SBLOCA Mass and Energy Release Analysis for Kori 3&4 EQ

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1. Introduction

Recently, Kori 3&4 have finished the power up-rating of 4.5%. According to the new Korean nuclear enforcement regulations for operating nuclear plants, periodic safety review (PSR), it is necessary to analyze mass and energy (M/E) release on small break loss-of-coolant accident (SBLOCA) for the equipment environmental qualification (EEQ) [1].

This paper provides the acceptability of the new methodology of SBLOCA M/E release analysis for the environmental qualification of equipment and the results for Kori nuclear power plant units 3&4 (Kori 3&4).

The acceptability is assessed by comparing the SBLOCA M/E results for Kori 3&4 with those of Kori 2.

2. Analysis Methodology

The new methodology of SBLOCA M/E release analysis for EEQ developed by KOPEC uses the unified computer code system [2] like KREM which couples RELAP5/MOD3.1K and CONTEMPT4/MOD5. The new code system used in the M/E analysis was developed by introducing the special conservative thermal-hydraulic model and adding the conservative long-term model after LOCA. Therefore, this new code system predicts thermal hydraulic behaviors more realistically by coupling the M/E release data and the containment back pressure simultaneously. In addition, the separate and simplified boil-off model is applied for the long-term thermal-hydraulic behavior.

3. Analysis Results

3.1 Plant Overview

Kori 3&4 are designed as the 1000 MWe Westinghouse standard 3-loop plants with complicated safety injection. The safety injection system consists of the accumulator, high pressure (charging pump) and low pressure (RHR pump) safety injection pumps. During the long-term recirculation after safety injection phase, the RHR (LPSI) pumps inject the coolant from the containment sump to the cold leg through the heat exchanger. Figure 1 shows the RELAP5/MOD3 nodal scheme for SBLOCA for Kori 3&4 with SI paths.

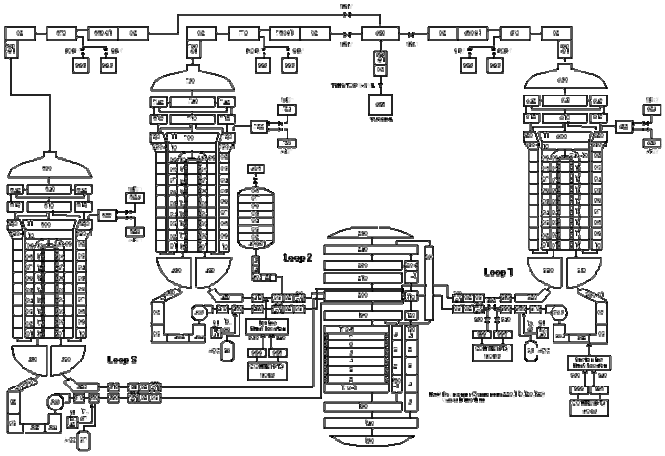

Figure 1 RELAP5/MOD3 Nodal Scheme for SBLOCA M/E

3.2 Initial Conditions and Major Assumptions

The major assumptions and initial conditions for the conservative M/E release are used such as 102% core power, volume increase in 3%, stored energy increase in core metal by 20%, 17% metal-water reaction during a LOCA, 0% U tube plugging and conservative uncertainty of operating parameters.

The plant initial conditions and assumptions used in the SBLOCA M/E release analysis are provided in Table 1 which shows both Kori 3&4 and Kori 2 [3, 4]. To increase M/E release, CONTEMPT4 input has the conditions keeping the minimum containment back pressure

Table 1 Plant Initial Conditions and Assumptions

Plant Parameters	Kori 3,4	Kori 2
Thermal Power (MWt)	2900 * 1.02 = 2958	1876 * 1.02 = 1913.5
Pressurizer Press (bar, psia)	158.924, 2305	158.58, 2300
Pressurizer Level (%)	62.0	69.0
RCS Flowrate (kg/sec)	4443.5 x 3	8952.15
Core Bypass Flow (%)	6.7	4.4
Avg. RCS Temp (K, °F)	585.5, 594.3	580.0, 584.6
SG Press (bar, psia)	65.43, 949	63.43, 920
SG Level (m)	12.93	12.91
SG Steam Flowrate (kg/sec)	567.0	525.0
Feedwater Temp (K, °F)	503.0, 445.9	494.3, 430.3
Net Free Volume (m^3, ft^3)	58899($2.08x10^6$)	40776($1.44x10^6$)

3.3 M/E Release Analysis

Kori 3&4 SBLOCA M/E analysis for EEQ is accomplished using the results of sensitivity studies for Kori 2 [4]. The sensitivity studies include the assumptions (increased initial core metal energy and metal-water reaction), containment back pressure conditions (P/T case; input for maximum containment pressure and temperature analysis, and BP case; input for minimum containment back pressure analysis) and the break size and locations. The metal-water reaction between the cladding and the coolant has negligible effect for M/E release due to the low clad temperature during SBLCOA. The BP case produced more M/E release due to the lower containment back pressure.

