RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

APR1400 Design Certification

Korea Electric Power Corporation / Korea Hydro & Nuclear Power Co., LTD

Docket No. 52-046

RAI No.:	**145-7932**
SRP Section:	**11.03 – Gaseous Waste Management System**
Application Section:	**11.03 – Gaseous Waste Management System**
Date of RAI Issue:	**08/10/2015**

Question No. 11.03-1

10 CFR 20 Appendix B, Table 2 Effluent Concentration Limits

DCD Table 11.2-10 and DCD Table 11.3-6

In accordance with SRP 11.2 and 11.3 the staff reviewed the application and performed this review to determine if the application provided information in the DCD application to show that the concentrations of radioactive materials in liquid effluents released to unrestricted areas should not exceed the concentration limits in Table 2, Column 2, of Appendix B, to 10 CFR Part 20.

Staff reviewed DCD Table 11.2-10 and DCD Table 11.3-6 for verification of the Unity requirement of 10 CFR 20 Appendix B, Table 2, note 4. The Design Basis Release values and the 10 CFR 20, Appendix B Column 2 values listed in these tables either do not have enough information to verify the values, or contain incorrect values from 10 CFR 20 Appendix B. The foot notes do not provide any significant information to be able to verify the numbers developed in DCD Table 11.2-10 and DCD Table 11.3-6. Staff requests clarification of the values displayed in these two tables.

Examples from the staff review of DCD Table 11.2-10:

1. The ECL value for Y-91m being used in this table is for Air, not Liquid. The correct value is 3.00E-7 µCi/mL or 1.11E4 Bq/m^3, not 7.40E3.

2. The ECL value for Te-131 being used in this table is for that of Te-131m. The correct value is 8E-5 µCi/mL or 2.96E6 Bq/m^3, not 2.96E5.

3. The staff is unable to confirm the Design Basis release values in column 2 of DCD Table 11.2-10 for Te-129, I-131, Cs-134, Cs-136, Cs-137, and H-3.

4. Staff has noted a potential typo where duplicate rows of the table show duplicate rows of values for Pr-144 and H-3.

Examples from the staff review of DCD Table 11.3-6:

1. The ECL value for C-14 is 3E-9 µCi/mL or 1.11E2 Bq/m^3. Review of this table indicated that the applicant is using 3E-7 µCi/mL or 1.11E4 in this table. The staff did not find any reasons listed for the use of a less conservative C-14 ECL value.

2. The staff was unable to confirm the Design Basis release values in column 2 of Table 11.3- 6 for I-131, I-132, I-133, I-134, I-135, Kr-85m, Kr-85, Kr-87, Kr-88, Xe-133, Xe-135, Xe-138, Cs- 134, Cs-136, and Cs-137.

The staff requests the applicant to:

1. Provide a detailed discussion and calculations for review and confirmation supporting DCD section 11.2.3.1. Provide the process utilized for determining the values in each column of Table 11.2-10 and Table 11.3-6.

2. Review the tables and the examples provided above and verify all values listed.

3. Provide footnote(s) in Table 11.2-10 to describe in more detail, the process used, and the values of flow rate, volume, etc., to derive the Effluent Concentration values.

4. Provide footnote(s) in Table 11.3-6 to describe in more detail, the process used, and the values of X/Q, flow rate, volume, etc., to derive the Effluent Concentration values.

5. Please provide a detailed explanation of the equation in DCD section 11.2.3.1 and DCD section 11.3.3.1. Please explain what the equations are meant to be used for, along with what and where the values used in the equation came from. If the equation is used for creating values in DCD Tables 11.2-10 and 11.3-6, please make reference to the equation in a foot note to DCD Table 11.2-10 and Table 11.3-6.

6. Please provide equation numbers for reference, for example, “Equation 11.2-1”

7. Please provide all tables and values in English units.

8. Please title or label all DCD Tables and table columns.

9. Please explain the derivation and use of the MFi variable in the equation in DCD section 11.2.3.1, and 11.3.3.1. Why is it important to be included in this equation?

Please address these items and provide a mark-up for the proposed DCD changes.

Response

1. In accordance with Standard Review Plan Section 11.2 and 11.3, it is required to evaluate the radionuclide effluent concentrations at the EAB based on 1 percent fuel failure. However, since the annual gaseous and liquid effluent releases calculated by PWR-GALE code are based on the expected primary coolant concentrations given in

ANSI/ANS-18.1 (1999), these releases should be adjusted to incorporate 1 percent fuel failure.

