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.:	**324-8362**
SRP Section:	**06.02.01.04 – Mass and Energy Release Analysis for Postulated Secondary System Pipe Ruptures**
Application Section:	**6.2.1.4**
Date of RAI Issue:	**12/02/2015**

Question No. 06.02.01.04-1

General Design Criteria (GDC) 50, "Containment design basis", and GDC 16, "Containment design", of Appendix A to 10 CFR Part 50 require, in part, that the reactor containment structure and associated heat removal system shall be designed with sufficient margin to accommodate the calculated pressure and temperature conditions resulting from any loss-of-coolant accident (LOCA). NUREG-0800, SRP Section 6.2.1.1A, Acceptance Criterion No. 1 specifies that the containment design pressure should provide at least a 10% margin above the accepted peak calculated containment pressure following a loss-of-coolant accident, a main steam line break (MSLB), or a main feedwater line break (MFLB), to satisfy the GDC 16 and 50 requirements for sufficient design margin. In addition, ANSI/ANS 56.4-1983, which has established detailed guidelines for containment response to design basis accidents (DBAs), specifies that initial conditions should be chosen to yield a conservatively high peak containment atmosphere pressure and temperature. These guidance documents ensure sufficient conservatism in the mass and energy release analysis for the postulated primary and secondary system pipe ruptures during the DBA such that the reactor containment structure and heat removal system design can accommodate the calculated peak pressure and temperature conditions.

In this backdrop, the staff seeks the following additional information to gain safety insights into the initial and boundary conditions the applicant used for the limiting MSLB analysis for the containment. The applicant is also requested to update the APR1400 DCD and/or the Technical Report (TeR), "LOCA Mass and Energy Release Methodology", APR1400-Z-A-NR-14007-P, Rev.0, to appropriately document the respective explanations.

Following the acceptance criteria, the limiting single failure MSLB analysis is based on two assumptions:

(1) maximizing the flow of saturated and superheated steam out of the break; and (2) minimizing the rate of heat removal from the containment atmosphere. Since the APR1400 containment response analysis does not credit any fan coolers, the latter assumption is accomplished by not crediting the containment spray system (CSS). The former assumption

can be based on any one of the several possible single failures including the failure of condensate booster pump to trip, FRV (Feedwater Regulating Valve) to close, or MSIV (Main Steam Isolation Valve) to shut. The APR1400 MSLB analysis has considered the CSS and MSIV single failures to see which one is conservative. The applicant is requested to clarify whether the single failure of the feedwater regulating valve to close was also examined. The staff is concerned that during the time the feedwater bypass valve takes to shut the flow, considerable amount of feedwater may enter the steam generator, gain heat from the hot primary-side, and the resulting additional steam would enter the containment to further increase the containment peak pressure and, especially, the peak temperature. Please demonstrate that the current limiting MSLB analysis is bounding for all possible single failures.

Response

• For added clarity regarding the initial conditions of the limiting main steam line break (MSLB), DCD Tier 2, Section 6.2.1.4.4 and Table 6.2.1-20 will be revised to state the maximum feedwater enthalpy is assumed in the analysis and provide the pressurizer pressure, respectively.

• The FCV (Feedwater Control Valve) is conservatively assumed to be wide-open in order to deliver the maximum feedwater flow to the affected steam generator in the MSLB analysis. There are two MFIVs in series in each main feedwater line. If one MFIV fails, the second MFIV provides isolation. The single failure of the MFIVs in the main feedwater line is not needed. The feedwater bypass control valve (FBCV) is a non-safety related, and normally closed, valve. The FBCV is used for the steam generator initial filling condition by operators. The FBCV is not designed to receive any automatic actuation signal. Therefore, the single failure of the FBCV is not considered for the MSLB analysis.

In conclusion, the single failure of these components has not been considered for the MSLB analysis, and the current limiting MSLB analysis is bounding for all possible single failures.

