Transactions of the Korean Nuclear Society Spring Meeting
Chuncheon, Korea, May 25-26 2006

Main Steam Line Break Mass/Energy and Pressure/Temperature Analysis for the Environmental Qualification

Young-Chan Park,a Dong-Soo Song,b Hwang-Yong Jun,b

a Atomic Creative Technology Co. 1688-5 Sinil-dong Daedeok-gu Daejeon 306-230, Korea.k2pyc@actbest.com
b Korea Electric Power Research Institute 103-16 MunJi-dong, Yusong-Gu, Daejeon, Korea, 305-380

1. Introduction

The Main steam line break(MSLB) occurring inside a reactor containment structure may result in significant releases of high energy fluid to the containment, possibly result in high containment pressure and temperature. The MSLB accident, along with the Loss Of Coolant Accident, is a design basis accident for determining the peak containment pressure and temperature. The analysis for a MSLB for inside containment should be performed to justify the structural integrity and equipment qualification in accordance with revision 1 of Reg. Guide 1.89. Rev1(1984), which is also required as part of obtaining the extended operating license for WestingHouse(WH) 3-Loops Nuclear Power Plant(NPP). Now, the WH NPP has been performed power uprating. Therefore, all initial conditions, setpoints and uncertainties were considered with MSLB analysis for environment qualification(EQ). The transient was analyzed to determine the worst set of mass and energy releases that impact the EQ aspects of safety related equipment inside containment. The most limiting single failure in this event was determined by a sensitivity study. The MSLB event was analyzed for a full set of power conditions and break sizes.

2. Methods and Assumptions

2.1 Methods

The mass and energy releases for the MSLB is calculated using LOFTRAN computer digital code. The pressure and temperature data for EQ is calculated using CONTEMPT-LT/028 code.

The MSLB inside containment analysis consists of a 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 downstream of the steam line flow restrictor. For this case the blow from the steam generator with broken line is controlled by the flow restrictor throat area(1.4ft^2). The other is split break that represents the largest break that will not generate a steam line isolation signal from the Engineered Safety Feature. Reactor protection and safety injection actuation signals are generated by containment pressure signals. A single failure analysis is selected four cases through experience of pressure and temperature analysis. Also, An entrainment model in this work was assumed. Generally, the temperature of inside containment vessel at MSLB is decreased by introducing the liquid entrainment effect. This effect makes a profit on the aspect of integrity evaluation for EQ in the containment. The steam generator of WH NPP has a F model type. Table 1 shows the entrainment data for F Model steam generator.

Table 1. Entrainment Data for Steam generator F Model

Break sizes	Entrainment	Power Level / Break size(ft^2)			
		102%	70%	30%	0%
Full-DER (forward flow area)	with	1.4	1.4	1.4	1.4
	without	1.4	1.4	1.4	1.4
Full-DER (reverse flow area)	with	1.4	1.4	1.4	1.4
	without	1.4	1.4	1.4	1.4
Small-DER (forward flow area)	with	0.6	0.53	0.36	0.2
	without	0.33	0.32	0.22	0.1
Small-DER (reverse flow area)	with	0.6	0.53	0.36	0.2
	without	0.33	0.32	0.22	0.1
Split Break	without	0.215*N	0.227*N	0.236*N	0.100*N
		0.645	0.681	0.708	0.3

Where,
- **N** is the number of steam generators.

2.2 Analysis

Table 2 shows the nominal conditions of WH NPP for the current operation conditions plus a 4.5% uprating.

Table 2. Nominal Conditions

Core Power (%)	102	75	50	30	0
NSSS Power (MWt)	2958	2175	1450	870	29
Thermal Design Flow *10^3(gpm)	282.6	282,6	282,6	282,6	282,6
Max. Pump Heat (MWt)	15	15	15	15	15
PZR Pressure (psia)	2250	2250	2250	2250	2250
PZR Level (ft^3)	798.3	685.1	580.4	489.1	375
RCS Tavg(°F) [587 °F]	587.6	579.5	572	566	557
Feedwater Temp. (°F)	445.9	419.5	386.3	347.2	100
Initial SG Inventory (lbm) [Nominal water level + 5%NRS], 0%TP	103414	113533	125328	137645	167641
SG Dome Pressure (psia)	922	966	1004	1037	1106

Uncertainties are considered for initial power, SG inventory and coolant temperature.

