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Sensitivity Studies on Containment Response for Main Steamline Break Events

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1. Introduction

Main steamline breaks(MSLB) occurring inside a reactor containment structure may result in significant releases of high-energy fluid to the containment environment, possibly resulting in high containment temperature and pressure. The MSLB accident, along with the LOCA, is a design-basis accident for determining the peak containment pressure and temperature. As a part of power uprate technology development program for operating plants in Korea, KNFC performs mass and energy release analyses for MSLB. To evaluate the effect of NSSS design changes on the containment response, sensitivity studies were performed using Westinghouse codes. In section 2, the analysis methods and important assumptions for the MSLB analysis are briefly described. In section 3, the results of sensitivity studies are presented. Finally the conclusions obtained from this study are summarized in section 4.

2. Methods and Assumptions

2.1 Methods

The mass and energy releases for the main steamline break is calculated using LOFTRAN[1] code. With the mass and energy release data the containment response is calculated using COCO[2] code for the convenience of sensitivity studies although the licensing containment analysis was performed using COPPATA code by Bechel.

The MSLB inside containment analysis consists of a large spectrum of cases encompassing different initial power levels, break sizes and possible single failures. Two break types have been defined. One is full double-ended rupture (DER) downstream of the steamline flow restrictor. For this case the blowdown from the steam generator with the broken line is controlled by the flow restrictor throat area (1.4 ft^2). The other is split rupture(SPLIT) that represents the largest break that will not generate a steamline isolation signal from the Engineered Safety Features. Reactor protection and safety injection actuation signals are generated by containment pressure signals.

2.2 Cases for Sensitivity Study

Table 1 shows the nominal conditions of Kori Unit 3 and 4 for both the current operation and a 4.5% uprating. Uncertainties are considered for initial power and coolant temperature. Eight sensitivity runs were done for the full power condition as shown in Table 2. These cases were chosen to evaluate the effect of following changes.

- Nominal condition and uncertainties for uprating
- Moderator Density Coefficient(MDC)
- Lead/Lag Constants of Low Steam Pressure
- Single failure

The effects of following kinds of single failure on calculated containment pressure and temperatures were investigated.

- Containment Safe Guards System (CSGS)
- Main Feedwater Line Isolation Valve (MFIV)
- Steam Line Isolation Valve (MSIV)

Table 1. Nominal Conditions

Parameters	Current	Uprating
NSSS Power, MWt	2787	2912
Reactor Coolant Flow (total), gpm	286,800	282,600
Pressurizer Pressure, psia	2250	2250
Reactor Coolant Temperatures (Vessel Average), °F	588.5	587.0
Steam Temperature, °F	540.2	538.3
Steam Pressure, psia	964	949
Steam Flow (total), 10^6 lbm/hr	12.30	12.95
Feedwater Temperature, °F	440	445.9

Table 2. Analysis Cases

	Break Size/ Type	Power	Single Failure	Low SG Pressure Setpoint (Lead/Lag)	MDC (Δk/gm/cc)
1	1.4 ft^2 DER	102% of 2787 MWt	CSGS Fail	554 psia 35/5	0.5
2	1.4 ft^2 DER	102% of 2912 MWt	CSGS Fail	554 psia 35/5	0.5
3	1.4 ft^2 DER	102% of 2912 MWt	CSGS Fail	554 psia 35/5	0.54
4	1.4 ft^2 DER	102% of 2912 MWt	CSGS Fail	554 psia 50/5	0.54
5	1.4 ft^2 DER	102% of 2912 MWt	MFIV Fail	554 psia 35/5	0.54
6	0.94 ft^2 SPLIT	102% of 2912 MWt	CSGS Fail	554 psia 35/5	0.54
7	0.65 ft^2 SPLIT	102% of 2912 MWt	CSGS Fail	554 psia 50/5	0.54
8	0.94 ft^2 SPLIT	102% of 2912 MWt	MSIV Fail	554 psia 35/5	0.54

3. Results

The containment peak pressure and temperature resulting from the eight SLB cases are summarized in Table 3.

