05	1.7E+00	3.1E+01	1.1E-01
2	Unit 2 RCDT Vent	1.5	170 max.	1.14E+6	6.4E-06	2.1E-05	1.7E+00	3.1E+01	1.1E-01
3	Sampling System VCT Vent Unit 1	1.5	115	0	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
4	Sampling System VCT Vent Unit 2	1.5	115	0	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
5	Vent Boron Recycle Holdup Tank Vent	-	-	2.18E+7	9.4E-08	9.9E-06	2.5E-02	8.6E+00	1.6E-03
6	Gas Analyzer	-	-	0	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
7	Waste Disposal System SRST Vent	-	-	0	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
8	BRS Evaporator Unit 1 Vent[3]	1.5	155	3.82E+5	6.2E-06	1.1E-03	1.7E+00	7.3+02	1.1E-01
9	BRS Evaporator Unit 2 Vent[3]	1.5	155	3.82E+5	6.2E-06	1.1E-03	1.7E+00	7.3+02	1.1E-01
10	CVCS VCT Vent Unit 1	1.5	115	0	1.0E-03	1.6E+00	2.4E+00	2.2E+02	1.2E-02
11	CVCS VCT Vent Unit 2	1.5	115	0	1.0E-03	1.6E+00	2.4E+00	2.2E+02	1.2E-02
12	Combination of Normal Letdown GWPS[5]	1.5	VAR	2.48E+7	3.7E-06	4.6E-04	9.9E-01	3.1E+02	6.4E-02
13	Compressor Recirculation Line	1.5	140	0	3.7E-06	4.6E-04	9.9E-01	3.1E+02	6.4E-02
14	Compressor Inlet	1.5	VAR	2.48E+7	3.7E-06	4.6E-04	9.9E-01	3.1E+02	6.4E-02

TABLE 11.3-3 (Cont'd)

POS NO.[2]	LOCATION	PRESSURE (psig)	TEMP. (°F)	FLOW RATE (cm^3/day)	KR89	XE131M[4]	XE133M[4]	XE133	XE135M[4]
15	Compressor Inlet	0.5	VAR	2.48E+7	3.7E-06	4.6E-04	9.9E-01	3.1E+02	6.4E-02
16	Downstream of Compressor	110 max.	140	2.48E+7	3.7E-06	4.6E-04	9.9E-01	3.1E+02	6.4E-02
17	Compressor Outlet to Gas Decay Tank	-	-	0	3.7E-06	4.6E-04	9.9E-01	3.1E+02	6.4E-02
18	Inlet to Filling Gas Decay Tanks	110 max.	140	2.48E+7	3.7E-06	4.6E-04	9.9E-01	3.1E+02	6.4E-02
19	Line to Gas Decay Tank Header	110	AMB	VAR	1.2E-09	3.5E-04	1.6E-03	1.8E-02	1.0E-04
20	Discharge Line	20	AMB	VAR	0.0E+00	1.0E-05	0.0E+00	6.4E-02	0.0E+00
21	Discharge Line	1	AMB	VAR	0.0E+00	1.0E-05	0.0E+00	6.4E-02	0.0E+00
22	Gas Analyzer	2	AMB	0	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
23	From Gas Decay Tank To Compressor Inlet	110	AMB	1.64E+8	1.2E-09	3.5E-04	1.6E-03	1.8E-02	1.0E-04
24	From Gas Decay Tanks to BRS Hts[6]	3	AMB	1.64E+8	1.2E-09	3.5E-04	1.6E-03	1.8E-02	1.0E-04

AMB - Ambient
VAR - Variable

TABLE 11.3-3 (Cont'd)

POS NO.[(2)]	LOCATION	PRESSURE (psig)	TEMP. (°F)	FLOW RATE (cm^3/day)	XE135	XE137	XE138	I130	I131
1	Unit 1 RCDT Vent	1.5	170 max.	1.14E+6	4.9E+01	1.4E-05	4.1E-01	1.1E-05	1.8E-06
2	Unit 1 RCDT Vent	1.5	170 max.	1.14E+6	4.9E+01	1.4E-05	4.1E-01	1.1E-05	1.8E-06
3	Sampling System VCT Vent Unit 1	1.5	115	0	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
4	Sampling System VCT Vent Unit 2	1.5	115	0	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
5	Boron Recycle Holdup Tank Vent	-	-	2.18E+7	1.8E+00	2.1E-07	6.2E-03	3.9E-08	5.7E-08
6	Gas Analyzer	-	-	0	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
7	Waste Disposal System SRST Vent	-	-	0	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
8	BRS Evaporator Unit 1 Vent[(3)]	1.5	1.5	3.82E+5	1.2E+02	1.4E-05	4.1E-01	0.0E+00	0.0E+00
9	BRS Evaporator Unit 2 Vent[(3)]	1.5	1.5	3.82E+5	1.2E+02	1.4E-05	4.1E-01	0.0E+00	0.0E+00
10	CVCS VCT Vent Unit 1	1.5	115	0	3.0E+00	2.2E-03	3.7E-02	0.0E+00	0.0E+00
11	CVCS VCT Vent Unit 2	1.5	115	0	3.0E+00	2.2E-03	3.7E-02	0.0E+00	0.0E+00
12	Combination of Normal Letdown to GWPS[(5)]	1.5	VAR	2.48E+7	5.9E+01	8.1E-06	2.4E-01	2.0E-06	3.4E-07
13	Compressor Recirculation Line	1.5	140	0	5.9E+01	8.1E-06	2.4E-01	2.0E-06	3.4E-07
14	Compressor Inlet	1.5	VAR	2.48E+7	5.9E+01	8.1E-06	2.4E-01	2.0E-06	3.4E-07
15	Compressor Inlet	0.5	VAR	2.48E+7	5.9E+01	8.1E-06	2.4E-01	2.0E-06	3.4E-07

TABLE 11.3-3 (Cont'd)

POS NO.[2]	LOCATION	PRESSURE (psig)	TEMP. (°F)	FLOW RATE (cm^3/day)	XE135	XE137	XE138	I130	I131
16	Downstream of Compressor	110 max.	140	2.48E+7	5.9E+01	8.1E-06	2.4E-01	2.0E-06	3.4E-07
17	Compressor Outlet to Gas Decay Tanks	-	-	0	5.9E+01	8.1E-06	2.4E-01	2.0E-06	3.4E-07
18	Inlet to Filling Gas Decay Tanks	110 max.	140	2.48E+7	5.9E+01	8.1E-06	2.4E-01	2.0E-06	3.4E-07
19	Line to Gas Decay Tank Header	110	AMB	VAR	3.4E+00	3.3E-09	4.3E-04	1.5E-07	2.3E-07
20	Discharge Line	20	AMB	VAR	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.3E-09
21	Discharge Line	1	AMB	VAR	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.3E-09
22	Gas Analyzer	2	AMB	0	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
23	From Gas Decay Tanks To Compressor Inlet	110	AMB	1.64E+8	3.4E+00	3.3E-09	4.3E-04	1.5E-07	2.3E-07
24	From Gas Decay Tanks To BRS HTs[6]	3	AMB	1.64E+8	3.4E+00	3.3E-09	4.3E-04	1.5E-07	2.3E-07

AMB - Ambient
VAR - Variable

TABLE 11.3-3 (Cont'd)

POS NO.[2]	LOCATION	PRESSURE (psig)	TEMP. (°F)	FLOW RATE (cm^3/day)	I132	I133	I134	I135
1	Unit 1 RCDT Vent	1.5	170 max.	1.14E+6	1.6E-07	2.3E-06	4.4E-08	8.4E-07
2	Unit 1 RCDT Vent	1.5	170 max.	1.14E+6	1.6E-07	2.3E-06	4.4E-08	8.4E-07
3	Sampling System VCT Vent Unit 1	1.5	115	0	0.0E+00	0.0E+00	0.0E+00	0.0E+00
4	Sampling System VCT Vent Unit 2	1.5	115	0	0.0E+00	0.0E+00	0.0E+00	0.0E+00
5	Boron Recycle Holdup Tank Vent	-	-	2.18E+7	2.9E-10	1.2E-08	7.4E-11	2.1E-09
6	Gas Analyzer	-	-	0	0.0E+00	0.0E+00	0.0E+00	0.0E+00
7	Waste Disposal System SRST Vent	-	-	0	0.0E+00	0.0E+00	0.0E+00	0.0E+00
8	BRS Evaporator Unit 1 Vent[3]	1.5	155	3.82E+5	0.0E+00	0.0E+00	0.0E+00	0.0E+00
9	BRS Evaporator Unit 2 Vent[3]	1.5	155	3.82E+5	0.0E+00	0.0E+00	0.0E+00	0.0E+00
10	CVCS VCT Vent Unit 1	1.5	155	0	0.0E+00	0.0E+00	0.0E+00	0.0E+00
11	CVCS VCT Vent Unit 2	1.5	155	0	0.0E+00	0.0E+00	0.0E+00	0.0E+00
12	Combination of Normal Letdown to GWPS[5]	1.5	VAR	2.48E+7	2.8E-08	4.1E-07	7.6E-09	1.5E-07
13	Compressor Recirculation Line	1.5	140	0	2.8E-08	4.1E-07	7.6E-09	1.5E-07
14	Compressor Inlet	1.5	VAR	2.48E+7	2.8E-08	4.1E-07	7.6E-09	1.5E-07
15	Compressor Inlet	0.5	VAR	2.48E+7	2.8E-08	4.1E-07	7.6E-09	1.5E-07

TABLE 11.3-3 (Cont'd)

POS NO.[2]	LOCATION	PRESSURE (psig)	TEMP. (°F)	FLOW RATE (cm^3/day)	I132	I133	I134	I135
16	Downstream of Compressor	110 max.	140	2.48E+7	2.8E-08	4.1E-07	7.6E-09	1.5E-07
17	Compressor Outlet to Gas Decay Tanks	-	-	0	2.8E-08	4.1E-07	7.6E-09	1.5E-07
18	Inlet to Filling Gas Decay Tanks	110 max.	140	2.48E+7	2.8E-08	4.1E-07	7.6E-09	1.5E-07
19	Line to Gas Decay Tank Header	110	AMB	VAR	3.9E-10	5.4E-08	4.1E-11	6.1E-09
20	Discharge Line	20	AMB	VAR	0.0E+00	0.0E+00	0.0E+00	0.0E+00
21	Discharge Line	1	AMB	VAR	0.0E+00	0.0E+00	0.0E+00	0.0E+00
22	Gas Analyzer	2	AMB	0	0.0E+00	0.0E+00	0.0E+00	0.0E+00
23	From Gas Decay Tanks To Compressor Inlet	110	AMB	1.64E+8	3.9E-10	5.4E-08	4.1-11	6.1E-09
24	From Gas Decay Tanks To BRS HTs [6]	3	AMB	1.64E+8	3.9E-10	5.4E-08	4.1-11	6.1E-09

AMB - Ambient
VAR - Variable

TABLE 11.3-3 (Cont'd)

NOTES:

1. This is a synthesis of information from operating reactors.
2. These position numbers correspond to positions marked on Figure 11.3-2.
3. Boron Recycle System (BRS).
4. Metastable (M).
5. Gaseous Waste Processing System (GWPS).
6. Holdup Tank (HT)

TABLE 11.3-4

ASSUMPTIONS USED IN CALCULATING EXPECTED SYSTEM ACTIVITIES

A. EXPECTED SYSTEM ACTIVITY

1. The major inputs to the gas system during normal operation are vents on the Boron Recycle System (BRS) holdup tanks (HUT), reactor coolant drain tanks (RCDT) and BRS evaporators. Inputs from the gas analyzer sampling system and CVCS volume control tank are assumed to be negligible.

2. Reactor coolant gaseous activities are based on Regulatory Guide 1.112 as modified to reflect Byron/Braidwood plant parameters.

3. Twenty-five percent of dissolved radiogases in the reactor coolant entering the RCDTs and HUTs leave solution and enter the vapor space.

4. Radioactive decay was assumed while the BRS HUTs, RCDTs and gas decay tanks were filling. No additional decay was assumed in the evaporator.

5. The BRS HUT is assumed to be filled to 80% capacity before processing by the BRS evaporator. The RCDTs are assumed to be filled to 280 gallons before draining.

6. Values for liquid flow rates to the tanks were based on estimates of annual average flows:

BRS HUT flow	1.0 gpm	(0.5 gpm per unit)
RCDT flow	300 gpd	(per each unit)
BRS Evaporator flow	1.0 gpm	(0.5 gpm/evaporator - from BRS HUTs)

7. The plant capacity factor is 0.8.

8. The iodine partition coefficient in the RCDTs and BRS HUTs was:

$$7.5 \times 10^{-3} \frac{\mu Ci / cc \text{ in vapor}}{\mu Ci / cc \text{ in liquid}}$$ (Based on Regulatory Guide 1.112).

9. The hydrogen concentration in the primary coolant was assumed 35 cc/kg.

TABLE 11.3-4 (Cont'd)

B. ANNUAL RELEASES

The following additional assumptions were used in calculating expected annual releases:

1. One refueling per year per unit was assumed, with complete degassing of reactor coolant and also transfer of noble gases and iodines present in the volume control tank vapor space at shutdown to the gaseous waste system. This gaseous activity is released after 60 days decay for this analysis only.

2. Kr-85 release to the environment is based on an entry rate of 0.15 Ci/MWt-yr Kr-85 into the primary coolant. It was assumed that all Kr-85 entering the coolant is eventually released to the environment.

3. From the calculation of system activities, the activity in a single gas decay tank was determined after 60 days decay. It was assumed that one tank was released every 60 days for purposes of this analysis only.

TABLE 11.3-5

TYPICAL GASEOUS RELEASES FROM

OPERATING REACTORS

	NOBLE GASES (10^3 Ci)		
	73	74	75
R. E. Ginna	0.576	0.78	1.81
Connecticut Yankee	0.032	0.008	1.81
San Onofre	11.0	1.78	1.07
Surry 1 & 2	0.87	54.4	9.47
H. B. Robinson 2	3.1	0.27	0.707
Point Beach 1 & 2	5.75	9.71	32.1

	IODINES (Ci)		
	73	74	75
R. E. Ginna	0.0006	0.0004	0.0037
Connecticut Yankee	0.0013	≤0.0001	0.0009
San Onofre	0.42	0.0002	0.0046
Surry 1 & 2	0.042	0.071	0.0456
H. B. Robinson 2	0.296	0.012	0.0115
Point Beach 1 & 2	0.011	0.098	0.0188

TABLE 11.3-6

EXPECTED ANNUAL AVERAGE RELEASE OF AIRBORNE RADIONUCLIDES*, **

NUCLIDE	PRIMARY COOLANT (μCi/g)	SECONDARY COOLANT (μCi/g)	GASEOUS RELEASE RATE - CURIES PER YEAR: GAS STRIPPING SHUTDOWN	GAS STRIPPING CONTINUOUS	BUILDING VENTILATION REACTOR	BUILDING VENTILATION AUXILIARY	BUILDING VENTILATION TURBINE	BLOWDOWN VENT OFF-GAS	AIR EJECTOR EXHAUST	TOTAL
KR 83M	2.265-02	6.255-09	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
KR 85M	1.184-01	3.337-08	0.0	0.0	0.0	3.0+00	0.0	0.0	2.0+00	5.0+00
KR 85	1.051-01	2.944-08	5.1+01	5.7+02	7.4+01	2.0+00	0.0	0.0	1.0+00	7.0+02
KR 87	6.474-02	1.726-08	0.0	0.0	0.0	1.0+00	0.0	0.0	0.0	1.0+00
KR 88	2.156-01	5.928-08	0.0	0.0	0.0	5.0+00	0.0	0.0	3.0+00	8.0+00
KR 89	5.399-03	1.512-09	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
XE131M	1.035-01	2.917-08	4.0+00	1.5+01	1.7+01	2.0+00	0.0	0.0	1.0+00	3.9+01
XE133M	2.293-01	6.461-08	0.0	0.0	7.0+00	5.0+00	0.0	0.0	3.0+00	1.5+01
XE133	1.804+01	5.010-06	2.4+01	4.7+01	1.3+03	3.8+02	0.0	0.0	2.4+02	2.0+03
XE135M	1.404-02	3.887-09	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
XE135	3.755-01	1.041-07	0.0	0.0	2.0+00	8.0+00	0.0	0.0	5.0+00	1.5+01

* 0.0 appearing in the table indicates release is less than 1.0 Ci/yr for noble gas, 0.0001 Ci/yr for I.
** For one unit.
KEY: 4.5-03 = 4.5 x 10^{-3}

TABLE 11.3-6 (Cont'd)

NUCLIDE	PRIMARY COOLANT (μCi/g)	SECONDARY COOLANT (μCi/g)	GASEOUS RELEASE RATE - CURIES PER YEAR: GAS STRIPPING: SHUTDOWN	GAS STRIPPING: CONTINUOUS	BUILDING VENTILATION: REACTOR	BUILDING VENTILATION: AUXILIARY	BUILDING VENTILATION: TURBINE	BLOWDOWN VENT OFF-GAS	AIR EJECTOR EXHAUST	TOTAL
XE137	9.719-03	2.700-09	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
XE138	4.751-02	1.296-08	0.0	0.0	0.0	1.0+00	0.0	0.0	0.0	1.0+00
TOTAL NOBLE GASES										2.8+03
I 131	2.795-01	4.215-05	0.0	0.0	1.7-03	4.4-02	2.3-03	0.0	2.8-03	5.1-02
I 133	3.986-01	3.831-05	0.0	0.0	7.7-04	6.3-02	2.1-03	0.0	4.0-03	7.0-02

TRITIUM GASEOUS RELEASE 1000 CURIES/YR

TABLE 11.3-6 (Cont'd)

AIRBORNE PARTICULATE RELEASE RATE - CURIES PER YEAR[1]

NUCLIDE	WASTE GAS SYSTEM	BUILDING VENTILATION REACTOR	BUILDING VENTILATION AUXILIARY	TOTAL
MN 54	4.5-03	6.1-06	1.8-04	4.7-03
FE 59	1.5-03	2.1-06	6.0-05	1.6-03
CO 58	1.5-02	2.1-05	6.0-04	1.6-02
CO 60	7.0-03	9.5-06	2.7-04	7.3-03
SR 89	3.3-04	4.7-07	1.3-05	3.4-04
SR 90	6.0-05	8.4-08	2.4-06	6.2-05
CS134	4.5-03	6.1-06	1.8-04	4.7-03
CS137	7.5-03	1.1-05	3.0-04	7.8-03

*In addition to these releases, 25 Ci/yr of argon-41 are released from the containment and 8 Ci/yr of carbon-14 are released from the waste gas processing system. This table was developed taking into account both releases from normal operations and also operational occurrences.

