REVISED 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.:	**108-7973**
SRP Section:	**15.00.03 - Design Basis Accidents Radiological Consequence Analyses for Advanced Light Water Reactors**
Application Section:	**Chapter 15 including 15A**
Date of RAI Issue:	**07/23/2015**

Question No. 15.00.03-2

10 CFR 52.47(a)(2)(iv) requires that an application for a design certification include a final safety analysis report that provides a description and safety assessment of the facility. The safety assessment analyses are done, in part, to show compliance with the radiological consequence evaluation factors in 52.47(a)(2)(iv)(A) and 52.47(a)(2)(iv)(B) for offsite doses, 10 CFR 50, Appendix A, GDC 19 for control room radiological habitability, and the requirements related to the technical support center in 10 CFR 52.47(b)(8) and (b)(11) and Paragraph IV.E.8 of Appendix E to 10 CFR Part 50. The radiological consequences of design basis accidents are evaluated against these regulatory requirements and the dose acceptance criteria given in SRP 15.0.3.

DCD Chapter 15A provides a description of the methods used to estimate coolant activity concentrations for input to the DCD Chapter 15 safety assessments. Provide the following information on the primary coolant concentration calculations:

a. Why are the DCD Table 15A-3 iodine concentrations and Table 15A-8 noble gas concentrations for 1% fuel defect are not the same as those in Table 11.1-2?

b. DCD Tables 15A-4 through 15A-7 list information on the accident-specific iodine appearance rates and iodine spiking. Explain the following differences:

   i. Column 2 values for total coolant activity per isotope are not the same between the four accident-specific tables. Clarify how the total isotopic activity was calculated for each accident.

   ii. Column 4 values for the letdown purification removal rate are not the same between tables. Provide the basis for letdown purification removal rate values used for each accident.

c. DCD 15A.1.2.4 states that alkali metal activities in the primary coolant are ignored because they have a low partition coefficient from the liquid to steam phase and the dose contribution is negligible. Guidance on particulate radionuclide transport from the RCS through the secondary system is given in RG 1.183, Appendix E, position 5.5.4, which states that the retention in the steam generators is limited by moisture carryover from the steam generators. This moisture carryover is applied to the steam release from the steam generators to give the alkali release fraction for those DBAs that model the secondary system release pathway. DCD Table 5.4.2-1, "Steam Generator Design Parameters," gives the maximum weight percent moisture carryover as 0.25%.

   i. Provide a justification for this difference from RG 1.183 guidance, including the statement that the dose contribution from alkali metals in the RCS (primary coolant) is negligible.

   ii. Alternatively, revise the analyses that include primary-to-secondary leakage through the steam generators (SGs) as a release pathway to include the transport of alkali metals.

d. In technical specification (TS) 3.4.12 the RCS primary-to-secondary leakage is limited to 0.39 L/min through any one SG. The bases for TS 3.4.12 state that the initial condition in the dose analyses assumes 0.39 L/min per SG primary-to-secondary leakage. In the DBA dose analyses, contrary to this, DCD Tables 15.1.5-12, 15.2.8-3, 15.3.3-3, 15.4.8-4, 15.6.2-4 and 15.6.3-5 list the primary-to-secondary leakage as 2.27 L/min total for two SGs. RG 1.183 guidance states that the primary-to-secondary leak rate in the steam generators should be assumed to be the leak rate limiting condition for operation specified in the technical specifications. What is the basis for this dose analysis assumption which greatly exceeds the technical specification limit?

Response – (Rev. 2)

a. The reactor coolant source term data in Table 11.1-2 represents the design basis fission and corrosion product specific activities calculated based on 1% fuel defect and continuous gas stripping operation. In order to maximize the RCS initial source term used for the dose analyses, values given in Table 15A-3 are calculated based on 0.25% fuel defect with no credit for gas stripping operation, which are provided in Table 12.2-5, and multiplied by a factor of 4 to account for the increase of fuel defect from 0.25% to 1%. For clarity, Table 15A-3 will be updated.

b. i. The radiological consequence analyses in Chapter 15 are based on the thermal-hydraulic (T/H) analyses. Since the T/H analyses for different DBAs use different initial RCS mass to maximize the radiological consequences, the total reactor coolant activity values in Column 2 of Tables 15A-4 through 15A-7 are different. The RCS mass values applied in each DBA are given in Table 1. The total RCS activities in Columns 3 through 6 in Table 1 are calculated by multiplying the DE I-131 concentration (Bq/g) in Column 2 by the corresponding RCS mass value for each DBA.