In order to adjust the expected annual releases to the design basis 1% fuel failure releases, the multiplication factor (MF) is applied. The multiplication factor for a specific radionuclide is defined as follows:

$$\mathrm{MF_i} = \frac{\mathrm{RCS_{i,1\%\ Failed\ Fuel}}}{\mathrm{RCS_{i,GALE}}}$$

where,

$RCS_{i,1\%\ Failed\ Fuel}$: RCS specific activity of nuclide i based on 1% fuel failure (μCi/g), which are provided in DCD Table 11.1-2

$RCS_{i,GALE}$: RCS specific activity of nuclide i calculated by PWR-GALE code (μCi/g), which are presented in the output of the PWR-GALE code run

Since the RCS specific activities based on 1% fuel failure are higher than those calculated by the PWR-GALE code, the MF values are typically greater than 1.0 such that the adjusted gaseous and liquid effluents calculated by multiplying the MF values are increased from those calculated by the PWR-GALE code.

There are some exceptions. For some nuclides of which MF values are less than 1, a value of 1 is used for conservatism. In addition, for the calculation of adjusted releases for liquid effluents of I-131 and Cs-137, since the calculated MF values are overly conservative, the MF values for these nuclides are limited to 100.

When the MF values are determined, the gaseous and liquid effluent concentrations at the EAB are calculated using the atmospheric dispersion factor and the dilution factor of the liquid discharge for gaseous and liquid effluents, respectively.

The design basis liquid effluent concentration values in Table 11.2-10 are calculated using the following equation:

$$\mathrm{C_{L,i}} = \frac{\mathrm{Q_{L,i} \cdot MF_i}}{\mathrm{F_{dil} \cdot CF}} \qquad \text{(Eq. 1)}$$

where,

$C_{L,i}$: Design basis liquid effluent concentration for nuclide i at the EAB (Ci/L)

$Q_{L,i}$: Expected liquid effluent release rate of the nuclide i calculated by PWR-GALE code (Ci/yr)

M_{Fi} : Multiplication factor for the nuclide i

F_{dil} : Dilution flow rate, which is the cooling tower blowdown rate of 22.29 ft^3/sec

CF : Conversion factor (8.93×10^8 L·sec/ft^3·yr)

The design basis gaseous effluent concentration values in Table 11.3-6 are calculated using the following equation:

$$C_{G,i} = CF \cdot Q_{G,i} \cdot MF_i \cdot \chi/Q \quad \text{(Eq. 2)}$$

where,

$C_{G,i}$: Design basis gaseous effluent concentration of nuclide i at the EAB (Ci/m^3)

$Q_{G,i}$: Expected gaseous effluent release rate of nuclide i calculated by PWR-GALE code (Ci/yr)

CF : Conversion factor (= 3.17×10^{-8} yr/sec)

χ/Q : Maximum directional annual average atmospheric dispersion factor at EAB (2.0×10^{-5} sec/ m^3)

The design basis liquid and gaseous effluent concentrations are provided in Column 2 of DCD Table 11.2-10 and Table 11.3-6, respectively. The values in Column 4 of these tables present the fractions of the concentrations to the limits in Table 2 of 10 CFR 20, Appendix B.

2. Responses to this question on DCD Table 11.2-10 are as follows:

   1) The ECL value for Y-91m for liquid is 2.0E-3 μCi/ml or 7.40E+7 Bq/m^3 as pointed out by the staff. This ECL value and the ratio for Y-91m will be updated as indicated in Attachment. The markup provided with this response will replace the previous DCD Markup in Attachment 4 (20~21/85) of the Response to RAI 110-7919 - Question 11.01-2.

   2) The ECL value for Te-131 for liquid is 8.0E-5 μCi/ml or 2.96E+6 Bq/m^3. The ECL value and the ratio for Te-131 will be updated.

   3) Design basis liquid effluent release values for Te-129, I-131, Cs-134, Cs-136, Cs-137 and H-3 are calculated using the expected release values provided in DCD Table 11.2-1 and Equation 1 provided in the Response to Item No.1 of this question.

   4) The duplicated rows will be deleted.

   Responses to this question on DCD Table 11.3-6 are as follows:

   1) The ECL value for C-14 for liquid is 3.0E-9 μCi/ml or 1.11E+2 Bq/m^3 as pointed out by the staff. The ECL value and the ratio for C-14 will be updated as indicated in

Attachment. The markup provided with this response will replace the previous DCD Markup in Attachment 4 (63~64/85) of the Response to RAI 110-7919 - Question 11.01-2.

2) Design basis gaseous effluent release values for I-131, I-132, I-133, I-134, I-135, Kr-85m, Kr-85, Kr-87, Kr-88, Xe-133, Xe-135, Ce-138, Cs-134, Cs-136 and Cs-137 are calculated using the expected release values provided in DCD Table 11.3-1 and Equation 2 provided in the Response to Item No.1 of this question.