KEY: 4.5-03 = 4.5×10^{-3}

TABLE 11.3-6 (Cont'd)

VOLUME REDUCTION SYSTEM* RELEASE RATE (Ci/yr)

Noble Gases:	
Xe 131m	5.1-01
Xe 133m	1.2+00
Xe 133	2.1+01
Halogens:	
I 131	2.8-03
I 132	3.7-03
I 133	2.1-03
Tritium:	
H 3	2.6+01
Particulates:	
Cr 51	5.3-08
Fe 55	7.0-07
Co 58	6.0-07
Co 60	9.2-08
Ni 63	7.0-07
Y 91	1.5-09
Mo 99	3.5-07
Tc 99m	2.1-09
Te 132	1.5-07
Cs 134	1.1-05
Cs 136	1.9-07
Cs 137	7.4-07

KEY: 5.1-01 = 5.1×10^{-1}

* The original estimate included release data for the volume reduction system. This system is no longer used.

TABLE 11.3-7

COMPARISON OF MAXIMUM OFFSITE AIRBORNE CONCENTRATIONS WITH 10 CFR 20 LIMITS

ISOTOPE	ANNUAL RELEASE FROM ONE UNIT (Ci/yr)	MAXIMUM SITE BOUNDARY* CONCENTRATION (μCi/ml)	10 CFR 20** CONCENTRATION (μCi/ml)
H 3	1.0+03	3.5-11	2.0-07
C 14	8.0+00	2.8-13	1.0-07
Ar 41	2.5+01	8.8-13	4.0-08
Kr 85m	5.0+00	1.8-13	1.0-07
Kr 85	7.0+02	2.5-11	3.0-07
Kr 87	1.0+00	3.5-14	2.0-08
Kr 88	8.0+00	2.8-13	2.0-08
Xe 131m	4.0+01	1.4-12	4.0-07
Xe 133m	1.6+01	5.6-13	3.0-07
Xe 133	2.0+03	7.0-11	3.0-07
Xe 135	1.5+01	5.3-13	1.0-07
Xe 138	1.0+00	3.5-14	3.0-08
I 131	5.4-02	1.9-15	1.0-10
I 132	3.7-03	1.3-16	3.0-09
I 133	7.2-02	2.5-15	4.0-10
Cr 51	5.3-08	1.9-21	8.0-08
Mn 54	4.7-03	1.7-16	1.0-09
Fe 55	7.0-07	2.5-20	3.0-08
Fe 59	1.6-03	5.6-17	2.0-09
Co 58	1.6-02	5.6-16	2.0-09
Co 60	7.3-03	2.6-16	3.0-10
Ni 63	7.0-07	2.5-20	2.0-09
Sr 89	3.4-04	1.2-17	3.0-10
Sr 90	6.2-05	2.2-18	3.0-11
Y 91	1.5-09	5.3-23	1.0-09
Mo 99	3.5-07	1.2-20	7.0-09
Tc 99m	2.1-09	7.4-23	5.0-07
Te 132	1.5-07	5.3-21	4.0-09
Cs 134	4.7-03	1.7-16	4.0-10
Cs 136	1.9-07	6.7-21	6.0-09
Cs 137	7.8-03	2.7-16	5.0-10

* 0.26 mi E $\chi/Q = 1.11 \times 10^{-6}$ sec/m^3

** Limits used are those that were in effect at the time of the analysis.

KEY: 3.5 - 11 = 3.5×10^{-11}

TABLE 11.3-8

ATMOSPHERIC DILUTION FACTORS USED IN DETERMINING OFFSITE DOSES

LOCATION	χ/Q^2 (sec/m^3)	D/Q* (l/m^2)
Nearest site boundary (0.26 mi E)	1.11 - 06	7.86 - 09
Nearest residence (0.30 mi ESE)	7.61 - 07	6.39 - 09
Nearest garden (0.60 mi SW)	1.43 - 07	1.68 - 09
Nearest meat animal (0.60 mi SSE)	2.53 - 07	1.75 - 09
Nearest milk cow (1.50 NE)	1.09 - 07	8.71 - 10

* Calculated using the methodology of NRC Regulatory Guide 1.111, Revision 1, July 1977.

KEY: 1.11 - 06 = 1.11×10^{-6}

TABLE 11.3-9

BYRON-EXPECTED INDIVIDUAL DOSES FROM GASEOUS EFFLUENTS

LOCATION	PATHWAY	DOSE RATE (mrem/yr) TOTAL BODY	SKIN	THYROID	BONE	LIVER	LUNG	GI-LLI
Nearest Residence (0.3 mi ESE)	Plume	0.023	0.073					
	Ground Deposition	0.057	0.067					
	Inhalation							
	Adult	0.030		0.048	0.004	0.030	0.032	0.030
	Teen	0.031		0.053	0.005	0.031	0.033	0.031
	Child	0.027		0.054	0.007	0.028	0.029	0.027
	Infant	0.016		0.040	0.005	0.016	0.017	0.016
Nearest Garden (0.6 mi SW)	Leafy Vegetables							
	Adult	0.006		0.028	0.002	0.006	0.006	0.006
	Teen	0.004		0.023	0.002	0.004	0.004	0.004
	Child	0.005		0.033	0.004	0.005	0.005	0.005
	Stored Vegetables							
	Adult	0.083		0.081	0.033	0.084	0.079	0.081
	Teen	0.103		0.102	0.057	0.108	0.100	0.101
	Child	0.169		0.171	0.138	0.180	0.167	0.167
Nearest Meat Animal (0.6 mi SSE)	Meat							
	Adult	0.019		0.023	0.016	0.019	0.019	0.019
	Teen	0.013		0.016	0.014	0.013	0.013	0.013
	Child	0.017		0.021	0.025	0.017	0.016	0.016
Nearest Milk Cow (1.5 mi NE)	Milk							
	Adult	0.027		0.102	0.012	0.027	0.025	0.025
	Teen	0.037		0.164	0.024	0.040	0.036	0.035
	Child	0.062		0.321	0.059	0.069	0.061	0.060
	Infant	0.099		0.730	0.113	0.115	0.099	0.097

TABLE 11.3-7

COMPARISON OF MAXIMUM OFFSITE AIRBORNE CONCENTRATIONS WITH 10 CFR 20 LIMITS

ISOTOPE	ANNUAL RELEASE FROM ONE UNIT (Ci/yr)	MAXIMUM SITE BOUNDARY[3] CONCENTRATION (μCi/ml)	10 CFR 20** CONCENTRATION (μCi/ml)
H 3	1.0+03	2.6-11	2.0-07
C 14	8.0+00	2.0-13	1.0-07
Ar 41	2.5+01	6.4-13	4.0-08
Kr 85m	5.0+00	1.3-13	1.0-07
Kr 85	7.0+02	1.8-11	3.0-07
Kr 87	1.0+00	2.6-14	2.0-08
Kr 88	8.0+00	2.1-13	2.0-08
Xe 131m	4.0+01	1.0-12	4.0-07
Xe 133m	1.6+01	4.1-13	3.0-07
Xe 133	2.0+03	5.1-11	3.0-07
Xe 135	1.5+01	3.9-13	1.0-07
Xe 138	1.0+00	2.6-14	3.0-08
I 131	5.4-02	1.4-15	1.0-10
I 132	3.7-03	9.5-17	3.0-09
I 133	7.2-02	1.8-15	4.0-10
Cr 51	5.3-08	1.4-21	8.0-08
Mn 54	4.7-03	1.2-16	1.0-09
Fe 55	7.0-07	1.8-20	3.0-08
Fe 59	1.6-03	4.1-17	2.0-09
Co 58	1.6-02	4.1-16	2.0-09
Co 60	7.3-03	1.9-16	3.0-10
Ni 63	7.0-07	1.8-20	2.0-09
Sr 89	3.4-04	8.7-18	3.0-10
Sr 90	6.2-05	1.6-18	3.0-11
Y 91	1.5-09	3.9-23	1.0-09
Mo 99	3.5-07	9.0-21	7.0-09
Tc 99m	2.1-09	5.4-23	5.0-07
Te 132	1.5-07	3.9-21	4.0-09
Cs 134	4.7-03	1.2-16	4.0-10
Cs 136	1.9-07	4.9-21	6.0-09
Cs 137	7.8-03	2.0-16	5.0-10

*0.30 mi NW $\chi/Q = 8.10 \times 10^{-7}$ sec/m^3

** Limits used are those that were in effect at the time of the analysis.

KEY: 2.6 - 11 = 2.6×10^{-11}

TABLE 11.3-8

ATMOSPHERIC DILUTION FACTORS USED
IN DETERMINING OFFSITE DOSES

LOCATION	χ/Q^4 (sec/m^3)	D/Q* (1/m^2)
Nearest site boundary (0.30 mi NW)	8.10 - 07	4.36 - 09
Nearest residence (0.30 mi NW)	8.10 - 07	4.36 - 09
Nearest garden (0.30 mi NW)	8.10 - 07	4.36 - 09
Nearest meat animal (1.70 mi NW)	7.73 - 08	4.49 - 10
Nearest milk cow (1.7 mi WSW)	7.79 - 07	3.70 - 10
Nearest milk goat (4.1 mi E)	3.43 - 08	1.49 - 10

* Calculated using the methodology of NRC Regulatory Guide 1.111, Revision 1, July 1977.

KEY: 8.10 - 07 = 8.10 x 10^{-7}

TABLE 11.3-9

BRAIDWOOD-EXPECTED INDIVIDUAL DOSES FROM GASEOUS EFFLUENTS

LOCATION	PATHWAY	DOSE RATE (mrem/yr) TOTAL BODY	SKIN	THYROID	BONE	LIVER	LUNG	GI-LLI
Nearest Residence (0.3 mi NW)	Plume	0.023	0.074					
	Ground Deposition	0.039	0.046					
	Inhalation							
	Adult	0.035		0.054	0.004	0.035	0.037	0.035
	Teen	0.036		0.059	0.005	0.036	0.038	0.036
	Child	0.032		0.060	0.007	0.032	0.034	0.032
	Infant	0.019		0.044	0.005	0.019	0.020	0.019
Nearest Garden (0.3 mi NW)	Leafy Vegetables							
	Adult	0.035		0.090	0.012	0.035	0.034	0.034
	Teen	0.025		0.072	0.012	0.025	0.024	0.024
	Child	0.031		0.102	0.022	0.031	0.030	0.030
	Stored Vegetables							
	Adult	0.498		0.491	0.173	0.500	0.488	0.491
	Teen	0.622		0.619	0.298	0.634	0.614	0.616
	Child	1.025		1.029	0.727	1.053	1.019	1.018
Nearest Meat Animal (1.7 mi NW)	Meat							
	Adult	0.006		0.007	0.005	0.006	0.006	0.006
	Teen	0.004		0.005	0.004	0.004	0.004	0.004
	Child	0.005		0.006	0.008	0.005	0.005	0.005

TABLE 11.3-9 (Cont'd)

LOCATION	PATHWAY	DOSE RATE (mrem/yr) TOTAL BODY	SKIN	THYROID	BONE	LIVER	LUNG	GI-LLI
Nearest Milk Cow	Milk							
(1.7 mi WSW)	Adult	0.020		0.051	0.008	0.020	0.019	0.019
	Teen	0.028		0.081	0.016	0.029	0.027	0.027
	Child	0.047		0.155	0.040	0.050	0.047	0.046
	Infant	0.075		0.339	0.077	0.082	0.075	0.075
Nearest Milk Goat	Milk							
(4.1 mi E)	Adult	0.018		0.032	0.004	0.018	0.017	0.017
	Teen	0.024		0.049	0.008	0.026	0.023	0.023
	Child	0.039		0.091	0.020	0.043	0.039	0.038
	Infant	0.061		0.188	0.038	0.068	0.061	0.060

TABLE 11.3-10

EXHAUST STACK AIRFLOW TABULATION

	CASE 1 REFUELING EXCEPT MINI-FLOW (cfm)	CASE 2 NORMAL PLANT OPERATION (cfm)
UNIT 1		
Auxiliary Building Exhaust	135,980	135,980
Laboratory System Exhaust	14,430 (Byron) 13,030 (Braidwood)	14,430 (Byron) 13,030 (Braidwood)
Off Gas System Steam Jet Air Ejector	0	32
Gland Steam Condenser Exhaust	0	1,400 (Nominal)
Containment Purge System Mini-Purge Exhaust (3000 CFM)	0	0
Main-Purge Exhaust	43,900	0
	194,310 (Byron) 192,910 (Braidwood)	151,842 (Byron) 150,442 (Braidwood)
UNIT 2		
Auxiliary Building Exhaust	135,980	135,980
Auxiliary Building Filtered Vents	1,000	1,000
Solid Radwaste Area Exhaust	8,630	8,630
Off Gas System Steam Jet Air Ejector	0	32
Gland Steam Condenser Exhaust	0	1,400 (Nominal)
Containment Purge System Mini-Purge Exhaust (3000 CFM)	0	0
Main-Purge Exhaust	43,900	0
	189,510	147,042

11.4 SOLID WASTE MANAGEMENT SYSTEM

11.4.1 Design Bases

The solid radwaste system has been designed to receive, concentrate, solidify if required, package, handle, and provide temporary storage facilities for radioactive wet solid wastes generated by Units 1 and 2 prior to offsite shipment and disposal. The system has provisions for transferring wet solid radwaste to vendor-supplied radwaste system for processing and disposal. The solid waste management system also receives, decontaminates and/or compacts (Byron only), and provides temporary storage facilities for radioactive dry wastes produced during station operation and maintenance prior to offsite shipment and disposal. This system does not normally handle large waste materials such as activated core components.

11.4.1.1 Power Generation Design Bases

The solid radwaste system is designed to minimize the volume of solidified waste requiring shipment offsite. The system is designed specifically for a 40-year service life, maximum reliability, minimum maintenance, and minimum exposure to operating and maintenance personnel. The system has the flexibility to handle a wide range of radioactive waste products.

Equipment and storage capacities, as noted in Table 11.4-1, are selected to meet the station's solid waste processing needs in all the operational modes of the station, including anticipated operational occurrences, without impairing the power generation availability of the station. Storage space is designed to accommodate approximately 2 years at the current normal output of packaged waste. This amount of time was selected to allow for some decay of drummed material, startups, trucking strikes, unavailability of burial sites, etc.

11.4.1.2 Safety Design Bases

The solid radwaste system is designed to package radioactive solid wastes for offsite shipment and burial in accordance with applicable NRC and DOT regulations including 49 CFR 170-178 and 10 CFR 71.

DOT-approved drums are used for packaging solidified wet solid wastes and for packaging dry solid wastes and spent filter cartridges. Steel liners and high integrity containers (HICs) are used for solidified wet solid wastes and dewatered resin. HICs are used for spent filter cartridges, dry solid wastes, or solidified, wet solid wastes.

System safety is emphasized through redundancy in design of primary components, compartmentalization of equipment layout, remote automatic and/or manual operation, shielding, containment of possible spills and displaced air, remote decontamination, if required, accurate process monitoring, and interlocking of process controls.

Complete solidification of wastes requiring solidification that is handled by the vendor-supplied radwaste system is ensured by complying with the vendor's process control program.

The solid radwaste system is designed to fail safe upon loss of system power, water, or air supply. System controls are designed to avoid a malfunction or spill due to operator error. The system is designed to keep the containers clean, reducing decontamination and cleaning requirements.

The solid radwaste storage area, the non used volume reduction (VR) system and the non used VR product solidification system are enclosed in a Safety Category II structure. The Byron non used solid radwaste processing equipment is in a Safety Category I structure. The below grade walls are part of the total structural shear wall system and as such are designed to withstand the effects of an earthquake. All piping and components of the system are designed and constructed in accordance with requirements for classification of Quality Group D.

Waste may be sent to an offsite vendor in acceptable DOT containers for processing prior to disposal. The vendor may volume reduce, sort, decontaminate, and process to produce a form acceptable for burial.

To reduce leakage, piping is welded and pump leakoffs are taken to the drain system. Most valves, except for a few specialty valves, are of the plug type designed to minimize leakage.

The design-basis solid radwaste system output volume is shown in Table 11.4-2.

11.4.1.3 Type of Waste

The types of wastes handled by the solid radwaste system consist of the following:

a. Expended deep bed demineralizer bead resins typically consisting primarily of a copolymer of styrene and divinylbenzene.

b. Disposable cartridge filter elements typically consisting of epoxy-impregnated cellulose fiber or resin-impregnated glass fiber bonded in stainless steel hardware.

c. Low-level dry active wastes consisting of air filters; miscellaneous paper, rags, etc., from contaminated areas; contaminated clothing, tools, and equipment parts which cannot be effectively decontaminated; and solid laboratory wastes.

d. Intermediate level dry wastes (e.g., core components) are not solidified, but decontaminated and shipped in special containers.

