CALCULATION METHODOLOGY for RADIOLOGICAL CONSEQUENCES in NORMAL OPERATION and TANK FAILURE ANALYSIS

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Abstract

This report contains the methodology used by Mitsubishi Heavy Industries (MHI) in the analysis of radiological consequences in normal operation and gas and liquid tank failure events.

This methodology includes the description of models, the explanation of input parameters selection and the confirmation of the compliance of analysis results with the related regulations.

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List of Acronyms

The following list defines the acronyms used in this document.

ALI	Annual Limits on Intake
ANS	American Nuclear Society
ANSI	American National Standard Institute
AOO	Anticipated Operating Occurrences
APWR	Advance Pressurized Water Reactor
BAT	Boric Acid Tank
BTP	Branch Technical Position
CFR	Code of Federal Regulations
COLA	Combined Operating License Application
CP	Corrosion Products
CV	Containment Vessel
CVCS	Chemical Volume Control System
DAC	Derived Air Concentrations
DCD	Design Control Document
DF	Decontamination Factors
DFB	Dose Factor of Body
EAB	Exclusion Area Boundary
GI	Gastro-Intestinal
GPD	Gallon Per Day
GPM	Gallon Per Minute
GWMS	Gaseous Waste Management System

HEPA	High Efficiency Particulate Air
HT	Holdup Tank
HVAC	Heating, Ventilation and Air-Conditioning
ISG	Interim Staff Guidance
LLI	Low Large Intestine
LWMS	Liquid Waste Management System
LWR	Light Water Reactor
MHI	Mitsubishi Heavy Industries
NRC	Nuclear Regulatory Commission
PCA	Primary Coolant Activity
PWR	Pressurized Water Reactor
RCP	Reactor Coolant Pump
RCS	Reactor Cooling System
RG	Regulatory Guide
RV	Reactor Vessel
SG	Steam Generator
SRP	Standard Review Plan
VCT	Volume Control Tank
WHT	Waste Holdup Tank

1 INTRODUCTION

This document presents the details of calculations included in chapter 11 and related to the radiological consequences in normal operation and tanks failure analysis.

The models, list of parameters and main assumptions of these analyses are described. The evidence of compliance with regulation is included in this document.

2 RADIOLOGICAL CONSEQUENCES IN NORMAL OPERATION AND AOO

This section presents the details of the calculation of gaseous and liquid effluent radiological consequences by a proprietary modified version of the NRC PWR-GALE code reflecting the design specificities of US-APWR design (PWR-GALE (99V2.1)). The purpose of this calculation is to determine the gaseous and liquid effluent activities concentration and the involved dose to the public during normal operation including AOO, and to confirm the calculation results are below the concentration limit and dose limit at the site boundary.

In the present report, the version of the code and its specificities are described and the selection of input parameters is explained.

2.1 Evaluation conditions

In gaseous and liquid effluent evaluation during normal operation including AOO, the evaluation inputs are based on the systems design, such as reactor coolant system, secondary coolant system, CVCS, LWMS, GWMS, HVAC and so forth of the US-APWR. The evaluation performs the amount of gaseous and liquid effluent releases and concentrations and doses at the site boundary.

Radioactive materials included in the generated gaseous radioactive waste are removed with disposal systems such as GWMS and HVAC and so forth (charcoal bed, HEPA filters etc). Decontamination factors of radioactive materials are provided with these components, and the values are based on NUREG-0017Rev.1 (Ref. 1). Radioactive materials included in the generated liquid waste are removed by each treatment facility of liquid waste management system such as demineralizers and evaporators. These facility or system compartments are provided with DF, which represents values to show the removal effectiveness of radioactive materials, and these values are based on the NUREG-0017, Rev.1 (Ref. 1). In addition, the dose evaluation of members of public exposure is based on NUREG/CR-4013 (Ref. 2) and R.G.1.109 (Ref. 3).

Gaseous and liquid effluent radioactive concentration and the radioactive concentration at the release point are calculated based on the effluent calculation conditions shown in Table 1, and then, the members of public exposure dose is calculated under the dose evaluation conditions shown in Table 2 for doses due to liquid releases and Table 3 for doses due to gaseous releases.

2.1.1 Evaluation procedure

In addition to the released amount based on the coolant activity as realistic values, the radioactive concentration and the dose at the site boundary (hereafter Realistic evaluation), the released amount based on coolant activity with 1% fuel defect assumption(hereafter Design Basis evaluation) and the radioactive concentration are required to describe in DCD.

First, the release amount calculation regarding Realistic evaluation is conducted with PWR-GALE code.

Following this, with the assumption that the release amount is proportionate to the reactor coolant activity, the release amount of Design Basis is calculated from the comparison value obtained by assuming the Realistic evaluation release amount as Realistic evaluation reactor coolant activity and the 1% fuel defect.

After that, with regard to Realistic evaluation, the dose calculation of the site boundary is performed with GASPAR code for doses due to gaseous releases and LADTAP for doses due to liquid releases.

2.1.2 Selection of input parameters

Most of parameters have been defined in accordance to the US-APWR design features described in DCD. For parameters not described in DCD, the basis for the selection of these parameter values is attached in appendix A.

2.2 Realistic evaluation, calculation model

2.2.1 Effluent evaluation

PWR-GALE (99V2.1) is used for the effluent calculation of Realistic evaluation. Table 4 and Table 5 show the analysis results by the PWR-GALE code. The input and output file contents are shown in appendix B of this document.

PWR-GALE (99V2.1) is a MHI proprietary modified version of NRC PWR-GALE code. The modifications include:

- Revision of RCS concentrations

The original PWR-GALE Code (hereinafter referred to as “PWR-GALE (84)”) uses concentration values of the coolants that are based on Table 6 of ANSI/ANS-18.1-1984.

In PWR-GALE (99V2.1), the concentrations of the coolants are changed from the PWR-GALE (84) Code to values based on Table 6 of ANSI/ANS-18.1-1999.

- Revision of the leakage rate of primary system coolant inventory (hereinafter referred to as “CLFNG”) to noble gas released into the CV atmosphere

CLFNG is changed from 3%-d set in the PWR-GALE (84) Code to 0.02%/d (hereinafter referred to as “PWR-GALE (99V2.1”). This change is made only in PGALEGS.

This value is determined by the ratio of 10 gpd described in Table 7 of ANSI/ANS-55.6-1993 and the reactor coolant mass of 646,000 lb (along with a unit conversion). As this value is integrated in the PWR-GALE program code, the code has been modified to reflect the parameter.

- Revision of Y-93 secondary coolant activity

Y-93 secondary coolant activity in Nuclear News Feb.2005 page 72 is corrected from 1.2E-8 to 1.2E-7 and reflected in PWR-GALE (99V2.1).

The verification procedure, results and evidence of this proprietary modified version of NRC PWR-GALE code can be found in appendix C.

2.2.2 Radioactive concentration and dose at the site boundary

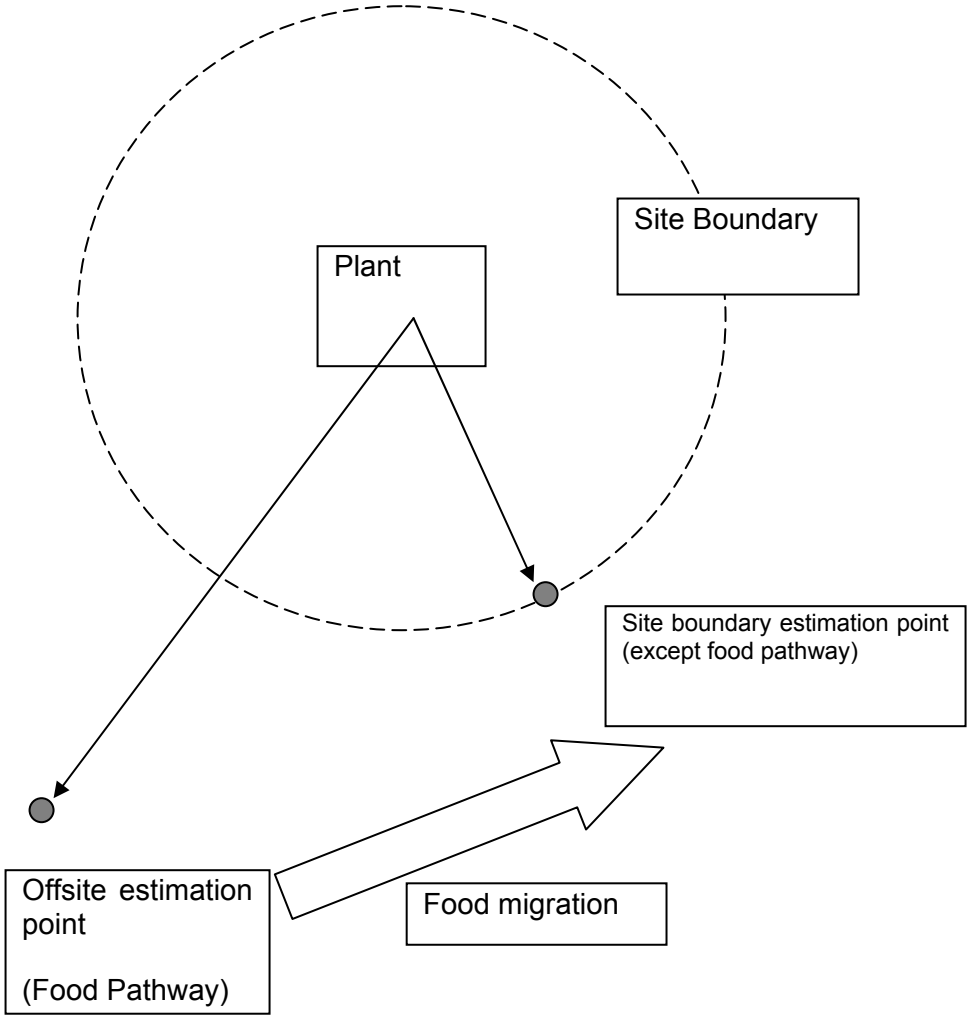
Gaseous effluents:

GASPAR (GASPAR_II V1.0) is used for the dose calculation. Contents of the GASPAR input and output files are given in appendix D of original calculation document.

The following values are applied to the site boundary X/Q and the off-site boundary X/Q. A schematic diagram is shown in Figure 1.

X/Q(s/m^3)		D/Q($1/m^2$)
site boundary *1	off-site *2	
1.6E-05	5.0E-06	4.0E-08

*1: For gamma dose in air, beta dose in air, dose total body, dose from ground, and dose due to inhalation.
*2: For dose from food (Vegetable, meat, and cow milk) pathway.



Following perspectives are applied to the evaluation with regard to respective criteria.

Criteria	Evaluative perspective
Other than organ dose	Assuming that target members of the public live in the site boundary, concentrations and doses are confirmed at the highest concentration site boundary among the potential residential area (or off-site boundary as well if potential residential area).
Organ dose	・ Assuming that target people live inside the site boundary but the realistic production source (farm, pasture, etc) is outside the site boundary. ・ Assuming the postulated food production source is provided outside the off-site boundary and radioactive concentration of the food is calculated with X/Q. ・ The food is consumed by the people in the site boundary. ・ Exposure from the Ground, inhalation and ingestion are performed in the site boundary.

Figure 1 General dose estimation diagram related to gaseous effluent releases

Table 6 shows the comparison between the radioactive concentration in the site boundary and the limited value described in 10CFR20 Appendix B (Ref. 5). It has been confirmed that these results meet the limit shown in equation (1) in realistic evaluation.

$\Sigma(C'i / Ci) \leqq 1$ ·····(1)

Where,

C'i : Atmospheric concentrations of nuclide i in the site boundary obtained under Realistic and Design Basis evaluation.

Ci : Effluent Concentrations (Air) value of 10CFR20 Appendix (Ref. 5) Table-2 Col.2.

The dose evaluation result shown in Table 8 has confirmed that the result is well below the criteria described in 10CFR50 Appendix I (Ref. 6).

Liquid effluents:

The liquid effluent radioactive concentrations are calculated by the equation (2) shown below.

$C'_i = C_{0i} / Q_{dil}$ ·····(2)

Here,

C'i : Nuclide i in the liquid effluent (microCi/ml)

C_{0i} : Annual effluent of Nuclide i (Ci/yr) calculated by Realistic evaluation and Design Basis evaluation

Q_{dil} : Dilution flow(ml/yr)

Q_{dil} = 12900 gal/min × 1440 min/day × 292 day/yr ×

3.785412E-3 m^3/gal ×1E+6 ml/m^3 = 2.05E+13 ml/yr

Comparison between the radioactive concentrations at the release point and the limit value described in 10CFR20 Appendix B (Ref. 5) is given in Table 7. These results have confirmed to meet the limit shown in equation (2) in Realistic evaluation.

$\Sigma(C'i / Ci) \leqq 1$ ·····(3)

Here,

C'i : Nuclide i in the liquid effluent (microCi/ml) obtained by realistic evaluation and design basis evaluation

Ci : Value of Effluent Concentrations (Water) (microCi/ml) in 10CFR20 AppendixB Table-2 Col.2.

2.3 Design Basis Evaluation

2.3.1 Effluent evaluation

Gaseous effluents:

For the fission products, the calculation for the release amount under design basis evaluation is performed with the use of equation (4) given below from the evaluation results of realistic evaluation and the reactor coolant activity of assumed 1% fuel defect. The calculation results are given in Table 10.

$$Ri\text{-}n_{Design} = Ri\text{-}n_{GALE} \times (Ci_{Design} / Ci_{GALE}) \quad \cdots\cdots (4)$$

Where,

$Ri\text{-}n_{Design}$: Nuclide i in design basis evaluation, effluent(Ci/y) of path n.

