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Analysis of MSLB for SKN 5&6 Containment Design using KIMERA Methodology

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1. Introduction

KEPCO E&C improved mass and energy release analysis (KIMERA) methodology developed for APR1400(Advanced Power Reactor 1400) LOCA M/E analysis[1] has been applied to the main steam line break (MSLB) for the Shin Kori 5&6 Nuclear Power Plants (SKN 5&6). This methodology uses the best estimate code for system simulation and added the special design features of APR1400 such as IRWST (in-containment refueling storage tank) and SIT (safety injection tank) with fluidic device (FD) from KIMERA [2, 3].

This paper compares the results of mass and energy (M/E), containment pressure and temperature (P/T) of SKN 5&6 during a main steam line break (MSLB) and those of SKN 3&4 FSAR [4] which use the traditional analysis method. As in the KIMERA methodology for OPR1000 (Optimized Power Reactor 1000) [2, 3], the analysis results showed that the peak pressure is similar to and the temperature is lower than those of SKN 3&4.

2. Major Model for MSLB

The special design features such as IRWST and FD-SIT which are modeled in RELAP5-ME for APR1400 are not functioned during an MSLB.

KIMERA methodology for OPR1000 did not use the break separation, and the mixture is released to the containment atmosphere. The modified and optional break separation model which is the separation of mixture as steam and liquid based on the containment temperature is applied to MSLB. The separated steam is released to the containment atmosphere and the liquid is released to the sump

3. Major Assumptions and Initial Conditions

Major assumptions and initial conditions for the M/E release analysis are basically the same as those of KIMERA topical report [2]. And the initial conditions are the same as SKN 3&4 [4]. The major assumptions used in the MSLB M/E analysis are as follows:

- Minimum containment back pressure conditions
- Offsite power is available (Non-LOOP)
- Turbine trip at break initiation
- Maximum total feedwater and auxiliary flow to ruptured SG only with maximum enthalpy
- Maximum RCS, feed and steam line volume without tube plugging
- Most negative moderator density coefficient and Doppler coefficient
- 2.0 of multiplier on heat transfer coefficient (HTC)

Conservative initial conditions for the M/E release analysis are assumed as Table 1.

Table 1 Conservative Combination of Initial Conditions

Parameters	Values	Remark
Core Power	4063 MWt (102% of 3983 MWt)	Max
PZR Pressure	2325 psia (16.03 MPa)	Max
Core Inlet Temperature	563 ^oF (568.15 K)	Max
PZR Water Level	60 % span	Max
RCS Flow Rate	95% of design flow	Min
SG Water Level	98.2% WR	Max

4. Analysis Results

Using the modified RELAP5-ME (version 2), the MSLB mass and energy release analysis for SKN 5&6 is performed and the resultant containment P/T are calculated by CONTEMPT-LT/028. The containment peak pressure and temperature are compared with those of SKN 3&4 FSAR to verify the applicability of the KIMERA methodology to the APR1400 type plant.

The MSLB mass and energy release analysis is performed for the spectrum of break size and power for SKN 5&6.

The single failure is assumed for the loss of containment cooling (LCC) or the closing failure of an MSIV (MSIVF). The results are compared for LCC cases since the limiting LCC case has the limiting containment pressure and temperature than the limiting MSIVF case.

4.1 Results of Containment Pressure and Temperature

Figure 1 compares the integrated M/E release for the limiting cases with a loss of containment cooling (LCC). As seen in the figure, 75% and 50% power cases provided much mass release after about 900~1,000 seconds whereas other cases have lower mass flow rate during the early transient.

Figure 2 & 3 provides the spectrum of the resultant containment pressure and temperature behaviors, respectively. The highest peak pressure occurred for 50% power with the discharge coefficient (Cd) of 0.2 whereas the peak temperature is for 20% power with Cd of 0.4.

The peak temperature is occurred at spray and the results are much similar for different power levels. The highest peak pressure is 50.3 psig (448.7 kPa) for 50%

with Cd 0.2 and the highest peak temperature is 317.4 °F (431.7 K) for 20% with Cd 0.3.

