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.: **434-8352**

SRP Section: **SRP 19**

Application Section: **19.1**

Date of RAI Issue: **03/08/2016**

Question No. 19-86

10 CFR 52.47(a)(27) states that a design certification (DC) application must contain an FSAR that includes a description of the design-specific PRA and its results. For additional guidance, Standard Review Plan (SRP) Chapter 19.0, draft Revision 3, Section II “Acceptance Criteria,” Item 28 states “The staff will determine that a seismic equipment list (SEL) has been prepared which documents the SSCs associated with the accident sequences that will require seismic fragility evaluation for determining sequence-level HCLPF.”

The staff reviewed APR1400 DCD Section 19.1.5.1.1.1 “Development of Seismic Equipment List” and the SEL provided in Table 19.1-42 and found the information provided in this section is insufficient for the staff to make a determination regarding the completeness and acceptability of this SEL.

Therefore, in order for the staff to reach a reasonable assurance finding, please address by discussing in detail in the APR1400 DCD the following items:

a) Why the medium loss of coolant accident (LOCA) is not considered as seismic initiating event

b) How the reactor coolant pump (RCP) seal cooling (especially, the components necessary to maintain RCP thermal barrier cooling) is modeled in PRA-based seismic margins assessment (SMA) to maintain cooling to the RCP seals and thereby maintain the integrity of RCS

c) Why the large fuel oil storage tanks are not included in the SEL

d) Why the non-seismic Category I major structures, where failure could impact the structures, systems, and components (SSCs) on the SEL, are not included in the SMA analysis (i.e., access building, fuel oil storage tanks building, etc.)

Response

a) In the analysis, fragility values for the RCS were based on the reference plant. These values showed that the RCS was considered rugged and that failures could be screened from further consideration. Subsequent APR1400-specific fragility evaluation has been performed and is documented in the response to RAI 19-75 and the update to DCD Table 19.1-43. These evaluations no longer support the conclusion that the RCS is seismically rugged. Therefore, the SMA has been updated to include medium LOCA as a potential consequence of a seismic event.

b) The SMA was developed to determine the plant-level HCLPF for key seismic-induced events. A loss of RCP seal cooling would result in a small LOCA which is explicitly evaluated on the seismic event trees. Therefore, the plant-level HCLPF for accident sequences that result from a loss of RCP seal cooling is considered.

The fragility of a seismically induced small LOCA is based on generic and conservative data. Evaluation of the specific equipment needed to maintain RCP seal cooling and, therefore, prevent a loss of RCP seal integrity is considered bounded by the fragility information used for the SLOCA.

Because the APR1400 SMA evaluates a proposed design, any assessment of component-specific, seismic induced failures would require that assumptions be made regarding HCLPF values. Use of such assumptions would provide no insights not already shown by the SLOCA sequences.

c) The fuel oil storage tanks are included on the SEL. The tanks are identified as “Diesel Fuel Oil Storage Tank.” These tanks are used as the makeup source to the day tanks and contain at least seven days of fuel for the associated EDG.

d) There are two non-seismic Category I structures adjacent to seismic category I structures. Both of the non-seismic Category I structures, the turbine building and the compound building, are seismic Category II, augmented quality structures. There is no access building. Two fuel oil storage tanks are located in the auxiliary building and two fuel oil storage tanks are located in the EDG building, both seismic Category I structures.

According to the major assumption item f of Seismic Fragility Analysis (see the subsection 19.1.5.1.1.2), the failure of non-seismic Category buildings such as turbine building and compound building does not impact seismic Category buildings by proper equipment layout and design, so non-seismic Category buildings are not included in SELs.

Impact on DCD

There is no impact on the DCD.

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 Environment Report.

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RAI No.: **434-8352**

SRP Section: **SRP 19**

Application Section: **19.1**

Date of RAI Issue: **03/08/2016**

Question No. 19-93

10 CFR 52.47(a)(27) states that a DC application must contain an FSAR that includes a description of the design-specific PRA and its results. For additional guidance, SRP Chapter 19.0, draft Revision 3, Section I, "Areas of Review," states that "The staff should issue a request for additional information (RAI) and conduct audits of the complete PRA (e.g., models, analyses, data, and codes) to obtain clarifying information as needed. The staff will document any NRC audits performed in audit reports so that they may be referenced in the staff's safety evaluation report (SER)."

