RESPONSE TO AUDIT ISSUES

APR1400 Topical Reports

Korea Electric Power Corporation / Korea Hydro & Nuclear Power Co., LTD

Docket No. PROJ0782

Review 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**
Issue Date	**08/13/2015**

Audit Issues No. 57

The guidance in RG 1.157, Section 4 establishes acceptable controls for the estimation of uncertainties. Address the following regarding the pump degradation multiplier uncertainty in Section 5.1.4:

a. Explain and justify the pump degradation multiplier uncertainty.

b. The minimum (and therefore, the mean) value of the head and torque degradation multiplier provided in Section 5.1.4 is different from that listed in Table 5-1. In addition, the range of pump resistance in Table 5-1 and Appendix J (page J-2) is also inconsistent. Address these inconsistencies.

c. [

]TS Explain:

i. The inconsistency between the mean of zero and the lower and upper bounds of the uniform distribution.

ii. The application of the distribution provided in the topical report for the pump degradation multiplier.

Response

a)

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.

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

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

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. And pump degradation multiplier uncertainty ranges were determined based on the following findings of reference [11].

1) Figure 1 shows the variations of two phase head multiplier of CE pump by system pressure as shown in Figure 3.IV-9 of reference [11] in the topical report. In this figure, it can be found that two phase head multiplier widely varies by system pressure at the same void fraction.

2) Figure 2 shows two phase head multiplier variations of WEC 93A pump which is evaluated by SECY-83-472 method. In this figure, two phase head multiplier could have from 0.1 ~ 1.0 for almost of all void fraction ranges.

3) Table 1 shows standard deviations of two phase head multiplier presented in CSAU. The maximum standard deviation of two phase head multiplier is 0.319.

Based on the above findings, it was concluded that pump two head multiplier has uncertainty ranges from 0.0 to 1.0 in reference [11]. This range means that pump two head multiplier can

cover from fully degraded pump head to single phase pump head. Uniform distribution is assumed because experimental data are insufficient to quantify their uncertainties. Also, two phase torque multiplier is assumed to have the same behavior with two phase head multiplier because head and torque multipliers are applied using the same form of equation. Consequently, following uncertainties for the pump degradation multipliers were determined.

- Parameter: pump two-phase head multiplier

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- Parameter: pump two-phase torque multiplier

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b)

Those are typing errors in which the mean and the minimum values are swapped each other. Therefore the topical report will be corrected as follows.

- Parameter: pump two-phase degradation multiplier

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The values of pump resistance in Appendix J (page 2) are also incorrect. Therefore those will be corrected into the minimum and maximum values in Table 5-1 of the topical report as follows.

- Parameter: pump resistance (or pump K-factor)

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However, the correct pump degradation and resistance uncertainty ranges are used in the plant SRS calculations in Appendix J of the topical report.

c-i)

See response to audit issue number 57-b.

c-ii)

As previously mentioned in the response to audit issue number 57-b, the mean and the minimum values are swapped each other. However, the plant SRS calculations of the topical report used the correct pump degradation uncertainty ranges.

Table 1. The Uncertainty of Pump Two Phase Head Multiplier in the CSAU

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Figure 1. Two Phase Head Multiplier Variations of CE Pump by System Pressure

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Figure 2. Two Phase Head Multiplier Variation of WEC 93A Pump by Void Fraction

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 Report

Topical report will be revised as discussed in this response.

There is no impact on Technical or Environmental Report.

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. [

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- Parameter; pump two-phase degradation multiplier

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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.

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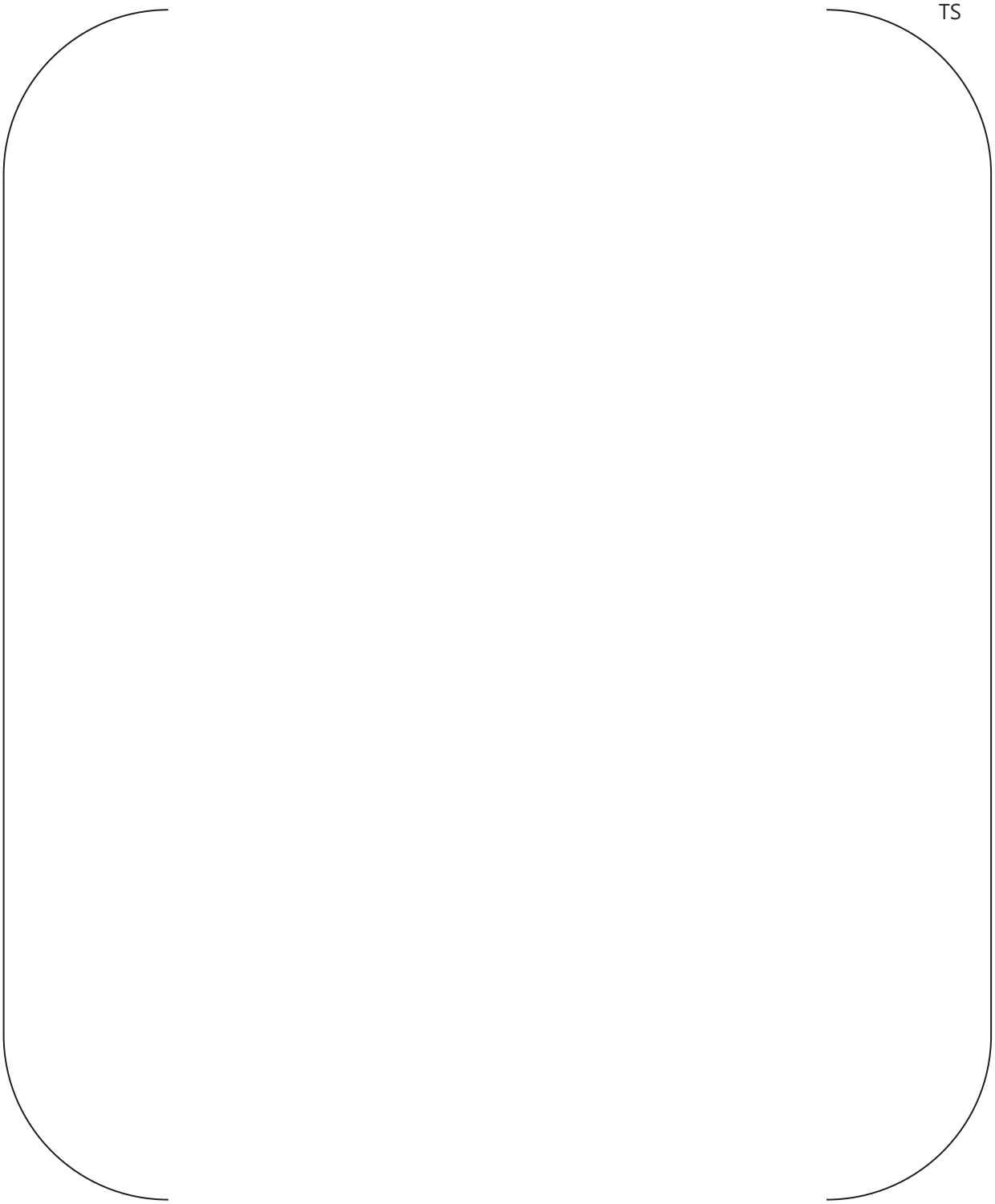
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