

SBLOCA Mass and Energy Release Analysis for EEQ of Kori 2

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1. Introduction

According to the new Korean nuclear enforcement regulations for operating nuclear plants, periodic safety review (PSR), the preliminary review for the nuclear power plants operating in Korea showed that it is additionally necessary to analyze mass and energy (M/E) release on small break loss-of-coolant accident (SBLOCA) for the environmental qualification of equipment (EEQ) [1, 2].

The present paper provides the acceptability of the new methodology of SBLOCA M/E release analysis for environmental qualification of equipment and the results for Kori nuclear power plant unit 2 (Kori 2).

It is provided that the applicability of the SBLOCA M/E release analysis methodology for EEQ is feasible and the resultant SBLOCA mass and energy release data are acceptable for the containment pressure-temperature (P-T) profile based on the Westinghouse standard EEQ curve (WCAP-8587) [3].

2. Analysis Methodology

The new methodology of SBLOCA M/E release analysis for EEQ developed by KOPEC uses the unified computer codes system [1] like KREM which couples RELAP5/MOD3.1K and CONTEMPT4/MOD5. The new codes 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 from KREM. Therefore this new codes system predicts the thermal hydraulic behavior 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.

The containment pressure and temperature (P/T) analyses are performed using the M/E release data provided by the above method. CONTEMPT-LT-028 computer code is used to evaluate the containment P/T behavior.

3. Analysis Results

3.1 Plant Overview

Kori 2 is designed as the 600 MWe Westinghouse standard 2-loop plant with complicated safety injection. The safety injection system consists of the accumulator, high pressure and low pressure safety injection pumps. During the long-term recirculation after safety injection phase, the RHR (LPSI) pumps inject the coolant from the containment sump through the heat exchanger with boosting of the HPSI pumps to the cold leg and RV down comer. Figure 1 showed the RELAP5/MOD3 nodal scheme for SBLOCA for Kori 2 with SI paths.

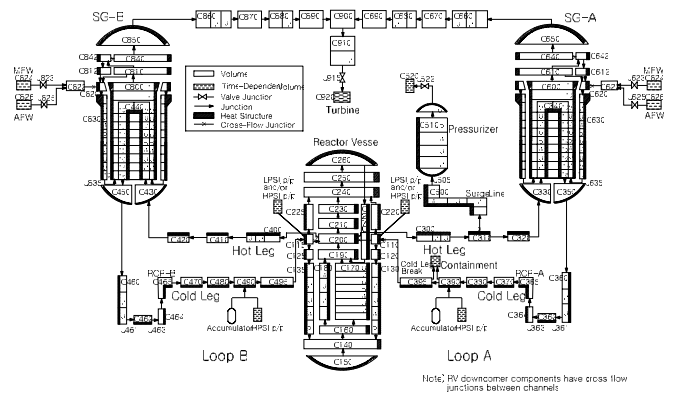


Figure 1 RELAP5/MOD3 Nodal Scheme for SBLOCA M/E

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 containment initial conditions and assumptions used in the SBLOCA M/E release analysis are provided in Table 1 for the P/T case (input for the containment P/T analysis) and BP case (input for the min. containment back pressure analysis), respectively. The P/T case assumes the minimum heat sink similar to the input for the containment peak pressure and temperature analysis. On the other hand, the BP case assumes the maximum heat sink data as in the minimum containment back pressure analysis for LOCA peak clad temperature analysis.

3.3 M/E Release and Containment P/T

Table 1 Containment Initial Conditions and Assumptions used in SBLOCA

Parameters	Value	
	P/T case	BP case
Net free volume, ft ³	1.44x10 ⁶	1.504x10 ⁶
Initial temperature, °F	120	50
Initial pressure, psia	15.7	14.7
Initial relative humidity, %	30	100
Initial ambient temperature, °F	120	-8.6
Initial ambient pressure, psia	14.7	14.7
Outside wall HTC, Btu/hr-°F-ft ²	0	13
Spray initiation, Setpoint & delay time	24.4 psig 94.4 sec	23 psig 74.4 sec
Spray flow rate, gpm	1064	1185 X 2 units
Spray temperature, °F	120 *	50
No. of fan cooler cooling units	1	4

Kori 2 SBLOCA M/E analysis for EEQ was performed with sensitivity studies with respect to the assumptions (increased initial core metal energy and metal-water reaction), containment back pressure condition (P/T case and BP case) and the break size and locations.