11.4.1.4 Expected Volumes and Isotopic Compositions

Table 11.4-2 indicates the design-basis solid radwaste system output (maximum and expected annual volumes). The radionuclide content of the various types of waste is indicated in Tables 11.1-7 through 11.1-12. These values are the expected values at the time the plants were licensed. Byron and Braidwood Nuclear stations have uprated the core power level twice. First to a core power level of 3586.6 MWt, then to the Measurement Uncertainty Recapture uprate power level of 3645 MWt. The original licensed power level was 3411 MWt. The original expected solid radwaste release data presented in the UFSAR is based on a power level of 3565 MWt.

As uprated does not appreciably change the estimated coolant activity, and maintenance and operational practices remain unaffected by uprate, the calculated specific activity of the solid waste is expected to remain essentially unchanged. The volume of solid waste is also not expected to increase since power uprate does not cause appreciable impact on equipment performance nor does it require drastic changes in system operation. Therefore, power uprate has no significant impact on the calculated solid waste estimates presented in this section. Actual data from discharged wastes are available in the effluent release reports, which are prepared in accordance with the ODCM.

Dry active waste and all other waste streams are sampled in accordance with 10 CFR 61 to support accurate characterization of the waste. Station and/or corporate procedures are then used to characterize and quantify the waste prior to shipment.

11.4.1.5 ETSB-BTP 11-3 Comparison

The solid radwaste system has been designed to meet the design criteria of the Effluent Treatment Systems Branch (ETSB), Branch Technical Position BTP 11-3.

11.4.1.6 Comparison of Processing Capacity and Design Basis Waste Volumes

The vendor-supplied radwaste system is capable of filling, dewatering, drying, and preparing a liner of spent resin for shipment. Each liner would contain varying amounts of resin based upon the radiation dose being emitted by the material on the resins. Based upon the preparation rate, there is adequate capacity to process the expected waste volume.

Table 11.4-2 gives the following annual expected values of waste to be processed and the resultant number of containers:

Exhausted deep bed resins	1,600 ft^3	10 liners or 2,393 drums
*Sludges and liquids	18,690 ft^3	5,140 drums
Cartridge filter elements	---	190 drums or 2 liners
Total:		7,723 drums or 5,140 drums and 12 liners

The number of drums and liners to be processed is based on the volumes of waste as indicated above and on the following drumming efficiencies:

Exhausted deep bed resins	110 to 200 ft^3/liner
*Sludges and liquids	27.5 gal/drum (average)

The actual data are available in the effluent release reports, which are prepared in accordance with the ODCM.

The processing capacity of the solid waste system is adequate to handle the maximum expected volumes of waste. The solid waste system has excess capacity.

*Sludges and liquids are normally processed by the liquid radwaste system.

11.4.1.6 Comparison of Processing Capacity and Design Basis Waste Volumes

The vendor-supplied radwaste system is capable of filling, dewatering, drying, and preparing a liner of spent resin for shipment. Each liner would contain varying amounts of resin based upon the radiation dose being emitted by the material on the resins. Based upon the preparation rate, there is adequate capacity to process the expected waste volume.

Station operating experience indicates that it requires approximately 1/2 shift, i.e., 4 hours, to remove a filter from its vessel, place it in a cement-lined drum, and transport the drum to the radwaste building for temporary storage and/or further processing.

Filters, after decay, are placed in a vendor-supplied container for disposal. Each container holds up to 150 filter elements. Operating experience indicates it takes approximately one shift to place 10 to 15 filters in a container. Based upon the aforementioned rate, there is adequate capacity to process the expected number of filters.

Table 11.4-2 gives the following annual expected values of waste to be handled and the resultant number of containers:

Exhausted deep bed resins	1,600 ft^3	10 liners
*Sludges and liquids	18,690 ft^3	156 liners or 5140 drums
Cartridge filter elements	---	2 liners
	Total:	168 liners or 12 liners and 5140 drums

The number of containers to be processed is based on the volumes of waste as indicated above and on the following drumming efficiencies:

* Sludges and liquids are normally processed by the liquid radwaste system.

Exhausted deep bed resins	110 to 200 ft^3/liner
Sludges and liquids	120 ft^3/liner
Cartridge filter elements	150 filter elements/liner

The actual data are available in the effluent release reports, which are prepared in accordance with the ODCM.

The processing capacity of the solid waste system is adequate to handle the maximum expected volumes of waste. The solid waste system has excess capacity.

11.4.1.7 Solid Radwaste System Monitoring

The solid radwaste system monitoring and instrumentation is discussed in Subsection 12.3.4. The design confidence level for each radiation monitoring channel is 95%. The confidence level is based upon equipment reliability and the statistical nature of the measurements. For a further discussion on the confidence levels and the indicated ranges of the monitoring equipment refer to Subsection 12.3.4.

11.4.2 System Description

Operation of the solid waste management system is indicated by Figure 11.4-1. Layouts of the packaging, storage, and shipping areas are shown on Drawings M-9 and M-12.

The solid radwaste system is comprised of a number of components or subsystems. They are listed in Table 11.4-1 along with their number, design capacity, and the materials of which they are constructed.

11.4.2.1 Deleted

11.4.2.2 Deleted

11.4.2.3 Deleted

Pages 11.4-8 through 11.4-10 have been deleted intentionally.

11.4.2.4 Drum-Handling Equipment

This equipment includes four remotely operated cranes with three of the cranes having television cameras for visual surveillance two drum transfer carts and one cartridge filter transfer vehicle (Braidwood only).

At Byron, the two fixed bridge cranes in the drumming area are used to remotely transport drums to and from the drum transfer carts.

The traveling bridge crane in the storage area is used to transport and position sealed containers in either intermediate or low level storage, retrieve and transport them to trucks for offsite disposal, and load prepared drums onto and remove processed drums from the drum transfer carts. Two electrical circuits are provided for the trolley, bridge, and hoist, one for the high-speed and one for the low-speed motors. This ensures that electrical failure will not prevent remote removal of the crane from a radiation zone or completing the operation in process at time of failure. An adaptor is supplied which can be attached to the grab for righting drums which have come to rest horizontally. A crane target grid system combined with television cameras is provided for accurate remote control positioning. For safety, the container must be raised to the full-up position before high speed operation is possible, and the container cannot be released from the grab while the container is suspended.

At Byron, the remotely operated crane without a television camera is used to lower the drum onto a drum transfer cart. At Braidwood, the remotely operated crane without a television camera is used to remove a drum containing a filter from the cartridge filter transfer vehicle and lower the drum onto a drum transfer cart.

At Byron, the drums are transported through the tunnel connecting the drumming area and the storage area by two drum transfer carts. At Braidwood, the drums are transported through the tunnel connecting the DAW sorting area and the storage area by two drum transfer carts. Each of the two carts is independently controlled.

The carts may be operated in parallel. Each cart is designed to carry one drum at a time; however, each cart has room to carry two drums if necessary. The carts are a-c powered with heavy duty 3-hp d-c motors and equipped with high and low-speed drives. The carts are equipped with automatic couplers so that a stalled cart in the tunnel may be retrieved by the second cart. Each cart is guided by rails set into the floor. Operation of the carts is semiautomatic.

The cartridge filter transfer vehicle holds one 55-gallon drum. This vehicle transports drums containing spent filters from the filter area to the filter drop area where the drum is lowered onto a drum transfer cart (Braidwood only).

The spent filter can be placed in a drum on the cartridge filter transfer vehicle (Braidwood only). If the filter dose rate indicates that shielding is required, a drum that contains a precast concrete liner would be used. The filter can be removed and placed into the drum by manual manipulation with reach rods. Filter drums may be lowered onto the drum transfer cart for transport to the radwaste building.

11.4.2.5 Smear Test and Label Station

This portion of the solid waste management system consists of a setdown position for a single drum within an open-topped shielded cubicle provided with side access opening and working tools to accomplish remote labeling, smear testing, and radiation monitoring of all external surfaces of sealed drums prior to offsite disposal. If a drum is found to be contaminated, it is decontaminated prior to storage. This system is normally not used.

11.4.2.6 Dry Waste Compactor (Byron only)

The dry waste compactor compresses paper, fabrics, plastics, and light metal into 55-gallon drums. An air filtration assembly is provided to maintain control of contaminated particles during compactor operation. Capture of radioactive dust is accomplished by means of a roughing filter and two HEPA filters operating in parallel.

The radioactivity of most of the dry waste is low enough to permit handling by contact. The compactor is designed to meet OSHA standards for safe operation and built to standards for a 40-year expected life of the station. This component is normally not used.

11.4.2.7 Storage Areas

Shielded areas are provided for storage of intermediate and low activity containers and compacted dry waste drums per requirements noted in Table 11.4-1. Visual surveillance for the intermediate and low-level storage area is provided by the traveling bridge crane television cameras or other remote cameras. Storage is provided for uncompressible dry solid waste. The storage areas are drained to the radwaste building sump with the exception of the low-level storage area at Braidwood. This bermed area may be used for low activity concentrated liquid waste storage tanks. The drains are sealed to prevent accidental spillage from entering the floor drain system, since the spilled liquid may have high boron concentration.

Radioactive waste may also be stored at an interim storage location away from the processing area while awaiting processing or shipment to a burial site.

Byron Station Dry Active Waste (DAW) may be stored in the DAW building in suitable containers until it is shipped offsite to a disposal facility. If needed, plant equipment and tools that have been packaged in tool or gang boxes can be stored in the DAW facility once they have been packaged in tool or gang boxes.

Braidwood Station Dry Active Waste (DAW) may be stored in the DAW storage facility in suitable shipping containers until it's shipped offsite to a disposal facility. If needed, plant equipment and tools that have been packaged in tool or gang boxes can be stored in the DAW facility once they have been packaged in tool or gang boxes. Volumetric liquids are not authorized for storage in the DAW facility. The only incidental liquids allowed in the building will be incidental to the tools and equipment themselves.

11.4.2.8 Control Room

This room houses the equipment which is capable of remote visual monitoring and control of the solid radwaste system. A record board is mounted on the radwaste control room wall to record the location of all containers within the storage area. Container setdown positions are represented by hooks onto which tags are placed. The volume reduction system control panel and the volume reduction product solidification system control panel are also in this area.

At Byron, a liquid/solid interface control panel is provided for transferring waste to the solid radwaste system from the liquid radwaste subsystem for processing.

In the solid radwaste system, compressed air is used as the handling system instrument air. It is at a pressure of 70-100 psig and is used to operate various valves. Service air is used in the solid radwaste system to operate air-driven pumps, vacuums, and other air-driven equipment. Instrument air is used to operate various valves.

11.4.2.9 Deleted

11.4.2.10 Deleted

11.4.2.11 Deleted

11.4.2.12 System Interfaces

The expected isotopic radioactivity for the feeds are given in Table 11.1-11. The interface descriptions, line numbers, sizes, design pressures, temperatures, flow rates, expected batch sizes, and expected gross radioisotope concentration are given in Table 11.4-3.

11.4.2.13 Deleted

11.4.3 Volume Reduction System Description

The text for Subsection 11.4.3 has been deleted intentionally. Byron and Braidwood Stations do not intend to use this equipment.

11.4.4 Polymer/VR Product Drumming Station

The text for Subsection 11.4.4 has been deleted intentionally. Byron and Braidwood Stations do not intend to use this equipment.

Pages 11.4-15 through 11.4-51 have been deleted intentionally.

TABLE 11.4-1

SOLID WASTE MANAGEMENT SYSTEM EQUIPMENT

AND STORAGE DESIGN CAPACITIES

PROCESSING EQUIPMENT	QUANTITY	DESIGN CAPACITY	MATERIALS
Decanting tank	2	500 gallons	304L SS
Decanting pump	2	18 gpm	304L SS
Metering pump	4	15 gpm	304L SS
Cement storage tank	1	1000 ft^3	CS
Drum processing unit	2	1 Drum	304L SS
Packaging container (drum)	-	55 gallons	CS
Packaging container (liner)	-	Up to 200 ft^3	CS or Polyethylene
Dry waste compactor	1	1 Drum	CS
Traveling bridge crane[1]	1	9.3 tons	CS
Fixed bridge crane[1]	2	1.0 ton	CS
Drum transfer car[2]	2	2 drums	CS
Startup heater	1	395 scfm	304SS/ 316L-SS/ 347SS
Air heater	1	320 scfm	304SS/ 316L-SS
Gas heater	1	786 scfm	304SS/ 316L-SS
Fluid bed dryer air blower	1	317 scfm	CS
Dry waste processor air blower	1	300 scfm	CS

TABLE 11.4-1 (Cont'd)

PROCESSING EQUIPMENT	QUANTITY	DESIGN CAPACITY	MATERIALS
Waste feed filter	1	30 gpm	316L-SS
FBD inlet air filter	1	320 scfm	CS
DWP inlet air filter	1	300 scfm	CS
Gas filter assembly	2	466 scfm	CS
Recirculating gas filter	1	320 scfm	CS
Caustic tank	1	1000 gal	304SS
Decon tank	1	650 gal	304SS
Contaminated oil tank	1	150 gal	CS
Bed storage and transfer hopper	2	2900 lb	304SS
Trash hopper	2	1500 lb	CS/Fe
Waste liquor storage tank	2	3500 gal	316L-SS
Fluid bed dryer	1	0.41 gpm	347SS/ Inconel 625
Dry waste processor	1	83 lb/hr	347SS
Trash conveyor	1	---	Rubber/CS
Trash elevator	1	20 lb/min	CS
Waste feed pump	1	120 gph	316L-SS
Waste recirc. pump	2	500 gpm	316L-SS
Decon. pump	1	50 gpm	304SS
Dryer feed pump	1	30 gph	316L-SS
Condensate pump	1	22 gpm	316SS
Contaminated oil pump	1	14 gpm	CS
Scrubber preconcentrator recirc. pump	1	20 gpm	316L-SS
Caustic additive pump	2	15 gpm	304SS

TABLE 11.4-1 (Cont'd)

PROCESSING EQUIPMENT	QUANTITY	DESIGN CAPACITY	MATERIALS
Scrubber preconcentrator	1	16.8 gpm	316L-SS/ Inconel 625
Secondary scrubber	1	1142 scfm	316L-SS
Condenser	1	22 gpm	316SS
Metal detector	1	1 Trash Bag	Al,Cu
Volume reduction system gas/solids separator	1	911 scfm	347SS
Trash shredder	1	20 lb/min	Fe/CS/CrMo Steel
Polymer storage tank	2	3000 gal	304L
Promoter additive storage tank	1	6 gal	304
Isolation hopper	1	7.5 ft^3	316L-SS
Storage hopper	1	80 ft^3	304L-SS
Drum processing enclosure	1	1 drum	304L
Flame arrester	2	---	---
Volume reduction system solidification system gas/solid separator	1	250 scfm	304L
Volume reduction product blower	1	250 scfm	SA285 Gr. C
Polymer circulating pump	1	15gpm/7.5gpm	316SS
Promoter metering pump	1	10oz/min	420SS
Roller conveyor	1	30 fpm	CS
Polymer filter	1	65 gpm	304SS
Polymer station vent filter	1	75 scfm	304SS
Volume reduction solidification system product blower filter	1	180 scfm	304L

TABLE 11.4-1 (Cont'd)

STORAGE AREA	NUMBER OF STORAGE AREAS	DESIGN CAPACITY PER STORAGE AREA
Low level	1	500 drums or 30 containers
Intermediate level	1	640 drums or 30 containers
Dry compacted waste	1	70 drums
Dry uncompacted waste	1	90 ft^3
Empty drum or container	2	100 drums or 6 containers (total)

NOTES

1. Overhead Crane Operating Speeds

	High-Speed	Low-Speed
Bridge	125 fpm	2.5 fpm
Trolley	125 fpm	2.5 fpm
Drum Grab Hoist	30 fpm	7.5 fpm

2. Drum Transfer Car Operating Speeds

High-Speed	Low-Speed
100 fpm	10 fpm

TABLE 11.4-2

EXPECTED AND DESIGN BASIS ANNUAL VOLUMES OF

(UNITS 1 AND 2) SOLID WASTE MANAGEMENT SYSTEM OUTPUT*

Solid waste processed by the solid radwaste management system and quantities of processed waste requiring onsite storage or offsite disposal

TYPE OF WASTE	EXPECTED VOLUMES	NUMBER OF CONTAINERS	DESIGN VOLUME	NUMBER OF CONTAINERS
Deep Bed Resin	1,600 ft^3	2,393 drums or 10 liners	1,600 ft^3	2,393 drums or 10 liners
Disposable Filter Elements	75 ft^3	190 drums or 2 liners	75 ft^3	190 drums or 2 liners
Sludges and Liquids***	16,850 ft^3	4,580 drums	18,690 ft^3	5,140 drums
Dry Active Waste	36,220 ft^3	580** drums 73 boxes	36,220 ft^3	1,160** drums 73 boxes
Total	54,745 ft^3	7,743 drums, 73 boxes or 12 liners, 5,350 drums and 73 boxes	56,585 ft^3	8,883 drums, 73 boxes or 12 liners, 6,490 drums and 73 boxes

* The values given are approximate. The actual data are available in the effluent release reports, which are prepared in accordance with the ODCM.

** Not solidified.

*** Sludges and liquids are normally processed in the liquid radwaste system.

TABLE 11.4-3

PLANT INTERFACES WITH SOLID RADWASTE SYSTEM

INTERFACE NUMBER AND DESCRIPTION	LINE* NUMBER	LINE SIZE	EXPECTED PRESSURE	ESTIMATED TEMPERATURE (°F)	EXPECTED FLOW RATE	ESTIMATED BATCH SIZE	ESTIMATED GROSS RADIOISOTOPE CONCENTRATION****
1. Spent Resin	OWXX9A	1-1/2 in.	50 psig	90	120 gpm	up to 400 gal	370 Ci/cc
2. Evaporator Concentrates†	OWX143BA	1-1/2 in.	35 psig	130-90	15 gpm	22.5-36.5 gal**	0.05 Ci/cc
3. Flush and Decontamination	OWX146BA	1-1/2 in.	52 psig	110	50 gpm	25 gal	0.16 Ci/cc
4. Volume Reduction System***							
a. Evaporator concentrates	OVR80A	1-1/2 in.	35 psig	190	30 gpm	3500 gal	0.05 Ci/cc
b. Waste oil	OVR69A	2 in.	25 psig	150	50 gpm	140 gal	low

* Typical line numbers, for Unit B line numbers the last letter is B.
** Directly to the drum from a recirculation loop via a metering pump.
*** Byron does not operate the volume reduction system.
**** Based on Table 11.1-11.
† Evaporator concentrates are normally processed in the liquid radwaste system.