These cases were chosen to evaluate the effect of following changes.

- Nominal condition and uncertainties for uprating
- Maximum pump heat
- Steam generator inventory
- Break types and sizes
- Moderator Density Coefficient(MDC)
- Single failure

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

- Containment Safe Guards System
- Steam Line Isolation Valve
- Auxiliary Feedwater Control Valve
- Main Feedwater Line Isolation Valve

The M/E release data generated from the analyses have been used as the input to the containment pressure and temperature analysis code, CONTEMPT/LT-28. To overcome the M/E data limit CONTEMPT/LT-28 has been modified to accommodate more data sets. At the EQ analysis, It is used 8% re-evaporation model at the inside containment analysis. That is to decrease a temperature of the inside containment following MSLB.

3. Results

The containment peak P/T resulting from MSLB cases are summarized in Table 3

Table 3. Typical results of Containment P/T Analysis

CSS(DG Failure)				
Cases	P_{peak} (psia)	Time (sec)	T_{peak} (^oF)	Time (sec)
1	61.25	150.0	367.25	150.0
2	60.96	150.0	367.15	150.0
3	62.73	1820.0	367.32	150.0
4	61.86	530.0	354.52	39.0
5	57.46	1820.0	293.68	130.0
6	58.03	1820.0	292.19	150.0
7	56.84	1800.0	289.83	120.0
8	54.16	1240.0	273.26	160.0

Figure 1, 2 show pressure and temperature profile change according to the entrainments. The liming break size is generally split break type. For single failure, the limiting case was CSS failure case.

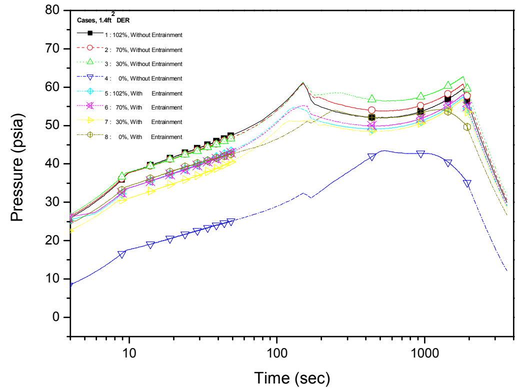

Figure 1. Pressure Profile Change According to the Entrainment Assumptions

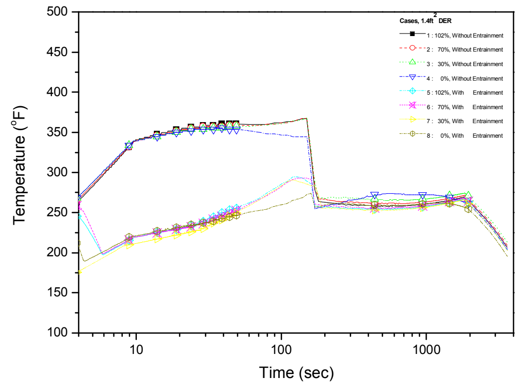

Figure 2. Temperature Profile Change According to the Entrainment Assumptions

4. Conclusion

To calculate the M/E assumed the entrainment of steam generator F model, and to calculate the P/T used 8% re-evaporation model at the inside containment analysis.

As a result of application to WH uprating NPP, the temperature and pressure have decreased by about 30 – 40 ^oF, 2 – 3 psi, respectively. The effect of entrainment in the steam flow is confirmed to make the temperature reduction of the inside containment.

REFERENCES

[1] SAS 12.2, “Mass and Energy Release to containment Following a Steam line Rupture,” Westinghouse Co., June. 2000.

[2] WCAP-8860, "Mass and Energy Releases Following a Steam line Rupture,” September, 1976.