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.: **343-8420**

SRP Section: **12.02 - Radiation Sources**

Application Section: **12.2**

Date of RAI Issue: **12/22/2015**

Question No. 12.02-25

This is a follow-up to RAI 7998, Question 12.02-11.

Regulatory Basis

10 CFR 52.47(a)(5) requires that the FSAR contain the kinds and quantities of radioactive materials expected to be produced in the operation and the means for controlling and limiting radioactive effluents and radiation exposures within the limits set forth in 10 CFR 20.

SRP Section 12.2 also indicates that source descriptions should include the methods, models and assumptions used as the bases for all values provided in SAR Section 12.2.

Information Needed

1. In the response to Question 12.02-11, the applicant provided information and added an equation to FSAR Section 11.3.1.5 to explain how the value for “at inlet” in FSAR Tables 11.3-11 and 12.2-19 were calculated.

    a. The addition to FSAR Section 11.3.1.5 does not clearly specify what the equation is used for. Please update the FSAR to specify that the equation is used to calculate the “at inlet” concentrations in FSAR Tables 11.3-11 and 12.2-19.

    b. To use the equation, the venting rates for the gas stripper, reactor drain tank, equipment drain tank, and volume control tank are needed. The venting rates for the reactor drain tank, gas stripper, and equipment drain tank are found in the footnotes to FSAR Table 11.1-8, but staff cannot find the venting rate for the volume control tank in the FSAR. Please update the FSAR to provide this information.

2. The header drain tank dimensions which the applicant added to FSAR Table 12.2-25 are inconsistent with the volume provided in FSAR Table 11.3-4. Please justify why the tank volume used for source term dimensions in Table 12.2-25 is much less than the volume in

Table 11.3-4, or correct the values. As a result of this response, please ensure that the source term used in the shielding analysis is based on the tank's full volume.

3. The waste gas dryer source term provided in the addition to FSAR Table 12.2-19 (0.25% Fuel Defect) is significantly lower than the source term provided in Table 11.3-11 (1% Fuel Defect). For many isotopes, the activity is 100 times lower or more. Staff understands that the values in Table 11.3-11 are based on continuous gas stripping and the values in Table 12.2-19 are based on processing RCS after operation with no gas stripping (so there will be differences with different isotopes), however, this would not appear to account for why all isotopes are so significantly lower for the gas dryer in Table 12.2-19. Please explain why the values in the proposed addition to FSAR Table 12.2-19 are so much lower than the values in FSAR Table 11.3-11, for the waste gas dryer.

4. The gaseous waste management system source terms do not include the contribution for daughter products which would accumulate from the decay of the noble gases (for example Rb-88). All source terms should include the contribution of daughters that are generated from the decay of the parent radionuclides (for, at a minimum, those daughters listed in ANSI 18.1), as indicated in the follow-up to RAI 8090, Question 12.02-13. Therefore, all components source terms, including the HEPA filter source term, should be updated to include the expected contribution from the daughter products.

Response

1. Information about DCD Section 11.3.1.5

   a. The descriptions provided in Attachment 1 of the response to RAI 103-7998 – Question 12.02-11 will be updated to specify that the equation is used to calculate the “at inlet” concentrations in DCD Tables 11.3-11 and 12.2-19, as indicated in Attachment 1.

   b. The venting from the Volume Control Tank (VCT) to the Gaseous Radwaste System (GRS) is intermittent and depends on the reactor coolant conditions. Therefore, it is assumed that the vapor activities of the VCT are continuously vented to the GRS with an estimated flowrate of 0.004 scfm. The basis for this estimated flowrate is discussed in the following paragraphs.

      The VCT ventilation flowrate is determined by using the expected maximum vapor volume of 17,500 L (618 ft^3), described in DCD Section 11.1.1.5, and the frequency of VCT purge operation. The purge operation of the VCT is conservatively assumed to have a frequency of 4 times per fuel cycle (once for refueling and 3 times for cold shutdown).

      Based on the description above, the VCT ventilation flowrate can be calculated as follows:

      The ideal gas law is used to determine the expected maximum vapor volume under standard temperature and pressure conditions, as follows:

$$\frac{P_1V_1}{T_1}=\frac{P_2V_2}{T_2} \rightarrow V_2 = \frac{P_1T_2}{P_2T_1}\ V_1$$

Where,

P_1 = Operating pressure for VCT purge operation (psia),
V_1 = Expected maximum vapor volume in VCT (ft^3),
T_1 = Operating temperature for VCT purge operation (^oR),
P_2 = Standard pressure (psia),
V_2 = Expected maximum vapor volume at STP
T_2 = Standard temperature (^oR), and
The conditions of VCT purge operation (P_1, T_1) = 5 psig, 120 ^oF.

Therefore, V_2 can be written as follows:

$$V_2=\frac{(5+14.7)\times(459.67+60)\times618}{14.7\times(459.67+120)}=742.48$$

Then, the VCT ventilation flowrate is determined using the following equation:

$$F=V_2\times N\times\frac{\text{one fuel cycle period}}{18\text{ months}}\times\frac{18\text{ months}}{365\times1.5\text{ days}}\times\frac{1\text{ day}}{24\text{ hrs}}\times\frac{1\text{ hr}}{60\text{ min}}$$

Where,

F = VCT ventilation flowrate (scfm), and
N = number of VCT purge operation per fuel cycle.
V_2 = Expected maximum vapor volume at STP (calculated above)

Then, the VCT ventilation flowrate can be written as follows:

$$F=742.48\times4\times\frac{1}{788400}=0.0038$$

Therefore, 0.004 scfm is estimated to be the VCT ventilation flowrate. The flowrates used to determine the inlet specific activities of the GRS are added in a footnote to Tables 11.3-10, 11.3-11 and 12.2-19, as indicated in Attachment 2.