Ci_{Design} : Reactor coolant activity (microCi/g) of nuclide i at 1% fuel defect situation.

Ci_{GALE} : Reactor coolant activity (microCi/g) of nuclide i at GALE output in realistic evaluation

$Ri\text{-}n_{GALE}$: Nuclide i at GALE output in realistic evaluation, total effluent(Ci/y) of path n

The Corrosion Product nuclides are generated from corrosion and not due to an escape from failed fuel. Therefore, the differences of the fuel defect rate have no impact on the corrosion products effluent. Consequently, the reactor coolant activity of Design Base is equivalent to that of Realistic evaluation and the same is applied with the effluent. Similarly, the effluent of Design Basis evaluation such as Tritium, Ar-41 and C-14 is the same as the effluent obtained in Realistic evaluation. Regarding Sb-125, its effluent is not proportional to the reactor coolant activity since it is not provide in the realistic primary coolant activity. Thus, the effluent of Design Basis is equivalent to that of Realistic evaluation.

$Ri\text{-}n_{Design} = Ri\text{-}n_{GALE}$(CP,H-3,Ar-41,C-14,Sb-125) ·····(5)

※ CP…Cr-51,Mn-54, Fe-59,Co-57,Co-58,Co-60

Liquid effluents:

The effluent calculation of Design Basis evaluation is performed by the evaluation result of the Realistic evaluation and the value of reactor coolant activity with an assumption of 1% fuel defect. The calculation results are given in Table 11. The nuclides without descriptions of the limitation value in reference (5) are exempt from the evaluation target.

Nuclide CP is mainly formed from corrosion rather than from escape from failed fuel. Whereby, the differences of the fuel defect rate have little impact on the effluent change. Therefore, the reactor coolant activity of 1% fuel defect is equivalent to that of Realistic evaluation. Similarly, the effluent of Tritium is the same as the effluent obtained in Realistic evaluation.

$Ci_{Design} = Ci_{GALE}$ (CP nuclide) ·····(6)

※ CP nuclide…Na-24,P-32,Cr-51,Mn-54,Fe-55,Fe-59,Co-58,Co-60,Ni-63,Zn-65, W-187,Np-239

➢ Effluent from boron recovery system

$$Ri_{D1} = \frac{Ci_{Design}}{Ci_{GALE}}\left(Ri_{BORON-RS}\right) \quad \cdots\cdots(7)$$

Ri_{D1} : Effluent of nuclide i from boron recovery system in Design Basis evaluation (Ci/y)

Ci_{Design} : Reactor coolant activity of nuclide i in Design Basis (microCi/g)

Ci_{GALE} : Reactor coolant activity of nuclide i in GALE output of Realistic evaluation (microCi/g)

$Ri_{BORON\text{-}RS}$: Effluent of nuclide i from boron recovery system in GALE output of Realistic evaluation (Ci/y)

➢ Effluent from miscellaneous waste (MISC.WASTES) systems

$$Ri_{D2} = \frac{Ci_{Design}}{Ci_{GALE}}\left(Ri_{MISC}\right) \quad \text{.....(8)}$$

Ri_{D2} : Effluent of nuclide i from miscellaneous waste system in Design Basis evaluation (Ci/y)

Ri_{MISC} : Effluent of nuclide i from miscellaneous waste system in GALE output of Realistic evaluation (microCi/g)

- Effluent from secondary (SECONDARY) system

$$Ri_{D3} = \frac{Ci_{Design}}{Ci_{GALE}}\left(Ri_{SECONDARY}\right) \quad \text{.....(9)}$$

Ri_{D3} : Effluent of nuclide i from secondary system in Design Basis evaluation (Ci/y)

$Ri_{SECONDARY}$: Effluent of nuclide i from secondary system in GALE output of Realistic evaluation (microCi/g)

- Effluent from Turbine (TURB BLDG) building

$$Ri_{D4} = \frac{Ci_{Design}}{Ci_{GALE}}\left(Ri_{TURB}\right) \quad \text{.....(10)}$$

Ri_{D2} : Effluent of nuclide i from Turbine building in Design Basis evaluation (Ci/y)

Ri_{TURB} : Effluent of nuclide i from Turbine building in GALE output of Realistic evaluation (Ci/y)

- Detergent waste (DETERGENT)

The same effluent as the Realistic evaluation

2.3.2 Radioactive concentration of gaseous effluents at the site boundary

In the same way as realistic evaluation, calculation of the radioactive concentration and the rate at the site boundary is performed.

The comparison between the radioactive concentration at the site boundary and the limit value described in 10CFR20 of Appendix B (Ref. 5) is shown in table 12. These results meet the limit shown in equation (1) in design basis evaluation.

2.3.3 Liquid effluent radioactive concentrations at the release point

As is the case with Realistic evaluation, Table 13 shows the comparison between the radioactive concentrations at the release point and the limit value described in 10CFR20 Appendix B (Ref. 5). These results also meet the limit shown in equation (3) in Design Basis evaluation.

2.4 Dose evaluation due to liquid effluent releases

The results containing descriptions of the evaluation of members of the public dose (maximum individual) are required to be described. As evaluation implementing procedures, the exposure dose calculation is performed with LADTAP(LADTAPII_V1.0) code (Ref. 2) for the Realistic evaluation results that was calculated by PWR-GALE code indicated in Table 5.

The analysis results by LADTAP code is shown in Table 9. The contents of input and output files are shown in appendix D.

Exposure dose evaluation of members of the public

The results in Table 9 have confirmed the evaluation results meet the limit when compared the exposure dose evaluation of members of the public to the limit value described in 10CFR50 Appendix I (Ref. 6).

Dose from liquid waste

The limit value of total body is 3mrem/yr. in 10CFR50 Appendix I, whereas 5mrem/yr. in RM-50-2. This analysis results have revealed that the dose children receive is 1.98mrem, which is the highest, and this has led to meet the limit.

In addition, the limit value of each organ is 10mrem/yr. in 10CFR50 Appendix I, whereas 5mrem/yr. in RM-50-2. In this analysis result, children's liver receives 2.54mrem, which is the highest dose, and this has led to meet the limit.

3 RADIOACTIVE EFFLUENT RELEASES AND DOSE CALCULATION DUE TO GASEOUS WASTE MANAGEMENT SYSTEM LEAK OR FAILURE

This document treats calculation sheets for Postulated Radioactive Releases Due to a Waste Gas System Leak or Failure.

3.1 Calculus equation and evaluation conditions

3.1.1 Waste gas surge tank leak

A waste gas surge tank leak is considered as an event that causes the maximum dose to the environment in case of a gaseous waste management system leak or failure.

The reactor coolant activity for the noble gases is based on a 300 μCi/g dose equivalent Xe-133 as stated in the technical specifications. All the noble gases in the reactor coolant are assumed to be transferred into the waste gas surge tank one day after the reactor shut down for a dose evaluation of a waste gas surge tank leak. The radioactive decay during this period is taken into account. The noble gas activity in the waste gas surge tank is calculated from the following equation.

$$A_i = \frac{C_i \cdot m \cdot \exp(-\lambda_i \cdot t)}{N} \quad \text{.....(11)}$$

where:

A_i = Activity of noble gas nuclide i in the waste gas surge tank (Ci)

C_i = Reactor coolant activity of nuclide i (μCi/g)

m = Reactor coolant mass (t)

λ_i = Decay constant of nuclide i (s^{-1})

t = Transfer time of all the noble gases from the reactor coolant to waste gas surge tank (s)

N = Number of gas surge tanks

All the gases released into the auxiliary building are assumed to be released into the atmosphere.

Dose to total body due to waste gas surge tank leak is calculated using the equation based on BTP 11-5 (Ref. 7) shown below.

$$D = \sum_i \frac{K_i \cdot A_i \cdot (X/Q) \cdot (1E+12pCi/Ci)}{3.15E+07s/yr} \quad \text{.....(12)}$$

where:

D = Dose to total body (mrem)

A_i = Activity of noble gas nuclide i determined in Eq. 11.3-1(Ci/event)

K_i = Dose factor of nuclide i for total body given as DFBi in Table B-1 of Regulatory Guide 1.109(mrem-m^3/pCi/yr) (Ref. 3)

(X/Q) = The short-tem atmospheric dispersion factor at EAB specified in Chapter 2, Subsection 2.3.4(s/m^3)

The parameters for calculation and results are tabulated in Table 14.

3.1.2 Charcoal bed leak

The released amount of radioactive noble gases in the charcoal bed leak is calculated from the following equations.

$$Q_i = (Q_{ni} + Q_{fi}) \cdot \frac{A_i}{A_i'} \quad \text{.....(13)}$$

where:

Q_i = Annual effluent of noble gas nuclide i (Ci/yr)

Q_{ni} = Annual effluent of noble gas nuclide i during normal operation (Ci/yr) (PWR-GALE code calculation)

Q_{fi} = Annual effluent of noble gas nuclide i without the charcoal bed (Ci/yr) (taking into account 30 minutes radioactive decay) (PWR GALE code calculation)

A_i = Reactor coolant activity for noble gas nuclide i that is equal to 300 μCi/g dose equivalent Xe-133 as stated in the technical specifications (μCi/g)

A_i' = Realistic reactor coolant activity for noble gas nuclide i that is calculated by the PWR-GALE Code (μCi/g)

Dose to total body due to charcoal bed leak is calculated using the equation based on BTP 11-5 (Ref. 7) shown below.

$$D = \sum_i K_i \cdot Q_i \cdot (X/Q) \cdot (1E+12 pCi/Ci) \cdot (7.25E-12 yr^2/event-s) \quad \cdots\cdots (14)$$

where:

D = Dose to total body (mrem)

Q_i = Annual effluent of noble gas nuclide i (Ci/yr)

K_i = Dose factor of nuclide i for total body given as DFBi in Table B-1 of Regulatory Guide 1.109(mrem-m3/pCi/yr) (Ref. 3)

(X/Q) = The short-tem atmospheric dispersion factor at EAB specified in Chapter 2, Subsection 2.3.4(s/m^3)

The parameters for the calculation and the results are tabulated in Table 16.

3.2 Evaluation results

For waste gas surge tank leak, the results have confirmed that the site boundary noble gas dose is 46 mrem (round-up value of 45.4 mrem). This meets the limit of 0.1 rem (for systems not designed to withstand explosions and earthquakes) which is described in BTP11-5 R3.

For charcoal bed leak, the dose at EAB is 2 mrem in case of a charcoal bed leak, which is lower than the dose in case of a waste gas surge tank leak and is less than the criterion of 100 mrem specified in BTP 11-5 (Ref. 7).

4 RADIOACTIVE EFFLUENT RELEASES DUE TO LIQUID CONTAINING TANK FAILURES – TANKS ACTIVITIES

In US-APWR design, the main tanks containing radioactive substances are the Boric Acid Tank, the Holdup Tank and the Waste Holdup Tank.

The Volume Control Tank, the Chemical Drain Tank, and Sump Tanks were eliminated from consideration based on smaller volumes and lower radionuclide contents than the Boric Acid Tank (BAT). The Primary Makeup Water Tank was eliminated from consideration based upon the fact that the Primary Makeup Water Tank stores demineralized water from the Treatment System, and low level radioactive condensate water from the Boric Acid Evaporator. Condensate water contains low levels of radionuclide concentrations, including tritium.

This section describes the calculation of these tanks activities. The radiological consequences in case of tank failure are site dependent analysis and are to be evaluated on a case-by-case basis (described in COLA).

4.1 Evaluation conditions

The concentrations given in Table 18 are calculated using the input parameters described in table 17 for RATAF (Ref. 8) calculation. This code calculates the concentrations in tanks based on a fuel cladding defect of 1%. The concentrations in Table 2 are adjusted considering recommendation of BTP 11.6 (Ref. 9) to use a RCS source term with a fuel cladding defect of 0.12 %.

The list of radionuclides much longer than in US-APWR DCD is due to the assumptions used for the hydrological travel time and dilution factor. RATAF code only displays results for radionuclides with high critical receptor concentrations. Using very conservative assumptions for the parameters impacting these concentrations enables displaying the tank concentrations of much more radionuclides.

This dilution factor was adjusted and modified in order to display the concentrations of all the radionuclides included in the Interim Staff Guidance (ISG) on standard review plan section 11.2. The nuclides are identified in table 2 through the second column. The RATAF calculation was first performed with a dilution factor of 1. A second calculation with a dilution of 1.00E-20 was performed in order to get the concentrations of the remaining nuclides present in ISG on SRP section 11.2. Only these nuclides were added to the list of nuclides that was obtained after the first calculation.

4.2 Evaluation results

The concentrations of the activities in considered tank are displayed in table 18.

5 REFERENCES

(1) NUREG-0017Rev.1 “Calculation of Release of Radioactive Materials in Gaseous and Liquid Effluents from Pressurized Water Reactors(PWR-GALE Code)”

(2) NUREG/CR-4013 “LADTAP-II Technical Reference and User Guide”

(3) Regulatory Guide 1.109 “Calculation of Annual Doses to Man from Routine Release of Reactor Effluents for the Purpose of Evaluating Compliance with 10CFR 50,Appendix I”

(4) Not used

(5) 10CFR20 Appendix.B, “Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage”

(6) 10CFR50 Appendix I, “Numerical Guides for Design Objectives and Limiting Conditions for Operation to Meet the Criterion "As Low as is Reasonably Achievable" for Radioactive Material in Light-Water-Cooled Nuclear Power Reactor Effluents”

(7) U.S. Nuclear Regulatory Commission, Postulated Radioactive Releases due to a Waste Gas System Leak or Failure. Branch Technical Position 11-5, NUREG-0800.

