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.:	**432-8377**
SRP Section:	**SRP 19**
Application Section:	**19.1**
Date of RAI Issue:	**03/08/2015**

Question No. 19-58

10 CFR 52.47(a)(27) requires that a standard design certification applicant provide a description of the design-specific PRA and its results.

APR1400 DCD Section 19.1.4.2.1.1, Rev. 0, states that “[t]he large break LOCA sequences result from a primary system break of greater than 15.24 cm (6 in) diameter. The large break LOCA sequences correspond to sequences that would result in RCS pressure in the low pressure range, less than 17.6 kg/cm2 (250 psia).”

The MAAP input file for Case-A01 in APR1400-K-P-NR-013601-P, Revision 0, shows that the large break LOCA break area was calculated for a double-ended guillotine break of a pipe with diameter “XDCL.” However, the MAAP input file does not provide the value used for XDCL.

The large break LOCA (LBLOCA) stated in the design control document (DCD) appears to be a single-ended guillotine break, which is inconsistent with the double-ended guillotine break used for the LBLOCA MAAP analysis provided in APR1400-K-P-NR-013601-P.

Explain the apparent discrepancy between the DCD and APR1400-K-P-NR-013601-P and update the DCD clarifying the type of break assumed.

Response

As documented in the PDS analysis notebook (APR1400-K-P-NR-013601-P, Rev.0) Appendix A, the Case-A01 is the double-ended guillotine break of RCS coldleg.
In the Case-A01, the parameter "XDCL" is the inner diameter of a cold leg (0.762 m (30 inch)). Most MAAP parameters such as “XDCL” are defined in the MAAP parameter file, so those are not defined in the MAAP input file.

APR1400 DCD Section 19.1.4.2.1.1 states that the large break LOCA (LLOCA) sequences result from a primary system break of greater than 15.24 cm (6 in) diameter. Per the definition

of LLOCA in APR1400 DCD, the most conservative break size of LOCA would be a double-ended guillotine break of coldleg (or hotleg). It does not mean that the maximum size of LLOCA is a single-ended guillotine break (SEGB). The Case-A01 simulates the most conservative case of LLOCA, which is a double-ended guillotine break (DEGB) of cold leg. Therefore, there is no discrepancy between the APR1400 DCD and the PDS analysis notebook.

In addition, the PDS analysis Appendix A also provides other LOCA sequences as below. As shown in below, the RCS pressures resulting from all the spectrum of LOCA sequences were reviewed in the APR1400 PDS analysis.

CASE	Accident Condition	Category of LOCA
A01	LOCA (a DEGB of coldleg) without safety injection (SI)	**Area of LLOCA**
A02	LOCA (6-inch piping break) without SI	
A03	LOCA (2-inch piping break) without SI & Secondary Heat Removal (SHR)	**Area of MLOCA**
A04	LOCA (3/8 inch piping break) without SI & SHR	**Area of SLOCA**

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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.:	**432-8377**
SRP Section:	**SRP 19**
Application Section:	**19.1**
Date of RAI Issue:	**03/08/2016**

Question No. 19-59

10 CFR 52.47(a)(2) states that it is expected that the standard plant will reflect through its design, construction, and operation an extremely low probability for accidents that could result in the release of radioactive fission products.

The source term evaluation results listed in APR1400 DCD Rev. 0, Table 19.1-29, show that the cesium iodide release fraction for source term category (STC)-21 is 357 times higher than that for STC-17 (5.0 versus 0.014 percent of total core inventory). However, MAAP calculations documented in APR1400-K-P-NR-013603-P show that STC-21 has only a 10 times larger release opening area than STC-17 (1.0 ft2 versus 0.1 ft2). Explain the significant variation in releases in two cases compared to the area assumed.

Response

Figure 1 shows the release fraction of CsI for STC-17 and STC-21. The release fraction of CsI for STC-21 at the end of MAAP run (approximately 5%) is much higher than that for STC-17 (i.e., approximately 0.014%). As shown in Figure 1, there is a big difference in the shape of release fraction for STC-17 and STC-21 after the containment failure (i.e., approximately 62 hours after the accident initiation).