Table 1. RCS Mass and Initial Iodine Total Activities Used in Dose Analyses

Nuclides	3.7×10^4 Bq/g (1.0 μCi/g) DE I-131 Activity Concentration (Bq/g)	Total Activity in RCS (Bq)				
		Steam Line Break (SLB)		Steam Generator Tube Rupture (SGTR)	Failure of Small Lines Carrying Primary Coolant Outside Containment (LDLB)	Feedwater Line Break (FLB)
		SLBFPDLOOP	SLBZPLOPD			
RCS Mass (kg)	-	274,392	286,829	290,680	292,431	288,086
I-131	2.93E+04	8.05E+12	8.41E+12	8.53E+12	8.58E+12	8.45E+12
I-132	7.88E+03	2.16E+12	2.26E+12	2.29E+12	2.30E+12	2.27E+12
I-133	4.16E+04	1.14E+13	1.19E+13	1.21E+13	1.22E+13	1.20E+13
I-134	4.81E+03	1.32E+12	1.38E+12	1.40E+12	1.41E+12	1.39E+12
I-135	2.37E+04	6.49E+12	6.78E+12	6.88E+12	6.92E+12	6.82E+10

ii. The iodine appearance rate is also calculated using an accident-specific mass as described in b.i above, and the methods to calculate letdown purification removal rate are provided in detail in DCD Section 15A.1.2.2.

c. The quantitative evaluation was performed to determine the dose contribution of alkali metals based on the initial concentration in the reactor coolant corresponding to a 1.0% fuel defect and, for the events that experience fuel cladding damage, the additional concentration activities resulted from the failed fuel. For this re-analysis of the radiological consequences, the updated on-site χ/Qs were used, which was submitted as the responses to RAI 20-7912 -Question 02.03.04-1 and RAI 174-8211-Question 02.03.04-05. The evaluation results have shown that their impact was not insignificant compared to the total doses. The transport of alkali metals such as cesium (Cs) and rubidium (Rb) in the reactor coolant to the environment should be therefore taken into account.

The related descriptions in DCD Chapter 15 and tables indicating results for the radiological consequences will be revised to integrate consideration of the alkali metals.

KHNP found input errors of unfiltered leakage 150 cfm in the SGTR MCR habitability calculation through the self-assessment of the calculations. The value was revised into 100 cfm and a recalculation was performed. In addition, incorrect values were taken from the code output for LPZ doses. This error was also corrected. Based on these changes, DCD Table 6.4-2 and 15.6.3-6 will be revised as indicated in Attachment 1.

In addition, please note that some of the results in the CEA Ejection were revised through the self-assessment as indicated in Attachment 2 and these results were already reflected in DCD Rev.1.

d. According to RG 1.183, Appendix F, Section 5.1, the primary-to-secondary leak rate in the SGs should be assumed to be the leak rate limiting condition for operation specified in the Technical Specifications (TS). The RCS operational leakage in technical specifications 3.4.12 is intended to limit to 150 gpd (0.39 L/min) per any one SG. In the DBA analysis for APR1400, however, the primary-to-secondary leakage of 0.6 gpm (2.27 L/min) for both SGs (total SGs) was used, which is higher than this TS limit. Section 3.4.12 of the TS Bases indicates that:

- The safety analysis for an event resulting in steam discharge to the atmosphere conservatively assumes a 1.13 L/min (0.3 gpm) primary to secondary leakage as the initial condition.

In addition, the primary to secondary leakage of 0.3 gpm for any one SG applied to the dose analysis corresponds to the maximum accident-induced leakage limit specified in the technical specification 5.5.9 "Steam Generator (SG) Program", which is determined based on design basis accident considerations. Therefore, although the primary-to-secondary leakage assumed in the radiological dose assessment is not consistent with the guidance specified in RG 1.183, Appendix F, Section 5.1, this leakage is conservatively used in the dose analyses to maximize the offsite doses.

Impact on DCD

DCD Table 6.4-2 and 15.6.3-6 will be revised as indicated in Attachment 1.

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.