It should be noted that this is an average flowrate calculated for an estimate of the VCT inlet specific activities. The actual VCT ventilation flowrate is intermittent and is controlled by a pressure relief valve setpoint based on gas accumulation. Hence, the instantaneous ventilation flowrate is expected to be higher. The GRS is designed to accommodate the higher flowrates from the various equipment vents.

2. Dimensions of Header Drain Tank

The header drain tank dimensions provided in DCD Table 12.2-25 are incorrect and will be revised to show the correct dimensions with a diameter of 76.20 cm (2.5 ft) and a height of 121.92 cm (4.0 ft), as indicated in Attachment 3.

The shielding analysis was performed based on the correct dimensions, which are consistent with the dimensions listed in Table 11.3-4 and represent the full volume of the tank. The shielding calculation is based on the source terms, including the daughter nuclide build-up as discussed in the item 4 of this RAI response. The source term and shielding analysis results are provided in Tables 1 and 2, respectively.

3. Source Terms for Waste Gas Dryer

The waste gas dryer source terms provided in DCD Table 11.3-11 were calculated based on the incorrect dimensions, and DCD Table 11.3-11 has already been revised to correct this error as shown in the response to RAI 171-8143, Question No. 11.03-4. The incorrect dimensions of the waste gas dryer provided in DCD Table 12.2-25 will be revised to show the correct dimensions as indicated in Attachment 3.

The shielding analysis for the waste gas dryer was reevaluated based on the correct dimensions with the source terms including the daughter nuclide build-up as discussed in item 4 of this RAI response. The source term and shielding analysis results are provided in Tables 1 and 2, respectively.

4. Effects of Daughter Products Buildup in GRS

KHNP performed a review of the source term for the shielding calculations of GRS and evaluated the impact of the daughter nuclides build-up on the plant shielding and radiation zoning.

The daughter nuclides considered in this evaluation are 6 radionuclides listed in ANSI/ANS 18.1. The decay chains of these daughter nuclides are as follows:

a. I-133, Xe-133m → **Xe-133**,

b. I-135, Xe-135m → **Xe-135**,

c. Kr-85m → **Kr-85**,

d. Kr-88 → **Rb-88**, and

e. Xe-137 → **Cs-137** → **Ba-137m**.

As shown in the DCD Tables 11.3-10, 11.3-11 and 12.2-19, Xe-133, Xe-135 and Kr-85 have large activities compare to those of their parent nuclide, so additional activities generated in decay of their parent nuclide are so small as to be negligible considering their initial activities.

Therefore, the build-up activities of Rb-88, Cs-137 and Ba-137m are only included in this evaluation, and the activities of Rb-88, Cs-137 and Ba-137m are conservatively assumed to be the same as those of their parent nuclides as shown in Table 1.

During the source term evaluation, it was found that the source terms for HEPA filter vessel provided in the response to RAI 103-7998 Question 12.02-11 were calculated based on incorrect dimension. To correct this error, the source terms for HEPA filter vessel are reevaluated and provided in Table 1.

Using the source terms provided in Table 1, the shielding analyses were reevaluated to determine the radiation zones and shielding thicknesses.

The summary of reevaluated radiation zones and shielding thicknesses are provided in Table 2. Based on the evaluation results provided in Tables 1 and 2, KHNP will revise the source terms for GRS, the radiation shield thickness and the radiation zone drawing as indicated in Attachments 2 and 4.

Table 1 Source Terms for GRS

Nuclide	at inlet [Bq/cc]	Buildup Activity on Charcoal Bed					at outlet [Bq/cc]	Header Drain Tank [Bq]	Waste Gas Dryer [Bq]	Vessel for HEPA Filter [Bq]
		Guard Bed [Bq]	1st Delay Bed [Bq]	2nd Delay Bed [Bq]	3rd Delay Bed [Bq]	4th Delay Bed [Bq]				
Kr-85m	3.22E+05	8.28E+09	3.67E+12	1.43E+11	5.53E+09	2.15E+08	7.32E-01	1.82E+11	6.20E+09	6.10E+04
Kr-85	1.38E+06	3.55E+10	5.32E+13	5.32E+13	5.32E+13	5.32E+13	1.38E+06	7.82E+11	2.66E+10	1.15E+11
Kr-87	2.48E+05	6.38E+09	8.35E+11	8.93E+06	9.54E+01	1.02E-03	3.24E-15	1.41E+11	4.78E+09	2.70E-10
Kr-88	6.99E+05	1.80E+10	5.22E+12	3.10E+10	1.84E+08	1.09E+06	8.65E-04	3.96E+11	1.35E+10	7.21E+01
Xe-131m	1.37E+06	3.53E+10	4.99E+14	2.59E+14	1.35E+14	6.98E+13	9.98E+04	7.77E+11	2.64E+10	8.32E+09
Xe-133m	8.24E+04	2.12E+09	1.11E+13	3.16E+11	8.99E+09	2.55E+08	5.37E-02	4.67E+10	1.59E+09	4.48E+03
Xe-133	8.88E+07	2.28E+12	2.29E+16	5.18E+15	1.17E+15	2.65E+14	2.32E+05	5.03E+13	1.71E+12	1.93E+10
Xe-135m	1.82E+05	4.69E+09	1.23E+11	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.03E+11	3.51E+09	2.59E-25
Xe-135	1.83E+06	4.70E+10	4.40E+13	5.02E+04	5.73E-05	6.54E-14	3.10E-30	1.04E+12	3.53E+10	0.00E+00
Xe-137	4.19E+04	1.08E+09	7.07E+09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.37E+10	8.07E+08	0.00E+00
Xe-138	1.55E+05	3.99E+09	9.69E+10	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.78E+10	2.99E+09	0.00E+00
Br-84	7.37E-02	1.03E+05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.17E+04	1.42E+03	0.00E+00
I-131	9.16E+00	4.68E+09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.19E+06	1.76E+05	0.00E+00
I-132	2.44E+00	1.48E+07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.38E+06	4.70E+04	0.00E+00
I-133	1.32E+01	7.27E+08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.48E+06	2.54E+05	0.00E+00
I-134	1.54E+00	3.58E+06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.73E+05	2.97E+04	0.00E+00
I-135	7.44E+00	1.30E+08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.21E+06	1.43E+05	0.00E+00
Rb-88	**6.99E+05**	**1.80E+10**	**5.22E+12**	**3.10E+10**	**1.84E+08**	**1.09E+06**	**8.65E-04**	**3.96E+11**	**1.35E+10**	**7.21E+01**
Cs-137	**4.19E+04**	**1.08E+09**	**7.07E+09**	**0.00E+00**	**0.00E+00**	**0.00E+00**	**0.00E+00**	**2.37E+10**	**8.07E+08**	**0.00E+00**
Ba-137m	**4.19E+04**	**1.08E+09**	**7.07E+09**	**0.00E+00**	**0.00E+00**	**0.00E+00**	**0.00E+00**	**2.37E+10**	**8.07E+08**	**0.00E+00**