The increases initial core metal energy provided more M/E release and thus a little conservative results in the containment P/T. However, the metal-water reaction between the cladding and the coolant during a SBLOCA has negligible impact on the containment P/T results due to the low clad temperature during SBLOCA. The assumptions in the final calculation used the increased core energy and the metal-water reaction for conservatism.

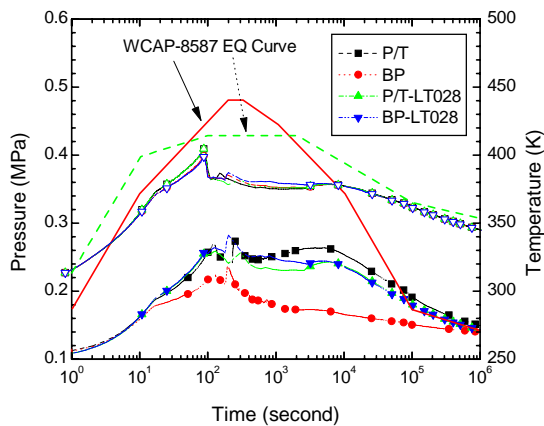


Figure 2 Comparisons of P/T and BP for 6 in. CLB

For the containment back pressure condition, the BP case produced more M/E release due to the lower back pressure. And the containment back pressure of BP case provided lower P/T than that of the P/T case (Figure 2). However, as shown in Figure 2, the resultant containment

P/T behaviors calculated by CONTEMPT-LT028 are very similar except the reflood and post-reflood periods. Also, the containment P/T behavior of P/T case of RELAP5K (RELAP5/MOD3 + CONTEMPT4 with LT model) produced higher P/T than those of CONTEMPT-028. This demonstrates the containment P/T of the new M/E methodology can be used for the containment P/T analysis for EEQ.

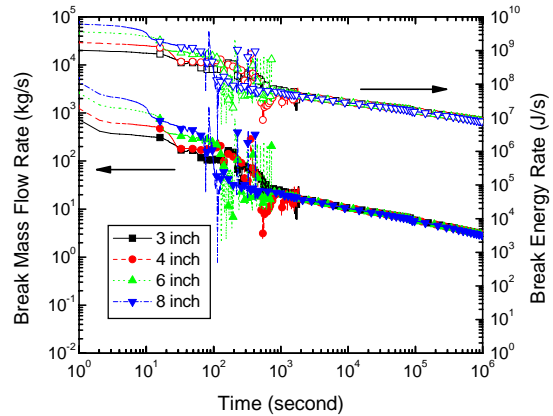


Figure 3 Break M/E Release Rate of CLB

The M/E release rate depending on the break size for 6 inch RCP discharge leg break are shown on Figure 3. The long-term M/E release during SBLOCA has little impact on the break size. And the containment back pressure calculated from RELAP5K provided in a similar result independent of break size.

4. Conclusion

A new M/E release methodology produced no reflood peak containment P/T unlike the previous method. Also, the M/E release rate and containment P/T during the long-term cooling period provided same results independent of the break size.

The applicability to SBLOCA of the new LOCA M/E release analysis methodology for EEQ is feasible and the WCAP-8587 standard EEQ curves are acceptable for the long-term cooling during SBLOCA for Kori 2.

References

- [1] C. W. Kim et al., "Development of LOCA M/E Release Analysis Methodology for Equipment Qualification," 2004 Autumn Conference, KNS, 2004.
- [2] H. R. Choi, C. W. Kim, et al., "Mass and Energy Release Analysis on Small Break LOCA for Environmental Equipment Qualification of Kori NPP Unit 1," 2003 Autumn Conference, KNS, 10.30-10.31, 2003.
- [3] Kori-2 FSAR, KEPCO.