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FLB Mass and Energy Release Analysis for Kori 1

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1. Introduction

According to the new Korean enforcement regulations for operating nuclear plants, periodic safety review (PSR), it is additionally required to analyze the mass and energy (M/E) release on feedwater line break (FLB) for the flooding and differential pressure analyses in the Auxiliary Building [1]. These analyses are necessary for the related work of equipment environmental qualification (EEQ).

This paper provides a new methodology of FLB M/E release analysis and the results for Kori nuclear power plant unit 1 (Kori-1).

The realistic FLB M/E release data are provided for the design optimization on flooding in the Auxiliary Building.

2. Analysis Methodology

2.1 Analysis Tools

The new methodology of M/E release analysis has been developed as a unified computer code system, KIMERA [2] which couples RELAP5/MOD3.1/K and CONTEMPT4/MOD5, with addition of the conservative model for enhanced M/E release and the long-term model. This new code system predicts the thermal hydraulic behavior more realistically by treating the M/E release data and the containment back pressure simultaneously. For FLB event which occurs outside containment RELAP5/MOD3.1/K is only used.

2.2 Analysis Model

Kori-1 is a 600 MWe Westinghouse 2-loop plant with the safety injection system which consists of the accumulator, high-pressure and low-pressure safety injection pumps. Figure 1 shows the RELAP5/MOD3 nodal scheme for the primary and main steam systems for Kori-1. The main steam system is modeled from the steam generator to the turbine including the main steam isolation valve and the main steam safety valve. Figure 2 shows the RELAP5/ MOD3 nodal scheme for the main feedwater system which is from the main feedwater pump to steam generators. The auxiliary feedwater system is added in the model. The break is located outside containment between the downstream of the main feedwater isolation valve and the feedwater nozzle of the steam generator.

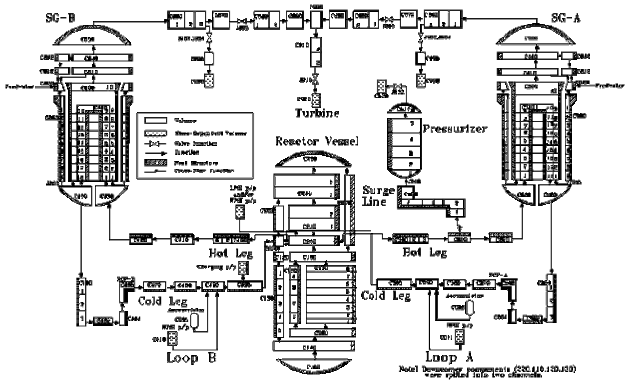

Figure 1. RELAP5 Model for Primary and Main Steam Systems

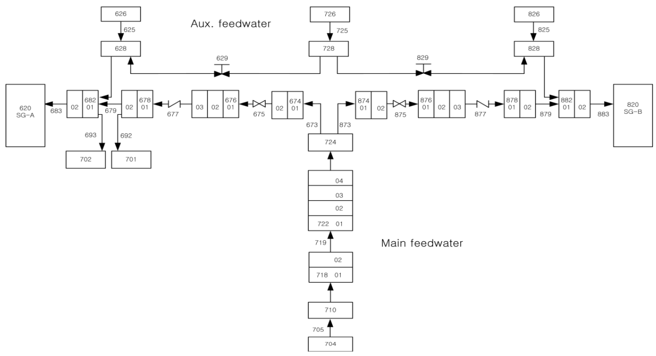

Figure 2. RELAP5 Model for Main Feedwater System

3. Analysis Results

3.1 Initial Conditions and Major Assumptions

The major assumptions and initial conditions for the conservative M/E release are such as 102% core power, stored energy increase in core metal by 20%, 0% U tube plugging and conservative uncertainty of operating parameters. The booster pump and the main feedwater pump are lumped to an equivalent pump based on the flow boundary conditions. Thus, the starting point of the feedwater system is the outlet of the main feedwater pump.

The plant initial conditions and assumptions used in the FLB M/E release analysis are provided in Table 1 [3, 4].

