Improved Methodology of MSLB M/E Release Analysis for OPR1000

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1. Introduction

A new mass and energy (M/E) release analysis methodology for the equipment environmental qualification (EEQ) on loss-of-coolant accident (LOCA) has been recently developed [1] and adopted on small break LOCA EEQ [2, 3]. The new methodology for the M/E release analysis is extended to the M/E release analysis for the containment design for large break LOCA and the main steam line break (MSLB) accident, and named KIMERA (KOPEC Improved Mass and Energy Release Analysis) methodology [4].

The computer code systems used in this methodology is RELAP5K/CONTEMPT4 (or RELAP5-ME) which couples RELAP5/MOD3.1/K with enhanced M/E model and LOCA long term model, and CONTEMPT4/ MOD5.

This KIMERA methodology is applied to the MSLB M/E release analysis to evaluate the validation of KIMERA methodology for MSLB in containment design. The results are compared with the OPR 1000 FSAR [5].

2. Analysis Methodology

The major assumptions used in the KIMERA for MSLB M/E release analysis are as follows:

- Conservative approach for the major thermal hydraulic model is performed using the multiplier on HTC, and interfacial area for the enhanced M/E release.
- The MSIVs are closed in 5.0 seconds and the MFIVSs are closed in 10.0 seconds.
- Auxiliary feedwater flow to the affected steam generator is assumed.
- The turbine stop valve is closed at 0 second for conservatism.
- The limiting break size and reactor power for MSLB are used.
- The operating conditions and parameters including containment parameters are assumed to provide the limiting results with respect to the containment peak pressure.
- The feedwater flow to the affected steam generator is conservatively modeled as 130% of total feedwater flow for the 102%, 75%, and 50% power and 65% of total feedwater flow for the 20% and 0% power cases.

The sensitivity studies for the initial power and discharge coefficient of the break flow were performed. To determine the limiting break size, sensitivity for Cd is performed.

3. Comparison of the Results

The major assumptions provided in the previous section and initial conditions are the same as those used in the UCN 3&4 FSAR analyses except for turbine stop logic such as maximum core inlet temperature and pressurizer pressure, maximum steam header and feedwater line volume, minimum steam line K-factor, etc.

Various power levels and break size spectrum analyses are performed for MSLB M/E release analysis for UCN 3&4. Single failures are MSIV failure and Loss of Containment Cooling (LCC). The initial steam generator (SG) pressure for 50% of core power is assumed as 1180 psia whereas 1112 psia in FSAR. The 50% of core power with the medium size break (Cd=0.4) which is a little larger than the steam nozzle throat area is determined as the limiting condition. This break size is much smaller than that assumed in FSAR, but similar to the break size used in WH type plants which assume the throat area.

The M/E release rates for KIMERA and those for UCN 3&4 FSAR for MSLB are compared in Figure 2 and the resultant containment P/T are compared in Figure 3 for MSIV failure case of 50% power. The M/E release rates decreased monotonically and stabilized at about 400 seconds. As shown in Figure 3, the pressure behavior is very similar to that of the FSAR whereas the temperature behavior is different from the FSAR. The comparison of the break flow between the results of KIMERA and those of FSAR in Figure 2 shows that KIMERA provides larger mass release than FSAR up to 100 seconds during early time period except just after the break. The mass release rates are nearly the same during long time period. Thus, KIMERA provided a larger peak containment pressure which occurred at around 300~400 seconds. However, the temperature behavior of the containment is quite different during first 20 seconds. After this time period, the temperature behavior is very similar.

The peak pressure is 60.6 psia at 355 sec. (vs. 56.1 psia at 400 sec. in FSAR) and the peak temperature is 292.2 °F at 116 sec. (vs. 304.7 °F at 95 sec. in FSAR). The peak containment pressures of KIMERA and FSAR for MSIV failure and LCC cases are shown in Tables 1 and 2, respectively. The highest peak containment pressure is determined as 60.6 psia at 50% power, Cd 0.4, MSIV failure case and this is higher than that of FSAR(vs. 59.3 psia at 50% power, LCC in FSAR). Since the trends of break flow and P/T are appropriate and much similar to those of UCN 3&4 FSAR, KIMERA methodology is acceptable to the MSLB M/E release for the containment design.