3. Footnotes in Table 11.2-10 will be revised to provide additional explanation.

4. Footnotes in Table 11.3-6 will be revised to provide additional explanation.

5. Detailed explanation of the equations in DCD Sections 11.2.3.1 and 11.3.3.1 is provided in Response to Item No. 1 of this question. Footnotes in DCD Tables 11.2-10 and 11.3-6 will be revised.

6. Equation numbers will be provided.

7. All tables and values in Chapter 11 were revised to provide the values in English units and provided as a response to RAI 110-7919.

8. All DCD tables and table columns were titled and labeled.

9. Details of the explanation on the MF variable were provided in the response to Item No. 1 of this question.

Impact on DCD

DCD Section 11.2.3.1, 11.3.3.1, Table 11.2-10 and Table 11.3-6 will be updated as indicated in Attachment.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

There is no impact on any Technical, Topical or Environmental Reports.

$$C(i) = \frac{R(i) \times MF_i}{F_{dil}}$$ (Eq 11.2-1)

Where:

C(i) = design basis liquid effluent concentration for the i^{th} isotope, ~~Bq~~/L

R(i) = total annual release rate of the i^{th} isotope, ~~Bq~~/yr (Table 11.2-1)

MFi = multiplication factor for the ith isotope (ratio of 1 % fuel defect design basis radionuclide concentration to ANSI/ANS-18.1-1999 expected concentration)

F_{dil} = dilution flow rate at discharge point, L/yr

Ci

Ci

The sum of concentration ratios for the design basis fuel leakage is 0.18, as presented in Table 11.2-10. This value is less than 1.0, which indicates that the releases meet the regulatory limit.

Offsite doses received by individuals as a result of radioactive liquid releases are calculated using the LADTAP II Code (Reference 29). The input parameters of the LADTAP II Code (Reference 29) are presented in Table 11.2-4. The dilution factor for aquatic food, boating, shoreline, swimming, and drinking water is assumed to be 5 for the normal operating conditions. The results of the dose calculation are presented in Table 11.2-5. The values are compared with the corresponding limits of 10 CFR 50, Appendix I (Reference 4). The maximum individual dose to total body is 0.018 mSv/yr for an adult. This value is less than the regulatory limit of 0.03 mSv/yr presented in 10 CFR 50, Appendix I (Reference 4). The maximum dose to any individual organ is 0.023 mSv/yr, which is the dose to a child's liver. This value is less than the limitation of 0.1 mSv/yr presented in 10 CFR 50, Appendix I (Reference 4).

The COL applicant is to calculate the dose to members of the public following the guidance of NRC RG 1.109 (Reference 30) and NRC RG 1.113 (Reference 31) using site-specific parameters and to compare the doses due to liquid effluents with the numerical design objectives of Appendix I to 10 CFR 50 (Reference 4), 10 CFR 20.1302 (Reference 32), and 40 CFR 190 (Reference 33) (COL 11.2(13)).

Replace this table with "A" after this table

Table 11.2-10 (1 of 2)

Design Basis Liquid Effluent Concentration at the Site Boundary

Nuclide	Design Basis Release(1) (Bq/yr)	Effluent Concentration (Bq/m^3)	10 CFR 20, Appendix B Limits (Bq/m^3)	Ratio
Na-24	7.03E+07	3.53E+00	1.85E+06	1.91E-06
P-32	6.66E+06	3.35E-01	3.33E+05	1.01E-06
Cr-51	9.61E+08	4.83E+01	1.85E+07	2.61E-06
Mn-54	1.81E+08	9.11E+00	1.11E+06	8.21E-06
Fe-55	3.00E+08	1.51E+01	3.70E+06	4.07E-06
Fe-59	8.88E+07	4.46E+00	3.70E+05	1.21E-05
Co-58	4.07E+08	2.05E+01	7.40E+05	2.76E-05
Co-60	5.18E+08	2.60E+01	1.11E+05	2.35E-04
Ni-63	6.29E+07	3.16E+00	3.70E+06	8.54E-07
Zn-65	1.30E+07	6.51E-01	1.85E+05	3.52E-06
W-187	5.18E+06	2.60E-01	1.11E+06	2.35E-07
Np-239	8.14E+06	4.09E-01	7.40E+05	5.53E-07
Sr-89	1.34E+08	6.74E+00	2.96E+05	2.28E-05
Sr-90	1.47E+07	7.38E-01	1.85E+04	3.99E-05
Sr-91	4.89E+06	2.46E-01	7.40E+05	3.32E-07
Y-91m	3.99E+06	2.01E-01	7.40E+03	2.71E-05
Y-91	2.96E+08	1.49E+01	2.96E+05	5.03E-05
Y-93	1.07E+06	5.39E-02	7.40E+05	7.29E-08
Zr-95	7.24E+07	3.64E+00	7.40E+05	4.92E-06
Nb-95	1.39E+08	6.97E+00	1.11E+06	6.28E-06
Mo-99	1.21E+09	6.06E+01	7.40E+05	8.19E-05
Tc-99m	7.55E+08	3.79E+01	3.70E+07	1.03E-06
Ru-103	1.44E+08	7.25E+00	1.11E+06	6.53E-06
Rh-103m	1.37E+08	6.88E+00	2.22E+08	3.10E-08
Ru-106	2.63E+09	1.32E+02	1.11E+05	1.19E-03
Rh-106	2.29E+09	1.15E+02	-	-
Ag-110m	7.77E+07	3.91E+00	2.22E+05	1.76E-05

