Application of KIMERA Methodology to Kori 3&4 LBLOCA M/E Release Analysis

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1. Introduction

A new mass and energy (M/E) release analysis methodology called KIMERA (KOPEC Improved Mass and Energy Release Analysis) has been developed [1]. This is a realistic evaluation methodology of the M/E release analysis for the containment design and is applicable to a LOCA and a main steam line break (MSLB) accident. This KIMERA methodology has the same engine as KREM (KEPRI Realistic Evaluation Model) [2] which is the realistic evaluation methodology for LOCA peak clad temperature analysis. This methodology also has several supplementary conservative models for the M/E release such as break spillage model and multiplier on heat transfer coefficient (HTC).

For estimating the applicability of the KIMERA methodology to the licensing analysis, the large break LOCA(LBLOCA) M/E analysis was performed for UCN 3&4 which is the typical plant of OPR1000 type [3]. The results showed that the peak pressure and temperature occurred earlier and had lower values than those of UCN 3&4 FSAR. The KIMERA methodology takes off the over-conservatism from the FSAR results during the post-blowdown period for the large break LOCA and provides more margin in containment design.

In this study, the LBLOCA M/E analysis using the KIMERA methodology is to be performed for Kori 3&4 which is the typical plant of Westinghouse type. The results are compared with those of the Kori Nuclear Unit 3&4 FSAR [4].

2. Analysis Method

The computer code used in the hydraulic behavior of the RCS is RELAP5K which adopts enhanced M/E models based on RELAP5/MOD3.1/K and the containment back pressure calculation is performed using CONTEMPT4/MOD5, which is coupled with the RELAP5K. The code calculation process is performed interactively between the two codes.

Major models and assumptions of the KIMERA methodology for M/E release analysis for Kori 3&4 are the same as those of Reference [3] and [4]. Principle items are as follows:

- The major concern of the analysis is to investigate the containment peak pressure until the end-of-post-reflood (EOPR).
- The containment back pressure at each time step is calculated in CONTEMPT4 code and transferred to RELAP5K as a boundary condition, whereas in FSAR analysis, the back pressure is initially assumed and assumed to be constant throughout the transient.
- The initial conditions of the plant parameters are selected within the plant operating range.
- The conservatisms of the plant parameters are based on the parameter sensitivity study of UCN 3&4 M/E analysis using KIMERA [3].
- The design data for input is based on those of Kori 3&4 Power Up-rated design.
- The sensitivity parameters in this study : Discharge leg break, Suction leg break, Hot leg break and maximum/minimum SI flow for each break case.

The major initial conditions of Kori 3&4 LOCA M/E analysis are summarized in Table 1.

Table 1. Initial Conditions for M/E Analysis

Plant Parameter	Direction
Core Power	102% Power
PZR Pressure	Max.
PZR Level	Max.
RCS Flow	Min.
Cold Leg Temperature	Max.
SG Level	Max.
Feedwater Temperature	Max.

3. Analysis Results

The sensitivity parameters in this study are ‘Break Location’ and ‘SI flow’. The results of the sensitivity study for these parameters are provided in Table 2. The results are compared with those of Kori 3&4 FSAR analysis and Kori 3&4 Power Up-rated analysis.

In all the cases, the containment pressure has reached the peak during the blowdown period and the safety injection pump starts after the end-of-blowdown. Though the maximum safety injection flow may have conservative effects on the containment P/T in the long-term basis, it has little effects on the peak pressure during the blowdown period.

The results of break location sensitivity show a remarkable difference in the limiting case comparing with the FSAR results. The hot leg break case has the highest

peak pressure during the blowdown period, which is the limiting case in KIMERA analysis, whereas suction leg break case is the limiting case with late peak during post-blowdown period in FSAR analysis. However, in Kori 3&4 Power Up-rated analysis, the peak time of the suction leg break case is changed to the early peak in the blowdown period and the peak value was decreased, which is not the limiting case any more. The limiting case is the hot leg break case like the results of KIMERA analysis. The comparison of the peak values in the blowdown period shows that the KIMERA analysis yields the most conservative results.