During the review of APR1400 DCD, Revision 0, and the regulatory audit (conducted from April 15, 2015 through October 15, 2015) of PRA, severe accident (SA) evaluation, and reliability assurance program (RAP), the staff has found several potential issues regarding the information provided in the design control document (DCD) and discussed these concerns at public meetings and teleconferences. In a number of instances, KHNP committed in its responses to revise the APR1400 DCD to resolve the staff's findings. These actions are documented in the PRA/SA/RAP tracking list (ADAMS ML15292A030), which contains proprietary information.

Therefore, in order for the staff to complete its review of the APR1400 DC application and to reach a reasonable assurance finding, the staff requests that KHNP revise the APR1400 DCD as committed during the PRA/SA/RAP regulatory audit, for the following tracking list items:

a) PRA-176 - Provide additional information in Chapter 19 to be consistent with Item "o" on Page 10.4-75 of Chapter 10, which stated "The AFWS is designed to have unavailability from 1E-5 to 1E-4 per demand as described in Chapter 19."

b) PRA-209 - Provide clarification for not including the probability of in-containment refueling water storage tank (IRWST) suction strainer plugging as a key risk insight. This probability value is assumed not to increase relative to the power operation PRA model.

c) PRA-210 - Provide clarification for not including the containment closure during reduced inventory conditions and the operability of safety injection during Modes 4, 5, and 6 as key risk insights.

d) PRA-227 – Provide clarification for not including the assumption that the core exit thermocouples (CETs) monitor coolant temperature down to 37.8 °C (100 °F) prior to withdrawal of CETs

e) PRA-128 - Describe in the DCD the methodology and key assumptions used in evaluating the core-concrete interaction in the sump.

f) PRA-224 - Revise DCD Table 19.1-29 to be consistent with Notebook APR100-K-P-NR-013603-P."

g) SA-3 - Provide justification for flow path of dispersed corium to the upper containment during high pressure melt ejection event.

Response

The responses are as follows;

a) PRA-176

The results of AFWS reliability analysis are provided as the response of RAI 86-8003, Question 10.04.09-6.

b) PRA-209

The response was provided as the response of AI 19-232 (PRA-209).

c) PRA-210

The response was provided as the response of AI 19-233 (PRA-210).

d) PRA-227

The core exit thermocouples (CETs) provide representative indications of the core exit temperature when shutdown cooling system (SCS) is operational, including reduced inventory operations. The CETs' instrument range 0 ~ 1,260 ^{o}C (32 ~2,300 ^{o}F) as shown in Table 2.8-1 of Shutdown Evaluation Report (SER).

e) PRA-128

a. The type of concrete (i.e. concrete mix design) is the Limestone-Common Sand (LCS) type of concrete based on the MCCI evaluation results, used for the MAAP4 calculations. The COL Item 3.8(3) specifies the requirements for the concrete mix design.

b. The length, width, and depth of the reactor cavity sump are 6 ft. (1.83 m), 5 ft. (1.52 m), and 4 ft. (1.22 m), respectively. It is assumed that the sump in the COREQUENCH model is a little bit bigger than the real design for the conservative

results in the ablation depth. The area of side walls is 105.8 sq ft. (9.83 m2) and the area of floor is 30.8 sq ft. (2.86 m2) in the CORQUENCH model.

c. The depth from the bottom of the reactor cavity sump to the containment liner is 3 ft. (0.91 m).

d. The corium pool in the reactor cavity sump has a different cross-section area from the pool in the remaining cavity, and the walls and the floor in the sump may be subject to deeper ablation than the remaining cavity walls and floor because of the dimensions of the reactor cavity sump provided above. The siliceous type shows deeper ablation than the other types which are the limestone-limestone and the limestone-common sand. Accordingly, the ablation depth in the reactor cavity sump for the siliceous concrete does not meet the requirement and it is not included as the applicable materials in the Table 9.

e. The surface area of side walls in the sump is about three times larger than the floor area. Thus, the sidewall surface area initially constitutes 77% of the total surface area in contact with the melt and available for gas release from core-concrete interaction. In our judgement, the COREQUENCH model assumes the uniform mixing of gases with melt for the gases generated from sidewall erosion.

f. In order to supplement this deficiency in MELTSPREAD, the CORQUENCH calculation is based on a very conservative assumption, which ignores the particle bed created during the initial jet breakup phase. This means that the particle bed can only be created through melt eruption when MCCI occurs.

g. The results for both axial and radial ablation depth are the same in the limestone type. If it is the siliceous type, the axial ablation depth is deeper than the radial direction. Those results correspond with the actual experiments.

f) PRA-224

The CsOH release fractions of STC-11, 20 and 21 in Table 19.1-29 of DCD need to be corrected as 5.9E-05 (0.0059 %), 3.4E-03 (0.34 %) and 4.9E-03 (0.49 %), respectively (See Attachment).

g) SA-3

The detailed description and analysis are provided in Severe Accident Analysis Report (APR1400-E-P-NR-14003-P), Appendix C-1, subsection 4.1.4.