Replace this table with "A" after this table

Table 11.2-10 (2 of 2)

Nuclide	Design Basis Release(1) (Bq/yr)	Effluent Concentration (Bq/m^3)	10 CFR 20, Appendix B Limits (Bq/m^3)	Ratio
Ag-110	4.07E+06	2.05E-01	-	-
Sb-124	1.59E+07	8.00E-01	2.59E+05	3.09E-06
Te-129m	5.74E+07	2.89E+00	2.59E+05	1.11E-05
Te-129	2.29E+06	1.15E-01	1.48E+07	7.79E-09
Te-131m	6.78E+07	3.41E+00	2.96E+05	1.15E-05
Te-131	1.01E+06	5.09E-02	7.40E+02	6.88E-05
I-131	9.99E+09	5.02E+02	3.70E+04	1.36E-02
Te-132	8.35E+08	4.20E+01	3.33E+05	1.26E-04
I-132	3.08E+08	1.55E+01	3.70E+06	4.18E-06
I-133	1.71E+10	8.57E+02	2.59E+05	3.31E-03
I-134	4.05E+06	2.04E-01	1.48E+07	1.38E-08
Cs-134	3.47E+09	1.74E+02	3.33E+04	5.24E-03
I-135	3.08E+09	1.55E+02	1.11E+06	1.40E-04
Cs-136	7.09E+09	3.56E+02	2.22E+05	1.60E-03
Cs-137	5.92E+10	2.98E+03	3.70E+04	8.04E-02
Ba-137m	1.55E+07	7.81E-01	-	-
Ba-140	1.67E+08	8.37E+00	2.96E+05	2.83E-05
La-140	1.81E+08	9.11E+00	3.33E+05	2.74E-05
Ce-141	1.11E+07	5.58E-01	1.11E+06	5.03E-07
Ce-143	7.03E+06	3.53E-01	7.40E+05	4.77E-07
Pr-143	2.41E+06	1.21E-01	7.40E+05	1.63E-07
Ce-144	2.44E+08	1.23E+01	1.11E+05	1.11E-04
Pr-144	9.99E+07	5.02E+00	2.22E+07	2.26E-07
H-3	5.40E+13	2.72E+06	3.70E+07	7.34E-02
Pr-144	9.99E+07	5.02E+00	2.22E+07	2.26E-07
H-3	5.40E+13	2.72E+06	3.70E+07	7.34E-02
			SUM	1.80E-01

(1) Design basis release rate is adjusted from expected liquid radioactive effluents (Table 11.2-1) using multiplication factors that are the ratios of design basis primary coolant activity to expected activity.

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Table 11.2-10 (1 of 2)