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Figure 1. Release fraction of CsI for STC-17 and STC-21

Following the source term grouping, the representative sequences for STC-17 and STC 21 are the same, except for the containment failure size. Hence, the only difference of accident progression between STC-17 and STC-21 is the containment failure size, so that the difference of the amount of source term releases as shown in Figure 1 results from different containment failure sizes.

Even though the containment failure size of STC-21 (i.e., 1.0 ft^2) is 10 times larger than that of STC-17 (i.e., 0.1 ft^2), it does not mean that the source term release of STC-21 would be 10 times larger than that of STC-17. In general, the release rate and the release amount (especially for airborne fission products) heavily depend on the containment failure area, the containment depressurization rate and/or the gas flow rate out of containment through the containment failure junction. Per the definition of the containment rupture and the containment leak as below, the containment rupture could result in a more rapid containment depressurization than the containment leak.

- A leak is defined as a containment breach that would arrest a gradual pressure buildup, but would not result in containment depressurization in less than 2 hours. The typical leak size is evaluated to be on the order of 9.29×10^{-3} m^2 (0.1 ft^2).
- A rupture is defined as a containment breach that would arrest a gradual pressure buildup and would depressurize the containment within 2 hours. The typical rupture size is evaluated to be on the order of approximately 9.29×10^{-2} m^2 (1.0 ft^2).

Figure 2 and Figure 3 show the containment pressure and the gas flow rate through the containment failure junction, respectively. In the STC-21, the containment is much more rapidly depressurized and gaseous materials accompanying the fission products such as CsI are much more rapidly released after the containment failure.

Therefore, the releases for STC-21 is much higher than STC-17 because of the containment failure area, the containment depressurization rate and/or the gas flow rate out of containment through the containment failure junction.

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Figure 2. Containment Pressure for STC-17 and STC-21

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Figure 3. Gas flow rate out of containment for STC-17 and STC-21

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.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

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RAI No.:	**432-8377**
SRP Section:	**SRP 19**
Application Section:	**19.1**
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Question No. 19-61

10 CFR 52.47(a)(27) requires that a standard design certification applicant provide a description of the design-specific PRA and its results.

Section 19.1.4.2.1.2.1 of APR1400 design control document (DCD), Rev. 0, states the following: "Containment event trees (CETs) are developed to model the containment response during severe accident progressions. These CETs depict the various phenomenological progress, containment conditions, and containment failure modes that could occur under severe accident conditions."

Section 19.1.4.2.1.2.3 of APR1400 DCD Rev. 0 states the following:

> The MAAP code was used to support many of the CET phenomenological evaluations. MAAP evaluations included evaluations of core melt, RCS failure, containment pressurization, ex-vessel core-concrete interactions, and releases from the containment. Containment failure due to overpressurization was considered using the results of the containment ultimate capacity evaluation. Many other calculations were performed to support the CET.

However, APR1400 DCD Rev. 0 does not provide information on MAAP runs performed and how results of MAAP runs were used to support the CET phenomenological evaluations. The staff needs this information to understand how containment response during severe accident progressions was addressed for the APR1400 design. Provide details of MAAP runs performed to support the APR1400 CET phenomenological evaluations. Revise the DCD as necessary.

Response

As described in Section 19.1.4.2.1.2.3 of APR1400 DCD, a very large number of MAAP calculations were performed to support the At-power Level 2 PRA analysis, including analyses for PDS binning, CET phenomenological evaluations, and source term evaluations. However,

the detailed description for each MAAP calculations is too specific to be documented in Section 19.1.4.2.1.2.3 of APR1400 design control document. Instead, the detailed information for each MAAP calculations are documented in the PDS analysis notebook (Doc No: APR1400-K-P-NR-013601-P, Rev. 0), the CET analysis notebook (Doc No: APR1400-K-P-NR-013602-P, Rev. 0), and the STC analysis notebook (Doc No: APR1400-K-P-NR-013603-P, Rev. 0). Each MAAP calculation documented in the PRA notebooks is as follows.