Table 2 Radiation Zone and Shielding Thickness

Room No.	Room Name	Radiation Zone	Minimum Required Shield Thickness (in.)					
			North	South	East	West	Floor	Ceiling
063-P02	GRS Header Drain Tank Room	7 (7)	35 (35)	42 (40)	48 (48)	41 (36)	Ground	18 (18)
063-P04	GRS Inlet Skid Room	7 (7)	22 (21)	34 (32)	10 (10)	22 (21)	Ground	13 (13)
085-P01	Waste Gas Dryer Skid Room	7 (6)	18 (17)	31 (25)	31 (25)	25 (19)	17 (17)	24 (22)
085-P02	Waste Gas Dryer Skid Room	7 (6)	11 (11)	18 (17)	22 (10)	25 (19)	17 (17)	24 (22)
085-P04	Charcoal Guard Bed Room	7 (7)	27 (26)	27 (26)	35 (34)	18 (18)	10 (10)	24 (23)
085-P21	Charcoal Guard Bed Room	7 (7)	27 (26)	27 (26)	18 (18)	35 (34)	10 (10)	24 (23)
096-P01	Charcoal Delay Bed Room	7 (7)	23 (22)	19 (19)	21 (21)	14 (14)	28 (28)	17 (17)
096-P02	Charcoal Delay Bed Room	7 (7)	49 (47)	47 (44)	15 (14)	40 (38)	36 (36)	43 (42)
100-P02	GRS Equip. Removal Area	6 (6)	13 (13)	11 (11)	40 (38)	10 (10)	23 (23)	10 (10)
120-P01	Gaseous Radwaste Sample Control Panel Room	6 (6)	16 (10)	21 (10)	21 (10)	12 (11)	18 (17)	26 (25)
120-P02	Gaseous Radwaste Sample Valve Rack Room	6 (6)	22 (20)	16 (10)	26 (25)	18 (17)	18 (17)	26 (25)

Note: The values in parentheses are the radiation zone and shielding thickness based on the source terms without daughter nuclide build up

Impact on DCD

DCD section 11.3.1.5 will be revised as indicated in Attachment 1. DCD Tables 11.3-10, 11.3-11 and 12.2-19 will be revised as indicated in Attachment 2. DCD Table 12.2-25 will be revised as indicated in Attachment 3. DCD Table 12.3-4 and Figure 12.3-12 will be revised as indicated in Attachment 4.

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 Report.

The GRS uses equipment that is commonly used in the nuclear power industry, whose performance is proven and documented. The equipment is sized to process waste gases using design basis source term and design conditions that bound normal operation including AOOs. The equipment is also housed in the compound building with sufficient shielding. Charcoal guard beds reduce the concentration of radioactive iodine in the effluent stream. Noble gases are delayed in the charcoal beds to facilitate decay prior to release.

GRS equipment is designed, located, and shielded to conform with the guidance of NRC RG 8.8 (Reference 11), thus maintaining occupational doses ALARA.

The GRS includes radiation monitoring to continuously measure the radioactivity in the effluent stream prior to release into the environment to conform with the requirements of GDC 60 (Reference 13) and 64 (Reference 15). Additional and redundant radiation monitors are provided in the building ventilation system to verify the radiation level. Upon detection of radiation levels above the setpoint, the monitor activates an alarm and sends signals to close the GRS discharge valves. Hence, the GRS design precludes the unmonitored and uncontrolled releases of radioactivity to the environment to meet the requirements of IE Bulletin 80-10 (Reference 19).

The GRS is designed with at least two isolation valves between the clean and contaminated systems to minimize the potential for contamination of clean systems. This feature meets the requirements of 10 CFR 20.1406 (Reference 23) and RG 4.21 (Reference 18).

