# RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

**APR1400 Design Certification**

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

**Docket No. 52-046**

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|---|---|
| **RAI No.:** | **318-8337** |
| **SRP Section:** | **15.06.05 – Loss of Coolant Accidents Resulting From Spectrum of Postulated Piping Breaks Within the Reactor Coolant Pressure Boundary** |
| **Application Section:** | **15.6.5** |
| **Date of RAI Issue:** | **11/24/2015** |

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## Question No. 15.06.05-2

**SBLOCA Break Spectrum Analysis & Core Two-Phase Level**

General Design Criterion (GDC) 35, "Emergency Core Cooling," in 10 CFR Part 50, Appendix A, mandates the requirements for the emergency core cooling system (ECCS) that need to be satisfied by conforming to the ECCS acceptance criteria for light-water reactors given in 10 CFR 50.46, "Acceptance Criteria for Emergency Core Cooling Systems for Light-water Nuclear Power Reactors." 10 CFR 50.46(b)(1) identifies the peak cladding temperature (PCT) requirement; and 10 CFR 50.46(b)(5) requires that after any calculated successful initial operation of the ECCS, the calculated core temperature shall be maintained at an acceptably low value and decay heat shall be removed for the extended period of time to prevent the core from being uncovered. These requirements, along with 10 CFR 50.46(a)(1), specify the need to calculate the ECCS cooling performance using an acceptable evaluation model for a number of postulated loss-of-coolant accidents (LOCAs) of different sizes, locations, and other properties sufficient to provide assurance that the most severe LOCAs have been evaluated.

The staff's review of the small-break LOCA (SBLOCA) analysis results presented in the APR1400 DCD Section 15.6.5, "Loss-of-Coolant Accidents Resulting from the Spectrum of Postulated Piping Breaks within the Reactor Coolant Pressure Boundary," and the referenced Technical Report (TeR) APR1400-F-A-NR-14001-P, Rev.0,"Small Break LOCA Evaluation Model," has raised three questions, as submitted in the current RAI.

The break spectrums presented in Table 15.6.5-10 of the DCD are insufficient to ensure that the limiting SBLOCA has been identified. Both the direct vessel injection (DVI) and the pump discharge leg (PDL) break spectrums show a trend of increasing PCT for decreasing break size. It is therefore possible that a break smaller than the smallest break analyzed could be more limiting. The SRP Section 15.6.5 notes that in the analysis of small breaks, evaluating integer diameter break sizes (i.e., 1, 2, 3, 4-inch, etc.) is considered insufficient to determine the worst break because the break areas associated with these integer diameters are too coarse to adequately identify the highest PCT. The applicant is requested to provide the results of a finer break spectrum for both the DVI line and PDL breaks to establish that the ECCS will function to meet acceptance criteria specified in 10 CFR 50.46. The results must include the PCT as well as the number of loop seals clearing for each SBLOCA break size in the following table.

| ID, in | A, $ft^2$ | A, $cm^2$ | ID, in | A, $ft^2$ | A, $cm^2$ |
|---|---|---|---|---|---|
| 0.5 | 0.0014 | 1.3 | 5.5 | 0.1650 | 153.3 |
| 1 | 0.0055 | 5.1 | 6 | 0.1963 | 182.4 |
| 1.5 | 0.0123 | 11.4 | 6.5 | 0.2304 | 214.1 |
| 2 | 0.0218 | 20.3 | 7 | 0.2673 | 248.3 |
| 2.5 | 0.0341 | 31.7 | 7.5 | 0.3068 | 285.0 |
| 3 | 0.0491 | 45.6 | 8 | 0.3491 | 324.3 |
| 3.5 | 0.0668 | 62.1 | 8.5 | 0.4006 | 372.2 |
| 4 | 0.0873 | 81.1 | 9 | 0.4418 | 410.4 |
| 4.5 | 0.1104 | 102.6 | 9.5 | 0.4922 | 457.3 |
| 5 | 0.1364 | 126.7 | 10 | 0.5454 | 506.7 |

## Response

According to the proposed finder break size table, the dense break spectrum analysis for small break LOCA of APR1400 are performed for the DVI line break and PDL break. The results of dense break spectrum are shown in the Table 8337-1~3 and Figure 8337-1~33, respectively.