TABLE 11.4-3 (Cont'd)

INTERFACE NUMBER AND DESCRIPTION	LINE* NUMBER	LINE SIZE	EXPECTED PRESSURE	ESTIMATED TEMPERATURE (°F)	EXPECTED FLOW RATE	ESTIMATED BATCH SIZE	ESTIMATED GROSS RADIOISOTOPE CONCENTRATION****
c. Pump seals/dilution water	OPW60A	2 in.	50 psig	120	75 gpm	continuous intermittent	Primary
d. Decon water supply	OPMK7A	2 in.	135 psig	100	100 gpm	600 gal	Primary
e. Cooling water supply	OWSJ4A	4 in.	140 psig	110	156 gpm	continuous	0.0
f. Cooling water return	OWSJ6A	3 in.	140 psig	124	156 gpm	continuous	0.0
g. Service air supply	2SA67A	1-1/2 in.	115/90 psig	120	78 scfm	continuous	0.0
h. Filtered exhaust	OVR084B	6 in.	2 in. H_2O	175	477 scfm	continuous	5.6×10^{-4} Ci/cc
i. Drains	OWF69A	3 in.	50 psig	150	50 gpm	intermittent	2.7×10^{-2} Ci/cc
j. Decon water return	OVR123A	2 in.	50 psig	180	50 gpm	150 gal	0.05 Ci/cc
k. Filter backwash inlet	OVR81A	3/4 in.	150 psig	250	50 gpm	50 gal	Primary water
l. Filter backwash outlet	OVR13A	3/4 in.	150 psig	200	50 gpm	50 gal	0.5 Ci/cc
m. Instrument air	OVA210A	1 in.	115 psig	150	82 scfm	continuous	0.0
n. Bed storage hopper fill	OVR47A	6 in.	ambient	ambient	gravity	50 lb	0.0
o. Dry active water	-	-	ambient	ambient	20 ft^3/min	7.5 ft^3	Low

TABLE 11.4-3 (Cont'd)

INTERFACE NUMBER AND DESCRIPTION	LINE* NUMBER	LINE SIZE	EXPECTED PRESSURE	ESTIMATED TEMPERATURE (°F)	EXPECTED FLOW RATE	ESTIMATED BATCH SIZE	ESTIMATED GROSS RADIOISOTOPE CONCENTRATION****
9. Volume Reduction System*** Production Solidification System							
a. Cooling water supply	OWO120A	1-1/2 in.	100 psig	100	10 gpm	intermittent	0.0
b. Cooling water return	OWO128A	1-1/2 in.	100 psig	100	10 gpm	intermittent	0.0
c. Instrument air (polymer)	OIA117A	1 in.	115 psig	120	5 scfm	intermittent	0.0
d. Instrument air (equipment)	OVR257A	1/2 in.	115 psig	120	58 scfm	intermittent	0.0
e. Instrument air (equipment)	OVR255A	1 in.	115 psig	120	58 scfm	continuous	0.0
f. Instrument air (storage hopper)	OVR256A	3/4 in.	115 psig	120	58 scfm	intermittent	0.0
g. Instrument air (blower)	OVR258A	1 in.	115 psig	120	60 scfm	intermittent	0.0
h. Drain (drum processing)	OVR169A	3 in.	4 psig	180	20 gpm	intermittent	Low
i. Drain (storage hopper)	OVR173A	2 in.	4 psig	180	15 gpm	intermittent	8.4 x 10^{-2} Ci/cc
j. Drain (surge hopper)	OVR181A	1-1/2 in.	4 psig	180	5 gpm	intermittent	8.4 x 10^{-2} Ci/cc
k. Polymer filling station vent	-------	2 in.	-1 in. H_2O	ambient	10 scfm	continuous	0.0
l. Blower discharge	OVR180A	2-1/2 in.	0.5 psig	120	60 scfm	intermittent	Low

Pages 11.4-60 through 11.4-63 have been deleted intentionally.

TABLE 11.4-1

SOLID WASTE MANAGEMENT SYSTEM EQUIPMENT

AND STORAGE DESIGN CAPACITIES

PROCESSING EQUIPMENT	QUANTITY	DESIGN CAPACITY	MATERIALS
Packaging container (liner)	-	up to 200 ft^3	CS or polyethylene
Packaging container (drum)	-	55 gal	CS
Traveling bridge crane[1]	1	9.3 tons	CS
Fixed bridge crane[1]	2	1.0 ton	CS
Drum transfer car[2]	2	2 drums	CS
Cartridge filter transfer vehicle[3]	1	1 drum	CS

NOTE: Processing equipment for the volume reduction and radwaste solidification systems has been intentionally deleted from this table. Braidwood station does not intend to use this equipment.

TABLE 11.4-1 (Cont'd)

Page 11.4-65 has been deleted intentionally.

TABLE 11.4-1 (Cont'd)

Page 11.4-66 has been deleted intentionally.

TABLE 11.4-1 (Cont'd)

STORAGE AREA	NUMBER OF STORAGE AREAS	DESIGN CAPACITY PER STORAGE AREA
Low level	1	500 drums or 30 containers
Intermediate level	1	640 drums or 30 containers
Dry compacted waste	1	70 drums
Dry uncompacted waste	1	90 ft^3
Empty drum or container	2	100 drums or 6 containers (total)

NOTES

1. Overhead Crane Operating Speeds

	High-Speed	Low-Speed
Bridge	125 fpm	2.5 fpm
Trolley	125 fpm	2.5 fpm
Drum Grab Hoist	30 fpm	7.5 fpm

2. Drum Transfer Car Operating Speeds

High-Speed	Low-Speed
100 fpm	10 fpm

3. Cartridge Filter Transfer Vehicle Operating Speeds

Variable
0 fpm to 250 fpm

TABLE 11.4-2

EXPECTED AND DESIGN BASIS ANNUAL VOLUMES OF

(UNITS 1 AND 2) SOLID WASTE MANAGEMENT SYSTEM OUTPUT*

Solid waste processed by the solid radwaste management system and quantities of processed waste requiring onsite storage or offsite disposal

TYPE OF WASTE	EXPECTED VOLUMES	NUMBER OF CONTAINERS	DESIGN VOLUME	NUMBER OF CONTAINERS
Deep Bed Resin	1,600 ft^3	10 liners	1,600 ft^3	10 liners
Disposable Filter Elements	75 ft^3	2 liners	75 ft^3	2 liners
Sludges and Liquids***	16,850 ft^3	141 liners	18,690 ft^3	156 liners
Dry Active Waste	36,220 ft^3	580 drums** 73 boxes	36,220 ft^3	1,160 drums** 73 boxes
Total	54,745 ft^3	153 liners 580 drums 73 boxes	56,585 ft^3	168 liners 1,160 drums 73 boxes

* The values given are approximate. The actual data are available in the effluent release reports, which are prepared in accordance with the ODCM.

** Not solidified.

*** Sludges and liquids are normally processed in the liquid radwaste system.

TABLE 11.4-3

PLANT INTERFACE WITH SOLID RADWASTE SYSTEM

	INTERFACE NUMBER AND DESCRIPTION	LINE* NUMBER	LINE SIZE	EXPECTED PRESSURE	ESTIMATED TEMPERATURE (°F)	EXPECTED FLOW RATE	ESTIMATED BATCH SIZE	ESTIMATED GROSS RADIOISOTOPE CONCENTRATION**
1.	Spent Resin	OWX425A	1-1/2 in.	75 psig	90	40 gpm	up to 845 gal	1500 Ci/cc
2.	Evaporator Concentrates***	OWXZ9D	1-1/2 in.	109 psig	130-190	45 gpm	100 gal	0.05 Ci/cc
3.	Resin Flush and Decontamination	OWX137A	2 in.	50 psig	120	50 gpm	115 gal	0.16 Ci/cc
4.	Pump Seals							
	a. Evaporator concentrates	OWX530AA	1/2 in.	5 psig	ambient	.25 gpm	intermittent	Low
	b. Spent resin	OWX589CA	3/8 in.	90 psig	120	.25 gpm	intermittent	Primary water
5.	Volume Reduction System†							
	a. Waste oil	OVR69A	2 in.	25 psig	150	50 gpm	140 gal	low
	b. Pump seals/dilution water	OWMK7A	2 in.	135 psig	100	75 gpm	continuous intermittent	0.0
	c. Decon water supply	OWMK7A	2 in.	135 psig	100	100 gpm	600 gal	0.0

* Typical line numbers, for Unit B line numbers the last letter is B.
** Based on Table 11.1-11.
*** Evaporator concentrates are normally processed in the liquid radwaste system.
† Braidwood does not operate the volume reduction system.

TABLE 11.4-3 (Cont'd)

INTERFACE NUMBER AND DESCRIPTION	LINE* NUMBER	LINE SIZE	EXPECTED PRESSURE	ESTIMATED TEMPERATURE (°F)	EXPECTED FLOW RATE	ESTIMATED BATCH SIZE	ESTIMATED GROSS RADIOISOTOPE CONCENTRATION**
d. Cooling water supply	OWSJ4A	4 in.	140 psig	110	156 gpm	continuous	0.0
e. Cooling water supply	OWSJ6A	3 in.	140 psig	124	156 gpm	continuous	0.0
f. Filtered exhaust	OVR084B	4 in.	2 in. H_2O	175	477 scfm	continuous	$5.6x10^{-4}$ Ci/cc
g. Drains	OWF69A	3 in.	50 psig	150	50 gpm	intermittent	$2.7x10^{-2}$ Ci/cc
h. Decon water supply	OVR123A	2 in.	50 psig	180	50 gpm	150 gal	0.05 Ci/cc
i. Filter backwash inlet	OVR81A	3/4 in.	150 psig	250	50 gpm	50 gal	Primary water
j. Filter backwash outlet	OVR13A	3/4 in.	150 psig	200	50 gpm	50 gal	0.5 Ci/cc
k. Instrument air	OVR210A	1 in.	115 psig	150	82 scfm	continuous	0.0
l. Bed storage hopper fill	OVR47A	6 in.	ambient	ambient	gravity	50 lb	Low
m. Dry active waste	-	-	ambient	ambient	20 ft^3/min	7.5 ft^3	Low
6. Volume Reduction System† Production Solidification System							
a. Cooling water supply	OWO348A	1-1/2 in.	100 psig	100	10 gpm	intermittent	0.0
b. Cooling water return	OWO349A	1-1/2 in.	100 psig	100	10 gpm	intermittent	0.0
c. Instrument air (polymer)	OIA116A	1 in.	115 psig	120	5 scfm	intermittent	0.0

TABLE 11.4-3 (Cont'd)

INTERFACE NUMBER AND DESCRIPTION	LINE* NUMBER	LINE SIZE	EXPECTED PRESSURE	ESTIMATED TEMPERATURE (°F)	EXPECTED FLOW RATE	ESTIMATED BATCH SIZE	ESTIMATED GROSS RADIOISOTOPE CONCENTRATION**
d. Instrument air (drum processing)	OVR257A	1/2 in.	115 psig	120	58 scfm	intermittent	0.0
e. Instrument air (equipment)	OVR255A	1 in.	115 psig	120	58 scfm	continuous	0.0
f. Air bump (surge hopper)	OVR307A	3/8 in.	40 psig	120	58 scfm	intermittent	0.0
g. Instrument air (storage hopper)	OVR256A	3/4 in.	115 psig	120	58 scfm	intermittent	0.0
h. Air bump (storage hopper)	OVR310A	3/8 in.	40 psig	120	58 scfm	intermittent	0.0
i. Instrument air (blower)	OVR258A	1 in.	115 psig	120	60 scfm	intermittent	0.0
j. Drain (drum processing)	OVR169A	3 in.	4 psig	180	20 gpm	intermittent	Low
k. Drain (storage hopper)	OVR173A	2 in.	4 psig	180	15 gpm	intermittent	$8.4x10^{-2}$ Ci/cc
l. Drain (surge hopper)	OVR181A	1-1/2 in.	4 psig	180	5 gpm	intermittent	$8.4x10^{-2}$ Ci/cc
m. Polymer filling station vent	-----	2 in.	-1 in. H_2O	ambient	10 scfm	continuous	0.0
n. Blower discharge	OVR180A	2-1/2 in.	0.5 psig	120	60 scfm	intermittent	Low

TABLE 11.4-3 (Cont'd)

INTERFACE NUMBER AND DESCRIPTION	LINE* NUMBER	LINE SIZE	EXPECTED PRESSURE	ESTIMATED TEMPERATURE (°F)	EXPECTED FLOW RATE	ESTIMATED BATCH SIZE	ESTIMATED GROSS RADIOISOTOPE CONCENTRATION**
7. Vendor Supplied Mobile Radwaste System							
a. Instrument air	O1A117A	3/4 in.	115 psig	120	50 scfm	continuous	0.0
b. Service air	OSAR1A	3/4 in.	115 psig	120	50 scfm	continuous	0.0
c. Demineralized water	OWMT2A	2 in.	135 psig	100	100 gpm	intermittent	0.0
d. Service water supply	OWS59A	2 in.	140 psig	96	25 gpm	continuous	0.0
e. Service water return	OWSX5A	2 in.	140 psig	96	25 gpm	continuous	0.0
f. Drain	OWX439A	2 in.	100 psig	100	25 gpm	continuous	0.16 Ci/cc
g. Vent	OVF075A	4 in.	3 psig	175	200 scfm	continuous	Low

11.5 PROCESS AND EFFLUENT RADIOLOGICAL MONITORING AND SAMPLING SYSTEMS

This section describes the systems that monitor and sample the process and effluent streams in order to control the release of radioactive materials generated as a result of normal operation, anticipated operational occurrences, and during postulated accidents.

11.5.1 Design Bases

11.5.1.1 Design Objectives

The process radiological monitoring and sampling system provides measurement, indication, and/or control of radioactivity in those streams which could conceivably be contaminated by radioactive substances.

The effluent radiological monitoring and sampling system provides measurement, indication, and control of radioactivity in those streams which discharge to the environs outside the plant boundaries.

The systems are subdivided into gaseous (airborne) systems, shown in Table 11.5-1, and liquid systems, shown in Table 11.5-2. Both continuous monitoring and sampling with associated laboratory analysis are used for all systems.

The process monitor systems provide operating personnel with radiological measurements within the plant process systems. The continuous monitors provide a continuous readout of the radiation levels, and they annunciate or generate automatic control of the process streams when a significant increase occurs. By sampling and laboratory analysis, the type of radioactive material and the specific radionuclide present can be determined qualitatively and/or quantitatively.

The effluent monitoring systems provide operating personnel with a continuous readout of the radioactivity levels present in the plant's air exhaust and liquid discharge streams.

The objective of the effluent radiological monitoring system is to sample and monitor each plant effluent discharge path for radioactivity prior to discharge. This is satisfied by the installation of sampling monitors on the following airborne effluent streams and liquid effluent streams:

a. Airborne effluent streams:

   1. station vent stacks.

b. Liquid effluent streams:

    1. station blowdown, and

    2. liquid radwaste effluent.

The objective of the process radiation monitoring system is to monitor those sections of the plant process to control the release of radioactivity into the effluent streams. This is satisfied by the installation of process gaseous and airborne radiation monitors and liquid process monitors in the following locations:

a. Process gaseous airborne monitors for:

    1. auxiliary building ventilation exhausts,

    2. fuel handling building ventilation exhausts,

    3. radwaste building ventilation exhaust,

    4. laundry room ventilation exhaust,

    5. lab fume hood exhaust,

    6. miscellaneous tank filtered vent exhaust,

    7. containment purge effluent,

    8. steam jet air ejector/gland steam exhaust, and

    9. gas decay tank effluent.

b. Process liquid monitors for:

    1. station blowdown,

    2. steam generator blowdown,

    3. boron thermal regeneration chiller surge tank return,

    4. component cooling heat exchanger water outlet,

    5. reactor containment fan coolers essential service water outlet,

    6. radwaste evaporators condensate return,

    7. gross failed fuel monitors,

8. condensate cleanup area sumps discharge, and

9. turbine building fire and oil sump discharge.

This group of monitors is used for surveillance and control of radioactive substances in gaseous and liquid effluents during normal reactor operations, including anticipated operational occurrences. Accident monitors are discussed separately in the subsequent text, in Subsection 12.3.4 and Section E.30 of Appendix E.

The design and operation characteristics of the process and effluent radiological monitoring and sampling system is based on requirements and guidance in 10 CFR 20, 10 CFR 50, 10 CFR 70, 10 CFR 100 for accidents analyzed using TID-14844 and 10 CFR 50.67 for AST, Regulatory Guides 1.21, 1.97, and 4.15, NUREG-0737, NUREG-0800, ANSI N13.1-1969, and ANSI N13.10-1974.