(8) Preparation of Radiological Effluent Technical Specification for Nuclear Power Plants. NUREG-0133. U.S. Nuclear Regulatory Commission, Washington, DC., October 1978.

(9) Postulated Radioactive Releases due to Liquid-Containing Tank Failures. Branch Technical Position 11-6, NUREG-0800, U.S. Nuclear Regulatory Commission, Washington DC., March 2007.

(10) ANSI/ANS-55.6-1993,”Liquid Radioactive Waste Processing System for Light Water Reactor Plants”

Table 1 Input Parameters for the PWR-GALE Code (1/4)

No.	Parameter	Unit	Value
1	Name of reactor	—	US-APWR
2	Type of reactor	—	PWR
3	Core thermal power	MWt	4451
4	Reactor coolant mass	10^3lb	646
5	Reactor coolant letdown flow rate	gal/min	180
6	CVCS cation demineralizer flow rate	gal/min	7
7	Number of SGs	—	4
8	Total main steam flow rate	10^6 lb/hr	20.2
9	Seccondary coolant mass in SG	10^3 lb	135
10	Total SG blowdown flow rate	10^3 lb/h	155.4
11	Blowdown treatment method	—	0
12	Regeneration time of condensate polishing system	—	0
13	Fraction of feedwater through the condensate polishing system	—	0
—	Name of liquid waste	—	—
14	Shim Bleed*	—	Shim Bleed
15	Coolant Drain*	—	Coolant Drain
16	Clean Waste*	—	N/A
17	Dirty Waste*	—	Dirty Waste
18	Blowdown Waste*	—	Blowdown Waste
19	Regenerant Waste*	—	Regenerant Waste
—	Flow rate	—	—
20	Shim Bleed	gal/day	2875
21	Coolant Drain	gal/day	900
22	Clean Waste	gal/day	N/A
23	Dirty Waste	gal/day	2023**
—	Fraction of reactor coolant activity(PCA)	—	—
24	Coolant Drain	—	0.1
25	Clean Waste	—	N/A
26	Dirty Waste	—	0.18**

Note:
* The name of each waste is as shown in the classification of NUREG-0017Rev.1.
** Refer to Appendix A for the basis of the numerical value.

Table 1 Input Parameters for the PWR-GALE Code (2/4)

No.	Parameter	Unit	Value
—	Decontamination factor for I	—	—
27	Shim Bleed	—	5E+3
28	Coolant Drain	—	5E+3
29	Clean Waste	—	N/A
30	Dirty Waste	—	1E+5
31	Blowdown Waste	—	1E+2
32	Regenerant Waste	—	N/A
—	Decontamination factor for Cs,Rb	—	—
33	Shim Bleed	—	2E+3
34	Coolant Drain	—	2E+3
35	Clean Waste	—	N/A
36	Dirty Waste	—	2E+2
37	Blowdown Waste	—	1E+2
38	Regenerant Waste	—	N/A
—	Decontamination factor for others	—	—
39	Shim Bleed	—	1E+5
40	Coolant Drain	—	1E+5
41	Clean Waste	—	N/A
42	Dirty Waste	—	1E+4
43	Blowdown Waste	—	1E+3
44	Regenerant Waste	—	N/A
—	Collection time	—	—
45	Shim Bleed	day	20
46	Coolant Drain	day	20
47	Clean Waste	day	N/A
48	Dirty Waste	day	5
49	Blowdown Waste	day	0
50	Regenerant Waste	day	N/A
—	Process and discharge time	—	—
51	Shim Bleed	day	2
52	Coolant Drain	day	2
53	Clean Waste	day	N/A
54	Dirty Waste	day	0
55	Blowdown Waste	day	0
56	Regenerant Waste	day	N/A

Table 1 Input Parameters for the PWR-GALE Code (3/4)

No.	Parameter	Unit	Value
—	Fraction of waste to be discharged	—	—
57	Shim Bleed	—	1.0
58	Coolant Drain	—	1.0
59	Clean Waste	—	N/A
60	Dirty Waste	—	1.0
61	Blowdown Waste	—	0.0
62	Regenerant Waste	—	N/A
63	Continuous gas stripping of full letdown flow None	—	0
64	Holdup time for Xe	day	45
65	Holdup time for Kr	day	2.55
66	Fill time of decay tanks for gas stripper	day	N/A
67	Gas waste system: High-efficiency particulate air (HEPA) filter	%	0
68	Fuel handling building: Removal efficiency of charcoal filter (%)	%	0
69	Fuel handling building: Removal efficiency of HEPA filter (%)	%	0
70	Auxiliary building: Removal efficiency of charcoal filter (%)	%	0
71	Auxiliary building: Removal efficiency of HEPA filter (%)	%	0
72	Containment volume	$10^6 ft^3$	2.74
73	Containment atmosphere internal cleanup system: Removal efficiency of charcoal filter (%)	%	0
74	Containment atmosphere internal cleanup system: Removal efficiency of HEPA filter (%)	%	0
75	Containment atmosphere internal cleanup system: flow rate	$10^3 ft^3$/min	0
76	Purges: Removal efficiency of charcoal filter (%)	%	0
77	Purges: Removal efficiency of HEPA filter (%)	%	99
78	Number of purges per year (in addition to two shutdown purges)	-	0
79	Containment low volume purge: Removal efficiency of charcoal filter (%)	%	70
80	Containment low volume purge: Removal efficiency of HEPA filter (%)	%	99

Table 1 Input Parameters for the PWR-GALE Code (4/4)

No.	Parameter	Unit	Value
81	Containment low volume purge rate	ft^3/min	2000
82	Fraction of iodine released from blowdown tank vent	—	0
83	Fraction of iodine removed from main condenser air ejector release	—	0
84	Decontamination factor for detergent waste	—	1
85	Reactor coolant leak rate to the containment for noble gas	%/d	0.02

Table 2 Input Parameters for the GASPAR Code (1/2)

No.	Parameter	Unit	Value
1	Type of calculation JC(1) JC(1)=0,calculate population doses JC(1)>0,calculate individual doses only	—	1
2	Number of source terms (Separation of source term by iodine, noble gases, particulate airborne)	—	5
3	Control printing JC(3) JC(3)=0,print reports of cumulative doses for each source term JC(3)>0,print reports following the last source term only	—	1
4	Control input of block data JC(4) JC(4)>0, read a set of block data change records	—	1
5	Control printing of data contained in the dose factor library JC(5) JC(5)>0, print reports	—	0
6	Control of the PARTS calculation option JC(6) JC(6)>0, select calculation option	—	0
7	To change the block data, single-character indicator	—	P
8	To change the block data, index of the variable	—	2
9	Midpoint of plant life	s	9.46E+08 (30y)
10	Distance (in mi) from the site to the northeast corner of the U.S. (CD)	mile	1260
11	Fraction of the year that leafy vegetables are grown	—	1.0
12	Fraction of the year that milk cows are on pasture	—	1.0
13	Fraction of the maximum individual's vegetable intake that is from his own garden	—	0.76
14	Fraction of milk-cow feed intake that is from pasture while on pasture	—	1.0
15	Average absolute humidity over the growing season (H)	(g/m^3)	8.0

Table 2 Input Parameters for the GASPAR Code (2/2)

No.	Parameter	Unit	Value
16	Average temperature over the growing season	(°F)	———
17	Fraction of the year that goat are on pasture	—	N/A
18	Fraction of the goat-feed intake that is from pasture while on pasture	—	N/A
19	Fraction of the year that beef cattle are on pasture	—	1.0
20	Fraction of the beef-cattle feed intake that is from pasture while on pasture	—	1.0
21	Source term multiplier	—	1.0
22	Control parameter for input of meteorological data (JC1) JC1=0, use new meteorological data JC1>0, use previous data	—	0
23	Control parameter for input of radionuclide release data (JC2) JC2=0, use new radionuclide release data JC2>0, use previous data	—	0
24	Release data	—	Blank
25	Release rate	Ci/y	———
26	Compass direction from site to special location	-	S
27	Distance from site to special location	(m)	800
28	χ／Q(Undecayed/Undepleted)	s/m^3	1.6E-5
29	χ／Q(Decayed/Undepleted)	s/m^3	1.6E-5
30	χ／Q(Decayed/Depleted)	s/m^3	1.6E-5
31	χ／Q(Undecayed/Undepleted)	s/m^3	5.0E-6
32	χ／Q(Decayed/Undepleted)	s/m^3	5.0E-6
33	χ／Q(Decayed/Depleted)	s/m^3	5.0E-6
34	D/Q	$1/m^2$	4.0E-8

Table 3 Input Parameters for the LADTAP Code

No.	Parameter	Unit	Value	Default Value
1	Plant half life	y	30	
2	Source term multiplier	Unit	1	
3	Dose factor	Refer to RG R.G.1.109	Reg. Guide 1.109 Table E6～14	○
4	Annual shoreline usage time	Refer to RG R.G.1.109	Reg. Guide 1.109 Table E-5	○
5	Site water type selection (LT) LT=0, fresh water LT>0, salt water	—	0 (fresh water)	
6	Reconcentration Model (M)	—	blank (no model)	
7	Liquid effluent discharge rate from the reactor to impoundment system	ft^3/sec	28.7	
8	Shore-width factor for shoreline exposure	—	0.2 (River Shoreline)	
9	Dilution factor for drinking water, boating, shoreline, swimming, aquatic food pathway and irrigation water	—	10	
10	Transit time from discharge to drinking water supply intake Transit time from discharge to exposure location(excluding drinking water)	Refer to RG R.G.1.109	(0) Reg. Guide 1.109 Table E-15	○
11	Irrigation rate for the current food product	L/m^2-month	31	
12	Animal's consumption of pasture/water	Refer to RG R.G.1.109	Reg. Guide 1.109 Table E-3	○
13	Animal considered for milk pathway	—	Cow	○
14	Fraction of animal feed not produced with contaminated irrigation water	—	0	
15	Fraction of animal drinking water not obtained from contaminated irrigation water supply	—	0	
16	Growing period for current food product	Refer to RG R.G.1.109	Reg. Guide 1.109 Table E-15	○

Table 4 Calculated Annual Average Release of Airborne Radionuclides (Ci/yr) (Realistic) (1/3)

Nuclide	Coolant Concentration		Building Ventilation				Blowdown Vent Offgas (Ci/yr)	Air Ejector Exhaust (Ci/yr)	Total (Ci/yr)
	Primary (μCi/g)	Secondary (μCi/g)	Fuel Handlg (Ci/yr)	Reactor (Ci/yr)	Auxiliary (Ci/yr)	Turbine (Ci/yr)			
Iodines									
I-131	1.111E-03	2.255E-08	1.50E-04	5.70E-04	3.50E-03	0.00E+00	0.00E+00	0.00E+00	4.20E-03
I-133	1.694E-02	3.120E-07	2.20E-03	7.40E-03	5.40E-02	0.00E+00	0.00E+00	0.00E+00	6.40E-02

Table 4 Calculated Annual Average Release of Airborne Radionuclides (Ci/yr) (Realistic) (2/3)

Nuclide	Coolant Concentration		Gas Stripping		Building Ventilation			Blowdown Vent Offgas (Ci/yr)	Air Ejector Exhaust (Ci/yr)	Total (Ci/yr)
	Primary (μCi/g)	Secondary (μCi/g)	Shutdown (Ci/yr)	Continuous (Ci/yr)	Reactor (Ci/yr)	Auxiliary (Ci/yr)	Turbine (Ci/yr)			
Noble Gases										
Kr-85m	1.776E-02	2.803E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Kr-85	2.798E-01	4.300E-08	1.60E+02	1.20E+03	5.00E+00	6.00E+00	0.00E+00	0.00E+00	3.00E+00	1.40E+03
Kr-87	1.892E-02	8.267E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Kr-88	2.001E-02	3.137E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Xe-131m	6.819E-01	1.040E-07	2.80E+01	2.00E+02	1.10E+01	1.40E+01	0.00E+00	0.00E+00	7.00E+00	2.60E+02
Xe-133m	7.449E-02	1.185E-08	0.00E+00	0.00E+00	0.00E+00	2.00E+00	0.00E+00	0.00E+00	0.00E+00	2.00E+00
Xe-133	2.934E-02	4.508E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Xe-135m	1.449E-01	2.234E-08	0.00E+00	0.00E+00	0.00E+00	3.00E+00	0.00E+00	0.00E+00	1.00E+00	4.00E+00
Xe-135	7.405E-02	1.149E-08	0.00E+00	0.00E+00	0.00E+00	2.00E+00	0.00E+00	0.00E+00	0.00E+00	2.00E+00
Xe-137	3.789E-02	5.876E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.00E+00	4.00E+00
Xe-138	6.797E-02	1.076E-08	0.00E+00	0.00E+00	0.00E+00	1.00E+00	0.00E+00	0.00E+00	0.00E+00	1.00E+00
Total Noble Gases										1.70E+03
Total H-3 Released via Gaseous Pathway										1.80E+02
C-14 Released via Gaseous Pathway										7.30E+00
Ar-41 Released via Gaseous Pathway										3.40E+01

Appearing in the Table Indicates Release is Less than 1.0 Ci/yr for Noble Gas, 0.0001 Ci/yr for I.