Impact on DCD

DCD Section 6.2.1.4.4 and Table 6.2.1-20 will be revised, as indicated in the attachment associated with this response.

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.

Steam line capacity is modeled by performing mass, energy, and volume balances on a steam line node. Figure 6.2.1-37 shows the flow paths into and out of the steam line node. The mass, energy, and volume balances for the steam line node are as follows:

$$\dot{M} = \sum \dot{m}$$

$$\dot{E} = \sum \dot{m} h$$

$$\dot{V} = 0$$

Where:

$\sum \dot{m} = \dot{m}_1 + \dot{m}_2 + \dot{m}_4 - \dot{m}_B - \dot{m}_T$ for slot breaks

$\sum \dot{m} = \dot{m}_1 + \dot{m}_2 - \dot{m}_T - \dot{m}_{B2}$ for guillotine breaks (see Figure 6.2.1-37 for subscript definition)

The break flow rate is obtained from the Moody critical flow model for zero flow resistance according to NUREG-0800, Section 6.2.1.4.

The contribution to the containment pressure of the feedwater flow is handled by a feedwater flow addition to the affected steam generator and the boiling off of the feedwater by a primary-to-secondary heat transfer. The feedwater flow is the sum of the pumped feedwater flow before isolation plus the expansion of the fluid in the feedwater line between the affected steam generator and its MFIV. The feedwater flow pumped to the affected steam generator is conservatively modeled as 165 percent of the full-power feedwater flow for the 102 percent and 75 percent power cases, 110 percent of the full-power feedwater for the 50 percent power case, and 55 percent of the full-power feedwater for the 20 percent and 0 percent power cases to account for spiking. No degradation of the feedwater flow occurs until the closure of the MFIVs. [The maximum feedwater enthalpy is assumed.] For consistency, no feedwater is added to the unaffected steam generator.

Following closure of the MFIVs, there is an inventory of feedwater between the MFIVs and the affected steam generator. As the affected steam generator depressurizes, this inventory starts to boil. As steam in the line expands, this feedwater inventory is pushed into the steam generator and is boiled off by primary-to-secondary heat transfer. The expansion of the feedwater inventory into the affected steam generator is considered in the analysis. The expansion is assumed to be isentropic.

Table 6.2.1-20 (1 of 2)

Initial Conditions for Containment Peak Pressure and Temperature Analysis

Part A. Reactor Coolant Systems (Based on a nominal core power of 3,983 MWt)

Parameter	Value
Reactor Coolant System	
Reactor power level (1), MWt	4,091.86
Pressurizer pressure, 10^6 Pa (psia)	16.030 (2325)
Average coolant temperature, °C (°F)	312.45 (594.4)
Mass of reactor coolant system liquid, kg (lbm)	304,767.84 (671,898.0)
Mass of reactor coolant system steam, kg (lbm)	3,025.05 (6,669.1)
Energy in Reactor coolant system liquid plus steam (2), 10^6 kcal (10^6 Btu)	103.04 (408.91)
Energy from feedwater nozzle to MSIV per Steam Generator (2), 10^6 kcal (10^6 Btu)	33.047 (131.14)

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.:	**324-8362**
SRP Section:	**06.02.01.04 – Mass and Energy Release Analysis for Postulated Secondary System Pipe Ruptures**
Application Section:	**6.2.1.4**
Date of RAI Issue:	**12/02/2015**

Question No. 06.02.01.04-2

Double-ended pipe breaks could be of the guillotine type or the slot type breaks. Typically, double-ended slot breaks and double-ended guillotine breaks are most severe pipe breaks for LOCA and MSLB, respectively. Please clarify the type of break (guillotine versus slot) that was used in the analysis of APR1400 to produce the MSLB mass and energy release for the containment, and explain how it was concluded to be the most conservative secondary pipe rupture.

Response

• In DCD Tier 2, Section 6.2.1.4, the slot type break is considered for all MSLB analyses.

TS

Table 1. Comparison of Containment Peak Pressures for Slot and Guillotine Break

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.