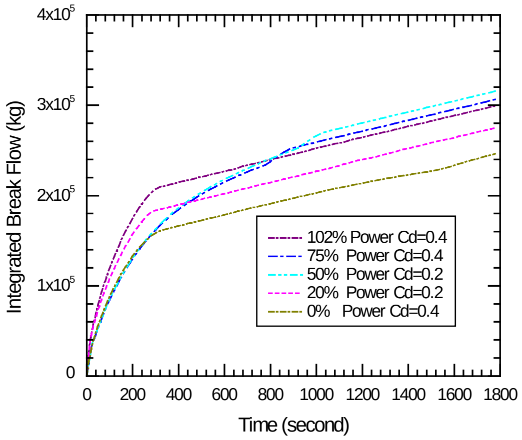

Figure 1 Comparison of Integrated Mass Release

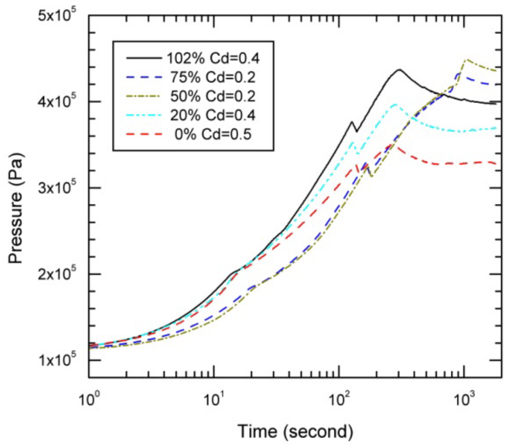

Figure 2 Comparison of Containment Pressure

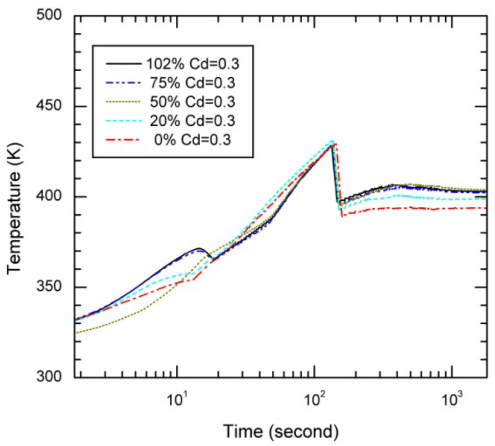

Figure 3 Comparison of Containment Temperature

4.2 Comparison with Traditional Method

Table 2 shows results of the peak containment P/T for MSLB depending on the single failure by comparing with those of SKN 3&4 FSAR. The blowdown behavior is much similar to the traditional method used in SKN 3&4[4]. The peak pressure is a little higher than the traditional method for different power and break size. However, the peak temperature is much lower than the traditional method as KIMERA for OPR1000 [3].

Table 2 Compare P/T Results with SKN 3&4

		SF: LCC		SF: MSIVF	
		Press. (psig)	Temp. (°F)	Press. (psig)	Temp. (°F)
SKN 3,4 FSAR	Peak	**49.9** @428	**336.2** @125	**47.5** @446	**334.1** @120
	Power /Size	102% Cd1.0	102% Cd1.0	102% Cd1.0	0% Cd0.48
APR1400 KIMERA	Peak	**50.3** @1060	**317.4** @136	**48.8** @264	**314.5** @137
	Power /Size	50% Cd0.2	20% Cd0.3	102% Cd0.4	20% Cd0.3

4.3 Comparison with LOCA

Figure 4 compares the results with those of the hot leg break LOCA which is the limiting case [1]. As shown in the figure, the peak pressure is higher than the LOCA case. So, like KIMERA results for OPR1000, the design limiting case is changed from LOCA to MSLB when compared with SKN 3&4.

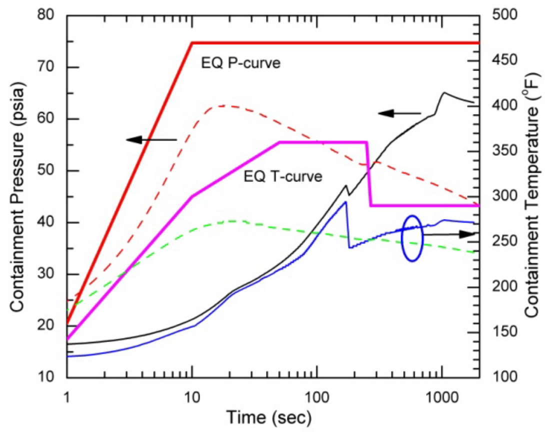

Figure 4 Comparison of P/T Behavior with LOCA

5. Conclusion

The containment P/T behavior during the main steam line break is similar to the results of SKN 3&4 and KIMERA for OPR1000. The peak P/T are much lower than those of SKN 3&4 since the peak is determined for MSLB. This margin can be used to optimize the containment design.

The KIMERA applicability to the MSLB M/E release analysis for SKN 5&6, which is an APR1400 type, is also verified.

REFERENCES

[1] Cheol Woo Kim et. al., “Analysis of LOCA M/E and Containment P/T using KIMERA Methodology for APR1400,” 2011 KNS Spring Conference, May 2011.

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[4] Shin Kori Nuclear Units 3&4, FSAR, KEPCO.