11.5.1.2 Design Criteria

The design of the process and effluent radiological monitoring and sampling system was based on the following:

a. The particulate airborne monitors are beta scintillators, the iodine airborne monitors are gamma scintillators and the noble gas monitors are beta scintillators.

b. Liquid monitors are gamma-responsive scintillation detectors to provide maximum sensitivity to a water medium.

c. Shielding is provided to reduce background and increase sensitivity.

d. Background compensation is provided on selected monitors to increase sensitivity.

e. The gaseous monitor range of detectability is based on actual experience at operating PWRs.

f. The monitors are designed to fail in the interlock mode in the event of loss of power, loss of signal, or operate failure. For OPR31J, OPR32J, OPR33J, and OPR34J, the associated ESF actuation will occur on a 2/2 per train coincidence.

g. All alarms annunciate in the main control room.

h. Monitors readout, alarm, and trend in the main control room.

i. Monitor pumps are initiated locally and in the main control room.

j. Monitor components are readily accessible for maintenance.

k. The monitoring systems are designed for operability within the environmental conditions anticipated. The plant environmental conditions are shown in Table 3.11-2. Instrument locations are shown in Tables 11.5-1 and 11.5-2.

l. Alarm setpoints are adjustable over the range of the instrument, excluding the upper (high) range detector setpoints 0RE-PR031A, C; 0RE-PR032A, C; 0RE-PR033A, C and 0RE-PR034A, C (these setpoints are above the range of the detector, thus eliminating each channel's interlock).

m. The following statements apply to the effluent monitors and samplers for airborne and gaseous radioactivity:

   1. They continuously withdraw an isokinetic and representative sample as recommended by ANSI N13.1-1969.

   2. The radioparticulates are concentrated on a high-efficiency filter and the radioiodines on an activated charcoal cartridge, which can be changed routinely for laboratory analysis.

   3. The radionoble gases are continuously monitored for gross beta activity.

   4. Grab sampling capability shall be provided to allow for periodic laboratory analysis.

n. Setpoints and ranges for effluent monitors are established to meet technical specification limits, which encompass 10 CFR 20 (including Table 2 of Appendix B) and 10 CFR 50 Appendix I objectives. Setpoints for process monitors are established to provide a warning of increased system activity and to initiate corrective action where appropriate. Also, see Subsection 12.3.4 and Section E.30 of Appendix E.

   Two independently adjustable radiation setpoints are provided for most monitors. The lower (alert) setpoint normally activates only an alarm, while the upper (high) setpoint activates an alarm and initiates corrective action where appropriate. Alarm and trip functions associated with the various monitors are listed in Tables 11.5-1 and 11.5-2. The setpoints are under the administrative control of the station manager or his authorized delegate and can be changed if needed within Radioactive Effluent Controls Program limits.

o. All process and effluent monitors are annunciated in the main control room. The radiation monitoring equipment in the main control room will feature an integrated audible (horn) and visual video display unit alarm system. Alarm conditions are automatically logged electronically for reporting and retrieval.

   The audible alarm is actuated each time a new alarm message is received. The video display unit provides a color coded indication of low level (failure), alert-interlock, high, and multi-level diagnostic alarms. The alarm message saved electronically includes the date, time, channel number, and alarm condition.

11.5.2 System Description

11.5.2.1 Instrumentation

The process and effluent radiological monitoring and sampling systems monitor radiation levels in various plant operating systems and effluent streams. This includes both liquid and gaseous radiation monitoring.

Continuous Monitoring

The system consists of a number of separate and distinct monitors and channels as listed in Tables 11.5-1 and 11.5-2. Each monitor consists of an isokinetic probe or a tap, detector(s) and associated electronics. The continuous sample is piped to a monitor where the sample is monitored for air particulate, gas, and iodine activity, as shown in Tables 11.5-1 and 11.5-2. Data and information from each channel is transmitted to the main control room.

The main control room for each unit contains a video display unit, an operator’s keyboard, and a work station that communicates with a server in the computer room. The server maintains an hourly record of radiation levels which may be stored on the recorder for historical purposes. When the radiation level for a particular channel is exceeded, the service, setpoint, and intensity level are displayed on the video display unit. In addition, the system alarms to indicate abnormal conditions.

The microprocessor for each monitor is provided with the following features:

a. monitor on-off switch and instrument available light,

b. high radiation level light, and

c. interlock alert radiation level light.

The operate failure alarm also annunciates in the main control room. This alarm will be initiated by loss of power, loss of signal, or operate failure. The operate failure will also initiate the interlock switching functions. For 0PR31J, 0PR32J, 0PR33J, and 0PR34J (Subsection 11.5.2.2.8) the associated ESF actuation will occur on a 2/2 per train coincidence. Reset action cannot be affected until the failure condition is corrected.

Sample probe locations are shown on HVAC drawings in Section 9.4. Monitor locations are shown on the drawings referenced in Tables 11.5-1 and 11.5-2 and are also shown and identified on the radiation shielding figures in Section 12.3 (M-24 series drawings Sheets 1 through 20).

For the type of radiation detector and measurement made, see Tables 11.5-1 and 11.5-2.

For most channels which are interlocked with the safety-related systems, redundancy is maintained by using two separate and completely independent channels. In cases where these channels are non-1E, input to the safety-related systems is through non-1E interfacing circuitry located outside the radiation monitoring system cabinets. The redundant channels are designated in Tables 11.5-1 and 11.5-2 under "Remarks".

The range of radioactive concentrations to be monitored is listed in Tables 11.5-1 and 11.5-2 for each detector. The range selected was based on the expected level of radiation for each service.

For alarm and control interlock setpoint values, refer to the "Setpoint" column in Tables 11.5-1 and 11.5-2. Radiation monitors which interlock automatic control functions are designated as such in the remarks column of Tables 11.5-1 and 11.5-2. A reference to the explanatory text section is included.

The radiation monitoring channels employ radioactive check sources. Monitors automatically bypass the interlock function if one is provided upon initiation of the check source test switch.

11.5.2.2 Airborne Process and Effluent Monitors

11.5.2.2.1 Auxiliary Building Vent Stack Effluent

Detectors lRE-PR028A, B, C, D, and E (air particulate, gas low range, iodine, gas high range and background subtraction channels, respectively) and 2RE-PR028A, B, C, D, and E (air particulate, gas low range, iodine, gas high range and background subtraction channels, respectively) monitor station stack effluent from the auxiliary building vent stacks (Units 1 and 2). Additional features associated with these monitors include:

a. automatic isokinetic sampling system,

b. automatic grab sampling system,

c. tritium sampling system,

d. low/high range gas channels, and

e. background subtraction channel.

11.5.2.2.2 Auxiliary Building Plant Areas (For Auxiliary Building Vent Exhausts)

Detectors 0RE-PR021A, B, C (air particulate, gas, and iodine channels respectively) and 0RE-PR022A, B, C monitor auxiliary building plant areas.

High radiation is annunciated in the main control room.

11.5.2.2.3 Pipe Tunnel (For Auxiliary Building Vent Exhausts)

Detectors lRE-PR021A, B, C (air particulate, gas, and iodine channels respectively) and 2RE-PR021A, B, and C monitor the pipe tunnel.

High radiation is annunciated in the main control room.

Refer to Subsection 9.4.5.1 for description of fans and dampers.

11.5.2.2.4 Fuel-Handling Building Exhaust

Detectors 0RE-PR024A, B, C (air particulate, gas, and iodine channels respectively) monitor fuel handling exhaust.

High radiation is annunciated in the main control room.

11.5.2.2.5 Containment Purge Effluent

Detectors lRE-PR001A, B, and C (air particulate, gas and iodine channels respectively) monitor containment effluent for Unit 1, while detectors 2RE-PR001A, B, and C monitor the same for Unit 2.
High radiation is annunciated in the main control room.

11.5.2.2.6 Fuel-Handling Incident in the Fuel Handling Building

Two area radiation detectors, 0RE-AR055 and 0RE-AR056, monitor for a postulated fuel-handling incident in the fuel handling building.

Area radiation monitor 0RT-AR055 is interlocked with booster fan 0VAO4CA. Area radiation monitor 0RT-AR056 is interlocked with booster fan 0VA04CB. Upon exceeding the interlock setpoint or as a result of certain monitor failures, a booster fan will automatically start and its associated bypass damper will close with proper VA system alignment.

The channels used for monitoring a postulated fuel-handling incident in the fuel handling building are Class lE.

Refer to Subsection 12.3.4 for further radiation monitor details.

11.5.2.2.7 Fuel-Handling Incident in the Containment Building

Two area radiation detectors, lRE-AR011 and lRE-AR012, monitor for postulated fuel-handling incidents in the containment building for Unit 1, while area detectors 2RE-AR011 and 2RE-AR012 monitor the same for Unit 2.

Area radiation monitor lRT-AR011 is interlocked with Train A of the normal containment purge and minipurge isolation valves. Area radiation monitor lRT-AR012 is interlocked with Train B of the normal containment purge and minipurge isolation valves.

At Byron, the normal containment purge isolation valves are normally closed during fuel movements and at Braidwood these valves are blocked closed.

Refer to Subsections 6.5.1.1.2, 9.4.8, and 9.4.9 for descriptions of the containment building HVAC system.

The channels used for monitoring a postulated fuel-handling incident in the containment building are Class lE.

Refer to Subsection 12.3.4 for further radiation monitor details.

11.5.2.2.8 Main Control Room Outside Air Intakes A and B

Detectors 0RE-PR031A, B, and C (air particulate, gas and iodine channels, respectively) and 0RE-PR032A, B, and C monitor main control room outside air intake A. Detectors 0RE-PR033A, B, and C and 0RE-PR034A, B, and C monitor main control room outside air intake B.

Detectors 0RE-PR031B and 0RE-PR032B are interlocked with the makeup area unit fan 0VC03CA and main control room outside air intake A dampers. Automatically on high radiation, the outside air intake A dampers close, and the fan starts and in turn opens the main control room turbine building air intake A dampers mentioned in Section 6.4 and Subsection 9.4.1.

Detectors 0RE-PR033B and 0RE-PR034B are interlocked with the makeup area unit fan 0VC03CB and main control room outside air intake B dampers. Automatically on high radiation, the outside air intake B dampers close, and the fan starts and in turn opens the main control room turbine building air intake B dampers mentioned in Section 6.4 and Subsection 9.4.1.

11.5.2.2.9 Main Control Room Turbine Building Air Intakes A and B

Detectors 0RE-PR035A, B, and C through 0RE-PR038A, B, and C monitor air from the turbine building intakes after it has passed through the makeup air filters.

Detectors 0RE-PR035A, B, and C (air particulate, gas and iodine channels, respectively) and 0RE-PR036A, B, and C monitor the discharge air from the makeup air filter unit A entering the main control room. Detectors 0RE-PR037A, B, and C and 0RE-PR038A, B, and C monitor the discharge air from the makeup filter unit B entering the main control room.

High radiation in the makeup air filter unit (A or B) discharge is annunciated in the main control room.

11.5.2.2.10 Containment Atmosphere Monitoring

Detectors lRE-PR011A, B, C, D, and E are used to monitor the Unit 1 containment atmosphere for airborne particulate, gaseous activity low range, iodine, gaseous activity high range and background subtraction, respectively. The detectors also provide leak detection as required by Regulatory Guide 1.45. See subsection 5.2.5.2 for additional information. Identical detectors provide the same function for Unit 2.

Interlocks are provided from the monitor to actuate certain system valves on high radiation to isolate the monitor. Additionally, monitor purge valves are opened by the interlock to provide a timed purge of any contaminated air from the monitor. Upon timeout of the purge function, the valves close and the monitor trips. This interlock function is normally bypassed via the bypass/normal control switch located on the containment air sample panel.

The monitor wetted parts are required to maintain pressure boundary integrity during abnormal pressure conditions. The detector is not required to meet performance requirements for this period.

For post-LOCA monitoring, the samples will be collected manually and analyzed in the laboratory as described in Section E.21 of Appendix E.

High range area type monitors are provided in containment to monitor post-LOCA radiation levels in the containment volume. These monitors are discussed in Subsection 12.3.4 and Section E.30 of Appendix E.

11.5.2.2.11 Miscellaneous Tank Vent System Exhaust

Detectors 0RE-PR025A, B and C (air particulate, gas and iodine channels respectively) monitor the miscellaneous tank vent system exhaust.

High radiation is annunciated in the main control room.

11.5.2.2.12 Radwaste Area Vent Exhaust

Detectors 0RE-PR026A, B and C (air particulate, gas and iodine channels respectively) monitor the radwaste area vent exhaust. The radwaste area vent exhaust is ducted to the auxiliary building vent stack.

The radiation monitor is interlocked with the radwaste building ventilation system supply and exhaust fans 0VW01C, 0VW13C, 0VW03CA, and 0VW03CB. The supply and exhaust fans trip on high radiation.

11.5.2.2.13 SJAE/Gland Steam Exhaust

Detectors lRE-PR027 (gas channel) and 2RE-PR027 monitor the off-gas system exhaust. The SJAE/gland steam exhaust monitor features sample conditioning and grab sample collection capability. Sample probe 1(2)RX-PR027 is located in the SJAE/gland steam condenser/hogger exhaust line. An additional sample tap is located in the SJAE exhaust line for 1/2PR27J. The system is normally aligned with the SJAE exhaust sample tap. The SJAE/Gland Steam exhaust is subsequently monitored by probes 1/2PR028A/B in the vent stack. No automatic action is taken on high radiation in the off-gas exhaust stream, as the off-gas vent filter unit 0OG0lS is bypassed under all conditions.

11.5.2.2.14 Gas Decay Tank Effluent

Detectors 0RE-PR002A and B (low and high range gas channels, respectively) monitor the radiation level of the gas decay tank discharge to the auxiliary building vent stack. Automatically, on high radiation in the gas decay tank discharge, valve 0GW014 closes.

11.5.2.2.15 VR System Areas and Cubicles Ventilation Exhaust

Detectors 0RE-PR040A, B and C (air particulate, gas and iodine channels respectively) monitor the ventilation exhaust from the volume reduction equipment areas and cubicles.

The radiation monitor is interlocked with the volume reduction ventilation exhaust fans OVW10C and OVW14C, associated bypass, filter inlet and outlet dampers. Automatically on high radiation the bypass dampers close and the fans start to route the exhaust through the filter unit.

Refer to Subsection 9.4.3.3 for a description of the radwaste building ventilation system.

11.5.2.2.16 TSC Ventilation System

The TSC ventilation system is provided with a permanently installed isokinetic sample probe 0RX-PR218 in the supply fan exhaust duct. During periods of TSC postaccident occupation, detectors 0RE-PR060A, B and C (air particulate, gas and iodine channels, respectively) will be used to monitor radiation levels in TSC. The monitor has an operating status lamp, two alarm lamps and an alarm horn both locally at the monitor and at a remote panel located in the TSC Health-Physics office. The monitor has a microprocessor which utilizes digital processing techniques to analyze data and control monitor functions.

11.5.2.2.17 Miscellaneous Process Monitors

Miscellaneous other monitors shown in Table 11.5-1 monitor the process as indicated.

High radiation is annunciated in the main control room.

11.5.2.2.18 Auxiliary Building Vent Stack Wide Range Gas Monitor

Radiation detectors 1RE-PR030A, B and C (low range, mid-range and high range gas channels, respectively) and 2RE-PR030A, B and C for Unit 2 are installed on the auxiliary building vent stacks (final release points). A detailed description of these monitors is included in Appendix E, Item E.30, position 1.

11.5.2.3 Liquid Effluent Monitors

11.5.2.3.1 Liquid Radwaste Effluent Monitor

At Byron, detector 0RE-PR00l monitors liquid radwaste effluent from either 30,000-gallon release tank. The release tank discharge valves 0WX353 and 0WX896 close on high radiation. Each release tank has a dedicated sample probe that is aligned to the detector (0RE-PR001) when its tank and pump are preparing for a release.

At Braidwood, detectors 0RE-PR001 and 0RE-PR090 separately monitor liquid radwaste effluent from 30,000 gallon release tanks

0WX01T and 0WX026T, respectively. The release tank discharge valves 0WX353 and 0WX896 close on a high radiation signal from the radiation monitor of the tank being released.

11.5.2.3.2 Component Cooling Water Monitors

Radiation detectors lRE-PR009, 2RE-PR009, and 0RE-PR009 continuously monitor the component cooling system for leakage of reactor coolant from the reactor coolant system and/or the residual heat removal system.

Detector 1RE-PR009 is interlocked with the component cooling surge tank 1CC01T vent valve 1CC017, and detector 2RE-PR009 is interlocked with the component cooling surge tank 2CC01T vent valve 2CC017. Detector 0RE-PR009 is interlocked with both vent valves, 1CC017 and 2CC017.

A high radiation level signal initiates automatic closure of the valve located in the component cooling surge tank vent line to prevent the release of airborne radioactivity.

11.5.2.3.3 Steam Generator Blowdown

Detectors lRE-PR008 and 2RE-PR008 monitor steam generator blowdown for Unit 1 and 2 respectively.

Steam generator blowdown sample flow is normally routed through the steam generator blowdown sample panel, 0PS01J, and on to the radiation monitor. Automatically on high radiation, detector lRE-PR008 interlocks to close steam generator blowdown sample valves lPS179A through D to terminate sample flow to the sample panel and radiation monitor. A similar interlock exists between detector 2RE-PR008 and valves 2PS179A through D. Termination of sample flow on high radiation protects personnel in the high level laboratory where the sample panel is located. Subsequent sampling of steam generator blowdown can be accomplished by manually redirecting sample flow to the primary sample room. Sequential isolation of steam generator blowdown can be used to determine which steam generator may be leaking.

11.5.2.3.4 Blowdown Filters

The flow from the blowdown mixed-bed demineralizers is normally sent to the condensate storage tank or respective unit hotwell condenser. Detectors 0RE-PR016 through 19 are interlocked with the blowdown after filter discharge valves 0WX119A through D and blowdown monitor tank inlet valves 0WX058A through D.

Automatically on high radiation, the flow from the blowdown mixed-bed demineralizers is redirected to the blowdown monitor tanks.

11.5.2.3.5 Gross Failed Fuel Monitor

Radiation detector lRE-PR006 (and 2RE-PR006 for Unit 2) continuously monitors the CVCS letdown line downstream of the letdown heat exchangers and upstream of the mixed bed demineralizers.

The CVCS is described and the piping and instrument diagram shown in Subsection 9.3.4 and Drawings M-64, M-64A. High radiation alarms are provided in the main control room to alert the operator of an abnormal increase in gross gamma activity in the letdown stream.