11.3.1.5 Radioactive Source Terms in GRS

As shown in Figure 11.3-1, the input sources to the GRS are the vent gases from the reactor drain tank (RDT), volume control tank (VCT), equipment drain tank (EDT), and gas stripper. The radioactive sources for each component of the GRS are calculated using the radioactive concentrations of the inflows to the GRS from the CVCS components shown in Table 11.1-8, which are determined based on the reactor coolant radionuclide concentrations provided in Table 11.1-2.

The mixed specific activities of sources to the GRS are then calculated by weighting each source contribution corresponding to its partial flow fractions. Activity buildup on the

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The average input source (C_{input}) from the CVCS to GRS is determined by using the equation below;

$$C_{input} = \frac{C_{Gas} \times F_{Gas} + C_{RDT} \times F_{RDT} + C_{VCT} \times F_{VCT} + C_{EDT} \times F_{EDT}}{F_{Gas} + F_{RDT} + F_{VCT} + F_{EDT}}$$

Where, C : concentration [μCi/cc (Bq/cc)]
F : flow rate [cfm]
Gas : Gas Stripper
RDT : Reactor Drain Tank
VCT : Volume Control Tank
EDT : Equipment Drain Tank

This equation is used to calculate the "at inlet" nuclide concentration in Tables 11.3-11 and 12.2-19.

RAI 110-7919-Question 11.01-2

RAI 343-8420-Question 12.02-25

"M" (Replace a new Table 11.3-10)

Table 11.3-10

Expected Radioactive Source Terms for GRS Components

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Nuclide	Inlet		Buildup Activity on Charcoal Bed								Outlet	
			1st Delay Bed		2nd Delay Bed		3rd Delay Bed		4th Delay Bed			
	µCi//cm^3	Bq/cm^3	µCi	Bq	µCi	Bq	µCi	Bq	µCi	Bq	µCi//cm^3	Bq/cm^3
Kr-85m	4.96E-01	1.83E+04	5.65E+06	2.09E+11	2.19E+05	8.12E+09	8.52E+03	3.15E+08	3.31E+02	1.22E+07	1.13E-06	4.17E-02
Kr-85	3.72E+01	1.38E+06	1.43E+09	5.30E+13	1.43E+09	5.30E+13	1.43E+09	5.30E+13	1.43E+09	5.30E+13	3.72E+01	1.38E+06
Kr-87	5.20E-01	1.92E+04	1.75E+06	6.47E+10	1.87E+01	6.92E+05	2.00E-04	7.39E+00	2.14E-09	7.90E-05	6.78E-21	2.51E-16
Kr-88	5.45E-01	2.02E+04	4.07E+06	1.51E+11	2.42E+04	8.94E+08	1.43E+02	5.30E+06	8.50E-01	3.15E+04	6.75E-10	2.50E-05
Xe-131m	2.72E+01	1.00E+06	9.87E+09	3.65E+14	5.13E+09	1.90E+14	2.66E+09	9.85E+13	1.38E+09	5.11E+13	1.97E+00	7.31E+04
Xe-133m	2.25E+00	8.31E+04	3.04E+08	1.12E+13	8.63E+06	3.19E+11	2.45E+05	9.07E+09	6.97E+03	2.58E+08	1.46E-06	5.42E-02
Xe-133	9.88E-01	3.66E+04	2.55E+08	9.43E+12	5.76E+07	2.13E+12	1.30E+07	4.82E+11	2.95E+06	1.09E+11	2.58E-03	9.56E+01
Xe-135m	3.94E+00	1.46E+05	2.66E+06	9.83E+10	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-135	2.07E+00	7.67E+04	4.99E+07	1.85E+12	5.70E-02	2.11E+03	6.50E-11	2.41E-06	7.42E-20	2.75E-15	3.52E-36	1.30E-31
Xe-137	1.03E+00	3.82E+04	1.74E+05	6.45E+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-138	1.87E+00	6.92E+04	1.17E+06	4.33E+10	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-84	5.97E-06	2.21E-01	0.00E+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	0.00E+00
I-131	8.34E-07	3.08E-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	0.00E+00	0.00E+00
I-132	2.27E-05	8.39E-01	0.00E+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	0.00E+00
I-133	1.04E-05	3.86E-01	0.00E+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	0.00E+00
I-134	3.87E-05	1.43E+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	0.00E+00	0.00E+00
I-135	2.13E-05	7.87E-01	0.00E+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	0.00E+00

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Add footnote
"(1) The continuous venting flowrates for the gas stripper, reactor drain tank, volume control tank and equipment drain tank are 0.32 scfm, 0.024 scfm, 0.004 scfm and 0.005 scfm, respectively."

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Nuclide	At inlet		Buildup Activity on Charcoal Bed								At outlet	
			1st Delay Bed		2nd Delay Bed		3rd Delay Bed		4th Delay Bed			
	µCi/cm^3	Bq/cm^3	µCi	Bq	µCi	Bq	µCi	Bq	µCi	Bq	µCi/cm^3	Bq/cm^3
Rb-88	5.45E-01	2.02E+04	4.07E+06	1.51E+11	2.42E+04	8.94E+08	1.43E+02	5.30E+06	8.50E-01	3.15E+04	6.75E-10	2.50E-05
Cs-137	1.03E+00	3.82E+04	1.74E+05	6.45E+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
Ba-137m	1.03E+00	3.82E+04	1.74E+05	6.45E+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

Table 11.3-11 (1 of 2)

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Design Basis Radioactive Source Terms for GRS Components (1 % Fuel Defect)