Design Basis Liquid Effluent Concentration at the Site Boundary

Nuclide	Design Basis Release[1]		Effluent Concentration[2]		10 CFR 20, Appendix B Limits		Ratio
	Ci/yr	Bq/yr	Ci/m^3	Bq/m^3	Ci/m^3	Bq/m^3	
Na-24	1.90E-03	7.03E+07	9.55E-11	3.53E+00	5.00E-05	1.85E+06	1.91E-06
P-32	1.80E-04	6.66E+06	9.05E-12	3.35E-01	9.00E-06	3.33E+05	1.01E-06
Cr-51	6.00E-03	9.61E+08	1.31E-09	4.83E+01	5.00E-04	1.85E+07	2.61E-06
Mn-54	4.90E-03	1.81E+08	2.46E-10	9.11E+00	3.00E-05	1.11E+06	8.21E-06
Fe-55	8.10E-03	3.00E+08	4.07E-10	1.51E+01	1.00E-04	3.70E+06	4.07E-06
Fe-59	2.40E-03	8.88E+07	1.21E-10	4.46E+00	1.00E-05	3.70E+05	1.21E-05
Co-58	1.10E-02	4.07E+08	5.53E-10	2.05E+01	2.00E-05	7.40E+05	2.76E-05
Co-60	1.40E-02	5.18E+08	7.04E-10	2.60E+01	3.00E-06	1.11E+05	2.35E-04
Ni-63	1.70E-03	6.29E+07	8.54E-11	3.16E+00	1.00E-04	3.70E+06	8.54E-07
Zn-65	3.50E-04	1.30E+07	1.76E-11	6.51E-01	5.00E-06	1.85E+05	3.52E-06
W-187	1.40E-04	5.18E+06	7.04E-12	2.60E-01	3.00E-05	1.11E+06	2.35E-07
Np-239	2.20E-04	8.14E+06	1.11E-11	4.09E-01	2.00E-05	7.40E+05	5.53E-07
Sr-89	1.60E-04	1.34E+08	1.82E-10	6.74E+00	8.00E-06	2.96E+05	2.28E-05
Sr-90	2.20E-05	1.47E+07	2.00E-11	7.38E-01	5.00E-07	1.85E+04	3.99E-05
Sr-91	2.60E-05	4.89E+06	6.65E-12	2.46E-01	2.00E-05	7.40E+05	3.32E-07
Y-91m	1.70E-05	3.99E+06	5.42E-12	2.01E-01	2.00E-03	7.40E+07	2.71E-09
Y-91	9.00E-05	2.96E+08	4.03E-10	1.49E+01	8.00E-06	2.96E+05	5.03E-05
Y-93	2.90E-05	1.07E+06	1.46E-12	5.39E-02	2.00E-05	7.40E+05	7.29E-08
Zr-95	1.30E-03	7.24E+07	9.83E-11	3.64E+00	2.00E-05	7.40E+05	4.92E-06
Nb-95	2.10E-03	1.39E+08	1.88E-10	6.97E+00	3.00E-05	1.11E+06	6.28E-06
Mo-99	7.60E-04	1.21E+09	1.64E-09	6.06E+01	2.00E-05	7.40E+05	8.19E-05
Tc-99m	5.60E-04	7.55E+08	1.03E-09	3.79E+01	1.00E-03	3.70E+07	1.03E-06
Ru-103	3.90E-03	1.44E+08	1.96E-10	7.25E+00	3.00E-05	1.11E+06	6.53E-06
Rh-103m	3.70E-03	1.37E+08	1.86E-10	6.88E+00	6.00E-03	2.22E+08	3.10E-08
Ru-106	7.10E-02	2.63E+09	3.57E-09	1.32E+02	3.00E-06	1.11E+05	1.19E-03
Rh-106	6.20E-02	2.29E+09	3.12E-09	1.15E+02	-	-	-

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Table 11.2-10 (2 of 2)

Nuclide	Design Basis Release[1]		Effluent Concentration[2]		10 CFR 20, Appendix B Limits		Ratio
	Ci/yr	Bq/yr	Ci/m^3	Bq/m^3	Ci/m^3	Bq/m^3	
Ag-110m	2.10E-03	7.77E+07	1.06E-10	3.91E+00	6.00E-06	2.22E+05	1.76E-05
Ag-110	1.10E-04	4.07E+06	5.53E-12	2.05E-01	-	-	-
Sb-124	4.30E-04	1.59E+07	2.16E-11	8.00E-01	7.00E-06	2.59E+05	3.09E-06
Te-129m	8.80E-05	5.74E+07	7.80E-11	2.89E+00	7.00E-06	2.59E+05	1.11E-05
Te-129	6.20E-05	2.29E+06	3.12E-12	1.15E-01	4.00E-04	1.48E+07	7.79E-09
Te-131m	9.90E-05	6.78E+07	9.21E-11	3.41E+00	8.00E-06	2.96E+05	1.15E-05
Te-131	1.80E-05	1.01E+06	1.38E-12	5.09E-02	8.00E-05	2.96E+06	1.72E-08
I-131	2.70E-03	9.99E+09	1.36E-08	5.02E+02	1.00E-06	3.70E+04	1.36E-02
Te-132	2.00E-04	8.35E+08	1.13E-09	4.20E+01	9.00E-06	3.33E+05	1.26E-04
I-132	7.20E-04	3.08E+08	4.18E-10	1.55E+01	1.00E-04	3.70E+06	4.18E-06
I-133	3.40E-03	1.71E+10	2.32E-08	8.57E+02	7.00E-06	2.59E+05	3.31E-03
I-134	2.50E-05	4.05E+06	5.51E-12	2.04E-01	4.00E-04	1.48E+07	1.38E-08
Cs-134	1.10E-02	3.47E+09	4.71E-09	1.74E+02	9.00E-07	3.33E+04	5.24E-03
I-135	2.30E-03	3.08E+09	4.19E-09	1.55E+02	3.00E-05	1.11E+06	1.40E-04
Cs-136	3.90E-03	7.09E+09	9.63E-09	3.56E+02	6.00E-06	2.22E+05	1.60E-03
Cs-137	1.60E-02	5.92E+10	8.04E-08	2.98E+03	1.00E-06	3.70E+04	8.04E-02
Ba-137m	4.20E-04	1.55E+07	2.11E-11	7.81E-01	-	-	-
Ba-140	4.50E-03	1.67E+08	2.26E-10	8.37E+00	8.00E-06	2.96E+05	2.83E-05
La-140	4.90E-03	1.81E+08	2.46E-10	9.11E+00	9.00E-06	3.33E+05	2.74E-05
Ce-141	3.00E-04	1.11E+07	1.51E-11	5.58E-01	3.00E-05	1.11E+06	5.03E-07
Ce-143	1.90E-04	7.03E+06	9.55E-12	3.53E-01	2.00E-05	7.40E+05	4.77E-07
Pr-143	6.50E-05	2.41E+06	3.27E-12	1.21E-01	2.00E-05	7.40E+05	1.63E-07
Ce-144	6.60E-03	2.44E+08	3.32E-10	1.23E+01	3.00E-06	1.11E+05	1.11E-04
Pr-144	2.70E-03	9.99E+07	1.36E-10	5.02E+00	6.00E-04	2.22E+07	2.26E-07
H-3	1.46E+03	5.40E+13	7.34E-05	2.72E+06	1.00E-03	3.70E+07	7.34E-02
						SUM	1.80E-01