Table 4 Calculated Annual Average Release of Airborne Radionuclides (Ci/yr) (Realistic) (3/3)

Nuclide	Coolant Concentration		Waste Gas System (Ci/yr)	Building Ventilation			Total (Ci/yr)
	Primary (μCi/g)	Secondary (μCi/g)		Reactor (Ci/yr)	Auxiliary (Ci/yr)	Fuel Handlg (Ci/yr)	
Cr-51	1.68E-03	3.48E-08	1.40E-05	9.20E-05	3.20E-04	1.80E-04	6.10E-04
Mn-54	8.61E-04	1.72E-08	2.10E-06	5.30E-05	7.80E-05	3.00E-04	4.30E-04
Co-57	0.00E+00	0.00E+00	0.00E+00	8.20E-06	0.00E+00	0.00E+00	8.20E-06
Co-58	2.48E-03	5.06E-08	8.70E-06	2.50E-04	1.90E-03	2.10E-02	2.30E-02
Co-60	2.85E-04	5.83E-09	1.40E-05	2.60E-05	5.10E-04	8.20E-03	8.80E-03
Fe-59	1.62E-04	3.20E-09	1.80E-06	2.70E-05	5.00E-05	0.00E+00	7.90E-05
Sr-89	7.56E-05	1.52E-09	4.40E-05	1.30E-04	7.50E-04	2.10E-03	3.00E-03
Sr-90	6.45E-06	1.30E-10	1.70E-05	5.20E-05	2.90E-04	8.00E-04	1.20E-03
Zr-95	2.10E-04	4.26E-09	4.80E-06	0.00E+00	1.00E-03	3.60E-06	1.00E-03
Nb-95	1.52E-04	2.94E-09	3.70E-06	1.80E-05	3.00E-05	2.40E-03	2.50E-03
Ru-103	4.06E-03	8.27E-08	3.20E-06	1.60E-05	2.30E-05	3.80E-05	8.00E-05
Ru-106	4.84E-02	9.81E-07	2.70E-06	0.00E+00	6.00E-06	6.90E-05	7.80E-05
Sb-125	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.90E-06	5.70E-05	6.10E-05
Cs-134	2.09E-05	4.22E-10	3.30E-05	2.50E-05	5.40E-04	1.70E-03	2.30E-03
Cs-136	5.06E-04	1.03E-08	5.30E-06	3.20E-05	4.80E-05	0.00E+00	8.50E-05
Cs-137	3.00E-05	6.20E-10	7.70E-05	5.50E-05	7.20E-04	2.70E-03	3.60E-03
Ba-137m	5.88E-05	2.30E-09	7.70E-05	5.50E-05	7.20E-04	2.70E-03	3.60E-03
Ba-140	7.11E-03	1.41E-07	2.30E-05	0.00E+00	4.00E-04	0.00E+00	4.20E-04
Ce-141	8.12E-05	1.63E-09	2.20E-06	1.30E-05	2.60E-05	4.40E-07	4.20E-05

Table 5 Calculated Annual Average Release of liquid Radionuclides (Ci/yr) (Realistic) (1/3)

Nuclide	Coolant Concentration		Boron RS (Ci/yr)	Misc. Wastes (Ci/yr)	Turb Bldg (Ci/yr)	Total-LWS* (Ci/yr)	Adjusted Total** (Ci/yr)	Detergent Wastes (Ci/yr)	Total (Ci/yr)
	Primary (μCi/ml)	Secondary (μCi/ml)							
Corrosion and Activation Products									
Na-24	3.21E-02	5.53E-07	0.00000	0.00029	0.00002	0.00031	0.00467	0.00000	4.70E-03
P-32	0.00E+00	0.00E+00	0.00000	0.00000	0.00000	0.00000	0.00000	0.00018	1.80E-04
Cr-51	1.68E-03	3.48E-08	0.00000	0.00008	0.00000	0.00008	0.00126	0.00470	6.00E-03
Mn-54	8.61E-04	1.72E-08	0.00000	0.00004	0.00000	0.00005	0.00068	0.00380	4.50E-03
Fe-55	6.45E-04	1.30E-08	0.00000	0.00003	0.00000	0.00003	0.00052	0.00720	7.70E-03
Fe-59	1.62E-04	3.20E-09	0.00000	0.00001	0.00000	0.00001	0.00012	0.00220	2.30E-03
Co-58	2.48E-03	5.06E-08	0.00000	0.00012	0.00000	0.00013	0.00193	0.00790	9.80E-03
Co-60	2.85E-04	5.83E-09	0.00000	0.00001	0.00000	0.00002	0.00023	0.01400	1.40E-02
Ni-63	0.00E+00	0.00E+00	0.00000	0.00000	0.00000	0.00000	0.00000	0.00170	1.70E-03
Zn-65	2.74E-04	5.57E-09	0.00000	0.00001	0.00000	0.00001	0.00022	0.00000	2.20E-04
W-187	1.60E-03	2.91E-08	0.00000	0.00002	0.00000	0.00002	0.00035	0.00000	3.50E-04
Np-239	1.29E-03	2.49E-08	0.00000	0.00003	0.00000	0.00004	0.00053	0.00000	5.30E-04
Fission Products									
Rb-88	2.09E-01	4.60E-07	0.00000	0.00187	0.00000	0.00187	0.02807	0.00000	2.80E-02
Sr-89	7.56E-05	1.52E-09	0.00000	0.00000	0.00000	0.00000	0.00006	0.00009	1.50E-04
Sr-90	6.45E-06	1.30E-10	0.00000	0.00000	0.00000	0.00000	0.00001	0.00001	1.80E-05
Sr-91	7.07E-04	1.16E-08	0.00000	0.00000	0.00000	0.00000	0.00007	0.00000	6.80E-05
Y-91m	4.75E-04	2.47E-09	0.00000	0.00000	0.00000	0.00000	0.00004	0.00000	4.40E-05
Y-91	2.81E-06	5.59E-11	0.00000	0.00000	0.00000	0.00000	0.00001	0.00008	9.00E-05
Y-93	3.06E-03	4.88E-08	0.00000	0.00002	0.00000	0.00002	0.00031	0.00000	3.10E-04

Table 5 Calculated Annual Average Release of liquid Radionuclides (Ci/yr) (Realistic) (2/3)

Nuclide	Coolant Concentration		Boron RS (Ci/yr)	Misc. Wastes (Ci/yr)	Turb Bldg (Ci/yr)	Total-LWS* (Ci/yr)	Adjusted Total** (Ci/yr)	Detergent Wastes (Ci/yr)	Total (Ci/yr)
	Primary (μCi/ml)	Secondary (μCi/ml)							
Zr-95	2.10E-04	4.26E-09	0.00000	0.00001	0.00000	0.00001	0.00016	0.00110	1.30E-03
Nb-95	1.52E-04	2.94E-09	0.00000	0.00001	0.00000	0.00001	0.00012	0.00190	2.00E-03
Mo-99	3.70E-03	7.29E-08	0.00000	0.00011	0.00000	0.00011	0.00166	0.00006	1.70E-03
Tc-99m	3.77E-03	5.21E-08	0.00000	0.00011	0.00000	0.00011	0.00165	0.00000	1.70E-03
Ru-103	4.06E-03	8.27E-08	0.00001	0.00020	0.00000	0.00021	0.00309	0.00029	3.40E-03
Rh-103m	0.00E+00	0.00E+00	0.00001	0.00020	0.00000	0.00021	0.00309	0.00000	3.10E-03
Ru-106	4.84E-02	9.81E-07	0.00010	0.00243	0.00005	0.00257	0.03854	0.00890	4.70E-02
Rh-106	0.00E+00	0.00E+00	0.00010	0.00243	0.00005	0.00257	0.03854	0.00000	3.90E-02
Ag-110m	7.00E-04	1.41E-08	0.00000	0.00003	0.00000	0.00004	0.00056	0.00120	1.80E-03
Ag-110	0.00E+00	0.00E+00	0.00000	0.00000	0.00000	0.00000	0.00007	0.00000	7.20E-05
Sb-124	0.00E+00	0.00E+00	0.00000	0.00000	0.00000	0.00000	0.00000	0.00043	4.30E-04
Te-129m	1.03E-04	2.08E-09	0.00000	0.00000	0.00000	0.00001	0.00008	0.00000	7.80E-05
Te-129	2.42E-02	1.60E-07	0.00000	0.00002	0.00000	0.00002	0.00031	0.00000	3.10E-04
Te-131m	9.32E-04	1.74E-08	0.00000	0.00002	0.00000	0.00002	0.00025	0.00000	2.50E-04
Te-131	8.24E-03	2.43E-08	0.00000	0.00000	0.00000	0.00001	0.00008	0.00000	7.60E-05
I-131	1.11E-03	2.26E-08	0.00002	0.00001	0.00000	0.00002	0.00037	0.00160	2.00E-03
Te-132	9.74E-04	1.90E-08	0.00000	0.00003	0.00000	0.00003	0.00047	0.00000	4.70E-04
I-132	5.61E-02	5.57E-07	0.00000	0.00001	0.00001	0.00002	0.00031	0.00000	3.10E-04
I-133	1.69E-02	3.12E-07	0.00001	0.00002	0.00003	0.00005	0.00081	0.00000	8.10E-04
I-134	1.03E-01	5.51E-07	0.00000	0.00001	0.00000	0.00001	0.00009	0.00000	8.90E-05
Cs-134	2.09E-05	4.22E-10	0.00002	0.00005	0.00000	0.00007	0.00112	0.01100	1.20E-02
I-135	4.33E-02	6.46E-07	0.00000	0.00002	0.00003	0.00005	0.00078	0.00000	7.80E-04

Table 5 Calculated Annual Average Release of liquid Radionuclides (Ci/yr) (Realistic) (3/3)

Nuclide	Coolant Concentration		Boron RS (Ci/yr)	Misc. Wastes (Ci/yr)	Turb Bldg (Ci/yr)	Total-LWS* (Ci/yr)	Adjusted Total** (Ci/yr)	Detergent Wastes (Ci/yr)	Total (Ci/yr)
	Primary (µCi/ml)	Secondary (µCi/ml)							
Cs-136	5.06E-04	1.03E-08	0.00030	0.00112	0.00000	0.00141	0.02119	0.00037	2.20E-02
Cs-137	3.00E-05	6.20E-10	0.00003	0.00008	0.00000	0.00011	0.00160	0.01600	1.80E-02
Ba-137m	5.88E-05	2.30E-09	0.00003	0.00000	0.00000	0.00003	0.00046	0.00000	4.60E-04
Ba-140	7.11E-03	1.41E-07	0.00001	0.00031	0.00001	0.00033	0.00492	0.00091	5.80E-03
La-140	1.51E-02	2.87E-07	0.00001	0.00051	0.00001	0.00053	0.00795	0.00000	8.00E-03
Ce-141	8.12E-05	1.63E-09	0.00000	0.00000	0.00000	0.00000	0.00006	0.00023	2.90E-04
Ce-143	1.72E-03	3.17E-08	0.00000	0.00003	0.00000	0.00003	0.00050	0.00000	5.00E-04
Pr-143	0.00E+00	0.00E+00	0.00000	0.00001	0.00000	0.00001	0.00008	0.00000	7.90E-05
Ce-144	2.15E-03	4.24E-08	0.00000	0.00011	0.00000	0.00011	0.00171	0.00390	5.60E-03
Pr-144	0.00E+00	0.00E+00	0.00000	0.00011	0.00000	0.00011	0.00171	0.00000	1.70E-03
All Others	1.70E-02	6.15E-08	0.00000	0.00000	0.00000	0.00000	0.00001	0.00000	1.20E-05
Total(Except Tritium)	6.14E-01	5.36E-06	0.00065	0.01053	0.00025	0.01143	0.17143	0.08975	2.60E-01
Tritium Release (Ci/yr)									1600

NOTE: 0.00000 Indicates that the value is less than 1.0E-5.

* The sum of Boron RS, Misc.and Wastes,Turb Bldg. It is written on DCD, "Combined Release".

** The release totals include an adjustment of 0.16 Ci/yr added by the PWR-GALE Code to account for unplanned release rate.

Because the release rate from "Secondary" under the output of GALE was all nuclides 0,

the description in the table was omitted.

Table 6 Comparison of Calculated Offsite Airborne Concentrations with 10 CFR 20 Limits (Realistic) (1/2)

Nuclide	Discharge Concentration (µCi/ml)	Effluent Concentration Limit* (µCi/ml)	Fraction of Concentration Limit
I-131	2.7E-15	2.00E-10	1.33E-05
I-133	4.1E-14	1.00E-09	4.06E-05
Kr-85m	0.0E+00	1.00E-07	0.00E+00
Kr-85	8.9E-10	7.00E-07	1.27E-03
Kr-87	0.0E+00	2.00E-08	0.00E+00
Kr-88	0.0E+00	9.00E-09	0.00E+00
Xe-131m	1.6E-10	2.00E-06	8.24E-05
Xe-133m	1.3E-12	6.00E-07	2.11E-06
Xe-133	0.0E+00	5.00E-07	0.00E+00
Xe-135m	2.5E-12	4.00E-08	6.34E-05
Xe-135	1.3E-12	7.00E-08	1.81E-05
Xe-137	2.5E-12	1.00E-09	2.54E-03
Xe-138	6.3E-13	2.00E-08	3.17E-05
Cr-51	3.9E-16	3.00E-08	1.29E-08
Mn-54	2.7E-16	1.00E-09	2.73E-07
Co-57	5.2E-18	9.00E-10	5.78E-09
Co-58	1.5E-14	1.00E-09	1.46E-05
Co-60	5.6E-15	5.00E-11	1.12E-04
Fe-59	5.0E-17	5.00E-10	1.00E-07
Sr-89	1.9E-15	2.00E-10	9.51E-06
Sr-90	7.6E-16	6.00E-12	1.27E-04
Zr-95	6.3E-16	4.00E-10	1.59E-06
Nb-95	1.6E-15	2.00E-09	7.93E-07
Ru-103	5.1E-17	9.00E-10	5.64E-08
Ru-106	4.9E-17	2.00E-11	2.47E-06
Sb-125	3.9E-17	7.00E-10	5.53E-08
Cs-134	1.5E-15	2.00E-10	7.29E-06
Cs-136	5.4E-17	9.00E-10	5.99E-08
Cs-137	2.3E-15	2.00E-10	1.14E-05
Ba-137m	2.3E-15	1.00E-09	2.28E-06
Ba-140	2.7E-16	2.00E-09	1.33E-07
Ce-141	2.7E-17	8.00E-10	3.33E-08
H-3	1.1E-10	1.00E-07	1.14E-03

Table 6 Comparison of Calculated Offsite Airborne Concentrations with 10 CFR 20 Limits (Realistic) (2/2)

Nuclide	Discharge Concentration (μCi/ml)	Effluent Concentration Limit* (μCi/ml)	Fraction of Concentration Limit
C-14	4.6E-12	3.00E-09	1.54E-03
Ar-41	2.2E-11	1.00E-08	2.16E-03
TOTAL			9.19E-03

* The value is based on Ref.(6) , Table2 Col.1 Effluent Concentrations (Air)

However, Xe-137 and Ba-137m are using the value that is the condition of radioactive half-life less than 2 hours, because these nuclides are unlisted.

