Non-Proprietary

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

APR1400 Topical Reports

Korea Hydro & Nuclear Power Co., LTD

Docket No. PROJ 0782

RAI No.:	**7-8567**
SRP Section:	**TR Realistic Evaluation Methodology for LBLOCA of the APR1400**
Application Section:	**Topical Report APR1400-F-A-TR-12004 Realistic Evaluation Methodology for Large-Break LOCA of the APR1400**
Date of RAI Issue:	**04/07/2016**

Question No. APR1400-6

10 CFR 50.46(a) states that the evaluation model for calculating the emergency core cooling system performance must adequately account for uncertainty in the calculated results. Section 15.0.2 of the standard review plan (NUREG-0800) states the uncertainty analysis must address all important sources of code uncertainty, including the mathematical models in the code and user modeling.

The phenomena identification and ranking table for the APR1400 large break loss of coolant accident identifies the cold leg to containment flow path as being a significant parameter during the refill and reflood phases. The friction and form losses associated with the cold leg to containment flow path are not included in the uncertainty parameters. This has caused NRC staff to question whether the treatment of uncertainty of these significant parameters is suitably conservative. NRC staff requests that KHNP justify their treatment of uncertainty associated with the cold leg to containment flow path in the refill and reflood phases.

Response

The phenomena “cold leg to containment flow path” is defined in reference [4] of the topical report as [

]TS

In CAREM, the discharge coefficients are determined by assessment against the [ ]TS test. In the determination of the discharge coefficients, it is believed that [

]TS Then, the limiting break condition is found instead of considering the uncertainty of the break location, type and size. Since the worst break condition is used, the uncertainty evaluation of the break condition is not required. However, there are concerns related with the flow resistance uncertainty.

These concerns can be treated by the uncertainty parameter for [ ]TS , which is already used in CAREM and is described in Section 5.1.7 of the topical report. The uncertainty parameter is intended to consider the uncertainty of [

]TS Also, the plant input making process of CAREM includes the checking of the steady state pressure differences with the designed values.
[ ]TS

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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Application Section:	**Topical Report APR1400-F-A-TR-12004 Realistic Evaluation Methodology for Large-Break LOCA of the APR1400**
Date of RAI Issue:	**04/07/2016**

Question No. APR1400-7

10 CFR 50.46(a) states that the evaluation model for calculating the emergency core cooling system (ECCS) performance must include sufficient supporting justification to show that the analytical technique realistically describes the behavior of the reactor system during a loss- of-coolant accident.

Evaluation of ECCS bypass included a comparison against data from the upper plenum test facility (UPTF). KHNP selected test UPTF-4A, with cold leg injection, to determine the ECCS bypass bias during the refill phase. Tests UPTF-21A and UPTF-21B involve downcomer injection of the ECCS. Because the APR1400 utilizes direct vessel injection, NRC staff is questioning if test UPTF-4A is the appropriate choice for determining ECCS bypass bias. NRC staff requests that KHNP justify their selection of the UPTF-4A test, with cold leg injection, to determine ECCS bypass bias during the refill phase in their evaluation model.

Response

The ECC bypass during the end-of-blowdown and refill period is mainly dependent on the flow mixing behavior below the cold leg bottom. Therefore, it has been considered that the ECC injection type is less important in comparison to the depressurization process. Also, the test configurations of UPTF-21A, -21B tests are not exactly the same as the LBLOCA conditions during the end-of-blowdown and refill period; the broken hot leg break valve and the pump simulators were closed. The initial pressure in the primary system and containment simulator was set at approximately 0.3 MPa, thus the depressurization process was not investigated through the tests. In other words, UPTF-21A, -21B tests are the tests for steady-state downcomer CCFL tests with DVI geometry and the steam flow rates injected from the core simulator were determined from the end-of-blowdown and refill condition, respectively.

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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Application Section:	**Topical Report APR1400-F-A-TR-12004 Realistic Evaluation Methodology for Large-Break LOCA of the APR1400**
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Question No. APR1400-8

10 CFR 50.46(a) states that the evaluation model for calculating the emergency core cooling system (ECCS) performance must include sufficient supporting justification to show that the analytical technique realistically describes the behavior of the reactor system during a loss-of-coolant accident.

Evaluation of ECCS bypass included a comparison against data from the advanced thermal-hydraulic test loop for accident simulation (ATLAS). For ATLAS Test 15, downcomer wall temperatures and collapsed liquid levels in the core and downcomer region appear to show that RELAP is under-predicting ECCS bypass. This has caused NRC staff to question whether the evaluation model can capture ECCS bypass during reflood in a suitably conservative way. NRC staff requests the following information of KHNP:

1. Explain the cause of RELAP5 over-predicting the collapsed liquid level in the core and downcomer for ATLAS Test 15.

2. Explain how the evaluation model for large break loss-of-coolant accident analysis captures the phenomena of ECCS bypass in a suitably conservative way.