Grab sample features are included on the monitor skid for laboratory analysis of primary coolant letdown activity. In addition, process sampling of the letdown line is available at the high radiation sampling system described in Subsection 9.3.2.1 and Appendix E.21.

11.5.2.3.6 Miscellaneous Process Liquid Monitors

A high radiation signal from other liquid detectors listed in Table 11.5-2 will be annunciated in the control room.

11.5.2.3.7 Turbine Building Fire and Oil Sump

Radiation detector 0RE-PR005 continuously monitors the Turbine Building Fire and Oil Sump liquid radiation levels. The monitor 0RT-PR005 annunciates a high radiation condition on local panel 0PL02J. Automatically on high radiation, pumps 0OD03PA through 0OD03PD are stopped and valve 0OD030 is closed.

11.5.2.3.8 Condensate Cleanup Area Sumps Discharge

Radiation detector 0RE-PR041 continuously monitors the water discharged from the condensate cleanup area high and low conductivity sumps to the circulating water system.

On high radiation level, radiation monitor 0RT-PR041 initiates an automatic interlock to trip the condensate cleanup system high conductivity sump pump 0CP04P, the condensate cleanup system low conductivity sump pump 0CP05P and the condensate polishing regeneration process to terminate the discharge flow to the circulating water system. The trip condition is also annunciated at the local condensate polishing system control panel 0CP01J. Both the sump pumps and the regeneration process are allowed to restart only when the reset switch is actuated after the radiation level has returned to normal.

Additionally, radiation monitor 0RT-PR041 also initiates on high radiation level two local horns, a local strobe light and a local indicating light. The horns and strobe light are reset by an "Alarm Acknowledge" push button, while the indicating light is extinguished only when the radiation level has returned to normal.

11.5.2.4 Sampling

Sampling systems are described in Subsections 9.3.2 and 12.3.4. The following subsections give a description of the procedures, frequencies, and objectives associated with sampling of plant process and effluent streams for radioactivity. The sampling program is used in conjunction with the process and effluent radiation monitoring system to assure compliance with applicable regulations.

11.5.2.4.1 Process Sampling

The gaseous and liquid process sampling points are identified in Tables 11.5-3 and 11.5-4. The sample frequency, type of analysis, sensitivity and purpose are listed in the tables. The analytical procedures used in the sample analysis are presented in Subsection 11.5.2.4.4. These samples serve to monitor radioactivity levels within various plant systems.

11.5.2.4.2 Effluent Sampling

Effluent sampling of all potential radioactive liquid and gaseous effluent paths is conducted on a regular basis in order to verify the adequacy of effluent processing to meet the discharge limits to offsite areas. This effluent sampling program provides the information for the effluent measuring and reporting programs required by 10 CFR 50.36a and 10 CFR 20. The frequency of the periodic sampling and analysis described herein is normal and may be increased if effluent levels approach their limits. Tables 11.5-5 and 11.5-6 summarize the sample and analysis schedules.

11.5.2.4.3 Representative Sampling

The pressure head of the fluid, if available, is used for taking samples. If enough pressure head is not available, then sample pumps are used to draw the sample from the process fluid to the detector panels and back to the process.

For obtaining representative samples, isokinetic probes are used for most gaseous samples.

11.5.2.4.4 Analytical Procedures

Typically, samples of process and effluent gases and liquids are analyzed in the station laboratory or by an outside laboratory by means of the following techniques:

a. gross alpha/beta counting,

b. gamma spectrometry, and

c. liquid scintillation counting.

Instrumentation which is available in the laboratory for the measurement of radioactivity at the time of initial fuel loading includes the following:

a. alpha/beta counter,

b. gamma spectrometer, and

c. liquid scintillator.

"Available" instrumentation and counting techniques change as other instruments and techniques become available. For this reason the frequency of sampling and the analysis of samples are generalized here but specifically identified in the station procedures. The following treatment is included as typical of those currently used at Commonwealth Edison Company generating stations.

Gross alpha/beta analysis may be performed directly on unprocessed samples (e.g., air filters) or on processed samples (e.g., evaporated liquid samples). Sample volume, counting geometry, and counting time are chosen to match measurement capability with sample activity. Correction factors for sample-detector geometry, self-absorption and counter resolving time are applied to assure required accuracy.

Liquid effluent samples are prepared for alpha/beta counting by evaporation onto steel planchets.

Gamma analysis may be done on any type of sample (solid or liquid) in the gamma spectrometer.

Tritiated water vapor samples are collected by condensation or adsorption, and the resultant liquid is analyzed by liquid scintillation counting techniques.

Radiochemical separations are used for the routine analysis of SR-89 and SR-90.

Liquid samples are collected in polyethylene bottles to minimize absorption of nuclides onto container walls.

11.5.2.5 <u>Instrument Inspection, Calibration, and Maintenance</u>

During reactor operation, daily checks of effluent monitoring system operability are made by observing channel behavior. Routinely during reactor operation, the detector response is observed with a remotely positioned check source supplied with the monitors. Instrument background count rate is also observed to ensure proper functioning of the monitors. Any detector whose response cannot be verified by observation during normal operation or by using the remotely positioned check source can have its response checked with a portable check source. A record is maintained showing the background radiation level and the detector response.

11.5.2.5.1 Calibration

Calibration of the continuous radiation monitors is done with commercial radionuclide standards that have been standardized using a measurement system traceable to the National Institute of Standards and Technology.

11.5.3 Effluent Monitoring and Sampling

In accordance with the requirements of General Design Criterion 64, each effluent discharge path is continuously monitored for radioactive effluents resulting from normal operations, including anticipated operational occurrences and from postulated accidents.

The implementation of the requirements of General Design Criterion 64 concerning monitoring of effluent discharge paths for radioactivity is covered in Subsection 11.5.2. This subsection provides applicable details for gaseous and liquid effluent monitors.

11.5.4 Process Monitoring and Sampling

The implementation of the requirements of General Design Criterion 60 concerning automatic closure of isolation valves in gaseous and liquid effluent discharge paths and GDC 63 concerning monitoring of radiation levels in radioactive waste process systems is covered in Subsections 11.5.2 and 11.5.3. These subsections provide applicable details for gaseous and liquid process radiation monitors.

TABLE 11.5-1

AIRBORNE PROCESS AND EFFLUENT MONITORS

RADIATION DETECTOR NO.	SERVICE	TYPE OF CHANNEL	TYPE OF DETECTOR	TYPE OF MEAS.	SENSITIVITY (μCi/cc)	RANGE (cpm)	DETECTOR PANEL NO.	PANEL LOCATION DWG. NO.	SEISMIC CAT. OF DETECTORS	SETPOINT*	REMARKS
0RE-PR011 A,B	Radwaste Evap. Cubicle	Air Part. Gas	β Scint. β Scint.	Gross β Gross β	10^{-11}-10^{-5} 10^{-6}-10^{-2}	10^{0}-10^{7} 10^{0}-10^{7}	0PR11J	M-831-6	II	Per RP Approved Proc.	
0RE-PR012	Recycle Evap. Cub.	Air Part.	β Scint.	Gross β	10^{-11}-10^{-5}	10^{0}-10^{7}	0PR12J	M-827-2	II	Per RP Approved Proc.	
0RE-PR014	Drum Station	Air Part.	β Scint.	Gross β	10^{-11}-10^{-5}	10^{0}-10^{7}	0PR14J	M-829-13	II	Per RP Approved Proc.	
0RE-PR015	Laundry Room	Air Part.	β Scint.	Gross β	10^{-11}-10^{-5}	10^{0}-10^{7}	0PR15J	M-831-9	II	Per RP Approved Proc.	
0RE-PR013 A,B	Gas Decay Tank Cubicle	Air Part. Gas	β Scint. β Scint.	Gross β Gross β	10^{-11}-10^{-5} 10^{-6}-10^{-2}	10^{0}-10^{7} 10^{0}-10^{7}	0PR13J	M-827-2	II	Per RP Approved Proc.	
1RE-PR013 A,B	RHR/CS Pump 1A Cubicle	Air Part. Gas	β Scint. β Scint.	Gross β Gross β	10^{-11}-10^{-5} 10^{-6}-10^{-2}	10^{0}-10^{7} 10^{0}-10^{7}	1PR13J	M-827-7	I	Per RP Approved Proc.	

*Alarm setpoints will be appropriately adjusted as operating experience is gained.

TABLE 11.5-1 (Cont'd)

RADIATION DETECTOR NO.	SERVICE	TYPE OF CHANNEL	TYPE OF DETECTOR	TYPE OF MEAS.	SENSITIVITY (μCi/cc)	RANGE (cpm)	DETECTOR PANEL NO.	PANEL LOCATION DWG. NO.	SEISMIC CAT. OF DETECTORS	SETPOINT*	REMARKS
2RE-PR013 A,B	RHR/CS Pump 2A Cubicle	Air Part. Gas	β Scint. β Scint.	Gross β Gross β	10^{-11}-10^{-5} 10^{-6}-10^{-2}	10^{0}-10^{7} 10^{0}-10^{7}	2PR13J	M-827-7	I	Per RP Approved Proc.	
1RE-PR014 A,B	RHR/CS Pump 1B Cubicle	Air Part. Gas	β Scint. β Scint.	Gross β Gross β	10^{-11}-10^{-5} 10^{-6}-10^{-2}	10^{0}-10^{7} 10^{0}-10^{7}	1PR14J	M-827-7	I	Per RP Approved Proc.	
2RE-PR014 A,B	RHR/CS Pump 2B Cubicle	Air Part. Gas	β Scint. β Scint.	Gross β Gross β	10^{-11}-10^{-5} 10^{-6}-10^{-2}	10^{0}-10^{7} 10^{0}-10^{7}	2PR14J	M-827-7	I	Per RP Approved Proc.	
1RE-PR015 A,B	RHR Ht. Exch. 1A Cubicle	Air Part. Gas	β Scint. β Scint.	Gross β Gross β	10^{-11}-10^{-5} 10^{-6}-10^{-2}	10^{0}-10^{7} 10^{0}-10^{7}	1PR15J	M-829-5	I	Per RP Approved Proc.	
2RE-PR015 A,B	RHR Ht. Exch. 2A Cubicle	Air Part. Gas	β Scint. β Scint.	Gross β Gross β	10^{-11}-10^{-5} 10^{-6}-10^{-2}	10^{0}-10^{7} 10^{0}-10^{7}	2PR15J	M-829-5	I	Per RP Approved Proc.	
1RE-PR016 A,B	RHR Ht. Exch. 1B Cubicle	Air Part. Gas	β Scint. β Scint.	Gross β Gross β	10^{-11}-10^{-5} 10^{-6}-10^{-2}	10^{0}-10^{7} 10^{0}-10^{7}	1PR16J	M-829-3	I	Per RP Approved Proc.	
2RE-PR016 A,B	RHR Ht. Exch. 2B Cubicle	Air Part. Gas	β Scint. β Scint.	Gross β Gross β	10^{-11}-10^{-5} 10^{-6}-10^{-2}	10^{0}-10^{7} 10^{0}-10^{7}	2PR16J	M-829-3	I	Per RP Approved Proc.	

TABLE 11.5-1 (Cont'd)

RADIATION DETECTOR NO.	SERVICE	TYPE OF CHANNEL	TYPE OF DETECTOR	TYPE OF MEAS.	SENSITIVITY (μCi/cc)	RANGE (cpm)	DETEC-TOR PANEL NO.	PANEL LOCATION DWG. NO.	SEISMIC CAT. OF DETEC-TORS	SETPOINT*	REMARKS
1RE-PR017 A,B	Centrifu-gal Charg-ing Pump 1A Cub.	Air Part. Gas	β Scint. β Scint.	Gross β Gross β	10^{-11}-10^{-5} 10^{-6}-10^{-2}	10^{0}-10^{7} 10^{0}-10^{7}	1PR17J	M-828-7	I	Per RP Approved Proc.	
2RE-PR017 A,B	Centrifu-gal Charg-ing Pump 2A Cub.	Air Part. Gas	β Scint. β Scint.	Gross β Gross β	10^{-11}-10^{-5} 10^{-6}-10^{-2}	10^{0}-10^{7} 10^{0}-10^{7}	2PR17J	M-828-7	I	Per RP Approved Proc.	
1RE-PR018 A,B	Centrifu-gal Charg-ing Pump 1B Cub.	Air Part. Gas	β Scint. β Scint.	Gross β Gross β	10^{-11}-10^{-5} 10^{-6}-10^{-2}	10^{0}-10^{7} 10^{0}-10^{7}	1PR18J	M-827-7	I	Per RP Approved Proc.	
2RE-PR018 A,B	Centrifu-gal Charg-ing Pump 2B Cub.	Air Part. Gas	β Scint. β Scint.	Gross β Gross β	10^{-11}-10^{-5} 10^{-6}-10^{-2}	10^{0}-10^{7} 10^{0}-10^{7}	2PR18J	M-827-7	I	Per RP Approved Proc.	
0RE-PR002 A,B	Gas Decay Tank Effluent	Gas (Low) Gas (High)	β Scint. β Scint.	Gross β Gross β	10^{-6}-10^{-2} 10^{-2}-10^{+2}	10^{0}-10^{7} 10^{0}-10^{7}	0PR02J	M-827-2	II	Per ODCM/RETS Limits	Interlock ref. 11.5.2.2.14
0RE-PR003 A,B,C	Lab. Fume Hood Exhaust	Air Part. Gas Iodine	β Scint. β Scint. NaI	Gross β Gross β γ(I-131)	10^{-11}-10^{-5} 10^{-6}-10^{-2} 10^{-11}-10^{-5}	10^{0}-10^{7} 10^{0}-10^{7} 10^{0}-10^{7}	0PR03J	M-831-8	II	Per RP Approved Proc.	

TABLE 11.5-1 (Cont'd)

RADIATION DETECTOR NO.	SERVICE	TYPE OF CHANNEL	TYPE OF DETECTOR	TYPE OF MEAS.	SENSITIVITY (μCi/cc)	RANGE (cpm)	DETECTOR PANEL NO.	PANEL LOCATION DWG. NO.	SEISMIC CAT. OF DETECTORS	SETPOINT*	REMARKS
0RE-PR025 A,B,C	Misc. Tank Filter Vent Effluent	Air Part. Gas Iodine	β Scint. β Scint. NaI	Gross β Gross β γ(I-131)	10^{-11}-10^{-5} 10^{-6}-10^{-2} 10^{-11}-10^{-5}	10^{0}-10^{7} 10^{0}-10^{7} 10^{0}-10^{7}	0PR25J	M-832-34	I	Per RP Approved Proc.	
0RE-PR026 A,B,C	Radwaste Area Vent Exhaust	Air Part. Gas Iodine	β Scint. β Scint. NaI	Gross β Gross β γ(I-131)	10^{-11}-10^{-5} 10^{-6}-10^{-2} 10^{-11}-10^{-5}	10^{0}-10^{7} 10^{0}-10^{7} 10^{0}-10^{7}	0PR26J	M-831-6	I	Per RP Approved Proc.	Interlock ref. 11.5.2.2.12
1RE-PR001 A,B,C	Contain-ment Purge Effluent	Air Part. Gas Iodine	β Scint. β Scint. NaI	Gross β Gross β γ(I-131)	10^{-11}-10^{-5} 10^{-6}-10^{-2} 10^{-11}-10^{-5}	10^{0}-10^{7} 10^{0}-10^{7} 10^{0}-10^{7}	1PR01J	M-832-26	I	Per ODCM/RETS Limits	
2RE-PR001 A,B,C	Contain-ment Purge Effluent	Air Part. Gas Iodine	β Scint. β Scint. NaI	Gross β Gross β γ(I-131)	10^{-11}-10^{-5} 10^{-6}-10^{-2} 10^{-11}-10^{-5}	10^{0}-10^{7} 10^{0}-10^{7} 10^{0}-10^{7}	2PR01J	M-832-26	I	Per ODCM/RETS Limits	
1RE-PR011 A,B,C,D,E	Contain-ment Atmos-phere	Air Part. Gas (low) Iodine Gas (high) Gas (back-ground)	β Scint. β Scint. NaI β Scint. β Scint.	Gross β Gross β γ(I-131) Gross β Gross β	10^{-11}-10^{-5} 10^{-6}-10^{-2} 10^{-11}-10^{-5} 10^{-2}-10^{+2} 10^{-6}-10^{-2}	10^{0}-10^{7} 10^{0}-10^{7} 10^{0}-10^{7} 10^{0}-10^{7} 10^{0}-10^{7}	1PR11J	M-828-7	II	Detect 1gpm RCS leak rate in less than 1 hr or as low as practicable	Interlock ref. 11.5.2.2.10

TABLE 11.5-1 (Cont'd)

RADIATION DETECTOR NO.	SERVICE	TYPE OF CHANNEL	TYPE OF DETECTOR	TYPE OF MEAS.	SENSITIVITY (μCi/cc)	RANGE (cpm)	DETECTOR PANEL NO.	PANEL LOCATION DWG. NO.	SEISMIC CAT. OF DETECTORS	SETPOINT*	REMARKS
2RE-PR011 A,B,C,D,E	Containment Atmosphere	Air Part. Gas (low) Iodine Gas (high) Gas (background)	β Scint. β Scint. NaI β Scint. β Scint.	Gross β Gross β γ(I-131) Gross β Gross β	10^{-11}-10^{-5} 10^{-6}-10^{-2} 10^{-11}-10^{-5} 10^{-2}-10^{+2} 10^{-6}-10^{-2}	10^{0}-10^{7} 10^{0}-10^{7} 10^{0}-10^{7} 10^{0}-10^{7} 10^{0}-10^{7}	2PR11J	M-828-7	II	Detect 1gpm RCS Leak Rate in less than 1 hr or as low as practicable	Interlock Ref. 11.5.2.2.10
1RE-PR028 A,B,C,D,E	Aux. Bldg. Vent Stack Effluent	Air Part. Gas (low) Iodine Gas (high) Gas (background)	β Scint. β Scint. NaI β Scint. β Scint.	Gross β Gross β γ(I-131) Gross β Gross β	10^{-11}-10^{-5} 10^{-6}-10^{-2} 10^{-11}-10^{-5} 10^{-2}-10^{+2} 10^{-6}-10^{-2}	10^{0}-10^{7} 10^{0}-10^{7} 10^{0}-10^{7} 10^{0}-10^{7} 10^{0}-10^{7}	1PR28J	M-832-34	I	Per ODCM/ RETS Limits	
2RE-PR028 A,B,C,D,E	Aux. Bldg. Vent Stack Effluent	Air Part. Gas (low) Iodine Gas (high) Gas (background)	β Scint. β Scint. NaI β Scint. β Scint.	Gross β Gross β γ(I-131) Gross β Gross β	10^{-11}-10^{-5} 10^{-6}-10^{-2} 10^{-11}-10^{-5} 10^{-2}-10^{+2} 10^{-6}-10^{-2}	10^{0}-10^{7} 10^{0}-10^{7} 10^{0}-10^{7} 10^{0}-10^{7} 10^{0}-10^{7}	2PR28J	M-832-34	I	Per ODCM/ RETS Limits	
0RE-PR021 A,B,C	Aux. Bldg. Vent Exhaust 0A	Air Part. Gas Iodine	β Scint. β Scint. NaI	Gross β Gross β γ(I-131)	10^{-11}-10^{-5} 10^{-6}-10^{-2} 10^{-11}-10^{-5}	10^{0}-10^{7} 10^{0}-10^{7} 10^{0}-10^{7}	0PR21J	M-831-6	I	Per RP Approved Proc.	