Nuclide	At Inlet		Buildup Activity on Charcoal Bed										At Outlet	
			Guard Bed		1st Delay Bed		2nd Delay Bed		3rd Delay Bed		4th Delay Bed			
	$\mu Ci//cm^3$	Bq/cm^3	μCi	Bq	μCi	Bq	μCi	Bq	μCi	Bq	μCi	Bq	$\mu Ci//cm^3$	Bq/cm^3
Kr-85m	2.46E+01	9.08E+05	6.31E+05	2.34E+10	2.80E+08	1.04E+13	1.09E+07	4.02E+11	4.22E+05	1.56E+10	1.64E+04	6.06E+08	5.58E-05	2.06E+00
Kr-85	6.14E-01	2.27E+04	1.58E+04	5.84E+08	2.36E+07	8.75E+11	2.36E+07	8.75E+11	2.36E+07	8.75E+11	2.36E+07	8.75E+11	6.13E-01	2.27E+04
Kr-87	2.41E+01	8.90E+05	6.19E+05	2.29E+10	8.10E+07	3.00E+12	8.66E+02	3.20E+07	9.25E-03	3.42E+02	9.89E-08	3.66E-03	3.14E-19	1.16E-14
Kr-88	6.14E+01	2.27E+06	1.58E+06	5.84E+10	4.59E+08	1.70E+13	2.72E+06	1.01E+11	1.61E+04	5.97E+08	9.57E+01	3.54E+06	7.60E-08	2.81E-03
Xe-131m	6.14E+00	2.27E+05	1.58E+05	5.84E+09	2.23E+09	8.25E+13	1.16E+09	4.29E+13	6.01E+08	2.23E+13	3.12E+08	1.16E+13	4.46E-01	1.65E+04
Xe-133m	1.57E+00	5.81E+04	4.04E+04	1.50E+09	2.12E+08	7.86E+12	6.03E+06	2.23E+11	1.71E+05	6.34E+09	4.87E+03	1.80E+08	1.02E-06	3.79E-02
Xe-133	7.86E+02	2.91E+07	2.02E+07	7.48E+11	2.03E+11	7.50E+15	4.58E+10	1.70E+15	1.04E+10	3.83E+14	2.34E+09	8.67E+13	2.05E+00	7.60E+04
Xe-135m	1.89E+01	6.99E+05	4.86E+05	1.80E+10	1.28E+07	4.72E+11	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-135	1.08E+02	4.00E+06	2.78E+06	1.03E+11	2.60E+09	9.62E+13	2.97E+00	1.10E+05	3.39E-09	1.25E-04	3.86E-18	1.43E-13	1.83E-34	6.78E-30
Xe-137	4.66E+00	1.73E+05	1.20E+05	4.44E+09	7.88E+05	2.92E+10	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-138	1.62E+01	5.99E+05	4.17E+05	1.54E+10	1.01E+07	3.75E+11	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-84	7.77E-06	2.88E-01	1.09E+01	4.04E+05	0.00E+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	0.00E+00
I-131	9.89E-04	3.66E+01	5.05E+05	1.87E+10	0.00E+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	0.00E+00
I-132	2.66E-04	9.84E+00	1.62E+03	5.99E+07	0.00E+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	0.00E+00
I-133	1.41E-03	5.22E+01	7.76E+04	2.87E+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	0.00E+00	0.00E+00
I-134	1.67E-04	6.17E+00	3.87E+02	1.43E+07	0.00E+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	0.00E+00
I-135	7.77E-04	2.88E+01	1.36E+04	5.03E+08	0.00E+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	0.00E+00
Sum of Fractions														
$\sum A_i/A_{1i}$	-		~~2.05E+01~~		~~8.94E+03~~		3.11E+02		2.62E+01		4.89E+00		-	
$\sum A_i/A_{2i}$	-		~~2.24E+02~~		~~9.55E+04~~		2.69E+03		1.10E+02		1.11E+01		-	
Radwaste Classification														
	-		RW-IIa		RW-IIa		RW-IIa		RW-IIa		RW-IIa		-	

2.67E+00

2.20E+01

Add "B" in the next page after this row

8.47E+03

9.02E+04

Add footnote
"(1) The continuous venting flowrates for the gas stripper, reactor drain tank, volume control tank and equipment drain tank are 0.32 scfm, 0.024 scfm, 0.004 scfm and 0.005 scfm, respectively."

RAI 343-8420-Question 12.02-25

Nuclide	At inlet		Buildup Activity on Charcoal Bed										At outlet	
			Guard Bed		1st Delay Bed		2nd Delay Bed		3rd Delay Bed		4th Delay Bed			
	µCi/cm^3	Bq/cm^3	µCi	Bq	µCi	Bq	µCi	Bq	µCi	Bq	µCi	Bq	µCi/cm^3	Bq/cm^3
Rb-88	6.14E+01	2.27E+06	1.58E+06	5.84E+10	4.59E+08	1.70E+13	2.72E+06	1.01E+11	1.61E+04	5.97E+08	9.57E+01	3.54E+06	7.60E-08	2.81E-03
Cs-137	4.66E+00	1.73E+05	1.20E+05	4.44E+09	7.88E+05	2.92E+10	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Ba-137m	4.66E+00	1.73E+05	1.20E+05	4.44E+09	7.88E+05	2.92E+10	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

"B"

Non-Security-Related Information

Table 11.3-11 (2 of 2)