For the APR1400 containment, the mixture of steam, gas, and corium particles flow through available flow paths between the reactor cavity and the upper compartment, and the only flow path that leads directly to the upper compartment without significant de-entrainment is the reactor pressure vessel (RPV) annulus, as described in section 19.2.3.3.4.1.2. Thus, the fraction of the dispersed corium that enters the containment dome can be calculated, as follows;

$$f\_dom = A\_an / (A\_an + A\_cav)$$

where,

A_an: cross-sectional flow area for the RPV annulus

A_cav: horizontal cross-sectional flow area for the reactor cavity.

For the APR1400 containment, the cross sectional flow area for the RPV annulus and the reactor cavity, and the fraction of the dispersed corium that enters the containment dome were A_an = 1.96 m^2, A_cav = 21.8 $m^{2,}$ and f_dom = 0.082, respectively.

Impact on DCD

The DCD will be revised to reflect the response as shown 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 Report.

APR1400 DCD TIER 2

Table 19.1-29 (2 of 3)

	MAAP CASE	STC-08	STC-09	STC-10	STC-11	STC-12	STC-13	STC-14
FP Releases at end of MAAP run	CsI (%)	25.4	0.00088	0.0024	0.0088	No sequence is assigned to STC-12	15.6	0.27
	TeO_2 (%)	18.9	0.00059	0.0023	0.0016		6.7	0.067
	CsOH (%)	19.4	0.00063	0.0015	~~0.059~~ 0.0059		4.1	0.060
	Te_2 (%)	0.15	0.0	0.0	0.0017		-	0.026
LRF or not		LRF	NOT LRF	NOT LRF	NOT LRF		LRF	NOT LRF
FP Releases at end of MAAP run 4 hours after a general emergency declaration	CsI (%)	15.3	-	-	0.0024		5.5	0.0018
	TeO_2 (%)	13.8	-	-	0.0016		6.1	0.0017
	CsOH (%)	14.8	-	-	0.012		3.3	0.0012
	Te_2 (%)	-	-	-	-		-	-
LERF or not		LERF	NOT LERF	NOT LERF	NOT LERF		LERF	NOT LERF

Table 19.1-29 (3 of 3)

	MAAP CASE	STC-15	STC-16	STC-17	STC-18	STC-19	STC-20	STC-21
FP Releases at end of MAAP run	CsI (%)	No sequence is assigned to STC-15	1.5	0.014	0.67	1.2	2.8	5.0
	TeO_2 (%)		0.049	0.0022	0.066	0.013	0.098	0.077
	CsOH (%)		0.20	0.0036	0.094	0.19	~~0.034~~ 0.34	~~0.049~~ 0.49
	Te_2 (%)		0.00061	-	0.027	-	0.0060	-
LRF or not			NOT LRF	NOT LRF	NOT LRF	NOT LRF	LRF	LRF
FP Releases at end of MAAP run 4 hours after a general emergency declaration	CsI (%)		0.0021	0.0018	0.0018	0.0017	0.0021	0.0018
	TeO_2 (%)		0.0017	0.0020	0.0017	0.0019	0.0017	0.0020
	CsOH (%)		0.0012	0.0014	0.0012	0.0013	0.0012	0.0014
	Te_2 (%)		-	-	-	-	-	-
LERF or not			NOT LERF	NOT LERF	NOT LERF	NOT LERF	NOT LERF	NOT LERF

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RAI No.: **434-8352**

SRP Section: **SRP 19**

Application Section: **19.1**

Date of RAI Issue: **03/08/2016**

Question No. 19-94

10 CFR 52.47(a)(27) states that a design certification (DC) application must contain an FSAR that includes a description of the design-specific PRA and its results. As discussed in Standard Review Plan (SRP) Chapter 19.0, draft Revision 3, Section I “Areas of Review,” the NRC expects that, generally, the information that it needs to perform its review of an application from a PRA perspective is that information contained in the applicant’s FSAR Chapter 19. The staff should issue a request for additional information (RAI) and conduct audits of the complete PRA (e.g., models, analyses, data, and codes) to obtain clarifying information as needed. The staff will document any NRC audits performed in audit reports so that they may be referenced in the staff’s safety evaluation report (SER).