RAI 108-7973 - Question 15.00.03-02_Rev.2

Table 6.4-2

MCR and TSC Doses from Design Basis Accidents

Design Basis Accident		TEDE (mSv)(1)
Steam system piping failure	1 % Fuel Failure	3.58E+01
	Pre-accident spike	2.10E+01
	Event-generated spike	2.22E+01
Feedwater system pipe break		1.98E+01
RCP rotor seizure		2.28E+01
Control element assembly ejection	Containment leakage	~~3.54E+01~~ 3.53E+01
	Steam system release case	2.91E+01
Failure of small lines carrying primary coolant outside containment		1.95E+01
Steam generator tube rupture	Pre-accident spike	~~2.02E+01~~ 2.03E+01
	Event-generated spike	~~1.96E+01~~ 1.97E+01
Loss of coolant accident		4.69E+01
Fuel handing accident		8.55E+00

(1) TEDE: Total effective dose equivalent

RAI 108-7973 - Question 15.00.03-02_Rev.2

Table 15.6.3-6

Radiological Consequences of the Steam Generator
Tube Rupture with a Loss of Offsite Power

Pre-accident Iodine Spike Case

Post-SGTR Activity Release Path	TEDE Dose (mSv)		
	MCR and TSC	EAB	LPZ
P-T-S Iodine Release	~~8.08E-01~~ 7.29E-01	6.02E+00	~~1.32E+00~~ 1.38E+00
P-T-S Noble Gas Release	~~2.37E-01~~ 3.66E-01	1.83E+00	~~4.02E-01~~ 4.05E-01
P-T-S Alkali Metal Release	~~1.21E-02~~ 1.09E-02	8.81E-02	~~1.94E-02~~ 2.01E-02
Secondary Liquid Iodine Release	~~2.06E-02~~ 2.64E-02	1.42E-01	~~3.13E-02~~ 5.87E-02
External Cloud	6.22E+00	0.00E+00	0.00E+00
Emergency Ventilation Filter Shine	1.29E+01	0.00E+00	0.00E+00
Total	~~2.02E+01~~ 2.03E+01	8.07E+00	~~1.78E+00~~ 1.87E+00
Allowable TEDE Limit	5.00E+01	2.50E+02	2.50E+02

Event-generated Iodine Spike Case

Post-SGTR Activity Release Path	TEDE Dose (mSv)		
	MCR and TSC	EAB	LPZ
P-T-S Iodine Release	~~2.01E-01~~ 1.97E-01	2.73E+00	~~6.01E-01~~ 7.13E-01
P-T-S Noble Gas Release	~~2.37E-01~~ 3.66E-01	1.83E+00	~~4.02E-01~~ 4.05E-01
P-T-S Alkali Metal Release	~~1.21E-02~~ 1.09E-02	8.81E-02	~~1.94E-02~~ 2.01E-02
Secondary Liquid Iodine Release	~~2.06E-02~~ 2.64E-02	1.42E-01	~~3.13E-02~~ 5.87E-02
External Cloud	6.22E+00	0.00E+00	0.00E+00
Emergency Ventilation Filter Shine	1.29E+01	0.00E+00	0.00E+00
Total	~~1.96E+01~~ 1.97E+01	4.79E+00	~~1.05E+00~~ 1.20E+00
Allowable TEDE Limit	5.00E+01	2.50E+01	2.50E+01

RAI 108-7973 - Question 15.00.03-2

Self-assessment

Table 15.4.8-5

Radiological Consequences of CEA Ejection

Containment Leakage Case

Post-CEA Ejection Activity Release Path	TEDE Dose (mSv)		
	MCR and TSC	EAB	LPZ
Containment Leakage	~~1.63E+01~~ 1.62E+01	~~5.90E+01~~ 5.86E+01	~~5.58E+01~~ 5.55E+01
External Cloud	6.22E+00	0.00E+00	0.00E+00
Emergency Ventilation Filter Shine	1.29E+01	0.00E+00	0.00E+00
Total	~~3.54E+01~~ 3.53E+01	~~5.90E+01~~ 5.86E+01	~~5.58E+01~~ 5.55E+01
Allowable TEDE Limit	5.00E+01	6.30E+01	6.30E+01

Steam System Release Case

Post-CEA Ejection Activity Release Path	TEDE Dose (mSv)		
	MCR and TSC	EAB	LPZ
P-T-S Iodine Release	2.60E+00	1.46E+01	1.01E+01
P-T-S Noble Gas Release	6.55E+00	2.04E+01	8.79E+00
P-T-S Alkali Metal Release	~~8.48E-01~~ 8.32E-01	~~5.01E+00~~ 4.92E+00	~~2.95E+00~~ 2.90E+00
Secondary Liquid Iodine Release	1.83E-02	1.22E-01	4.65E-02
External Cloud	6.22E+00	0.00E+00	0.00E+00
Emergency Ventilation Filter Shine	1.29E+01	0.00E+00	0.00E+00
Total	2.91E+01	4.00E+01	2.18E+01
Allowable TEDE Limit	5.00E+01	6.30E+01	6.30E+01

This page was already reflected in DCD, Rev.1 by self-assessment.