(1) PDS analysis notebook (Doc No: APR1400-K-P-NR-013601-P, Rev. 0), Appendix A

- Purpose: To review the RCS pressure at the time of core damage

Case	Accident Condition
A01	LOCA (a DEGB of coldleg) without safety injection (SI)
A02	LOCA (6-inch piping break) without SI
A03	LOCA (2-inch piping break) without SI & Secondary Heat Removal (SHR)
A04	LOCA (3/8 inch piping break) without SI & SHR
A05	LOFW without SHR
A06	SBO without SHR
A07	“Case A06” + “RCP seal LOCA occurs (250 gpm/Pump)”
A08	“Case A06” + “RCP seal LOCA occurs (480 gpm/Pump)”
A09	“Case A06” + “RCP seal LOCA occurs (21 gpm/Pump)”
A10	“Case A05” + “2 POSRVs open right after CET > 1200℉”
A11	“Case A05” + “2 POSRVs open 30 minutes after CET > 1200℉”
A12	“Case A05” + “2 POSRVs open 1 hours after CET > 1200℉”
A13	“Case A06” + “2 POSRVs open right after CET > 1200℉”
A14	“Case A06” + “2 POSRVs open 30 minutes after CET > 1200℉”
A15	“Case A06” + “2 POSRVs open 1 hours after CET > 1200℉”

(2) CET analysis notebook (Doc No: APR1400-K-P-NR-013602-P, Rev. 0), Appendix A

- Purpose: To review the number of cycling of POSRV and MSSV cycles before core damage

Case	Accident Condition
T01	SLOCA without SI injection without secondary heat removal
T02	GTRN without secondary heat removal
T03	LOFW without secondary heat removal
T04	SBO without secondary heat removal

- Purpose: To review the ECSBS performance for containment depressurization

Case	Accident Condition
S01	LLOCA with SI, w/o CS
S02	LLOCA with wet cavity, w/o SI & CS
S03	LLOCA with wet cavity, w/o SI & CS, with ECSBS
S04	LLOCA with SI & wet cavity, w/o CS, with ECSBS

- Purpose: To review the containment pressurization for the sequences with a dry cavity without containment sprays

Case	Accident Condition
Q01	LLOCA with dry cavity, w/o sprays
Q02	LOFW with dry cavity, w/o sprays
Q03	SBO with dry cavity, w/o sprays

- Purpose: To review the maximum AICC pressure inside the containment

Case	Accident Condition
R01	Early CS, Wet-Cavity, Coolable debris, No early hydrogen burns
R02	Early CS, Wet-Cavity, Non-coolable debris
R03	Early CS, Dry-Cavity, PARs operate successfully
R04	Early CS, Dry-Cavity, PARs fail to operate
R05	Late CS, Wet-Cavity, Coolable debris, No early hydrogen burns
R06	Late CS, Wet-Cavity, Non-coolable debris
R07	Late CS, Dry-Cavity, PARs operate successfully
R08	Late CS, Dry-Cavity, PARs fail to operate
R09	No CS, Dry-Cavity, PARs operate successfully
R10	No CS, Dry-Cavity, PARs fail to operate

(3) STC analysis notebook (Doc No: APR1400-K-P-NR-013603-P, Rev. 0), Section 6

- Purpose: To evaluate the source term releases for each release category

Case	Accident Condition
STC-01	SGTR without scrubbing - Representative Sequence for STC-01 : Main Steam Line Break downstream the MSIVs, the pressure-induced SGTR, the success of SI system, the failure of SG isolation
STC-02	SGTR with scrubbing - Representative Sequence for STC-02 : SGTR initiating event, the success of the SI system, the success of the secondary heat removal, the failure of RCS cooldown, the failure to refill the IRWST, the success of rapid depressurization and the success of injecting the feedwater into ruptured SG