Response

1)

As discussed in Appendix E of the topical report, the result of the initial period (the period before 200 sec after the beginning of the test) of the ATLAS tests include [

]TS

Therefore, it was concluded that the test results of initial period in ATLAS test 9 and 11 are neglected.

However, it was determined to assess whole test period for the ATLAS test 15 because the initial condition of test 15 is adjusted to have a [

]TS And it has low flow rate of ECCW as boundary condition. These conditions decrease [

]TS compared to the test results of the other tests. Therefore, the ATLAS test 15 is assessed by the code for the whole reflood test period, and ECCW bypass phenomenon during the whole reflood period is evaluated.

Consequently, the water level and ECCW bypass of the initial period are [

]TS, thus it is concluded that RELAP5/MOD3.3/K code conservatively predicts water level and ECCW bypass during general reflood period.

2)

Code predictability on the ECCW bypass phenomenon is evaluated by experimental data of ATLAS, MIDAS and UPTF as described in Appendix E and F of the topical report, and it is concluded that ECCW bypass during the refill period is considered [

]TS

Code assessment on the ECCW bypass during reflood period is performed using ATLAS, MIDAS and UPTF-21D test data.

Impact on DCD

There is no impact on the DCD.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

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Impact on Technical/Topical/Environmental Reports

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Question No. APR1400-9

10 CFR 50.46(a) states that the evaluation model for calculating the emergency core cooling system performance must adequately account for uncertainty in the calculated results. Section 15.0.2 of the standard review plan (NUREG-0800) states the uncertainty analysis must address all important sources of code uncertainty, including the mathematical models in the code and user modeling.

Section 5.1.4 of topical report APR1400-F-A-TR-12004-P, Rev. 0, discusses the treatment of the uncertainty associated with the pump two-phase degradation multiplier. The topical report states that the pump is assumed to be [

]^{TS} This has caused NRC staff to question the treatment of uncertainty associated with pump two-phase performance. Additionally, the mean value provided for the distribution function is stated to be below the minimum value for the distribution. NRC staff requests the following additional information:

1. Provide justification for the chosen uncertainty range for the pump two-phase pump degradation multiplier.

2. Correct the information in Section 5.1.4 regarding the distribution.

Response

1)

Pump degradation multiplier is used to model a pump performance for 2-phase flow and it is divided into the 2-phase head multiplier and 2-phase torque multiplier as follows.

$$H = H_{1\Phi} - M_H(\alpha_g)\left(H_{1\Phi} - H_{2\Phi}\right) \qquad \text{Eq. (1)}$$

$$\tau = \tau_{1\Phi} - M_\tau(\alpha_g)\left(\tau_{1\Phi} - \tau_{2\Phi}\right) \qquad \text{Eq. (2)}$$

where,

H = the total pump head

$H_{1\Phi}$ = the single-phase pump head

$H_{2\Phi}$ = the fully degraded pump head

M_H = the head degradation multiplier (or the 2-phase head multiplier)

$\tau_{1\Phi}$ = the single-phase pump torque

$\tau_{2\Phi}$ = the fully degraded pump torque

M_τ = the torque degradation multiplier (or the 2-phase torque multiplier)

α_g = the vapor fraction

Pump degradation is expressed via two-phase multiplier curves. [

]TS

Based on the sensitivity studies as described in Section 5.1.4 of topical report, [

]TS

- Parameter; pump two-phase degradation multiplier

[

]TS

2)

The topical report will be corrected as follows:

- Parameter; pump two-phase degradation multiplier

[

]TS

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

Topical report (APR1400-F-A-TR-12004) will be revised as attached markup.

multiplier values are relatively lower at low void fractions; the other is for such pumps such as the B&W pump, CREARE air/water pump, Semiscale pump, and the pump used for CE evaluation model, of which head multiplier values approach nearly 1.0 above the 30 % void fraction. Sensitivity studies were performed using the Byron-Jackson and the Semiscale pump data. These data are the representative pump data of each pump group. [

]TS

- Parameter; pump two-phase degradation multiplier
- [

]TS

5.1.5 Safety Injection System Related Parameters

Parameters associated with the safety injection system can be divided into SIT parameters and SIP parameters. SIT parameters include water volume, water temperature, and nitrogen gas pressure. SIP parameters include IRWST water temperature and injection flow rate.

[

]TS

- Parameter; [

]TS

- Parameter; [

]TS

- Parameter; [