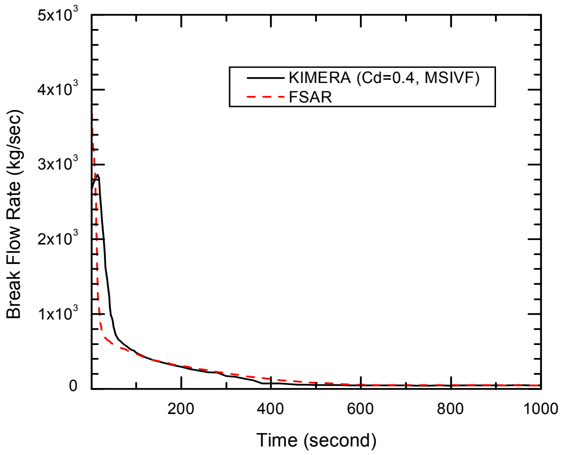

Figure 2 Containment P/T Responses for MSLB (50% power, MSIV Failure)

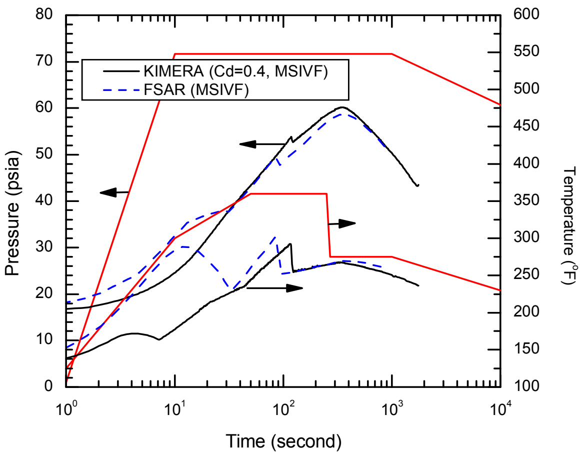

Figure 3 Break Flow Energy Release for MSLB (50% power, MSIV Failure)

Table 1 Comparison of Peak Containment Pressure for FSAR and KIMERA results (MSIV Failure)

Power	FSAR	KIMERA
102 %	57.4 psia at 292 sec	416322 Pa (60.4 psia) at 325 sec, Cd 0.4
75 %	57.9 psia at 347 sec	417417 Pa (60.5 psia) at 330 sec, Cd 0.4
50 %	56.1 psia at 400 sec	418769 Pa (60.6 psia) at 355 sec, Cd 0.4
20 %	52.1 psia at 358 sec	403700 Pa (58.6 psia) at 440 sec, Cd 0.5
0 %	57.3 psia at 332 sec	389555 Pa (56.5 psia) at 415 sec, Cd 0.5

Table 2 Comparison of Peak Containment Pressure for FSAR and KIMERA results (LCC)

Power	FSAR	KIMERA
102 %	57.0 psia at 318 sec	408906 Pa (59.3 psia) at 335 sec, Cd 0.4
75 %	58.0 psia at 391 sec	410276 Pa (59.5 psia) at 340 sec, Cd 0.4
50 %	59.3 psia at 504 sec	409817 Pa (59.4 psia) at 400 sec, Cd 0.5
20 %	56.1 psia at 935 sec	402218 Pa (58.3 psia) at 500 sec, Cd 0.5
0 %	56.8 psia at 349 sec	386782 Pa (56.1 psia) at 550 sec, Cd 0.6

4. Conclusion

KIMERA is applied to MSLB M/E release analysis of OPR 1000 (UCN 3&4). The resultant containment peak pressure is larger than that of FSAR. However, the smaller break size (Cd=0.4) provided higher containment peak pressure than the full break area selected in FSAR.

In conclusion, the proposed KOPEC Improved Mass and Energy Release Analysis (KIMERA) for M/E release using the realistic evaluation code is acceptable for the MSLB M/E release analysis for the containment design.

References

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[5] Ulchin Nuclear Units 3&4, FSAR, KEPCO.