Table 7 Comparison of Annual Average Liquid Release Concentrations

With 10CFR20 (Realistic) (1/2)

Nuclide	Discharge Concentration (μCi/ml)	Effluent Concentration Limit* (μCi/ml)	Fraction of Concentration Limit
Na-24	2.29E-10	5.00E-05	4.58E-06
P-32	8.77E-12	9.00E-06	9.74E-07
Cr-51	2.92E-10	5.00E-04	5.84E-07
Mn-54	2.19E-10	3.00E-05	7.31E-06
Fe-55	3.75E-10	1.00E-04	3.75E-06
Fe-59	1.12E-10	1.00E-05	1.12E-05
Co-58	4.77E-10	2.00E-05	2.39E-05
Co-60	6.82E-10	3.00E-06	2.27E-04
Ni-63	8.28E-11	1.00E-04	8.28E-07
Zn-65	1.07E-11	5.00E-06	2.14E-06
W-187	1.70E-11	3.00E-05	5.68E-07
Np-239	2.58E-11	2.00E-05	1.29E-06
Rb-88	1.36E-09	4.00E-04	3.41E-06
Sr-89	7.31E-12	8.00E-06	9.13E-07
Sr-90	8.77E-13	5.00E-07	1.75E-06
Sr-91	3.31E-12	2.00E-05	1.66E-07
Y-91m	2.14E-12	2.00E-03	1.07E-09
Y-91	4.38E-12	8.00E-06	5.48E-07
Y-93	1.51E-11	2.00E-05	7.55E-07
Zr-95	6.33E-11	2.00E-05	3.17E-06
Nb-95	9.74E-11	3.00E-05	3.25E-06
Mo-99	8.28E-11	2.00E-05	4.14E-06
Tc-99m	8.28E-11	1.00E-03	8.28E-08
Ru-103	1.66E-10	3.00E-05	5.52E-06
Rh-103m	1.51E-10	6.00E-03	2.52E-08
Ru-106	2.29E-09	3.00E-06	7.63E-04
Ag-110m	8.77E-11	6.00E-06	1.46E-05
Sb-124	2.09E-11	7.00E-06	2.99E-06
Te-129m	3.80E-12	7.00E-06	5.43E-07
Te-129	1.51E-11	4.00E-04	3.77E-08
Te-131m	1.22E-11	8.00E-06	1.52E-06
Te-131	3.70E-12	8.00E-05	4.63E-08

Table 7 Comparison of Annual Average Liquid Release Concentrations

With 10CFR20 (Realistic) (2/2)

Nuclide	Discharge Concentration (μCi/ml)	Effluent Concentration Limit* (μCi/ml)	Fraction of Concentration Limit
I-131	9.74E-11	1.00E-06	9.74E-05
Te-132	2.29E-11	9.00E-06	2.54E-06
I-132	1.51E-11	1.00E-04	1.51E-07
I-133	3.94E-11	7.00E-06	5.64E-06
I-134	4.33E-12	4.00E-04	1.08E-08
Cs-134	5.84E-10	9.00E-07	6.49E-04
I-135	3.80E-11	3.00E-05	1.27E-06
Cs-136	1.07E-09	6.00E-06	1.79E-04
Cs-137	8.77E-10	1.00E-06	8.77E-04
Ba-140	2.82E-10	8.00E-06	3.53E-05
La-140	3.90E-10	9.00E-06	4.33E-05
Ce-141	1.41E-11	3.00E-05	4.71E-07
Ce-143	2.44E-11	2.00E-05	1.22E-06
Pr-143	3.85E-12	2.00E-05	1.92E-07
Ce-144	2.73E-10	3.00E-06	9.09E-05
Pr-144	8.28E-11	6.00E-04	1.38E-07
H-3	7.79E-05	1.00E-03	7.79E-02
			Total =8.10E-2

* The value is based on an Effluent Concentrations (Water) column of Table2 Col.2 in ref. (8). The value of the chemical form with which the limitation was the severest was selected.

Table 8 Calculated Dose from Gaseous Effluents at the exclusion area boundary (Realistic) (1/2)

	Dose(Noble gas include Ar-41)	Criteria
Gamma dose in air	2.10E-01	< 10 mrad/y
Beta dose in air	1.62E+00	< 20 mrad/y
Total body	1.34E-01	< 5 mrem/y
Skin	1.26E+00	< 15 mrem/y

Table 8 Calculated Dose from Gaseous Effluents at the exclusion area boundary (Realistic) (2/2)

Pathway/Agegroup		Organ dose(Iodine,Particulate,H-3 and C-14) (mrem/y)						Criteria (mrem/y)
		GI-Tract	Bone	Liver	Kidney	Thyroid	Lung	
Ground		3.86E-01	3.86E-01	3.86E-01	3.86E-01	3.86E-01	3.86E-01	
Vegetable	Adult	4.00E-01	2.24E+00	3.68E-01	3.14E-01	6.00E-01	2.95E-01	
	Teen	5.31E-01	3.25E+00	5.32E-01	4.49E-01	7.94E-01	4.23E-01	
	Child	9.54E-01	7.17E+00	1.07E+00	9.32E-01	1.59E+00	8.88E-01	
Meat	Adult	1.41E-01	3.36E-01	8.86E-02	8.25E-02	9.25E-02	8.02E-02	
	Teen	9.74E-02	2.81E-01	7.02E-02	6.53E-02	7.23E-02	6.36E-02	
	Child	1.30E-01	5.24E-01	1.21E-01	1.14E-01	1.26E-01	1.12E-01	
Cow Milk	Adult	1.18E-01	4.57E-01	1.79E-01	1.33E-01	5.11E-01	1.16E-01	
	Teen	1.90E-01	8.17E-01	3.01E-01	2.22E-01	8.20E-01	1.93E-01	
	Child	4.00E-01	1.96E+00	5.98E-01	4.62E-01	1.69E+00	4.14E-01	
	Infant	7.78E-01	3.59E+00	1.17E+00	8.83E-01	3.92E+00	8.10E-01	
Inhalation	Adult	6.97E-02	1.97E-02	6.84E-02	6.73E-02	1.61E-01	1.14E-01	
	Teen	7.02E-02	2.32E-02	7.00E-02	6.86E-02	1.92E-01	1.39E-01	
	Child	6.01E-02	2.75E-02	6.20E-02	6.07E-02	2.18E-01	1.19E-01	
	Infant	3.42E-02	1.21E-02	3.64E-02	3.50E-02	1.81E-01	7.56E-02	
Total	Adult	1.11E+00	3.44E+00	1.09E+00	9.83E-01	1.75E+00	9.91E-01	< 15
	Teen	1.27E+00	4.76E+00	1.36E+00	1.19E+00	2.26E+00	1.20E+00	< 15
	Child	1.93E+00	1.01E+01	2.24E+00	1.95E+00	4.01E+00	1.92E+00	< 15
	Infant	1.20E+00	3.99E+00	1.59E+00	1.30E+00	4.49E+00	1.27E+00	< 15

Table 9 Calculated Dose from Liquid Effluents

	Annual Doses (mrem/yr)							
PATHWAY	**SKIN**	**BONE**	**LIVER**	**T.BODY**	**THYROID**	**KIDNEY**	**LUNG**	**GI-LLI**
Drinking								
Adult	—	8.69E-03	4.91E-01	4.88E-01	4.89E-01	4.83E-01	4.79E-01	5.11E-01
Teenager	—	8.32E-03	3.49E-01	3.43E-01	3.47E-01	3.42E-01	3.39E-01	3.61E-01
Child	—	2.38E-02	6.70E-01	6.52E-01	6.69E-01	6.56E-01	6.48E-01	6.69E-01
Infant	—	2.50E-02	6.64E-01	6.39E-01	6.71E-01	6.44E-01	6.37E-01	6.49E-01
Fish								
Adult	—	6.53E-01	7.31E-01	5.35E-01	1.70E-02	2.66E-01	8.67E-02	1.82E-01
Teenager	—	6.97E-01	7.47E-01	3.34E-01	1.39E-02	2.66E-01	9.72E-02	1.34E-01
Child	—	8.78E-01	6.51E-01	1.68E-01	1.24E-02	2.23E-01	7.69E-02	5.46E-02
Shoreline								
Adult	8.61E-04	7.34E-04	7.34E-04	7.34E-04	7.34E-04	7.34E-04	7.34E-04	7.34E-04
Teenager	4.81E-03	4.10E-03	4.10E-03	4.10E-03	4.10E-03	4.10E-03	4.10E-03	4.10E-03
Child	1.00E-03	8.56E-04	8.56E-04	8.56E-04	8.56E-04	8.56E-04	8.56E-04	8.56E-04
Irrigated Foods : Vegetables								
Adult	—	1.22E-02	3.51E-01	3.47E-01	3.36E-01	3.41E-01	3.36E-01	3.76E-01
Teenager	—	2.02E-02	4.36E-01	4.21E-01	4.12E-01	4.20E-01	4.12E-01	4.62E-01
Child	—	4.78E-02	6.92E-01	6.57E-01	6.52E-01	6.64E-01	6.51E-01	6.88E-01
Irrigated Foods : Leafy Vegetables								
Adult	—	1.55E-03	4.34E-02	4.28E-02	4.20E-02	4.21E-02	4.14E-02	4.67E-02
Teenager	—	1.40E-03	2.92E-02	2.82E-02	2.80E-02	2.81E-02	2.75E-02	3.10E-02
Child	—	2.48E-03	3.48E-02	3.30E-02	3.33E-02	3.33E-02	3.26E-02	3.46E-02
Irrigated Foods : Milk								
Adult	—	5.94E-03	2.09E-01	2.07E-01	2.02E-01	2.03E-01	2.01E-01	2.01E-01
Teenager	—	1.06E-02	2.77E-01	2.67E-01	2.64E-01	2.66E-01	2.62E-01	2.62E-01
Child	—	2.52E-02	4.39E-01	4.17E-01	4.19E-01	4.20E-01	4.14E-01	4.12E-01
Irrigated Foods : Meat								
Adult	—	4.04E-03	7.20E-02	7.21E-02	7.09E-02	7.75E-02	7.10E-02	2.83E-01
Teenager	—	3.38E-03	4.32E-02	4.30E-02	4.23E-02	4.78E-02	4.24E-02	1.75E-01
Child	—	6.33E-03	5.22E-02	5.20E-02	5.11E-02	5.84E-02	5.12E-02	1.32E-01
Total								
Adult	8.61E-04	6.86E-01	1.90E+00	1.69E+00	1.16E+00	1.41E+00	1.22E+00	1.60E+00
Teenager	4.81E-03	7.45E-01	1.89E+00	1.44E+00	1.11E+00	1.37E+00	1.18E+00	1.43E+00
Child	1.00E-03	9.84E-01	2.54E+00	1.98E+00	1.84E+00	2.06E+00	1.87E+00	1.99E+00
Infant	—	2.50E-02	6.64E-01	6.39E-01	6.71E-01	6.44E-01	6.37E-01	6.49E-01

Table 10 Calculated Annual Average Release of Airborne Radionuclides (Ci/yr) (Design Basis) (1/3)

Nuclide	Primary Coolant Concentration (μCi/g)	Building Ventilation				Blowdown Vent Offgas (Ci/yr)	Air Ejector Exhaust (Ci/yr)	Total (Ci/yr)
		Fuel Handlg (Ci/yr)	Reactor (Ci/yr)	Auxiliary (Ci/yr)	Turbine (Ci/yr)			
Iodines								
I-131	1.6050E+00	2.17E-01	8.23E-01	5.06E+00	0.00E+00	0.00E+00	0.00E+00	6.10E+00
I-133	2.7683E+00	3.60E-01	1.21E+00	8.82E+00	0.00E+00	0.00E+00	0.00E+00	1.04E+01

Table 10 Calculated Annual Average Release of Airborne Radionuclides (Ci/yr) (Design Basis) (2/3)

Nuclide	Primary Coolant Concentration (μCi/g)	Gas Stripping		Building Ventilation			Blowdown Vent Offgas (Ci/yr)	Air Ejector Exhaust (Ci/yr)	Total (Ci/yr)
		Shutdown (Ci/yr)	Continuous (Ci/yr)	Reactor (Ci/yr)	Auxiliary (Ci/yr)	Turbine (Ci/yr)			
Kr-85m	1.80E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Kr-85	9.32E+01	5.33E+04	4.00E+05	1.67E+03	2.00E+03	0.00E+00	0.00E+00	1.00E+03	4.58E+05
Kr-87	1.17E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Kr-88	3.37E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Xe-131m	4.17E+00	1.71E+02	1.22E+03	6.72E+01	8.55E+01	0.00E+00	0.00E+00	4.28E+01	1.59E+03
Xe-133m	4.25E+00	0.00E+00	0.00E+00	0.00E+00	1.14E+02	0.00E+00	0.00E+00	0.00E+00	1.14E+02
Xe-133	3.17E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Xe-135m	7.74E-01	0.00E+00	0.00E+00	0.00E+00	1.60E+01	0.00E+00	0.00E+00	5.34E+00	2.14E+01
Xe-135	1.04E+01	0.00E+00	0.00E+00	0.00E+00	2.80E+02	0.00E+00	0.00E+00	0.00E+00	2.80E+02
Xe-137	1.92E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.02E+01	2.02E+01
Xe-138	6.75E-01	0.00E+00	0.00E+00	0.00E+00	9.93E+00	0.00E+00	0.00E+00	0.00E+00	9.93E+00
Total Noble Gases									4.60E+05

Appearing in the Table Indicates Release is Less than 1.0 Ci/yr for Noble Gas, 0.0001 Ci/yr for I.