STC-03	ISLOCA without scrubbing - Representative Sequence for STC-03 : ISLOCA initiating event, The break point of interfacing system piping is not submerged in the water in the auxiliary building
STC-04	ISLOCA with scrubbing - Representative Sequence for STC-04 : ISLOCA initiating event, The break point of interfacing system piping is submerged in the water in the auxiliary building
STC-05	Not isolation with CS - Representative Sequence for STC-05 : LOOP initiating event, the success of EDG, the failure of secondary heat removal, the failure of F&B operation, the failure of containment isolation and the success of the containment spray.
STC-06	Not isolation without CS - Representative Sequence for STC-06 : PLOCCW initiating event, the failure of secondary heat removal, the success of bleed operation, the failure of feed operation, the failure of containment isolation and the failure of the containment spray.
STC-07	CFBRB with a leak failure size - Representative Sequence for STC-07 : MLOCA initiating event, the success of safety injection system, the failure of the containment spray and the containment fails with failure size of 0.1 ft2
STC-08	CFBRB with a rupture failure size - Representative Sequence for STC-08 : MLOCA initiating event, the success of safety injection system, the failure of the containment spray and the containment fails with failure size of 1.0 ft2
STC-09	Intact containment without RPV breach - Representative Sequence for STC-09 : LOOP initiating event, the success of EDG, the failure of secondary heat removal, the failure of bleed operation, the success of rapid depressurization, the success of in-vessel injection, the success of cavity flooding system, the success of containment spray and the core melt arrest in vessel.
STC-10	Intact containment with RPV breach - Representative Sequence for STC-10 : PLOCCW initiating event, the failure of secondary heat removal, the success of bleed operation, the failure of feed operation, the success of rapid depressurization, the success of cavity flooding system, the success of late containment spray (i.e., ECSBS) and the containment maintains its integrity
STC-11	Basemat Melt-through - Representative Sequence for STC-11 : PLOCCW initiating event, the failure of secondary heat removal, the success of bleed operation, the failure of feed operation, the success of rapid depressurization, the failure of cavity flooding system, the success of late containment spray (i.e., ECSBS) and the basemat melt-through.
STC-12	Early containment failure with a leak failure size - There is no sequence assigned in this category
STC-13	Early containment failure with a rupture failure size - Representative Sequence for STC-13 : PLOCCW initiating event, the failure of secondary heat removal, the success of bleed operation, the failure of feed operation, the failure of containment spray system, the success of rapid depressurization, the success of cavity flooding system and the containment fails approximately at the time of reactor vessel failure.

STC-14	Late containment failure with a leak failure size, with CS, with a dry cavity - Representative Sequence for STC-14 : PLOCCW initiating event, the failure of secondary heat removal, the success of bleed operation, the failure of feed operation, the success of rapid depressurization, the failure of cavity flooding system, the success of late containment spray (i.e., ECSBS) and the containment fails in late phase.
STC-15	Late containment failure with a leak failure size, with CS, with a wet cavity - There is no sequence assigned in this category
STC-16	Late containment failure with a leak failure size, w/o CS, with a dry cavity - Representative Sequence for STC-16 : PLOCCW initiating event, the failure of secondary heat removal, the success of bleed operation, the failure of feed operation, the success of rapid depressurization, the failure of cavity flooding system, the failure of containment spray system and the containment fails in late phase
STC-17	Late containment failure with a leak failure size, w/o CS, with a wet cavity - Representative Sequence for STC-17 : PLOCCW initiating event, the failure of secondary heat removal, the success of bleed operation, the failure of feed operation, the success of rapid depressurization, the success of cavity flooding system, the failure of containment spray system and the containment fails in late phase
STC-18	Late containment failure with a rupture failure size, with CS, with a dry cavity - Representative Sequence for STC-18 : PLOCCW initiating event, the failure of secondary heat removal, the success of bleed operation, the failure of feed operation, the success of rapid depressurization, the failure of cavity flooding system, the success of late containment spray (i.e., ECSBS) and the containment fails in late phase
STC-19	Late containment failure with a rupture failure size, with CS, with a wet cavity - Representative Sequence for STC-19 : PLOCCW initiating event, the failure of secondary heat removal, the success of bleed operation, the failure of feed operation, the success of rapid depressurization, the success of cavity flooding system, the success of late containment spray (i.e., ECSBS) and the containment fails in late phase
STC-20	Late containment failure with a rupture failure size, w/o CS, with a dry cavity - Representative Sequence for STC-20 : PLOCCW initiating event, the failure of secondary heat removal, the success of bleed operation, the failure of feed operation, the success of rapid depressurization, the failure of cavity flooding system, the failure of containment spray and the containment fails in late phase
STC-21	Late containment failure with a rupture failure size, w/o CS, with a wet cavity - Representative Sequence for STC-21 : PLOCCW initiating event, the failure of secondary heat removal, the success of bleed operation, the failure of feed operation, the success of rapid depressurization, the success of cavity flooding system, the failure of containment spray system and the containment fails in late phase

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.