Table 1. Plant Initial Conditions and Assumptions

Plant Parameters	Operating Value	Analysis Value
Thermal Power (MWt)	1723.5	1723.5 * 1.02 = 1758
Pressurizer Press (MPa, psia)	15.514(2250)	15.872(2302)
Pressurizer Level (m)	5.140	5.944
RCS Loop Flow (kg/sec)	4060(target)	4115.8
Avg. RCS Temp (K, °F)	574.4 (574.1)	575.5 (576.1)
SG Press (MPa, psia)	5.695 (826)	5.702 (827)
SG Level (m)	13.335	13.650
SG Steam/Feed Flow (kg/sec)	472.5	480.5
Feedwater Temp (K, °F)	496.5 (434)	497.2 (435.2)

3.2 M/E Release Result

FLB M/E analysis for the flooding design of Kori-1 is performed for various break sizes and locations. When FLB occurs, the following reactor trip signals are possible: pressurizer (PZR) low-pressure, SG low-low level and low feedwater rate. And safety injection signals initiates on steam line low pressure, PZR low pressure or containment high pressure. Table 2 shows the event sequence for the guillotine break downstream feedwater isolation valve (FWIV).

Table2.Event Sequence for Guillotine Break Downstream FWIV

Time(sec)	**Event Sequence**
0.0	Event initiation
9.8	SG-A Aux-feedwater injection (SG Lo-Lo Level)
14.8	Reactor trip (SG Lo-Lo Level) Turbine trip
22.1	Main feedwater isolation (Lo-Tavg)
78.1	Safety injection signal (PZR Lo press)
124.7	SG-B Aux-feedwater injection (SG Lo-Lo Level) Turbine driven Aux-feedwater pump initiation
170	SG-A depletion

The mass release rates depending on the break size for FWIV downstream break are illustrated in Figure 3. The integral energy releases depending on the break size for the FWIV downstream break are shown in Figure 4. The case of 'slot 4in' in figures means the auxiliary feedwater line break.

The early peak of M/E discharge occurs within 1 second. Mass release rates after about 40 seconds have little difference on the break size. In Figure 4, the integral discharge energy rate for each case is much different up to 100 seconds. But after that, it shows no difference on the break size.

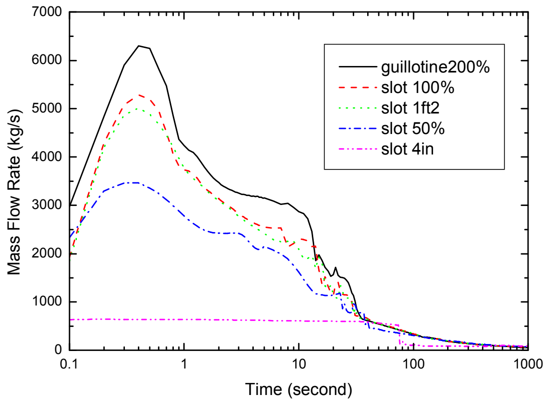

Figure 3. Comparison of Break Mass Release Rate

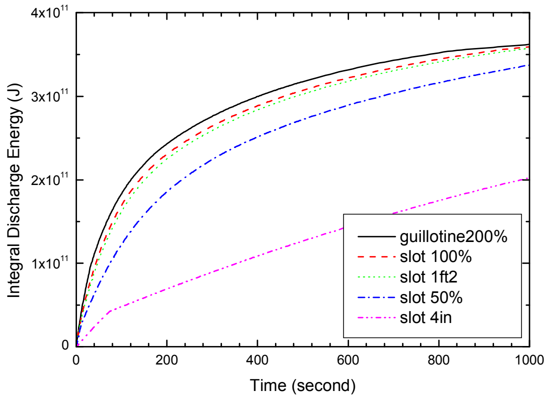

Figure 4. Comparison of Integral Energy Release

4. Conclusion

Using the newly developed methodology, FLB M/E release analysis was performed for Kori-1. The M/E release rate at the early stage provided different trends depending on the break size. However, the difference decreased at the late stage.

The calculated M/E release rate and the flooding water level during FLB in the Auxiliary Building are less than half of the previous results in FSAR. The reduced M/E could be contributed to the design optimization for the flooding protection in the Auxiliary Building.

References

[1] Atomic Energy Laws for PSR, item 23.3, 2001 and MOST Notice 2002-5.
[2] Topical Report, "KOPEC Improved Mass and Energy Release Analysis Methodology," KOPEC, July 2006.
[3] Kori-1 FSAR, KEPCO.
[4] Feedwater System for Kori NPP Unit No.1, Design Report, Gilbert Associates, 1975.