From the results of case 1 and 2, it can be known that 4.5% nominal power increase bring about a pressure increase less than 0.6 psi and a temperature increase of 2 °F. From the results from case 2 and 3, it can be known that the increase of MDC bring about a first peak pressure increase less than 0.27 psi and a temperature increase of 1 °F. The changes of second peak pressure occurred around 1800 seconds are negligible since the second peak is related to the total mass of release rather than the peak nuclear power level. From the results of case 3 and 4, it can be known that the change of SG pressure lead/lag constants from 50/5 to 35/5 results in 0.8 psi peak pressure increase for DER case but from the results of case 6 and 7 for split rupture the increase of pressure and temperature is considerable since the limiting break size is affected by the SG pressure setpoints. Even though the results of split rupture changed considerably by the change of lead/lag constants for low steam pressure, the peak pressure and temperature are lower than those of DER cases. Case 5 and 8 shows that the MFIV fail or MSIV fail is not limiting compared to CSGS fail. Figure 1 and 2 show the containment pressure and temperature response for case 1 and 3.

Table 3. Summary of Containment Analysis Results

Case	First Peak Pressure (psig)	Second Peak Pressure (psig)	Peak Temperature (°F)
1	50.64	49.88	380.96
2	51.23	49.97	382.97
3	51.49	49.97	384.00
4	50.70	49.34	382.77
5	51.25	32.04	374.01
6	46.19	48.65	367.64
7	42.36	48.59	350.94
8	43.45	30.81	355.29

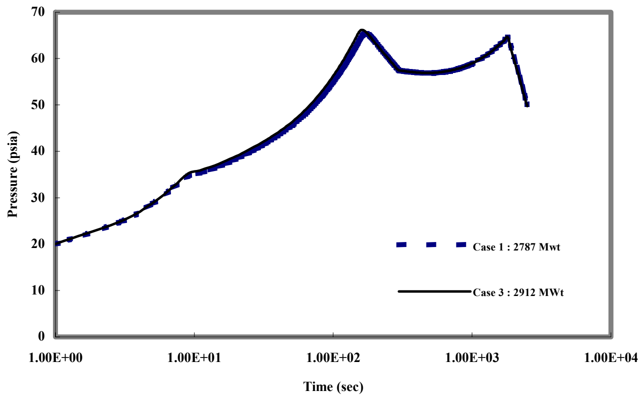

Figure 1. Containment Pressure vs. Time for MSLB

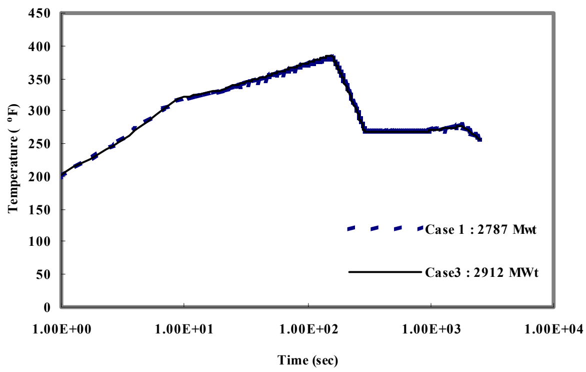

Figure 2. Containment Temperature vs. Time for MSLB

4. Conclusion

The design pressure of Kori 3 and 4 is 60 psig and the available margin in FSAR analysis is more than 10 psi. In this study it is shown that the effect of peak containment pressure for MSLB by the 4.5% uprating is less than 1 psi. Incorporating the changes of uncertainties, MDC and setpoints, there are still plenty of margins in the containment pressure for MSLB.

REFERENCES

[1] Burnett, T.W.T., et al, "LOFTRAN code description," WCAP-7907, April 1984

[2] F.M. Bordelon, E.T. Murphy, "Containment Pressure Analysis Code," WCAP-8326 , June 1974.