During the review of APR1400 DCD, Revision 0, and the regulatory audit (conducted from April 15, 2015 through October 15, 2015) of PRA, severe accident (SA) evaluation, and reliability assurance program (RAP), the staff has found inconsistencies with information in the DCD and audited documents and discussed these concerns at public meetings and teleconferences. In its responses, KHNP committed to revise the APR 1400 PRA notebook(s) to be consistent with the information provided in the DCD. These actions are documented in the PRA/SA/RAP tracking list (ADAMS ML15292A030), which contains proprietary information.

Therefore, in order for the staff to complete its review of the APR1400 DC application and to reach a reasonable assurance finding, the staff requests that KHNP revise the PRA notebooks or DCD, as committed during the PRA/SA/RAP regulatory audit, for the following tracking list items:

a) PRA-140 - The Level 2 At-power internal flooding information.

b) PRA-190 - The hydrogen control system notebook regarding the operations of passive autocatalytic recombiners during Modes 1 through 6.

c) PRA-218 - Notebook “APR1400-K-P-NR-013602-P,” Event 5 branch split fraction.

d) PRA-219 - The core damage frequency (CDF) and large release frequency (LRF) values in notebook APR1400-K-P-NR-013604-P.

Response

a) The results of at-power Level 2 internal flooding are included in Full Power Level 2 PRA - Quantification Notebook (APR1400-K-P-NR-013604-P, Rev.0A). However the current results are revised because it included outdated information (See Attachment 1).

Note: Attachment 1 is placed in the electronic reading room.

b) DCD Section 16 did not include the TS item for PARs, so Section 4.3 of the Full Power Level 1 PRA - Hydrogen Control System Notebook (APR1400-K-P-NR-013223-P, Rev. 0) is revised (See Attachment 2).

Note: Attachment 2 (APR1400-K-P-NR-013223-P, Rev. 0A) is placed in the electronic reading room.

c) The correct value is 9.786E-01, and the CET /DET Analysis notebook (APR1400-K-P-013602-P, Rev. 0) is revised to reflect the correct value (See Attachment 3).

Note: Attachment 3 (APR1400-K-P-NR-013602-P, Rev. 0A) is placed in the electronic reading room.

d) The total PDS frequencies for Internal Flooding Events and Internal Fire Events are 4.24E-7/ry and 2.06E-6/ry and the LRF for Internal Flooding Events and Internal Fire Events are 3.07E-08/ry and 1.68E-07/yr in Full Power Level 2 PRA-Quantification Notebook (APR1400-K-P-NR-013604-P, Rev.0).

e) The PDS frequencies for Internal Flooding Events and Internal Fire Events were not included in DCD 19.1. And the LRF for Internal Flooding Events and Internal Fire Events are 1.7E-8/yr (Section 19.1.5.3.2) and 1.7E-7/yr (19.1.5.2.2) in DCD 19.1.

The summary of results is as follows;

	Large Release Frequency (LRF)	
	Level 2 PRA Notebook (APR1400-K-P-NR-013606-P)	DCD 19.1
Internal Events PRA	1.11E-07	1.1E-07 (19.1.4.2.2.1)
Internal Fire PRA	1.68E-07	1.7E-7 (19.1.5.2.2)
Internal Flooding PRA	3.07E-8	1.7E-8 (19.1.5.3.2)

The LRF for Internal Flooding Events in DCD 19.1.5.3.2 are the correct values, thus the LRF for Internal Flooding Events in the Full Power Level 2 PRA-Quantification Notebook (APR1400-K-P-NR-013604-P, Rev.0) should be revised (See Attachment 1).

Note: Attachment 1 (APR1400-K-P-NR-013604-P, Rev.0A) is placed in the electronic reading room.

Impact on DCD

There is no impact on the DCD.

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

The Full Power Level 2 PRA - Quantification Notebook (APR1400-K-P-NR-013604-P, Rev.0), Full Power Level 1 PRA - Hydrogen Control System Notebook (of APR1400-K-P-NR-013223-P, Rev. 0) and CET/DET Analysis notebook (APR1400-K-P-013602-P, Rev. 0) will be revised as stated in the response.