(1) Design basis release rates are adjusted from expected liquid radioactive effluents (Table 11.2-1) using multiplication factors that are the ratios of design basis primary coolant activity to expected activity. If a multiplication factor is less than 1, a value of 1 is used for conservatism. For I-131, Cs-137, a multiplication factor of 100 is used.

(2) Effluent concentrations are calculated from Equation 11.2-1 in Section 11.2.3.1.

summarizes the expected annual release activities from the various streams: GRS waste gas, fuel handling area, RCB, AB, TGB, and condenser offgas air ejector exhaust. The normalized design basis gaseous effluent concentrations at the site boundary, and a comparison to the 10 CFR 20, Appendix B limits, are tabulated in Table 11.3-6. The design basis gaseous effluent release fraction is 0.16, indicating that the release concentrations are lower than the release limits by a significant margin.

An offline radiation monitor is provided in the GRS to measure the activities of the gross gas gamma. The gas sample is taken at the downstream of the charcoal delay beds but upstream of the treated gas effluent isolation valve for analysis of the activities. The gas sample is returned back to a point downstream of the discharge check valve, which is located close to the connection to the suction side of the compound building HVAC exhaust blowers. The analysis is used to provide reasonable assurance that the short-lived nuclides in the gaseous effluent are treated adequately for the delayed removal of noble gases and to monitor the performance of the charcoal delay beds.

The low (WARN) and high (ALARM) setpoints of the radiation monitors are to be determined by the COL applicant when the site-specific environmental information is available so that the sum of the radioactive releases from all vents does not exceed the concentration limits of 10 CFR 20 Appendix B and dose limits of 10 CFR 50 Appendix I (COL 11.5(8)).

The gaseous releases from plant sources during normal operation, including AOOs, are calculated by using the PWR-GALE Code, which conforms with the methodology of NUREG-0017 (Reference 3). The input data for calculating gaseous releases are presented in Table 11.2-2. The χ/Q value at the exclusion area boundary (EAB) is assumed to be 2.0×10^{-5} sec/m^3 for the calculation of gamma dose in air, beta dose in air, dose to total body, dose from ground, and dose due to inhalation. The χ/Q value at the offsite food production area is assumed to be 1.0×10^{-5} sec/m^3 for the calculation of dose from food intake. The D/Q value at the site boundary is 2.0×10^{-7}/m^2. Expected annual gaseous effluent releases are presented in Table 11.3-1. The design basis effluent concentrations are calculated using Eq. 11.3-1 and are then compared against the concentrations of 10 CFR 20, Appendix B (Reference 4). The sum of ratios of concentrations for the design basis fuel defect is ~~0.162~~ as presented in Table 11.3-6. This value is less than 1.0, which indicates that the releases meet the regulatory limit.