Nuclide	Header Drain Tank		Waste Gas Dryer	
	µCi	Bq	µCi	Bq
H-3	2.48E+02	9.18E+06	8.44E+00	3.12E+05
Kr-85m	1.39E+07	5.14E+11	4.73E+05	1.75E+10
Kr-85	3.48E+05	1.29E+10	1.18E+04	4.37E+08
Kr-87	1.36E+07	5.04E+11	4.63E+05	1.71E+10
Kr-88	3.48E+07	1.29E+12	1.18E+06	4.37E+10
Xe-131m	3.48E+06	1.29E+11	1.18E+05	4.37E+09
Xe-133m	8.90E+05	3.29E+10	3.03E+04	1.12E+09
Xe-133	4.45E+08	1.65E+13	1.52E+07	5.61E+11
Xe-135m	1.07E+07	3.96E+11	3.64E+05	1.35E+10
Xe-135	6.12E+07	2.26E+12	2.08E+06	7.71E+10
Xe-137	2.64E+06	9.77E+10	9.01E+04	3.33E+09
Xe-138	9.18E+06	3.40E+11	3.12E+05	1.15E+10
Br-84	4.40E+00	1.63E+05	1.50E-01	5.55E+03
I-131	5.60E+02	2.07E+07	1.91E+01	7.05E+05
I-132	1.51E+02	5.58E+06	5.12E+00	1.90E+05
I-133	7.99E+02	2.95E+07	2.72E+01	1.01E+06
I-134	9.44E+01	3.49E+06	3.21E+00	1.19E+05
I-135	4.40E+02	1.63E+07	1.50E+01	5.55E+05
Sum of Fractions				
$\sum A_i/A_{1i}$	~~4.51E+02~~		~~1.53E+01~~	
$\sum A_i/A_{2i}$	~~4.92E+03~~		~~1.67E+02~~	
Radwaste Classification				
	RW-IIa		RW-IIa	

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5.84E+01

4.82E+02

1.98E+00

1.64E+01

RAI 343-8420-Question 12.02-25

C

Nuclide	Header Drain Tank		Waste Gas Dryer	
	µCi	Bq	µCi	Bq
Rb-88	3.48E+07	1.29E+12	1.18E+06	4.37E+10
Cs-137	2.64E+06	9.77E+10	9.01E+04	3.33E+09
Ba-137m	2.64E+06	9.77E+10	9.01E+04	3.33E+09

B

Add superscript "(1)"

Table 12.2-19 (1 of 2)

RAI 103-7998-Question 12.02-11

RAI 343-8420-Question 12.02-25

Gaseous Radwaste System Source Terms (0.25 % Fuel Defect)

Nuclide	At Inlet	Buildup Activity on Charcoal Bed					At Outlet
		Guard Bed	1st Delay Bed	2nd Delay Bed	3rd Delay Bed	4th Delay Bed	
	Bq/cm^3	Bq	Bq	Bq	Bq	Bq	Bq/cm^3
Kr-85m	3.22E+05	8.28E+09	3.67E+12	1.43E+11	5.53E+09	2.15E+08	7.32E-01
Kr-85	1.38E+06	3.55E+10	5.32E+13	5.32E+13	5.32E+13	5.32E+13	1.38E+06
Kr-87	2.48E+05	6.38E+09	8.35E+11	8.93E+06	9.54E+01	1.02E-03	3.24E-15
Kr-88	6.99E+05	1.80E+10	5.22E+12	3.10E+10	1.84E+08	1.09E+06	8.65E-04
Xe-131m	1.37E+06	3.53E+10	4.99E+14	2.59E+14	1.35E+14	6.98E+13	9.98E+04
Xe-133m	8.24E+04	2.12E+09	1.11E+13	3.16E+11	8.99E+09	2.55E+08	5.37E-02
Xe-133	8.88E+07	2.28E+12	2.29E+16	5.18E+15	1.17E+15	2.65E+14	2.32E+05
Xe-135m	1.82E+05	4.69E+09	1.23E+11	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Xe-135	1.83E+06	4.70E+10	4.40E+13	5.02E+04	5.73E-05	6.54E-14	3.10E-30
Xe-137	4.19E+04	1.08E+09	7.07E+09	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Xe-138	1.55E+05	3.99E+09	9.69E+10	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-84	7.37E-02	1.03E+05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
I-131	9.16E+00	4.68E+09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
I-132	2.44E+00	1.48E+07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
I-133	1.32E+01	7.27E+08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
I-134	1.54E+00	3.58E+06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
I-135	7.44E+00	1.30E+08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Add "D" in the next page after last row

Add footnote

"(1) The continuous venting flowrates for the gas stripper, reactor drain tank, volume control tank and equipment drain tank are 0.32 scfm, 0.024 scfm, 0.004 scfm and 0.005 scfm, respectively."

RAI 343-8420-Question 12.02-25

D

Nuclide	at inlet [Bq/cc]	Buildup Activity on Charcoal Bed					at outlet [Bq/cc]
		Guard Bed [Bq]	1st Delay Bed [Bq]	2nd Delay Bed [Bq]	3rd Delay Bed [Bq]	4th Delay Bed [Bq]	
Rb-88	**6.99E+05**	**1.80E+10**	**5.22E+12**	**3.10E+10**	**1.84E+08**	**1.09E+06**	**8.65E-04**
Cs-137	**4.19E+04**	**1.08E+09**	**7.07E+09**	**0.00E+00**	**0.00E+00**	**0.00E+00**	**0.00E+00**
Ba-137m	**4.19E+04**	**1.08E+09**	**7.07E+09**	**0.00E+00**	**0.00E+00**	**0.00E+00**	**0.00E+00**