To increase M/E release during the transient, increased initial core metal energy, BP case input for CONTEMPT4 and metal-water reaction are used.

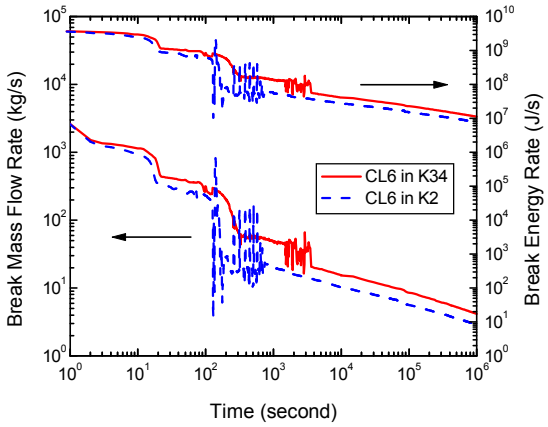

Figure 2 Comparisons of M/E Release for 6 in. CLB

Figure 2 illustrates the comparison of M/E release rates of 6 inch RCP discharge leg break(CLB) for Kori 3&4 and Kori 2. The results of Kori 3&4 show high M/E release during transients. The reason is that the thermal power and RCS flowrate (inventory) of Kori 3&4 is about 1.5 times higher than Kori 2 as shown in Table 1. However, the trend of release rate is similar to both cases. Also the difference of integral M/E at 10^6 second is about 1.5 times each other in Table 2.

Thus the M/E release calculation for Kori 3&4 using the new methodology for SBLOCA M/E release analysis is considered to be reasonable.

Table 2 Comparison of integral M/E for 6 inch CLB

Parameters	Kori 3,4	Kori 2
Integral Mass (kg)	6.162 x10^6	4.388 x10^6
Integral Energy (J)	1.654 x10^{13}	1.127 x10^{13}

The Kori 3&4 M/E release rates depending on the break size for RCP discharge leg break are shown on Figure 3. In the early period, M/E release rates decrease as the break sizes are decreasing, and the time is passing. After EOPR(end of post-recovery), M/E release rate is similar for all cases. The long-term M/E release during SBLOCA has little impact on the break size.

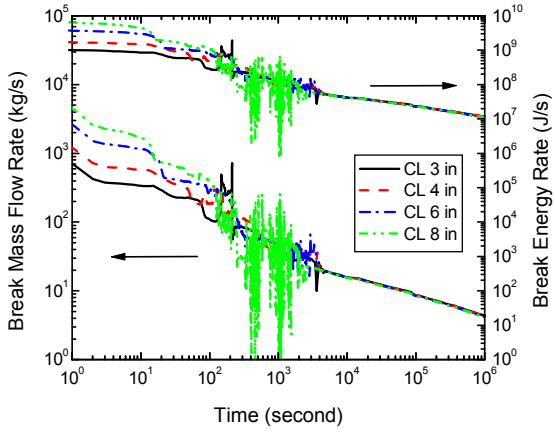

Figure 3 Break M/E Release Rate of CLB

4. Conclusion

The new M/E release methodology is applied for Kori 3&4 M/E analysis of Westinghouse type plant. The acceptability is assured by comparing the SBLOCA M/E release rate for Kori 3&4 with Kori 2. Like Kori 2, the SBLOCA M/E release rates during the long-term cooling period provided same results independent of the break size.

The SBLOCA M/E release data are to be provided for the containment pressure and temperature analysis in order to create the EQ envelope curves for Kori 3&4.

References

[1] Atomic Energy Laws for PSR, item 23.3, 2001 and MOST Notice 2002-5.
[2] C. W. Kim et al., "Development of LOCA M/E Release Analysis Methodology for Equipment Qualification," 2004 Autumn Conference, KNS, 2004.
[3] Kori-3&4 FSAR, KEPCO.
[4] C. W. Kim et al., "SBLOCA M/E Release Analysis for EEQ of Kori 2," 2005 Autumn Conference, KNS, 2005.