Table 8337-1 Summary of DVI line break spectrum analysis results

TS

Non-Proprietary



Table 8337-2 Summary of Pump Discharge Leg break spectrum analysis results

TS

Table 8337-3 Summary of evaluation results for minimum break sizes

TS

Figure 8337-1 DVI Line Break - 0.0123 $ft^2$

Non-Proprietary



TS

Figure 8337-2 DVI Line Break - 0.0218 $ft^2$

TS

Figure 8337-3 DVI Line Break - 0.0341 $ft^2$

Figure 8337-4 DVI Line Break - 0.0491 $ft^2$

Figure 8337-5 DVI Line Break - 0.0668 $ft^2$

TS

Figure 8337-6 DVI Line Break - 0.0873 $ft^2$

Figure 8337-7 DVI Line Break - 0.1104 $ft^2$

TS

Figure 8337-8 DVI Line Break - 0.1364 $ft^2$

Figure 8337-9 DVI Line Break - 0.1650 $ft^2$

Figure 8337-10 DVI Line Break - 0.1963 $ft^2$

Figure 8337-11 DVI Line Break - 0.2304 $ft^2$

Non-Proprietary



TS

Figure 8337-12 DVI Line Break - 0.2673 $ft^2$

Figure 8337-13 DVI Line Break - 0.3068 $ft^2$

Non-Proprietary



TS

Figure 8337-14 DVI Line Break - 0.3491 $ft^2$

TS

Figure 8337-15 DVI Line Break - 0.4006 $ft^2$

**Non-Proprietary**



TS

Figure 8337-16 PDL Break - 0.0218 $ft^2$

Figure 8337-17 PDL Break - 0.0341 $ft^2$

Figure 8337-18 PDL Break - 0.0491 $ft^2$

Figure 8337-19 PDL Break - 0.0668 $ft^2$

TS

Figure 8337-20 PDL Break - 0.0873 $ft^2$

TS

Figure 8337-21 PDL Break - 0.1104 $ft^2$

TS

Figure 8337-22 PDL Break - 0.1364 $ft^2$

Figure 8337-23 PDL Break - 0.1650 $ft^2$

TS

Figure 8337-24 PDL Break - 0.1963 $ft^2$

Non-Proprietary



Figure 8337-25 PDL Break - 0.2304 $ft^2$

TS

Figure 8337-26 PDL Break - 0.2673 $ft^2$

Figure 8337-27 PDL Break - 0.3068 $ft^2$

Figure 8337-28 PDL Break - 0.3491 $ft^2$

TS

Figure 8337-29 PDL Break - 0.4006 $ft^2$

TS

Figure 8337-30 PDL Break - 0.4418 $ft^2$

TS

Figure 8337-31 PDL Break - 0.4922 $ft^2$

Figure 8337-32 PDL Break - 0.5454 $ft^2$

TS

Figure 8337-33 Peak Cladding Temperature vs. Break Size

**Impact on DCD**

There is an 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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## Question No. 15.06.05-4

General Design Criterion (GDC) 35, "Emergency Core Cooling," in 10 CFR Part 50, Appendix A, mandates the requirements for the emergency core cooling system (ECCS) that need to be satisfied by conforming to the ECCS acceptance criteria for light-water reactors given in 10 CFR 50.46, "Acceptance Criteria for Emergency Core Cooling Systems for Light-water Nuclear Power Reactors." 10 CFR 50.46(b)(1) identifies the peak cladding temperature (PCT) requirement; and 10 CFR 50.46(b)(5) requires that after any calculated successful initial operation of the ECCS, the calculated core temperature shall be maintained at an acceptably low value and decay heat shall be removed for the extended period of time to prevent the core from being uncovered. These requirements, along with 10 CFR 50.46(a)(1), specify the need to calculate the ECCS cooling performance using an acceptable evaluation model for a number of postulated loss-of-coolant accidents (LOCAs) of different sizes, locations, and other properties sufficient to provide assurance that the most severe LOCAs have been evaluated.

The SRP Section 15.6.5 analytical procedures that the staff uses to establish that the ECCS will function to meet acceptance criteria specified in 10 CFR 50.46, emphasize that the cladding temperature be reduced to near the saturation temperature. However, for several of the break sizes shown in DCD Section 15.6.5 the cladding temperature is more than 100oC higher than the saturation temperature when the calculation is terminated. The applicant is requested to provide the results of all break sizes in the above table out to the time when the cladding temperatures approach the saturation temperature, in order to address the staff concerns about potential core reheating. The applicant is also requested to update the DCD and the TeR as appropriate to ensure that the analysis method and results are documented.

## Response

Generally, in order to prevent potential core reheating after SBLOCA or in order to determine the SBLOCA transient termination criteria, the five categories should be checked as follows:

- The core mixture level should have recovered a level above the active fuel.
- The total SI flow should be greater than the total break flow.
- The system pressure should be steadily decreasing or have leveled off to an acceptable pressure.
- The hot rod clad temperatures at all axial elevations should have reached a maximum value less than 2200°F, be steadily decreasing or leveled off, and have reached a temperature low enough to preclude further oxidation at the end of the transient.
- The hot rod local oxidation at all axial elevations should have leveled off to a value of less than 17% by the end of the transient.

As shown in the figures of RAI 8337-2 responses, the core mixture level has completely recovered, the SI flow is greater than the break flow, and the RCS system pressure has leveled off or the RCS system pressure slowly decreases at the same time when SI flow is greater than break flow. By the end of the transient, the hot rod cladding temperatures for the elevations of interest have reached their maximums (less than 2200°F), are rapidly decreasing, and the hot rod temperature is steadily decreased.

Since all of SBLOCA transient termination criteria are met, it is determined that the total analysis results of SBLOCA dense break spectrum display acceptable transient termination.

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**Impact on DCD**

There is an 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.