RAI 103-7998-Question 12.02-11

RAI 343-8420-Question 12.02-25

B

Table 12.2-19 (2 of 2)

Nuclide	Header Drain Tank Bq	Waste Gas Dryer Bq	Vessel for HEPA Filter Bq
Kr-85m	1.82E+11	6.20E+09	5.86E+03
Kr-85	7.82E+11	2.66E+10	1.10E+10
Kr-87	1.41E+11	4.78E+09	2.59E-11
Kr-88	3.96E+11	1.35E+10	6.93E+00
Xe-131m	7.77E+11	2.64E+10	7.99E+08
Xe-133m	4.67E+10	1.59E+09	4.30E+02
Xe-133	5.03E+13	1.71E+12	1.86E+09
Xe-135m	1.03E+11	3.51E+09	0.00E+00
Xe-135	1.04E+12	3.53E+10	2.48E-26
Xe-137	2.37E+10	8.07E+08	0.00E+00
Xe-138	8.78E+10	2.99E+09	0.00E+00
Br-84	4.17E+04	1.42E+03	0.00E+00
I-131	5.19E+06	1.76E+05	0.00E+00
I-132	1.38E+06	4.70E+04	0.00E+00
I-133	7.48E+06	2.54E+05	0.00E+00
I-134	8.73E+05	2.97E+04	0.00E+00
I-135	4.21E+06	1.43E+05	0.00E+00

Add "E" in the next page after last row

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RAI 343-8420-Question 12.02-25

E

Nuclide	Header Drain Tank	Waste Gas Dryer
	Bq	Bq
Rb-88	3.96E+11	1.35E+10
Cs-137	2.37E+10	8.07E+08
Ba-137m	2.37E+10	8.07E+08

F

Nuclide	Vessel for HEPA Filter
	Bq
Kr-85m	6.10E+04
Kr-85	1.15E+11
Kr-87	2.70E-10
Kr-88	7.21E+01
Xe-131m	8.32E+09
Xe-133m	4.48E+03
Xe-133	1.93E+10
Xe-135m	2.59E-25
Xe-135	0.00E+00
Xe-137	0.00E+00
Xe-138	0.00E+00
Br-84	0.00E+00
I-131	0.00E+00
I-132	0.00E+00
I-133	0.00E+00
I-134	0.00E+00
I-135	0.00E+00
Rb-88	7.21E+01
Cs-137	0.00E+00
Ba-137m	0.00E+00

Non-Security-Related Information

C

RAI 103-7998-Question 12.02-11

RAI 343-8420-Question 12.02-25

Building	Component	Source Dimension				Source Characteristic		Housing	
		Shape	Diameter (or Width) (cm)	Length (cm)	Height (cm)	Material	Partial Density (g/cm^3)	Material	Thickness (cm)
Compound Building	Header Drain Tank	Cylinder	76.20 ~~45.72~~	-	121.92 ~~172.48~~	Vapor : 100%	0.001293	Steel ~~Not considered~~	0.6
	Waste Gas Dryer	Cylinder	30.318 ~~0.629~~	-	91.72	Vapor : ~~96~~ 82.73% Steel : 4% 17.27	~~0.00117~~ 0.001009 ~~0.339~~ 1.357	Steel	1.03
	Guard Bed	Cylinder	50.80	-	139.71	Carbon : 100%	0.41	Not considered	
	Delay Bed	Cylinder	180.08	-	456.05	Carbon : 100%	0.41	Not considered	
	HEPA filter	Cylinder	45.72	-	50.80	Vapor : 100%	0.001293	Not considered	

Table 12.3-4 (5 of 7)

RAI 141-8098 - Question 12.03-08

RAI 141-8098-Question 12 03-10, Rev.1

RAI 343-8420-Question 12.02-25

10

Room Number	Room Name	Minimum Requi					
		North	South	East	West	Floor	Ceiling
Compound Building							
063-P01	Hot Pipe Chase	10	28	28	10	Ground	17
063-P02	GRS Header Drain Tank Room	35	40	48	36	Ground	18
063-P03	Valve Room	27	30	37	10	Ground	10
063-P04	GRS Inlet Skid Room	21	32	10	21	Ground	13
063-P05	Spent Resin Long-term Storage Tank Room	27	35	48	36	Ground	46
063-P06	Future Use	36	27	48	36	Ground	39
063-P07	Valve Room	16	29	36	30	Ground	14
063-P08	Low-activity Spent Resin Tank Room	27	32	35	10	Ground	10
063-P09	Valve Room	16	36	10	16	Ground	18
063-P13	Hot Pipe Chase	40	33	40	33	Ground	19
063-P14	Hot Tool Room	15	10	10	10	Ground	32
063-P21	Equip. Waste Pump Room	17	19	10	20	Ground	17
063-P22	Equip. Waste Pump Room	10	17	10	21	Ground	17
063-P23	Equip. Waste Tank Room	13	33	20	22	Ground	27
063-P24	Equip. Waste Tank Room	16	13	21	22	Ground	27
063-P25	Floor Drain Pump Room	14	10	11	19	Ground	10
063-P26	Normal Sump Pump Room	14	14	10	19	Ground	16
063-P27	Chemical Waste Pump Room	10	14	10	15	Ground	16
063-P28	Floor Drain Tank Room	16	16	19	20	Ground	29
063-P29	Floor Drain Tank Room	16	16	19	20	Ground	29
063-P30	Chemical Waste Tank Room	10	16	15	10	Ground	15
063-P31	Chemical Waste Tank Room	10	10	15	10	Ground	15
063-P36	DWS Drain Sump Pump Room	10	10	10	10	Ground	10