0.164

Replace this table with "B" after this table

Table 11.3-6 (1 of 2)

Design Basis Gaseous Effluent Concentration at the Site Boundary

Nuclide	Design Basis Release[(1)] (Bq/yr)	Effluent Concentration (Bq/m^3)	10 CFR 20 Appendix B Limits (Bq/m^3)	Ratio
H-3	2.08E+13	1.32E+01	3.70E+03	3.56E-03
C-14	2.70E+11	1.71E-01	1.11E+04	1.54E-05
Ar-41	1.26E+12	7.98E-01	3.70E+02	2.16E-03
I-131	3.62E+09	5.15E-02	7.40E+00	6.96E-03
I-132	6.00E+09	1.30E-02	7.40E+02	1.76E-05
I-133	2.17E+10	7.32E-02	3.70E+01	1.98E-03
I-134	3.87E+09	8.14E-03	2.22E+03	3.67E-06
I-135	1.33E+10	3.90E-02	2.22E+02	1.76E-04
Kr-85m	1.32E+12	8.11E+00	3.70E+03	2.19E-03
Kr-85	3.04E+12	1.15E+02	2.59E+04	4.44E-03
Kr-87	3.91E+11	2.13E+00	7.40E+02	2.88E-03
Kr-88	1.33E+12	1.27E+01	3.33E+02	3.82E-02
Xe-131m	8.14E+13	1.15E+01	7.40E+04	1.55E-04
Xe-133m	4.81E+12	3.05E+00	2.22E+04	1.37E-04
Xe-133	2.37E+13	1.31E+03	1.85E+04	7.09E-02
Xe-135m	1.42E+12	8.74E-01	1.48E+03	5.91E-04
Xe-135	7.79E+12	6.09E+01	2.59E+03	2.35E-02
Xe-137	4.93E+11	3.04E-01	-	-
Xe-138	4.93E+11	5.98E-01	7.40E+02	8.08E-04
Cr-51	1.55E+07	9.85E-06	1.11E+03	8.88E-09
Mn-54	2.11E+06	1.34E-06	3.70E+01	3.61E-08
Co-57	3.03E+05	1.92E-07	3.33E+01	5.78E-09
Co-58	1.78E+07	1.13E-05	3.70E+01	3.04E-07
Co-60	4.07E+06	2.58E-06	1.85E+00	1.39E-06
Fe-59	1.04E+06	6.57E-07	1.85E+01	3.55E-08

Replace this table with "B" after this table

Table 11.3-6 (2 of 2)

Nuclide	Design Basis Release(1) (Bq/yr)	Effluent Concentration (Bq/m^3)	10 CFR 20 Appendix B Limits (Bq/m^3)	Ratio
Sr-89	1.34E+08	8.51E-05	7.40E+00	1.15E-05
Sr-90	4.21E+07	2.67E-05	2.22E-01	1.20E-04
Zr-95	5.57E+05	3.53E-07	1.48E+01	2.39E-08
Nb-95	2.77E+06	1.76E-06	7.40E+01	2.38E-08
Ru-103	6.29E+05	3.99E-07	3.33E+01	1.20E-08
Ru-106	2.89E+04	1.83E-08	7.40E-01	2.47E-08
Sb-125	2.26E+04	1.43E-08	2.59E+01	5.52E-10
Cs-134	7.89E+07	9.60E-03	7.40E+00	1.30E-03
Cs-136	6.00E+07	3.80E-05	3.33E+01	1.14E-06
Cs-137	1.29E+08	1.45E-02	7.40E+00	1.96E-03
Ba-140	1.55E+05	9.85E-08	7.40E+01	1.33E-09
Ce-141	4.81E+05	3.05E-07	2.96E+01	1.03E-08
			SUM	1.62E-01

(1) The design basis release rates are adjusted from the expected values in Table 11.3-1 using multiplication factors that are the ratios of design basis RCS concentrations to expected concentrations. If a multiplication factor is less than 1, a value of 1 is used for conservatism.

B

Table 11.3-6 (1 of 2)