TABLE 11.5-1 (Cont'd)

RADIATION DETECTOR NO.	SERVICE	TYPE OF CHANNEL	TYPE OF DETECTOR	TYPE OF MEAS.	SENSITIVITY (μCi/cc)	RANGE (cpm)	DETECTOR PANEL NO.	PANEL LOCATION DWG. NO.	SEISMIC CAT. OF DETECTORS	SETPOINT*	REMARKS
0RE-PR022 A,B,C	Aux. Bldg. Vent Exhaust 0B	Air Part. Gas Iodine	β Scint. β Scint. NaI	Gross β Gross β γ(I-131)	10^{-11}-10^{-5} 10^{-6}-10^{-2} 10^{-11}-10^{-5}	10^{0}-10^{7} 10^{0}-10^{7} 10^{0}-10^{7}	0PR22J	M-831-6	I	Per RP Approved Proc.	
0RE-PR024 A,B,C	Fuel Handling Bldg. Exh.	Air Part. Gas Iodine	β Scint. β Scint. NaI	Gross β Gross β γ(I-131)	10^{-11}-10^{-5} 10^{-6}-10^{-2} 10^{-11}-10^{-5}	10^{0}-10^{7} 10^{0}-10^{7} 10^{0}-10^{7}	0PR24J	M-831-6	I	Per RP Approved Proc.	
0RE-PR031 A,B,C	Control Room Outside Air Intake A	Air Part. Gas Iodine	β Scint. β Scint. NaI	Gross β Gross β γ(I-131)	10^{-11}-10^{-5} 10^{-6}-10^{-2} 10^{-11}-10^{-5}	10^{0}-10^{7} 10^{0}-10^{7} 10^{0}-10^{7}	0PR31J	M-832-12	I	Per RP Approved Proc. ≤2 mR/hr Submersion dose Per RP Approved Proc.	Redundant function with 0RE-PR032A,B,C Interlock ref. 11.5.2.2.8
0RE-PR032 A,B,C	Control Room Outside Air Intake A	Air Part. Gas Iodine	β Scint. β Scint. NaI	Gross β Gross β γ(I-131)	10^{-11}-10^{-5} 10^{-6}-10^{-2} 10^{-11}-10^{-5}	10^{0}-10^{7} 10^{0}-10^{7} 10^{0}-10^{7}	0PR32J	M-832-17	I	Per RP Approved Proc. ≤2 mR/hr Submersion dose Per RP Approved Proc.	Redundant function with 0RE-PR031A,B,C Interlock ref. 11.5.2.2.8

TABLE 11.5-1 (Cont'd)

RADIATION DETECTOR NO.	SERVICE	TYPE OF CHANNEL	TYPE OF DETECTOR	TYPE OF MEAS.	SENSITIVITY (μCi/cc)	RANGE (cpm)	DETECTOR PANEL NO.	PANEL LOCATION DWG. NO.	SEISMIC CAT. OF DETECTORS	SETPOINT*	REMARKS
0RE-PR033 A,B,C	Control Room Outside Air Intake B	Air Part.	β Scint.	Gross β	10^{-11}-10^{-5}	10^{0}-10^{7}	0PR33J	M-832-14	I	Per RP Approved Proc.	Redundant function with 0RE-PR034A,B,C Interlock ref. 11.5.2.2.8
		Gas	β Scint.	Gross β	10^{-6}-10^{-2}	10^{0}-10^{7}				≤2 mR/hr Submersion dose	
		Iodine	NaI	γ(I-131)	10^{-11}-10^{-5}	10^{0}-10^{7}				Per RP Approved Proc.	
0RE-PR034 A,B,C	Control Room Outside Air	Air Part.	β Scint.	Gross β	10^{-11}-10^{-5}	10^{0}-10^{7}	0PR34J	M-832-19	I	Per RP Approved Proc.	Redundant function with 0RE-PR033A,B,C Interlock ref. 11.5.2.2.8
		Gas	β Scint.	Gross β	10^{-6}-10^{-2}	10^{0}-10^{7}				≤2 mR/hr Submersion dose	
		Iodine	NaI	γ(I-131)	10^{-11}-10^{-5}	10^{0}-10^{7}				Per RP Approved Proc	
0RE-PR035 A,B,C	Control Room Turb. Bldg. Air Intake A	Air Part.	β Scint.	Gross β	10^{-11}-10^{-5}	10^{0}-10^{7}	0PR35J	M-832-12	I	Per RP Approved Proc.	Redundant function with 0RE-PR036A,B,C
		Gas	β Scint.	Gross β	10^{-6}-10^{-2}	10^{0}-10^{7}				≤2 mR/hr submersion dose	
		Iodine	NaI	γ(I-131)	10^{-11}-10^{-5}	10^{0}-10^{7}				Per RP Approved Proc.	
0RE-PR036 A,B,C	Control Room Turb. Bldg. Air Intake A	Air Part.	β Scint.	Gross β	10^{-11}-10^{-5}	10^{0}-10^{7}	0PR36J	M-832-12	I	Per RP Approved Proc.	Redundant function with 0RE-PR035A,B,C
		Gas	β Scint.	Gross β	10^{-6}-10^{-2}	10^{0}-10^{7}				≤2 mR/hr submersion dose	
		Iodine	NaI	γ(I-131)	10^{-11}-10^{-5}	10^{0}-10^{7}				Per RP Approved Proc.	

TABLE 11.5-1 (Cont'd)

RADIATION DETECTOR NO.	SERVICE	TYPE OF CHANNEL	TYPE OF DETECTOR	TYPE OF MEAS.	SENSITIVITY (μCi/cc)	RANGE (cpm)	DETECTOR PANEL NO.	PANEL LOCATION DWG. NO.	SEISMIC CAT. OF DETECTORS	SETPOINT*	REMARKS
0RE-PR037 A,B,C	Control Room Turb. Bldg. Air Intake B	Air Part.	β Scint.	Gross β	10^{-11}-10^{-5}	10^{0}-10^{7}	0PR37J	M-832-14	I	Per RP Approved Proc.	Redundant function with 0RE-PR038 A,B,C
		Gas	β Scint.	Gross β	10^{-6}-10^{-2}	10^{0}-10^{7}				$\leq$2 mR/hr Submersion dose	
		Iodine	NaI	γ(I-131)	10^{-11}-10^{-5}	10^{0}-10^{7}				Per RP Approved Proc.	
0RE-PR038 A,B,C	Control Room Turb. Bldg. Air Intake B	Air Part.	β Scint.	Gross β	10^{-11}-10^{-5}	10^{0}-10^{7}	0PR38J	M-832-14	I	Per RP Approved Proc.	Redundant function with 0RE-PR037 A,B,C
		Gas	β Scint.	Gross β	10^{-6}-10^{-2}	10^{0}-10^{7}				$\leq$2 mR/hr submersion dose	
		Iodine	NaI	γ(I-131)	10^{-11}-10^{-5}	10^{0}-10^{7}				Per RP Approved Proc.	

TABLE 11.5-1 (Cont'd)

RADIATION DETECTOR NO.	SERVICE	TYPE OF CHANNEL	TYPE OF DETECTOR	TYPE OF MEAS.	SENSITIVITY (μCi/cc)	RANGE (cpm)	DETECTOR PANEL NO.	PANEL LOCATION DWG. NO.	SEISMIC CAT. OF DETECTORS	SETPOINT*	REMARKS
1RE-PR021 A,B,C	Pipe Tunnel	Air Part. Gas Iodine	β Scint. β Scint. NaI	Gross β Gross β γ(I-131)	10^{-11}-10^{-5} 10^{-6}-10^{-2} 10^{-11}-10^{-5}	10^{0}-10^{7} 10^{0}-10^{7} 10^{0}-10^{7}	1PR21J	M-831-6	I	Per RP Approved Proc.	
2RE-PR021 A,B,C	Pipe Tunnel	Air Part. Gas Iodine	β Scint. β Scint. NaI	Gross β Gross β γ(I-131)	10^{-11}-10^{-5} 10^{-6}-10^{-2} 10^{-11}-10^{-5}	10^{0}-10^{7} 10^{0}-10^{7} 10^{0}-10^{7}	2PR21J	M-831-6	I	Per RP Approved Proc.	
0RE-PR040 A,B,C	VR System Areas & Cub. Ventilation Exhaust	Air Part. Gas Iodine	β Scint. β Scint. NaI	Gross β Gross β γ(I-131)	10^{-11}-10^{-5} 10^{-6}-10^{-2} 10^{-11}-10^{-5}	10^{0}-10^{7} 10^{0}-10^{7} 10^{0}-10^{7}	0PR40J	M-844-5	II	Per RP Approved Proc.	Interlock ref. 11.5.2.2.15
1RE-PR027	SJAE/ Gland Stm. Exhaust	Gas	β Scint.	Gross β	10^{-6}-10^{-2}	10^{0}-10^{7}	1PR27J	M-836-3	II	Detect 150 gpd Leak Rate	Interlock ref. 11.5.2.2.13
2RE-PR027	SJAE/ Gland Stm. Exhaust	Gas	β Scint.	Gross β	10^{-6}-10^{-2}	10^{0}-10^{7}	2PR27J	M-836-19	II	Detect 150 gpd Leak Rate	Interlock ref. 11.5.2.2.13
1RE-PR030 A,B,C	Aux. Bldg. Vent Stack (WRGM)	Gas-Low Gas-Mid Gas-High	β Scint. CdTe CdTe	Gross β Gross β Gross β	10^{-7}-10^{-1} 10^{-4}-10^{2} 10^{-1}-10^{5}	10^{0}-10^{7} 10^{0}-10^{7} 10^{0}-10^{7}	1PR30J	M-832-34	I	Per E-Plan EALS	

TABLE 11.5-1 (Cont'd)

RADIATION DETECTOR NO.	SERVICE	TYPE OF CHANNEL	TYPE OF DETECTOR	TYPE OF MEAS.	SENSITIVITY (μCi/cc)	RANGE (cpm)	DETEC-TOR PANEL NO.	PANEL LOCATION DWG. NO.	SEISMIC CAT. OF DETEC-TORS	SETPOINT*	REMARKS
2RE-PR030 A,B,C	Aux. Bldg. Vent Stack (WRGM)	Gas-Low Gas-Mid Gas-High	β Scint. CdTe CdTe	Gross β Gross β Gross β	10^{-7}-10^{-1} 10^{-4}-10^{2} 10^{-1}-10^{5}	10^{0}-10^{7} 10^{0}-10^{7} 10^{0}-10^{7}	2PR30J	M-832-34	I	Per E-Plan EALS	
0RE-PR060 A,B,C	TSC Vent System	Air Part. Gas Iodine	β Scint. β Scint. NaI	Gross β Gross β γ(I-131)	10^{-11}-10^{-5} 10^{-6}-10^{-2} 10^{-11}-10^{-5}	10^{0}-10^{7} 10^{0}-10^{7} 10^{0}-10^{7}	0PR60J	M-850-2	II	Per RP Approved Proc.	

TABLE 11.5-2

PROCESS LIQUID MONITORS

RADIATION DETECTOR NO.	SERVICE	TYPE OF CHANNEL	TYPE OF DETECTOR	TYPE OF MEAS.	SENSITIVITY (μCi/cc)	RANGE (cpm)	DETEC-TOR PANEL NO.	PANEL LOCATION DWG. NO.	SEISMIC CAT. OF DETEC-TORS	REMARKS
0RE-PR001	Liq. Rad-waste Eff.	Liquid	NaI	γ	10^{-6}-10^{-2}	10^{0}-10^{7}	0PR01J	M-836-3	II	Interlock ref. 11.5.2.3.1
0RE-PR090 (BWD Only)	Liq. Rad-waste Eff.	Liquid	NaI	γ	10^{-6}-10^{-2}	10^{0}-10^{7}	0PR90J	M-836-3	II	Interlock ref. 11.5.2.3.1
0RE-PR006	Radwaste Evap. 0A Cnds. Return	Liquid	NaI	γ	10^{-6}-10^{-2}	10^{0}-10^{7}	0PR06J	M-830-10	II	
0RE-PR007	Radwaste Evap. 0B Cnds. Return	Liquid	NaI	γ	10^{-6}-10^{-2}	10^{0}-10^{7}	0PR07J	M-830-10	II	
0RE-PR008	Radwaste Evap. 0C Cnds. Return	Liquid	NaI	γ	10^{-6}-10^{-2}	10^{0}-10^{7}	0PR08J	M-830-10	II	
0RE-PR009	CC Ht. Exch. 0 Wtr. Outlet	Liquid	NaI	γ	10^{-6}-10^{-2}	10^{0}-10^{7}	0PR09J	M-828-5	I	Interlock ref. 11.5.2.3.2
0RE-PR041	Condensate Polisher Conductivity Sump	Liquid	NaI	γ	10^{-6}-10^{-2}	10^{0}-10^{7}	0PR41J	M-836-15A	II	Interlock ref. 11.5.2.3.8
1RE-PR009	CC Ht. Exch. 1 Wtr. Outlet	Liquid	NaI	γ	10^{-6}-10^{-2}	10^{0}-10^{7}	1PR09J	M-828-5	I	Interlock ref. 11.5.2.3.2

Note: Alarm setpoints are established to provide a warning of increased system activity and ensure agreement with calculational methodology and limits described in the Offsite Dose Calculation Manual.

TABLE 11.5-2 (Cont'd)

RADIATION DETECTOR NO.	SERVICE	TYPE OF CHANNEL	TYPE OF DETECTOR	TYPE OF MEAS.	SENSITIVITY (μCi/cc)	RANGE (cpm)	DETECTOR PANEL NO.	PANEL LOCATION DWG. NO.	SEISMIC CAT. OF DETECTORS	REMARKS
2RE-PR009	CC Ht. Exch. 2 Wtr. Outlet	Liquid	NaI	γ	10^{-6}-10^{-2}	10^{0}-10^{7}	2PR09J	M-828-5	I	Interlock ref. 11.5.2.3.2
1RE-PR007	Boron Thermal Regeneration Chiller Surge Tank Return	Liquid	NaI	γ	10^{-6}-10^{-2}	10^{0}-10^{7}	1PR07J	M-827-7	II	
2RE-PR007	Boron Thermal Regeneration Chiller Surge Tank Return	Liquid	NaI	γ	10^{-6}-10^{-2}	10^{0}-10^{7}	2PR07J	M-827-7	II	
1RE-PR006	Gross Failed Fuel	Liquid	NaI	γ (I-135)	10^{-4}-10^{0}	10^{0}-10^{7}	1PR06J	M-829-5 M-830-4	I	
2RE-PR006	Gross Failed Fuel	Liquid	NaI	γ (I-135)	10^{-4}-10^{0}	10^{0}-10^{7}	2PR06J	M-829-5 M-830-6	I	
1RE-PR002	RCFC 1A&1C Ess. Service Wtr. Outlet	Liquid	NaI	γ	10^{-6}-10^{-2}	10^{0}-10^{7}	1PR02J	M-830-4	I	

TABLE 11.5-2 (Cont'd)

RADIATION DETECTOR NO.	SERVICE	TYPE OF CHANNEL	TYPE OF DETECTOR	TYPE OF MEAS.	SENSITIVITY (μCi/cc)	RANGE (cpm)	DETECTOR PANEL NO.	PANEL LOCATION DWG. NO.	SEISMIC CAT. OF DETECTORS	REMARKS
2RE-PR002	RCFC 2A&2C Ess. Service Wtr. Outlet	Liquid	NaI	γ	10^{-6}-10^{-2}	10^{0}-10^{7}	2PR02J	M-830-6	I	
1RE-PR003	RCFC 1B&1D Ess. Service Wtr. Outlet	Liquid	NaI	γ	10^{-6}-10^{-2}	10^{0}-10^{7}	1PR03J	M-830-4	I	
2RE-PR003	RCFC 2B&2D Ess. Service Wtr. Outlet	Liquid	NaI	γ	10^{-6}-10^{-2}	10^{0}-10^{7}	2PR03J	M-830-6	I	
1RE-PR008	Steam Generator Blowdown	Liquid	NaI	γ	10^{-6}-10^{-2}	10^{0}-10^{7}	1PR08J	M-831-8	II	Interlock ref. 11.5.2.3.3
2RE-PR008	Steam Generator Blowdown	Liquid	NaI	γ	10^{-6}-10^{-2}	10^{0}-10^{7}	2PR08J	M-831-8	II	Interlock ref. 11.5.2.3.3
0RE-PR010	Station Blowdown	Liquid	NaI	γ	10^{-6}-10^{-2}	10^{0}-10^{7}	0PR10J	M-834-13	II	
0RE-PR016	Bldn. After Filter 0A Outlet	Liquid	NaI	γ	10^{-6}-10^{-2}	10^{0}-10^{7}	0PR16J	M-829-7A	II	Interlock ref. 11.5.2.3.4
0RE-PR017	Bldn. After Filter 0B Outlet	Liquid	NaI	γ	10^{-6}-10^{-2}	10^{0}-10^{7}	0PR17J	M-829-7A	II	Interlock ref. 11.5.2.3.4