In the similar condition of peak pressure occurrence during the blowdown period, the determination of the limiting case is dependent on the high pressure and high enthalpy of the break flow.

The resultant containment P/T responses of suction leg break with maximum SI flow case are provided in Figure 1 by comparing with the results of the Kori 3&4 Power Up-rated analysis. The comparison shows that the P/T of KIMERA have similar behavior to that of Kori 3&4 Power Up-rated and the peak value is a little higher than that of Kori 3&4 Power Up-rated. For UCN 3&4 calculation [3], the P/T of KIMERA had much different behavior from that of FSAR and the peak value was much lower than that of FSAR. Though KIMERA methodology has taken off much over-conservatism from the UCN 3&4 FSAR results, it still has more conservatism than the Kori 3&4 FSAR or Power Up-rated analysis has. The containment pressure and temperature in all the cases of KIMERA have much margin to the envelope curves as shown in Figure 1.

Table 2. Comparison of LOCA P/T Results

	DEDL max ECCS	DEDL min ECCS	DESL max ECCS	DESL min ECCS	DEHL max ECCS	DEHL min ECCS
Kori 3&4 FSAR						
Pressure, psig @sec	36.8 @ 13.0		**40.5** @150	38.4 @152	39.5 @ 13.1	
Temp., F @sec	306 @ 152.0		**326** @150	316 @152	264 @ 13.1	
Kori 3&4 Power Uprated						
Pressure, psig @sec	NA		36.7 @15.9	36.7 @15.9	**38.9** @ 15.9	
Temp., F @sec	NA		257 @15.9	257 @15.9	**262** @ 16.4	
KIMERA						
Pressure, psig @sec	39.94 @18.6	40.07 @18.6	37.75 @ 19.4	38.06 @19.6	40.98 @19.2	**41.20** @18.8
Temp., F @sec	262.6 F @18.6	262.8 @18.6	259.0 @21.0	258.86 @19.6	**264.76** @17.2	264.7 @18.2

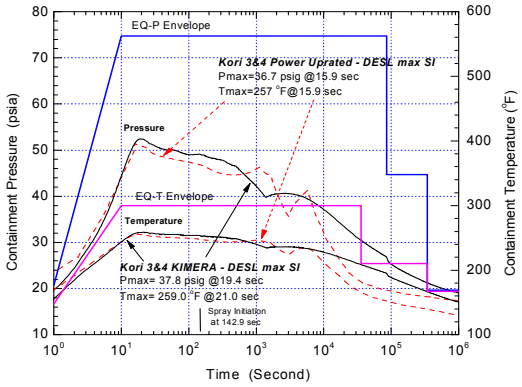

Figure 1. Containment P/T Responses for LOCA

4. Conclusion

The resultant containment P/T values are a little higher than those of Kori 3&4 FSAR or Kori 3&4 Power Up-rated analysis. The blowdown M/E model of KIMERA methodology is determined to be more conservative than that of Kori 3&4 FSAR or Power Up-rated analysis.

The containment pressure for the post-blowdown period has no distinct second peak, while the containment pressure of Kori 3&4 FSAR or Kori 3&4 Power Up-rated analysis has the second peak during the post-blowdown period, which is lower than the first peak. This is due to the over-conservative and non-physical M/E release model of the post-blowdown period in FSAR. The realistic model of improved methodology provides a peak P/T during the blowdown period.

The results of break location sensitivity study show that the limiting case is hot leg break case unlike suction leg break case in FSAR. The values of peak P/T are a little higher than those in FSAR or Power-Up-rated analysis. However, the peak value still has much margin to the design limit. This margin can be used for the optimization of the containment design.

In conclusion, the proposed improved methodology for M/E release analysis, KIMERA using the realistic evaluation code is applicable to the licensing analysis of LBLOCA M/E release for the Westinghouse type plant.

References

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