Table 10 Calculated Annual Average Release of Airborne Radionuclides (Ci/yr) (Design Basis) (3/3)

Nuclide	Primary Coolant Concentration (μCi/g)	Waste Gas System (Ci/yr)	Building Ventilation			Total (Ci/yr)
			Reactor (Ci/yr)	Auxiliary (Ci/yr)	Fuel Handlg (Ci/yr)	
Cr-51	1.68E-03	1.40E-05	9.20E-05	3.20E-04	1.80E-04	6.10E-04
Mn-54	8.61E-04	2.10E-06	5.30E-05	7.80E-05	3.00E-04	4.30E-04
Co-57	0.00E+00	0.00E+00	8.20E-06	0.00E+00	0.00E+00	8.20E-06
Co-58	2.48E-03	8.70E-06	2.50E-04	1.90E-03	2.10E-02	2.30E-02
Co-60	2.85E-04	1.40E-05	2.60E-05	5.10E-04	8.20E-03	8.80E-03
Fe-59	1.62E-04	1.80E-06	2.70E-05	5.00E-05	0.00E+00	7.90E-05
Sr-89	1.90E-03	1.11E-03	3.27E-03	1.89E-02	5.28E-02	7.60E-02
Sr-90	1.23E-04	3.25E-04	9.95E-04	5.55E-03	1.53E-02	2.22E-02
Zr-95	3.68E-04	8.41E-06	0.00E+00	1.75E-03	6.31E-06	1.77E-03
Nb-95	3.71E-04	9.02E-06	4.39E-05	7.31E-05	5.85E-03	5.98E-03
Ru-103	3.05E-04	2.40E-07	1.20E-06	1.73E-06	2.86E-06	6.03E-06
Ru-106	1.07E-04	5.98E-09	0.00E+00	1.33E-08	1.53E-07	1.72E-07
Sb-125	0.00E+00	0.00E+00	0.00E+00	3.90E-06	5.70E-05	6.10E-05
Cs-134	7.68E-01	1.21E+00	9.18E-01	1.98E+01	6.24E+01	8.44E+01
Cs-136	2.03E-01	2.12E-03	1.28E-02	1.92E-02	0.00E+00	3.42E-02
Cs-137	4.37E-01	1.12E+00	8.01E-01	1.05E+01	3.93E+01	5.17E+01
Ba-137m	4.10E-01	5.37E-01	3.83E-01	5.02E+00	1.88E+01	2.48E+01
Ba-140	2.33E-03	7.53E-06	0.00E+00	1.31E-04	0.00E+00	1.39E-04
Ce-141	3.57E-04	9.67E-06	5.71E-05	1.14E-04	1.93E-06	1.83E-04

Table 11 Calculated Annual Average Release of liquid Radionuclides (Ci/yr) (Design Basis) (1/3)

Nuclide	Primary Coolant Concentration (μCi/ml)	Boron RS (Ci/yr)	Misc. Wastes (Ci/yr)	Turb Bldg (Ci/yr)	Total-LWS* (Ci/yr)	Detergent Wastes (Ci/yr)	Total (Ci/yr)
Corrosion and Activation Products							
Na-24	3.21E-02	0.00000	0.00029	0.00002	0.00031	0.00000	3.20E-04
P-32	0.00E+00	0.00000	0.00000	0.00000	0.00000	0.00018	1.80E-04
Cr-51	1.68E-03	0.00000	0.00008	0.00000	0.00008	0.00470	4.78E-03
Mn-54	8.61E-04	0.00000	0.00004	0.00000	0.00004	0.00380	3.84E-03
Fe-55	6.45E-04	0.00000	0.00003	0.00000	0.00003	0.00720	7.23E-03
Fe-59	1.62E-04	0.00000	0.00001	0.00000	0.00001	0.00220	2.21E-03
Co-58	2.48E-03	0.00000	0.00012	0.00000	0.00012	0.00790	8.02E-03
Co-60	2.85E-04	0.00000	0.00001	0.00000	0.00001	0.01400	1.40E-02
Ni-63	0.00E+00	0.00000	0.00000	0.00000	0.00000	0.00170	1.70E-03
Zn-65	2.74E-04	0.00000	0.00001	0.00000	0.00001	0.00000	1.03E-05
W-187	1.60E-03	0.00000	0.00002	0.00000	0.00002	0.00000	2.06E-05
Np-239	1.29E-03	0.00000	0.00003	0.00000	0.00003	0.00000	3.10E-05
Fission Products							
Rb-88	4.30E+00	0.00000	0.03849	0.00000	0.03849	0.00000	3.97E-02
Sr-89	1.90E-03	0.00000	0.00000	0.00000	0.00000	0.00009	9.00E-05
Sr-90	1.23E-04	0.00000	0.00000	0.00000	0.00000	0.00001	1.00E-05
Sr-91	1.28E-03	0.00000	0.00000	0.00000	0.00000	0.00000	0.00E+00
Y-91m	6.62E-04	0.00000	0.00000	0.00000	0.00000	0.00000	0.00E+00
Y-91	3.01E-04	0.00000	0.00000	0.00000	0.00000	0.00008	8.00E-05
Y-93	2.43E-04	0.00000	0.00000	0.00000	0.00000	0.00000	0.00E+00

Table 11 Calculated Annual Average Release of liquid Radionuclides (Ci/yr) (Design Basis) (2/3)

Nuclide	Primary Coolant Concentration (μCi/ml)	Boron RS (Ci/yr)	Misc. Wastes (Ci/yr)	Turb Bldg (Ci/yr)	Total-LWS* (Ci/yr)	Detergent Wastes (Ci/yr)	Total (Ci/yr)
Zr-95	3.68E-04	0.00000	0.00001	0.00000	0.00001	0.00110	1.11E-03
Nb-95	3.71E-04	0.00000	0.00002	0.00000	0.00002	0.00190	1.92E-03
Mo-99	4.49E-01	0.00000	0.01333	0.00000	0.01333	0.00006	1.38E-02
Tc-99m	1.81E-01	0.00000	0.00527	0.00000	0.00527	0.00000	5.44E-03
Ru-103	3.05E-04	0.00000	0.00001	0.00000	0.00001	0.00029	3.00E-04
Rh-103m	3.00E-04	0.00000	0.00001	0.00000	0.00001	0.00000	1.03E-05
Ru-106	1.07E-04	0.00000	0.00001	0.00000	0.00001	0.00890	8.91E-03
Rh-106	1.07E-04	0.00000	0.00001	0.00000	0.00001	0.00000	1.03E-05
Ag-110m	9.82E-07	0.00000	0.00000	0.00000	0.00000	0.00120	1.20E-03
Ag-110	5.64E-08	0.00000	0.00000	0.00000	0.00000	0.00000	0.00E+00
Sb-124	0.00E+00	0.00000	0.00000	0.00000	0.00000	0.00043	4.30E-04
Te-129m	5.91E-03	0.00000	0.00000	0.00000	0.00000	0.00000	0.00E+00
Te-129	7.37E-03	0.00000	0.00000	0.00000	0.00000	0.00000	0.00E+00
Te-131m	1.57E-02	0.00000	0.00033	0.00000	0.00033	0.00000	3.40E-04
Te-131	8.54E-03	0.00000	0.00000	0.00000	0.00000	0.00000	0.00E+00
I-131	6.29E-02	0.00113	0.00056	0.00000	0.00169	0.00160	3.34E-03
Te-132	1.71E-01	0.00000	0.00526	0.00000	0.00526	0.00000	5.43E-03
I-132	8.61E-01	0.00000	0.00015	0.00015	0.00030	0.00000	3.10E-04
I-133	2.77E+00	0.00163	0.00327	0.00491	0.00981	0.00000	1.01E-02
I-134	5.90E-01	0.00000	0.00005	0.00000	0.00005	0.00000	5.16E-05
Cs-134	7.68E-01	0.73457	1.83643	0.00000	2.57100	0.01100	2.66E+00
I-135	1.82E+00	0.00000	0.00083	0.00125	0.00208	0.00000	2.15E-03

Table 11 Calculated Annual Average Release of liquid Radionuclides (Ci/yr) (Design Basis) (3/3)

Nuclide	Primary Coolant Concentration (μCi/ml)	Boron RS (Ci/yr)	Misc. Wastes (Ci/yr)	Turb Bldg (Ci/yr)	Total-LWS* (Ci/yr)	Detergent Wastes (Ci/yr)	Total (Ci/yr)
Cs-136	2.03E-01	0.12019	0.44873	0.00000	0.56892	0.00037	5.87E-01
Cs-137	4.37E-01	0.43698	1.16528	0.00000	1.60226	0.01600	1.67E+00
Ba-137m	4.10E-01	0.20917	0.00000	0.00000	0.20917	0.00000	2.16E-01
Ba-140	2.33E-03	0.00000	0.00010	0.00000	0.00010	0.00091	1.01E-03
La-140	6.04E-04	0.00000	0.00002	0.00000	0.00002	0.00000	2.06E-05
Ce-141	3.57E-04	0.00000	0.00000	0.00000	0.00000	0.00023	2.30E-04
Ce-143	3.02E-04	0.00000	0.00000	0.00000	0.00000	0.00000	0.00E+00
Pr-143	3.28E-04	0.00000	0.00000	0.00000	0.00000	0.00000	0.00E+00
Ce-144	2.70E-04	0.00000	0.00001	0.00000	0.00001	0.00390	3.91E-03
Pr-144	2.70E-04	0.00000	0.00001	0.00000	0.00001	0.00000	1.03E-05
Total(Except Tritium)		1.50367	3.51883	0.00633	5.02883	0.08975	5.28E+00
Tritium Release (Ci/yr)							1600

NOTE: 0.00000 Indicates that the value is less than 1.0E-5.

* The sum of Boron RS, Misc.and Wastes,Turb Bldg. It is written on DCD, "Combined Release".

Table 12 Comparison of Calculated Offsite Airborne Concentrations with 10 CFR 20 Limits (Design Basis)(1/2)

Nuclide	Discharge Concentration (µCi/ml)	Effluent Concentration Limit* (µCi/ml)	Fraction of Concentration Limit
I-131	3.9E-12	2.00E-10	1.93E-02
I-133	6.6E-12	1.00E-09	6.59E-03
Kr-85m	0.0E+00	1.00E-07	0.00E+00
Kr-85	2.9E-07	7.00E-07	4.15E-01
Kr-87	0.0E+00	2.00E-08	0.00E+00
Kr-88	0.0E+00	9.00E-09	0.00E+00
Xe-131m	1.0E-09	2.00E-06	5.04E-04
Xe-133m	7.2E-11	6.00E-07	1.20E-04
Xe-133	0.0E+00	5.00E-07	0.00E+00
Xe-135m	1.4E-11	4.00E-08	3.39E-04
Xe-135	1.8E-10	7.00E-08	2.54E-03
Xe-137	1.3E-11	1.00E-09	1.28E-02
Xe-138	6.3E-12	2.00E-08	3.15E-04
Cr-51	3.9E-16	3.00E-08	1.29E-08
Mn-54	2.7E-16	1.00E-09	2.73E-07
Co-57	5.2E-18	9.00E-10	5.78E-09
Co-58	1.5E-14	1.00E-09	1.46E-05
Co-60	5.6E-15	5.00E-11	1.12E-04
Fe-59	5.0E-17	5.00E-10	1.00E-07
Sr-89	4.8E-14	2.00E-10	2.41E-04
Sr-90	1.4E-14	6.00E-12	2.34E-03
Zr-95	1.1E-15	4.00E-10	2.80E-06
Nb-95	3.8E-15	2.00E-09	1.89E-06
Ru-103	3.8E-18	9.00E-10	4.25E-09
Ru-106	1.1E-19	2.00E-11	5.45E-09
Sb-125	3.9E-17	7.00E-10	5.53E-08
Cs-134	5.4E-11	2.00E-10	2.68E-01
Cs-136	2.2E-14	9.00E-10	2.41E-05
Cs-137	3.3E-11	2.00E-10	1.64E-01
Ba-137m	1.6E-11	1.00E-09	1.57E-02
Ba-140	8.8E-17	2.00E-09	4.39E-08
Ce-141	1.2E-16	8.00E-10	1.45E-07
H-3	1.1E-10	1.00E-07	1.14E-03

Table 12 Comparison of Calculated Offsite Airborne Concentrations with 10 CFR 20 Limits (Design Basis) (2/2)

Nuclide	Discharge Concentration (μCi/ml)	Effluent Concentration Limit* (μCi/ml)	Fraction of Concentration Limit
C-14	4.6E-12	3.00E-09	1.54E-03
Ar-41	2.2E-11	1.00E-08	2.16E-03
TOTAL			9.12E-01

* The value is based on Table2 Col.1 Effluent Concentrations (Air)in Ref(6)

However, Xe-137 and Ba-137m are using the value that is the condition of radioactive half-life less than 2 hours, because these nuclides are unlisted.