TABLE 11.5-2 (Cont'd)

RADIATION DETECTOR NO.	SERVICE	TYPE OF CHANNEL	TYPE OF DETECTOR	TYPE OF MEAS.	SENSITIVITY (μCi/cc)	RANGE (cpm)	DETEC-TOR PANEL NO.	PANEL LOCATION DWG. NO.	SEISMIC CAT. OF DETEC-TORS	REMARKS
0RE-PR018	Bldn. After Filter 0C Outlet	Liquid	NaI	γ	10^{-6}-10^{-2}	10^{0}-10^{7}	0PR18J	M-829-7A	II	Interlock ref. 11.5.2.3.4
0RE-PR019	Bldn. After Filter 0D Outlet	Liquid	NaI	γ	10^{-6}-10^{-2}	10^{0}-10^{7}	0PR19J	M-829-11A	II	Interlock ref. 11.5.2.3.4
0RE-PR005	Turb. Bldg. Fire and Oil Sump	Liquid	NaI	γ	10^{-6}-10^{-2}	10^{0}-10^{7}	0PRO5J	M-834-2	II	Interlock ref. 11.5.2.3.7

TABLE 11.5-3

RADIOLOGICAL ANALYSIS SUMMARY OF LIQUID PROCESS SAMPLES

SAMPLE DESCRIPTION	TYPICAL SAMPLE FREQUENCY	ANALYSIS	SENSITIVITY (μCi/ml)	PURPOSE
1. Reactor coolant				
Liquid	Daily†	Gamma isotopic	N/A	Evaluate reactor water activity
Crud	Weekly	Gamma isotopic	N/A	Evaluate crud activity
Liquid	Daily†	I-131, Dose equivalent	N/A	Evaluate fuel cladding integrity
2. Condensate storage tank - Unit 1.	Weekly	Gamma isotopic	10^{-6}	Tank inventory
3. Condensate storage tank - Unit 2.	Weekly	Gamma isotopic	10^{-6}	Tank inventory
4. Fuel pool filter-demineralizer				
Inlet and Outlet	Periodically when fuel is present	Gamma isotopic Gross β	10^{-6} 10^{-6}	Evaluate system performance

* When sample is available.
Actual frequency is determined by plant needs and operational circumstances per the Technical Specifications.

TABLE 11.5-4

RADIOLOGICAL ANALYSIS SUMMARY OF GASEOUS PROCESS SAMPLES

	SAMPLE DESCRIPTION	TYPICAL SAMPLE FREQUENCY	ANALYSIS	SENSITIVITY (μCi/ml)	PURPOSE
1.	Containment atmosphere	Periodically and prior to entry*	Noble gas Gamma isotopic** I-131*** I-133*** Tritium	10^{-4} 10^{-11} 10^{-12} 10^{-10} 10^{-7}	Determine need for personnel protection and effluent release record

* As determined by plant needs and operational circumstances per the Technical Specifications.

** On particulate filter.

*** On charcoal cartridge.

TABLE 11.5-5

RADIOLOGICAL ANALYSIS SUMMARY OF LIQUID EFFLUENT SAMPLES

	SAMPLE DESCRIPTION	TYPICAL SAMPLE FREQUENCY	ANALYSIS	SENSITIVITY (μCi/ml)	PURPOSE
1.	Aux. bldg. floor drain tank	On request	Gamma isotopic	$5x10^{-7}$	
			tritium	10^{-5}	
2.	Laundry drain tank	On request	Gamma isotopic	$5x10^{-7}$	
			tritium	10^{-5}	
3.	Liquid release tanks (2)	Batch*	Gamma isotopic	5×10^{-7}	Effluent release record
			tritium	10^{-5}	
		Monthly	Gamma isotopic (noble gas)	10^{-5}	
			Alpha	10^{-7}	
	Composite of all release tanks discharged	Quarterly	Sr-89/90	$5x10^{-8}$	
			Fe-55	10^{-6}	
4.	Circulating water**	Weekly	Gamma isotopic	$5x10^{-7}$	Effluent release record
			I-131	10^{-6}	
		Monthly	Gamma isotopic (noble gas)	10^{-5}	
			Tritium	10^{-5}	
			Gross alpha	10^{-7}	
		Quarterly	Sr-89/90	$5x10^{-8}$	
			Fe-55	10^{-6}	

* If tank is to be discharged, analyses will be performed on each batch. If tank is not to be discharged, analyses may be performed.

** Daily sample collected continuously; composited weekly, monthly, and quarterly.

TABLE 11.5-6

RADIOLOGICAL ANALYSIS SUMMARY OF GASEOUS EFFLUENT SAMPLES

SAMPLE DESCRIPTION	SAMPLE FREQUENCY	ANALYSIS	SENSITIVITY ($\mu Ci/cm^3$)	PURPOSE
1. Aux. Bldg. Vent Stack Unit 1 & Unit 2	Weekly	Gamma isotopic*	10^{-11}	Effluent release record
		I-131**	10^{-12}	
		I-133	10^{-10}	
	Monthly	Tritium	10^{-7}	
		Noble Gas	10^{-4}	
	Quarterly***	Sr-89, Sr-90	10^{-11}	
		Alpha	10^{-11}	

* On particulate filter.

** On charcoal cartridge.

*** Performed by off-site vendor.

Figures 11.2-1 through 11.2-41 have been deleted intentionally.

Figure 11.3-1 has been deleted intentionally.

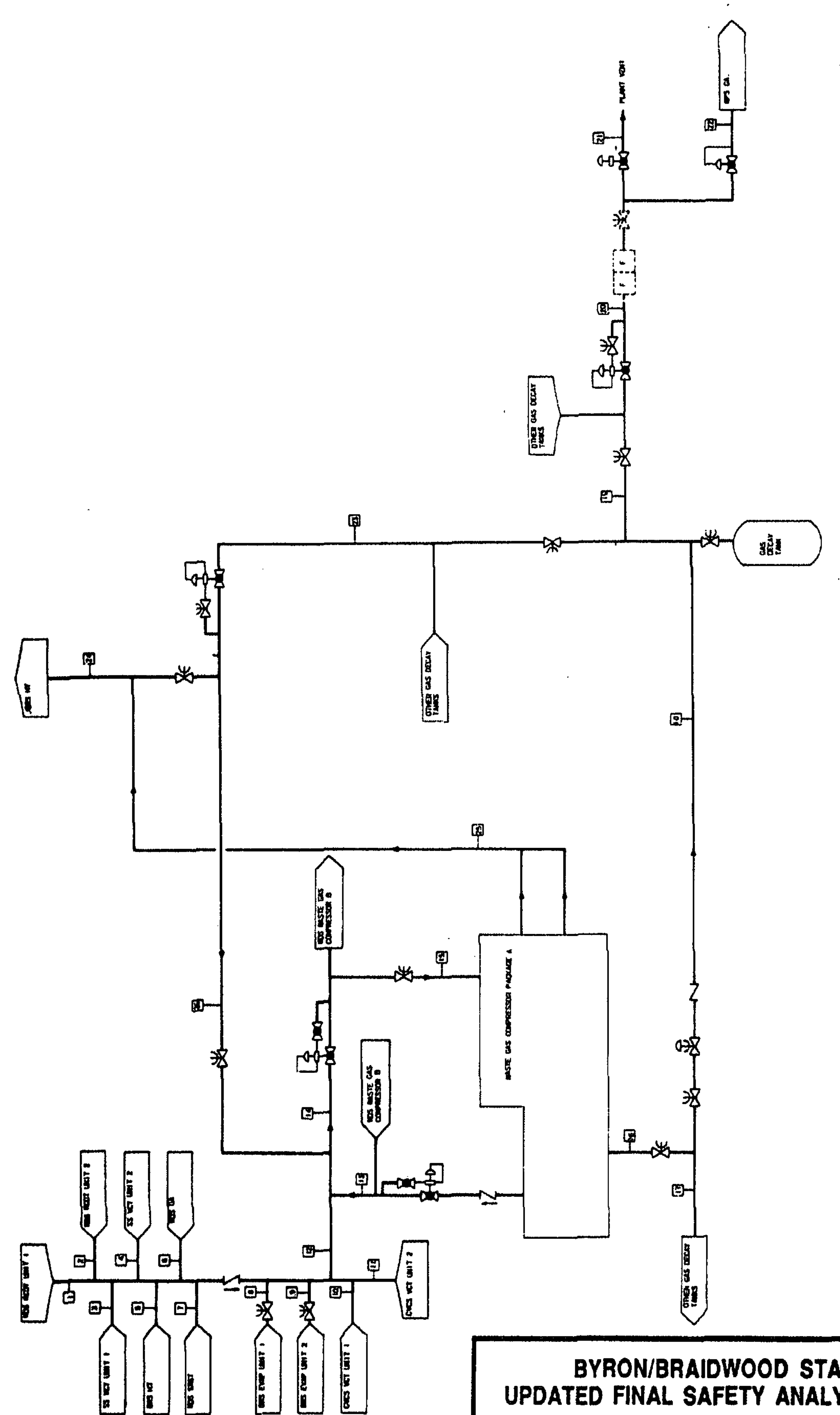

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FIGURE 11.3-2

GASEOUS WASTE PROCESSING SYSTEM
FLOW DIAGRAM

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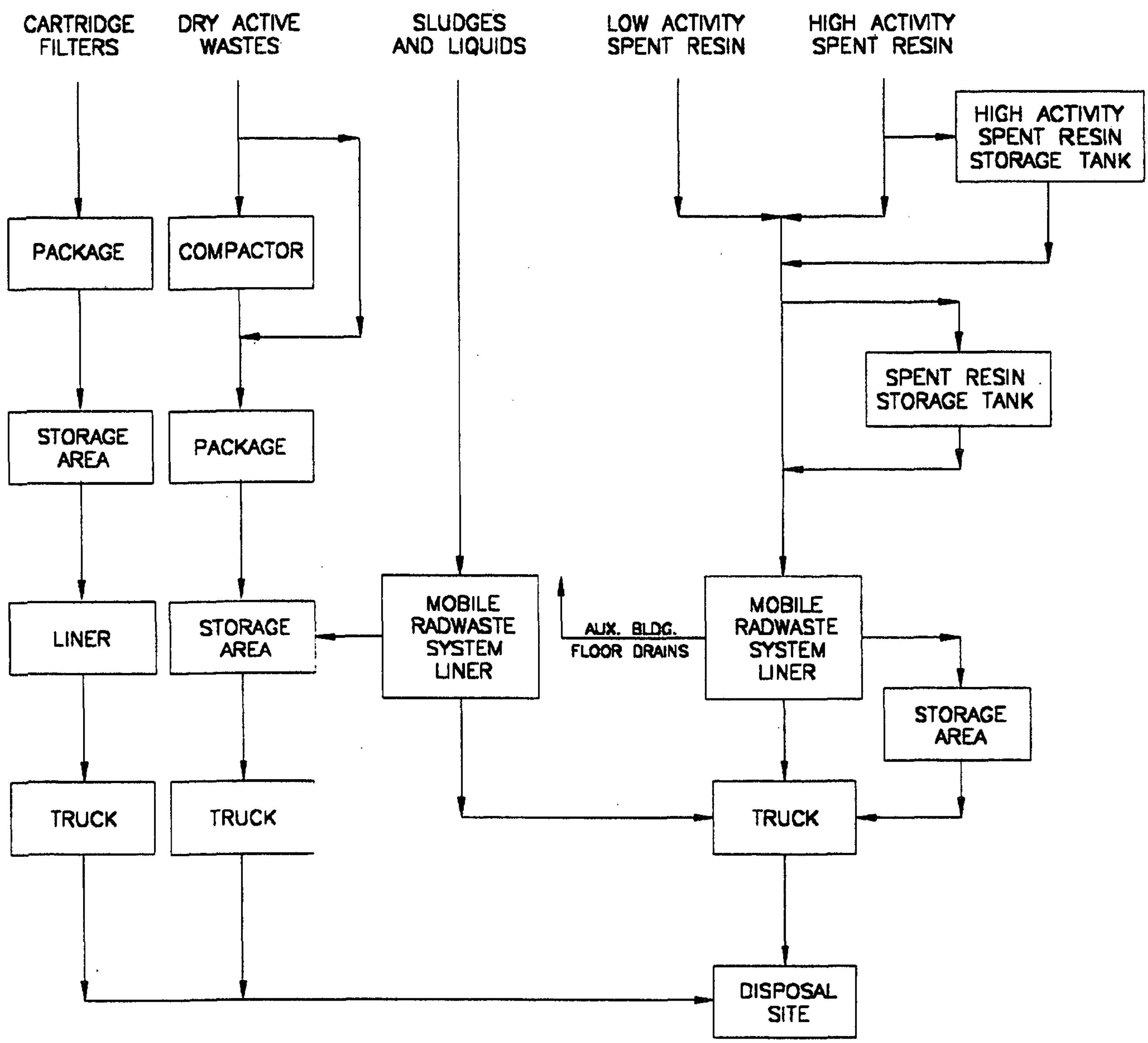

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FIGURE 11.4-1

RADWASTE DISPOSAL SYSTEM FLOW DIAGRAM

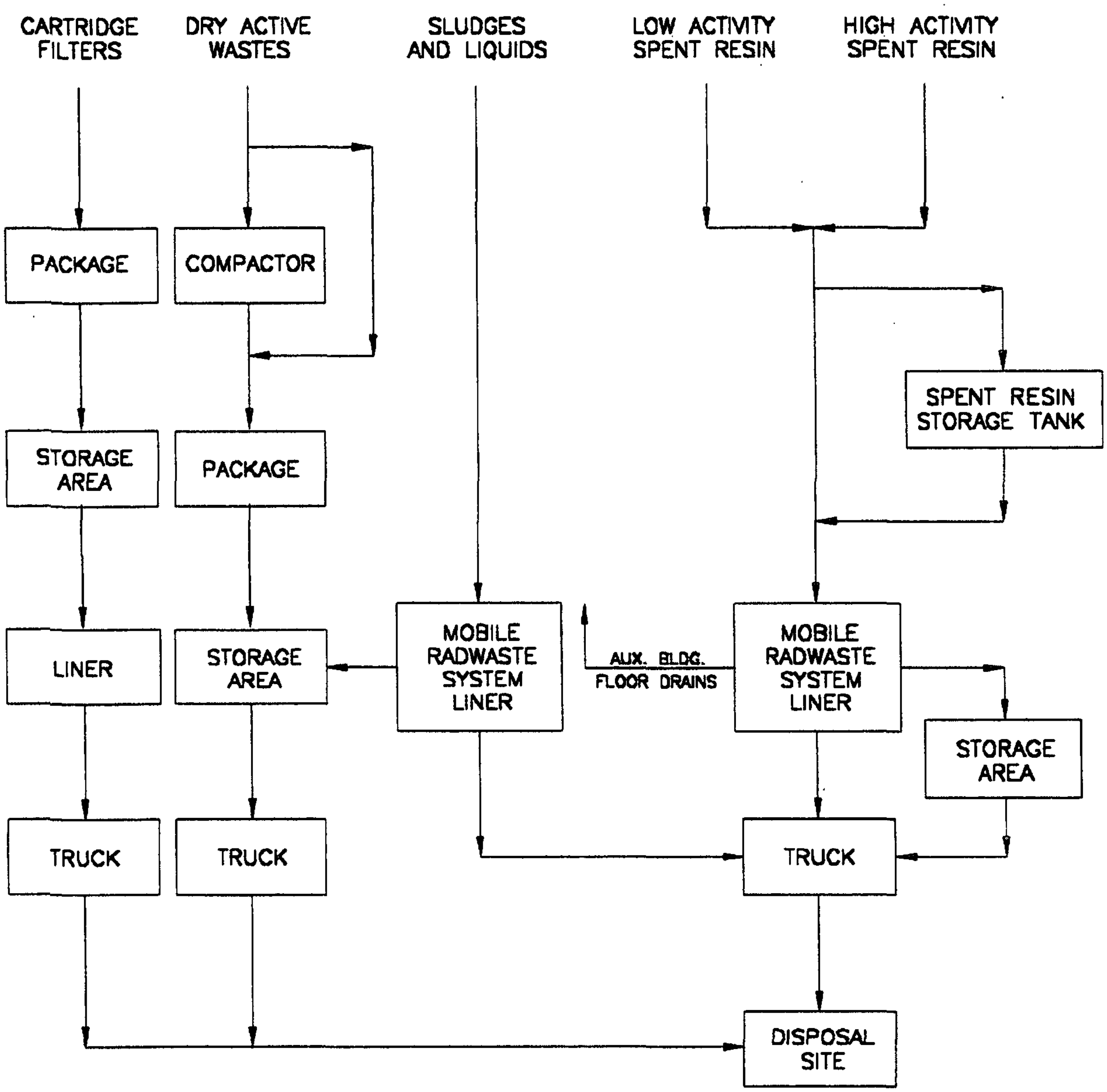

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FIGURE 11.4-1

RADWASTE DISPOSAL SYSTEM FLOW DIAGRAM

Figures 11.4-2 through 11.4-4 have been deleted intentionally.