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RAI 141-8098 - Question 12.03-08

RAI 141-8098-Question 12 03-10, Rev.1

RAI 343-8420-Question 12.02-25

Room No.	Room Name	Minimum Required Shield Thickness (in.)					
		North	South	East	West	Floor	Ceiling
A 063-P02	GRS Header Drain Tank Room	35	42	48	41	Ground	18
B 063-P04	GRS Inlet Skid Room	22	34	10	22	Ground	13

RAI 141-8098 - Question 12.03-08

RAI 141-8098-Question 12 03-10, Rev.1

RAI 343-8420-Question 12.02-25

Table 12.3-4 (6 of 7)

10

Room Number	Room Name	Minimum Req					
		North	South	East	West	Floor	Ceiling
Compound Building (cont.)							
063-P37	Monitor Tank Room	10	18	11	18	Ground	10
063-P38	PSS-Solidification & Drum Conveyer Room	17	24	24	21	Ground	14
063-P39	Spent Resin Long-term Storage Tank Sump Pump Room	18	20	18	21	Ground	18
063-P40	Concentrate Pump Room	27	24	20	16	Ground	19
063-P41	Concentrate Holding Tank Room	21	27	33	28	Ground	10
063-P42	RO Feed Pump Room	10	10	28	16	Ground	24
063-P43	IX Feed Pump Room	16	10	16	10	Ground	24
063-P44	IX Feed Tank Room	14	16	11	10	Ground	23
063-P47	CTS HEPA Vacuum Skid Room	24	10	21	10	Ground	10
063-P48	CTS Dryer Skid Room	31	24	17	21	Ground	15
063-P49	CTS Vacuum Skid Room	10	10	21	10	Ground	18
		10	10	10	10	Ground	14
063-P73	Instrument Calibrator Facility	36	43	18	48	Ground	36
085-P01	Waste Gas Dryer Skid Room	17	25	25	19	17	22
085-P02	Waste Gas Dryer Skid Room	11	17	10	19	17	22
085-P03	Valve Room	48	11	30	26	18	36
085-P04	Charcoal Guard Bed Room	26	26	34	18	10	23
085-P06	Valve Room	19	26	36	30	19	27
		27	24	30	30	14	24
085-P08	Valve Room	24	19	22	24	19	24
085-P15	Valve Room	10	21	21	18	10	23
085-P16	Valve Room	10	22	18	19	10	22
085-P17	Valve Room	10	10	10	14	10	17
085-P20	Valve Room	16	16	16	16	10	16
085-P21	Charcoal Guard Bed Room	26	26	18	34	10	23
085-P31	Primary Sampling Room	10	10	10	10	10	10

Replace these rows with “C” in the next page

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Room No.	Room Name	Minimum Required Shield Thickness (in.)					
		North	South	East	West	Floor	Ceiling
085-P01	Waste Gas Dryer Skid Room	18	31	31	25	17	24
085-P02	Waste Gas Dryer Skid Room	11	18	22	25	17	24
085-P04	Charcoal Guard Bed Room	27	27	35	18	10	24
085-P21	Charcoal Guard Bed Room	27	27	18	35	10	24

Table 12.3-4 (7 of 7)

RAI 141-8098 - Question 12.03-08

RAI 141-8098-Question 12 03-10, Rev.1

RAI 343-8420-Question 12.02-25

10

Room Number	Room Name	Minimum Require					
		North	South	East	West	Floor	Ceiling
Compound Building (cont.)							
085-P32	Primary Sampling Sink Room	10	13	12	12	14	18
085-P42	IX Module Room	10	30	30	27	14	28
085-P43	IX Module Room	30	10	30	30	14	28
085-P44	RO Feed Tank Room	10	27	32	22	19	25
085-P45	Drum Removal Chase	15	15	15	15	-	25
085-P46	MF Membrane Module Room	23	10	20	15	18	16
085-P47	MF Membrane Module Room	23	16	10	12	15	16
085-P48	RO Membrane Module and Valve Skid Room	43	24	43	34		
096-P01	Charcoal Delay Bed Room	22	19	21	14	28	17
096-P02	Charcoal Delay Bed Room	47	44	14	38	36	42
100-P02	GRS Equipment Removal Area	13	11	38	10	23	10
100-P07	Future Extension Area	24	30	36	37	24	31
100-P08	Truck Bay	24	24	36	37	36	31
100-P09	Waste Drum Storage Area	28	24	36	26	34	31
100-P10	Spent Filter Drum Storage Area	36	28	48	37	36	43
120-P01	Gaseous Radwaste Sample Control Panel Room	10	10	10	11	17	25
120-P02	Gaseous Radwaste Sample Valve Rack Room	20	10	25	17	17	25

Replace these rows with "F" in the next page

Replace these rows with "G" in the next page

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Room No.	Room Name	Minimum Required Shield Thickness (in.)					
		North	South	East	West	Floor	Ceiling
096-P01	Charcoal Delay Bed Room	23	19	21	14	28	17
096-P02	Charcoal Delay Bed Room	49	47	15	40	36	43
100-P02	GRS Equip. Removal Area	13	11	40	10	23	10
120-P01	Gaseous Radwaste Sample Control Panel Room	16	21	21	12	18	26
120-P02	Gaseous Radwaste Sample Valve Rack Room	22	16	26	18	18	26

Figure 12.3-12 Radiation Zones (Normal) Compound Building El. 85'-0"