Table 13 Comparison of Annual Average Liquid Release Concentrations

With 10CFR20 (Design Basis) (1/2)

Nuclide	Discharge Concentration (μCi/ml)	Effluent Concentration Limit* (μCi/ml)	Fraction of Concentration Limit
Na-24	1.56E-11	5.00E-05	3.12E-07
P-32	8.77E-12	9.00E-06	9.74E-07
Cr-51	2.33E-10	5.00E-04	4.66E-07
Mn-54	1.87E-10	3.00E-05	6.24E-06
Fe-55	3.52E-10	1.00E-04	3.52E-06
Fe-59	1.08E-10	1.00E-05	1.08E-05
Co-58	3.91E-10	2.00E-05	1.95E-05
Co-60	6.82E-10	3.00E-06	2.27E-04
Ni-63	8.28E-11	1.00E-04	8.28E-07
Zn-65	5.03E-13	5.00E-06	1.01E-07
W-187	1.01E-12	3.00E-05	3.35E-08
Np-239	1.51E-12	2.00E-05	7.54E-08
Rb-88	1.93E-09	4.00E-04	4.84E-06
Sr-89	4.38E-12	8.00E-06	5.48E-07
Sr-90	4.87E-13	5.00E-07	9.74E-07
Sr-91	0.00E+00	2.00E-05	0.00E+00
Y-91m	0.00E+00	2.00E-03	0.00E+00
Y-91	3.90E-12	8.00E-06	4.87E-07
Y-93	0.00E+00	2.00E-05	0.00E+00
Zr-95	5.41E-11	2.00E-05	2.70E-06
Nb-95	9.35E-11	3.00E-05	3.12E-06
Mo-99	6.73E-10	2.00E-05	3.36E-05
Tc-99m	2.65E-10	1.00E-03	2.65E-07
Ru-103	1.46E-11	3.00E-05	4.88E-07
Rh-103m	5.03E-13	6.00E-03	8.38E-11
Ru-106	4.34E-10	3.00E-06	1.45E-04
Ag-110m	5.84E-11	6.00E-06	9.74E-06
Sb-124	2.09E-11	7.00E-06	2.99E-06
Te-129m	0.00E+00	7.00E-06	0.00E+00
Te-129	0.00E+00	4.00E-04	0.00E+00
Te-131m	1.66E-11	8.00E-06	2.07E-06
Te-131	0.00E+00	8.00E-05	0.00E+00

Table 13 Comparison of Annual Average Liquid Release Concentrations

With 10CFR20(Design Basis)(2/2)

Nuclide	Discharge Concentration (μCi/ml)	Effluent Concentration Limit* (μCi/ml)	Fraction of Concentration Limit
I-131	1.63E-10	1.00E-06	1.63E-04
Te-132	2.64E-10	9.00E-06	2.94E-05
I-132	1.51E-11	1.00E-04	1.51E-07
I-133	4.93E-10	7.00E-06	7.04E-05
I-134	2.51E-12	4.00E-04	6.28E-09
Cs-134	1.30E-07	9.00E-07	1.44E-01
I-135	1.05E-10	3.00E-05	3.48E-06
Cs-136	2.86E-08	6.00E-06	4.77E-03
Cs-137	8.13E-08	1.00E-06	8.13E-02
Ba-140	4.93E-11	8.00E-06	6.17E-06
La-140	1.01E-12	9.00E-06	1.12E-07
Ce-141	1.12E-11	3.00E-05	3.73E-07
Ce-143	0.00E+00	2.00E-05	0.00E+00
Pr-143	0.00E+00	2.00E-05	0.00E+00
Ce-144	1.90E-10	3.00E-06	6.35E-05
Pr-144	5.03E-13	6.00E-04	8.38E-10
H-3	7.79E-05	1.00E-03	7.79E-02
			Total = 3.09E-1

* The value is used by an Effluent Concentrations (Water) column of Table2 Col.2 in ref. (8). The value of the chemical form with which the limitation was the severest was selected.

Table 14 Input parameters and results for gas surge tank failure analysis

I. Input Parameters for the Waste Gas Surge Tank Leak	
Reactor coolant activity (μCi/g)[1]	Kr-85m 8.15E-01 Kr-85 4.22E+01 Kr-87 5.30E-01 Kr-88 1.52E+00 Xe-133 1.43E+02 Xe-135 4.69E+00
Reactor coolant mass (lb)	646,000
Transfer time of all the noble gases from the reactor coolant to the waste gas surge tank (day)	1
Number of waste gas surge tank	4
Noble gas activity in the waste gas surge tank （Ci）	Kr-85m 1.46E+00 Kr-85 3.09E+03 Kr-87 8.09E-05 Kr-88 2.95E-01 Xe-133 9.20E+03 Xe-135 5.52E+01
Dose factor for total body	RG 1.109
X/Q(s/m^3)[2]	5.0E-4
II. Result and Criteria	
Calculated dose (mrem)	46
Dose criteria(mrem)	100

Note:

1. Based on a 300 μCi/g Dose Equivalent Xe-133 as stated in the technical specifications

2. The short-term X/Q at EAB (See Section 2.3.4)

Table 15 Input parameters and results for charcoal delay bed failure analysis

I. Input Parameters for the Charcoal Bed Leak	
Reactor coolant activity(μCi/g)[1]	Kr-85m 8.15E-01 Kr-85 4.22E+01 Kr-87 5.30E-01 Kr-88 1.52E+00 Xe-133 1.43E+02 Xe-135 4.69E+00
Holdup time for Xe (days)	0.02
Holdup time for Kr (days)	0.02
Other parameters	Same as Table 1
Annual effluent of noble gas (Ci/yr)	Kr-85m 3.58E+03 Kr-85 4.10E+05 Kr-87 1.85E+03 Kr-88 6.25E+03 Xe-133 6.70E+05 Xe-135 2.17E+04
Dose factor for total body	RG 1.109
X/Q(s/m^3)[2]	5.0E-4
II. Result and Criteria	
Calculated dose(mrem)	2
Dose criteria(mrem)	100

Note:
1. Based on a 300 μCi/g Dose Equivalent Xe-133 as stated in the technical specifications
2. The short-term X/Q at EAB

Table 16 Input parameters for RATAF code

Name of input	Unit	HT	BAT	WHT
Name of the reactor	-	US-APWR		
Type	-	PWR		
Thermal power level	MWth	4451		
Mass of primary coolant	lbs	646		
Primary system letdown rate	GPM	180		
Letdown cation demineralizer flow	GPM	7		
Hydrological travel time	day	0		
Hydrological dilution factor	-	1.00E-20		
Shim bleed flow rate (for HT and BAT)	GPD	2875		Not used
Shim bleed PCA (for HT and BAT)	-	1		Not used
Drains flow rate (for HT and BAT)	GPD	900		Not used
Drains PCA (for HT and BAT)	-	0.1		Not used
Tank name	-	HOLDUP TANK	BORON ACID TANK	Waste Holdup Tank
Tank volume	gal	119688.3*	66000	30000
Bottom tank (0 if no 1 if yes)	-	0	1	0
Tank factors	-	1 for all nuclides	DFI=0.2 DFCS=0.04 DFO=0.2	1 for all nuclides
Dirty waste flow rate (for WHT and RWSAT)	GPD	Not used		2023
Dirty waste PCA (for WHT and RWSAT)	-	Not used		0.18

* 16 000 ft3

Table 17 Source term for Liquid Containing Tank Failures (1/2)

Isotope (Note 1)	Concentration in the tank (μCi/ml) (Note 2)		
	Holdup Tank	Boric Acid Tank	Waste Holdup Tank
Corrosion and activation products			
H-3	7.8E-01	7.4E-01	1.8E-01
Cr-51	7.7E-05	3.0E-05	1.6E-04
Mn-54	1.6E-05	4.2E-05	3.0E-05
Mn-56	Note 1		
Fe-55	8.6E-05	3.4E-04	1.6E-04
Fe-59	4.5E-05	2.5E-05	8.9E-05
Co-58	7.7E-04	6.4E-04	1.5E-03
Co-60	1.1E-04	4.8E-04	1.9E-04
Zn-65	Note 1		
W-187	Note 1		
Np-239	7.9E-05	1.4E-05	3.0E-04
Fission products			
Br-84	3.5E-07	6.4E-08	1.3E-06
Rb-88	6.2E-05	5.6E-05	6.0E-05
Sr-89	1.6E-05	1.0E-05	3.1E-05
Sr-90	5.4E-07	2.6E-06	9.7E-07
Sr-91	1.1E-06	2.0E-07	4.3E-06
Y-91m	7.3E-07	1.3E-07	2.8E-06
Y-91	3.4E-06	2.3E-06	6.4E-06
Y-92	Note 1		
Y-93	6.1E-08	1.1E-08	2.4E-07
Zr-95	2.9E-06	2.2E-06	5.5E-06
Nb-95	2.8E-06	3.1E-06	4.9E-06
Mo-99	7.8E-04	1.4E-04	2.9E-03

Note:
1. These radionuclides are listed in the Interim Staff Guidance on standard review plan section 11.2 and Branch Technical Position 11-6 but are not included in the RCS source term radionuclides list used by RATAF.

2. Adjusted values of RATAF output to 0.12% fuel defect level (except for corrosion and activation products).

Table 17 Source term for Liquid Containing Tank Failures (2/2)

Isotope (Note 1)	Concentration in the tank (μCi/ml) (Note 2)		
	Holdup Tank	Boric Acid Tank	Waste Holdup Tank
Fission products			
Tc-99m	7.3E-04	1.3E-04	2.6E-03
Tc-99	1.6E-10	9.5E-10	2.4E-10
Ru-103	1.9E-06	1.0E-06	4.0E-06
Ru-106	5.3E-07	1.6E-06	9.6E-07
Ag-110m	Note 1		
I-129	9.2E-14	2.0E-12	8.6E-14
Te-129m	6.0E-05	2.6E-05	1.2E-04
Te-129	3.8E-05	1.7E-05	7.9E-05
Te-131m	1.1E-05	2.0E-06	4.3E-05
Te-131	2.2E-06	3.8E-07	8.2E-06
I-131	6.1E-03	1.2E-03	1.7E-02
Te-132	2.9E-04	5.3E-05	1.0E-03
I-132	3.4E-04	6.1E-05	1.2E-03
I-133	1.2E-03	2.3E-04	4.8E-03
I-134	1.0E-05	1.8E-06	4.0E-05
Cs-134	5.6E-03	1.1E-01	2.5E-03
I-135	2.4E-04	4.3E-05	9.2E-04
Cs-136	1.7E-03	2.0E-03	1.0E-03
Cs-137	4.1E-03	1.0E-01	1.8E-03
Ba-140	6.6E-06	1.6E-06	1.6E-05
La-140	7.4E-06	1.8E-06	1.7E-05
Ce-141	3.0E-06	1.3E-06	6.1E-06
Ce-143	1.9E-07	3.5E-08	7.4E-07
Ce-144	1.7E-06	4.3E-06	3.1E-06

Note:

1. These radionuclides are listed in the Interim Staff Guidance on standard review plan section 11.2 and Branch Technical Position 11-6 but are not included in the RCS source term radionuclides list used by RATAF.

2. Adjusted values of RATAF output to 0.12% fuel defect level (except for corrosion and activation products)

APPENDIX A BASIS for PWR-GALE code inputs

Most of parameters described in table 1 and used for the PWR-GALE calculations are design basis values of US-APWR that are described in the different chapters of US-APWR DCD.

Some parameters are not directly parts of the design scope of US-APWR and where defined for the specific purposes of PWR GALE calculations.

The following displays the basis for the parameter selection defined for PWR-GALE calculation purposes.

A.1 Card 3: mass of RCS coolant:

The mass of RCS coolant was calculated using as inputs, the volumes of each component of RCS and the temperatures under normal operation conditions. These temperatures affect the densities of water that are used to calculate the mass of coolant in each of these components.

The following describes the details of calculation and explains.

Table A-1 RCS Component Reactor Coolant Inventory for US-APWR Systems
(at full power operation: without thermal expansion)

A.2 Card 5: cation demineralizer flow rate

- Cation Demineralizer Functions:

The cation demineralizer is used for adjusting the pH in reactor coolant by removing lithium during power operation. It is normally required a not so big water flow rate through the cation demineralizer for lithium removal.

The cation demineralizer is also used for purification in case of fuel defects, to improve the purification function and remove the fission products such as Cs isotopes.

In this case, it is necessary to supply additional lithium later to sustain the required lithium concentration for pH control (lithium is supplied as LiOH solution from the chemical mixing tank) because lithium is removed excessively from reactor coolant.

At the evaluation of the radioactive concentration in the reactor coolant (assumed 1% fuel failure), if the water flow rate through the cation demineralizer for fuel failure is set to a high level, the low radioactive concentration can be achieved, meanwhile it is necessary to decrease the frequency of lithium addition. Required water flow rate is as determined below.