Design Basis Gaseous Effluent Concentration at the Site Boundary

Nuclide	Design Basis Release[1]		Effluent Concentration[2]		10 CFR 20 Appendix B Limits		Ratio
	μCi/yr	Bq/yr	μCi/m^3	Bq/m^3	μCi/m^3	Bq/m^3	
H-3	5.62E+08	2.08E+13	3.56E-04	1.32E+01	1.00E-01	3.70E+03	3.56E-03
C-14	7.30E+06	2.70E+11	4.63E-06	1.71E-01	3.00E-03	1.11E+02	1.54E-03
Ar-41	3.40E+07	1.26E+12	2.16E-05	7.98E-01	1.00E-02	3.70E+02	2.16E-03
I-131	2.20E+06	8.13E+10	1.39E-06	5.15E-02	2.00E-04	7.40E+00	6.96E-03
I-132	5.55E+05	2.05E+10	3.52E-07	1.30E-02	2.00E-02	7.40E+02	1.76E-05
I-133	3.12E+06	1.15E+11	1.98E-06	7.32E-02	1.00E-03	3.70E+01	1.98E-03
I-134	3.47E+05	1.28E+10	2.20E-07	8.14E-03	6.00E-02	2.22E+03	3.67E-06
I-135	1.66E+06	6.16E+10	1.06E-06	3.90E-02	6.00E-03	2.22E+02	1.76E-04
Kr-85m	3.46E+08	1.28E+13	2.19E-04	8.11E+00	1.00E-01	3.70E+03	2.19E-03
Kr-85	4.90E+09	1.81E+14	3.11E-03	1.15E+02	7.00E-01	2.59E+04	4.44E-03
Kr-87	9.08E+07	3.36E+12	5.75E-05	2.13E+00	2.00E-02	7.40E+02	2.88E-03
Kr-88	5.42E+08	2.01E+13	3.44E-04	1.27E+01	9.00E-03	3.33E+02	3.82E-02
Xe-131m	4.89E+08	1.81E+13	3.10E-04	1.15E+01	2.00E+00	7.40E+04	1.55E-04
Xe-133m	1.30E+08	4.81E+12	8.24E-05	3.05E+00	6.00E-01	2.22E+04	1.37E-04
Xe-133	5.59E+10	2.07E+15	3.54E-02	1.31E+03	5.00E-01	1.85E+04	7.09E-02
Xe-135m	3.73E+07	1.38E+12	2.36E-05	8.74E-01	4.00E-02	1.48E+03	5.91E-04
Xe-135	2.60E+09	9.61E+13	1.65E-03	6.09E+01	7.00E-02	2.59E+03	2.35E-02
Xe-137	1.29E+07	4.79E+11	8.21E-06	3.04E-01	-	-	-
Xe-138	2.55E+07	9.43E+11	1.62E-05	5.98E-01	2.00E-02	7.40E+02	8.08E-04
Cr-51	4.20E+02	1.55E+07	2.66E-10	9.85E-06	3.00E-02	1.11E+03	8.88E-09
Mn-54	5.70E+01	2.11E+06	3.61E-11	1.34E-06	1.00E-03	3.70E+01	3.61E-08
Co-57	8.20E+00	3.03E+05	5.20E-12	1.92E-07	9.00E-04	3.33E+01	5.78E-09
Co-58	4.80E+02	1.78E+07	3.04E-10	1.13E-05	1.00E-03	3.70E+01	3.04E-07
Co-60	1.10E+02	4.07E+06	6.97E-11	2.58E-06	5.00E-05	1.85E+00	1.39E-06
Fe-59	2.80E+01	1.04E+06	1.78E-11	6.57E-07	5.00E-04	1.85E+01	3.55E-08

B

Table 11.3-6 (2 of 2)

Nuclide	Design Basis Release[1]		Effluent Concentration[2]		10 CFR 20 Appendix B Limits		Ratio
	μCi/yr	Bq/yr	μCi/m^3	Bq/m^3	μCi/m^3	Bq/m^3	
Sr-89	3.63E+03	1.34E+08	2.30E-09	8.51E-05	2.00E-04	7.40E+00	1.15E-05
Sr-90	1.14E+03	4.21E+07	7.21E-10	2.67E-05	6.00E-06	2.22E-01	1.20E-04
Zr-95	1.50E+01	5.57E+05	9.54E-12	3.53E-07	4.00E-04	1.48E+01	2.39E-08
Nb-95	7.49E+01	2.77E+06	4.75E-11	1.76E-06	2.00E-03	7.40E+01	2.38E-08
Ru-103	1.70E+01	6.29E+05	1.08E-11	3.99E-07	9.00E-04	3.33E+01	1.20E-08
Ru-106	7.80E-01	2.89E+04	4.95E-13	1.83E-08	2.00E-05	7.40E-01	2.47E-08
Sb-125	6.10E-01	2.26E+04	3.87E-13	1.43E-08	7.00E-04	2.59E+01	5.52E-10
Cs-134	4.09E+05	1.51E+10	2.59E-07	9.60E-03	2.00E-04	7.40E+00	1.30E-03
Cs-136	1.62E+03	6.00E+07	1.03E-09	3.80E-05	9.00E-04	3.33E+01	1.14E-06
Cs-137	6.20E+05	2.29E+10	3.93E-07	1.45E-02	2.00E-04	7.40E+00	1.96E-03
Ba-140	4.20E+00	1.55E+05	2.66E-12	9.85E-08	2.00E-03	7.40E+01	1.33E-09
Ce-141	1.30E+01	4.81E+05	8.24E-12	3.05E-07	8.00E-04	2.96E+01	1.03E-08
						SUM	1.64E-01

(1) The design basis release rates are adjusted from the expected values in Table 11.3-1 using multiplication factors that are the ratios of design basis primary coolant concentrations to expected concentrations. If a multiplication factor is less than 1, a value of 1 is used for conservatism.

(2) Effluent concentrations are calculated from Equation 11.3-1 in Section 11.3.3.1.