- Definition of Cation Demineralizer Water Flow Rate:

A.3 Card 8: Mass of liquids in each SG

The mass of liquids in each SG was calculated using as inputs, the volume of each part of SG and the temperatures under normal operation conditions.

The steady state thermal hydraulic performance for non-preheat type vertical U-tube steam generators from 0% to 100% thermal power condition of PWR plants is calculated. This calculation has the following capabilities:

- Heat transfer performance
- Primary side pressure loss
- Secondary side pressure loss at the circulation loop and the flow restrictor
- Circulation ratio
- Secondary volume and secondary mass

This calculates the thermal hydraulic parameters using the one-dimensional model. Steam generator secondary volume is calculated by dividing the steam generator into the following 7 regions. The secondary mass is calculated by using calculated secondary volumes for each region and the associated quality for each region, based on heat balance. By summing the liquid mass of each region, the liquid mass in each steam generator value of 135 x 10^3 lbs is calculated.

A.4 Card 9: SG blowdown rate

- Resolution

Therefore, we get the flashed liquid flow rate by above calculation, the flashed flow rate 155400lb/hr is assumed conservatively small.

The steam generator blowdown of US-APWR is entirely recycled. Therefore, the treatment method value for PWR-GALE code is accordingly zero.

A.5. Other parameters

- Decontamination Factors (DFs) described in DCD Table 11.2-7
The values are taken from NUREG-0017 Rev.1, Subsections 2.2.18, 2.2.19 and 2.2.20.

-Core thermal power: 4,451 MWt
This is the value for 100% thermal power (DCD Table 1.3-1).

- Reactor coolant letdown flow rate: 180 gpm
This is the design value (DCD Table 9.3.4-2).

- Number of SGs: 4
This is the design value (DCD Table 1.3-2).

- Total main steam flow rate: 2.02E+07 lb/hr
This is the design value (DCD Table 10.1-1).

- Regeneration time of condensate polishing system: N/A
The condensate demineralizer is not assumed to be used for regeneration (DCD Subsection 10.4.6.2.3.1).

- Fraction of feedwater through the condensate polishing system: 0
Since the condensate demineralizer is conservatively assumed not to be used, "0" is input according to NUREG-0017, Rev.1, Subsection 1.5.2.10.

- Decontamination factor for detergent waste: 1.0
Since it is assumed that detergent waste will be discharged without treatment, "1.0" is used as input according to NUREG-0017, Rev.1, Subsection 1.5.2.23.

- Shim bleed
> Shim bleed rate: 2,875 gpd
Based on WASH-1258, eight shutdowns per 24 months (four hot shutdowns, three cold shutdowns and one refueling shutdown) are assumed, and on this basis, the amount of water that will be generated due to addition and dilution of boron in the primary coolant and expansion of the coolant is obtained as input for the parameter.
> Decontamination factors for "I", "Cs and Rb" and "others"
Total DFs for each demineralizer and the boric acid evaporator are the values given in DCD Table 11.2-7, while Table Al-1 below shows the itemized list of equipment and calculation results for the total DFs.

Table A1-1 Demineralizers of Shim Bleed and Coolant Drain

	I	Cs and Rb	Others
Boric acid evaporator feed demineralizer	10	2	10
Boric acid evaporator	10^2	10^3	10^3
C - Waste demineraliizer (Mix bed)(1)	5	1	10
D - Waste demineraliizer (Mix bed)	1(2)	1(2)	1(2)
Total	$5x10^3$	$2x10^3$	10^5

(1) As this demineralizer is installed downstream of the boric acid evaporator, the DF of the evaporator condensate described in DCD Table 11.2-7 is applied to the shim bleed and coolant drain.
(2) No credit is taken for this demineralizer.

> Collection time: 20 days
The capacity of the holdup tank to receive shim bleed and coolant drain is 16,000 ft3/unit (DCD Table 9.3.4-3) x 3 units, while the total in-flow rate of shim bleed and coolant drain is 3,775 gpd. The above values are calculated according to the formula described in NUREG-0017, Rev.1, Subsection 1.5.2.12.3.

> Process and discharge time: 2 days
The process time has been calculated based on the values below and according to the formula described in NUREG-0017, Rev.1, Subsection 1.5.2.12.4, with the discharge time neglected for conservatism. The initial capacity of the tank in-flow is 16000 ff3/unit x 3 units (holdup tanks). The equipment flow processing capacity is 30 gpm (the capacity of the Boric acid evaporator) from DCD Table 9.3.4-3.

> Fraction of waste to be discharged : 1.0
The total discharge of waste is conservatively assumed.

- Coolant Drain
> Coolant drainage flow rate: 900 gpd

> Fraction of reactor coolant activity: 0.1
RCP seal leakage is assumed as coolant drain. The amount of drain to be generated and the activity are given in DCD Table 11.2-2.

>, Decontamination factor for "I", "Cs and Rb" and "others"

>' Collection time : 20 days

> Process and discharge time: 2 days
Since the coolant drain flows into the holdup tank like the shim bleed, the parameter values are the same as those for shim bleed.

>' Fraction waste to be discharged: 1.0
The total discharge of waste is conservatively assumed.

- Dirty waste
> Dirty waste flow rate: 2,023 gpd

> Fraction of reactor coolant activity: 0.18
Waste liquid flowing into the waste hold tank is treated as dirty waste. The itemized amount of dirty waste and activity are given in DCD Table 11.2-2. This information and the totals are shown in Table A1-2 below. As for the equipment and area decontamination, a shutdown period of 30 days with an input rate of 3,000 gpd is assumed, while the remaining period regarded as a normal operation period with an input rate of 40 gpd. Thus, the average amount of waste liquid per day is calculated as in the following: (3,000 x 30 + 40 x *335)* **/** 365 = 283 gpd

Table A1-2 Breakdown of Dirty Waste

Sources	Expected Input Rate (gpd)	Activity
Reactor containment cooling	500	0.1% of reactor coolant
Leakage inside containment (to containment sump)	10	167% of reactor coolant
Leakage outside containment	80	100% of reactor coolant
Equipment drainage	250	100% of reactor coolant
Spent fuel pool liner leakage	25	0.1% of reactor coolant
Miscellaneous drainage	675	0.1% of reactor coolant
Equipment and area decontamination	283	1% of reactor coolant
Sampling drainage	200	5% of reactor coolant
	2,023(Total)	18% of reactor coolant(Average)

> Decontamination factor for "I", "Cs and Rb" and "others"
Total DFs for each demineralizer and the boric acid evaporator are the values given in DCD Table 11.2-7, while Table A1-3 shows the itemized list of equipment and calculation results for the total DFs.

Table A1-3 Demineralizers of Dirty Waste

	I	Cs and Rb	Others
A – Waste demineralizer (Anion bed)	10^2	1	1
B – Waste demineralizer (Cation bed)	1	10	10
C – Waste demineraliizer (Mix bed)(1)	10^2	2	10^2
D – Waste demineraliizer (Mix bed)(1)	10(2)	10(2)	10(2)
Total	10^5	$2x10^2$	10^4

(1) As the processing system for dirty waste has no evaporator, the radwaste DF described in DCD Table 11.2-7 is applied to dirty waste.
(2) The DF of the second one of the series-connected demineralizers is used.

> Collection time: 5 days
The capacity of the holdup tank to receive dirty waste is 30,000 gal/unit (DCD Table 11.2-3) x 4 units. An in-flow rate of 4,740 gpd at the time of shutdown with higher drain generation is conservatively assumed. The above values have been calculated according to the formula described in NUREG-0017, Rev.1, Subsection 1.5.2.12.3.

> Process and discharge time: 0 days
The process time has been calculated based on the values below and according to the formula described in NUREG-0017, Rev.1, Subsection 1.5.2.12.4. The initial capacity of the tank in flow is 30,000 gal/unit x 4 units (waste holdup tanks). The equipment flow processing capacity is 90 gpm (the design flow of the waste demineralizer) from DCD Table 11.2-6. The overall result is less than one day, which is rounded down to "0" days.
The discharge time is also conservatively neglected.

> Fraction of waste to be discharged: 1.0
The total discharge of waste is conservatively assumed.

- Blowdown waste
> Fraction of the blowdown stream processed: 1.0
It was assumed that the total amount of blowdown waste would be processed by the blowdown demineralizer.

> Decontamination factor for "I", "Cs and Rb" and "others"
Total DFs for each demineralizer and the boric acid evaporator are the values given in DCD Table 11.2-7, while Table A1-4 shows the itemized list of equipment and calculation results for the total DFs.

Table A1-4 SG Blowdown Demineralizers

	I	Cs and Rb	Others
SG blowdown cation bed demineralizer	1	10	10
SG blowdown mix bed demineralizer	10^2	10	10^2
Total	10^2	10^2	10^3

> Fraction of waste to be discharged: 0
As the total amount of blowdown waste is to be reused, none of the waste is to be discharged and "0" is set.

- Regenerant waste
As the demineralizer is not assumed to be used for regeneration, no regenerant waste will be generated and thus is not applicable.

Gaseous Waste Management System and HVAC System

- Continuous gas stripping of full letdown flow: None

- Continuous gas stripping will not be used.

- Holdup time for Xe: 45 days
This is the design value (DCD Table 11.3-1).

- Holdup time for Kr: 2.55 days
This is the design value of the expected delay time based on the adsorption coefficient for Kr.

- Fill time of decay tanks for gas stripper
No decay tank is installed.

- Gas waste system: High-efficiency particulate air (HEPA) filter: None
No HEPA filter is installed (DCD Figure 9.4.3-1 and Figure 11.3-1).

- Auxiliary building: Charcoal filter: None
No charcoal filter is installed (DCD Figure 9.4.3-1).

- Auxiliary building: HEPA filter: None
No HEPA filter is installed (DCD Figure 9.4.3-1).

- Containment volume: 2.74E+06 ft3
This is the design value (DCD Table 6.2.1-5).

- Containment atmosphere internal cleanup rate: 0 ft3/min

- Removal efficiency of charcoal filter: 0%

- Removal efficiency of HEPA filter: 0%
There is no containment atmosphere internal cleanup system, HEPA filters, or charcoal filters.

- Number of purges per year (in addition to two shutdown purges): 0
Only the two shutdown purges per year are assumed.

- Removal efficiency of charcoal filter: 0%
No charcoal filter is installed in the high volume purge exhaust system (DCD Figure 9.4.6-1).

- Removal efficiency of HEPA filter: 99%
Following NUREG-0017, Rev.1, Subsection 1.5.2.19, the removal efficiency of the HEPA filter is set at 99% (DCD Figure 9.4.6-1).

- Containment low volume purge rate: 2,000 ft3/min
This is the design value (DCD Table 9.4.6-1)

- Removal efficiency of charcoal filter: 70%
Following NUREG-0017, Rev.1, Subsection 1.5.2.20, the removal efficiency of the charcoal filter is set at 70% (DCD Figure 9.4.6-1).

- Removal efficiency of HEPA filter: 99%
Following NUREG-0017, Rev.1, Subsection 1.5.2.20, the removal efficiency of the HEPA filter is set at 99% (DCD Figure 9.4.6-1).

- Fraction of iodine released from blowdown tank vent: 0
Since there is no direct vent from the blowdown tank to the atmosphere, "0" is used as input according to NUREG-0017, Rev.1, Subsection 1.5.2.21.

- Fraction of iodine removed from main condenser air ejector release: 0
Since direct release is assumed as no charcoal filter is installed, "0" is used as input according to NUREG-0017, Rev.1, Subsection 1.5.2.22.

APPENDIX B BASIS for the transfer time to the waste gas surge tank using gaseous waste management system leak or failure

Estimation of released radioactivity about degassing from gas surge tank

Burping operation is done to control the liquid level of the volume control tank. It is applied for noble gas transition to the gas surge tank. Duration for degassing of noble gas in the RCS is dependent on the interval of the burping. The shorter interval of burping is operated, the shorter duration of burping is attained. However the short duration of burping brings on the augmentation of the waste gas because the noble gas is not discharged to the gas surge tank before it is moved into the VCT enough. On the contrary, the longer interval of burping is operated, the less volume of waste gas discharge and the longer duration of burping is occurred.

The relationship between the interval of burping and the volume of waste gas is described on table-1.

Short duration of the noble gas discharging makes the exposure estimation more conservative during the damage accident of the GWMS. Table B-1 indicates that more than [ ]hours is necessary to discharge the waste gas at the earliest. In this case, a few tanks are needed to hold waste gas. If only the single tank is applied to hold waste gas, total burping time takes about [ ] hours at the earliest to prolong the interval of burping.

Therefore, the assumed transfer time (24hr) using gaseous tank failure analysis is conservative about the duration of the noble gas discharging and the volume of noble gas.

Table B-1 The relationship between the interval of burping and the volume of the noble gas discharging

APPENDIX C PWR-GALE(99V2.1) Quality Assurance documents

Purpose

This document contains summary of the quality assurance documents regarding the modification and the use of PWR-GALE code (99V2.1). This document describes the validation procedures for the computer software PWR-GALE (99V2.1).

The PWR-GALE Code is an open code [(3)] distributed by the U.S. NRC. Mitsubishi Heavy Industries, Ltd. (hereinafter referred to as “MHI”) purchased PWR-GALE (GALE86) through the Nuclear Code Center of the Research Organization for Information Science and Technology (RIST) and uses it. MHI makes modifications to the original version of the PWR-GALE Code so that it can run in MHI’s computer environment. PWR-GALE consists of the PGALEGS Code evaluating the activity released from gaseous radioactive waste and the PGALELQ Code evaluating the activity released from liquid radioactive waste.

PWR-GALE code Validation and Installation Report