Flooding Analysis Following a LOCA for Kori 1 Unit

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1. Introduction

The performance assessment of recirculation sump which is required by GSI-191[1] of the NRC needs the evaluation of available Net Positive Suction Head(NPSH) of Residual Heat Removal(RHR) and Containment Spray System(CSS) pumps during recirculation mode of operation. One of the most important factors affecting the NPSH is the level of water on the containment floor. In addition, the amount of chemical products generated by post-LOCA(Loss of Coolant Accident) chemical reactions inside containment is dependent on the water pool volume. In general, the minimum water level is used in the calculation of NPSH[2] while the maximum water level is needed for the calculation of the amount of chemical products[3].

Both the minimum and maximum post-LOCA water levels in the containment are calculated in this analysis. Various water sources and distributions inside containment are considered in the calculation in a conservative manner according to the purpose of the analysis.

2. Analytical Assumptions

2.1 Water Sources and Losses

2.1.1 Water Sources

The initial mass on the containment floor following a LOCA is reactor coolant from the blow-down. Water is then added to the sump by the sprays.

In addition to the above volume, water from the Boric Acid Tank (BAT) is injected via the charging pumps. If Reactor Coolant System (RCS) pressure is sufficiently reduced by the LOCA, the water of the accumulators will be injected to the core and could potentially reach the containment floor.

Therefore, the following potential sources of water are included for filling the containment basement during a LOCA [2]:

1) Reactor Coolant System (RCS)
2) Refueling Water Storage Tank (RWST)
3) Accumulator
4) Boric Acid Tank (BAT)

2.1.2 Water Losses

Water may be prevented from reaching the containment basement area, or lost from the system during the recirculation phase of a LOCA. This section evaluates the following potential water losses from the containment basement during a LOCA [2]:

1) Volume held up as vapor in the containment atmosphere
To calculate a total volume of the vapor, following correlation is adopted.

$$W = 0.622 \times [P_w / (P_t - P_w)] \qquad [4, \text{eq.}8.22]$$

Where, W= *humidity ratio,* lb·water vapor/lb·dry air
P_w=*saturation pressure at the temperature of mixture,* psia
P_t=*total pressure of mixture,* psia

2) Volume held up on the containment floors above the 6' Elevation, including the refueling cavity
Based on engineering judgment [5, eq.10.51], a condensation film thickness of 0.05 inch is assumed for all gratings and a uniform 0.25 inch layer of water is assumed for all horizontal concrete floor surfaces inside the containment.

3) Volume held up in condensation on heat sink surfaces [6]

4) Volume held up as mist (droplets) in the atmosphere
The volume of droplets is calculated by determining the time for a droplet to fall from the spray ring to the basement area [7].

5) Volume required to establish containment spray [8]

6) Leakage from the SI and CS System components during the LOCA recirculation phase [6]

7) Volume held up in the reactor cavity that is above the containment sump level [6]

3. Methodology of Analysis

The water volumes of the Refueling Water Storage Tank (RWST), Accumulator, Boric Acid Tanks, and the Reactor Coolant System (RCS) could be discharged into the containment following a LOCA. The water sources to

the containment are identified, and the water losses not contributing to filling the containment basement are considered during the recirculation phase of the LOCA.

To get a net water volume in the containment, the total water volume of losses is subtracted from the total water volume of sources. The following LOCA cases were analyzed for minimum level and maximum level.

1) Minimum Pool Depth Cases
   i. LBLOCA: RCS, Accumulator, RWST (with thermal expansion)
   ii. MBLOCA: Accumulator, RWST (without thermal expansion)
   iii. SBLOCA: RWST (without thermal expansion)
2) Maximum Pool Depth Case
   i. LBLOCA: RCS, Accumulator, RWST (with thermal expansion), BAT

Finally, the containment basement water level can be calculated by the volume vs. level correlations which are developed with calculation of areas versus an elevation in the containment. For minimum and maximum level cases, the developed correlations for Kori 1 unit are as follows:

1) Correlation for Min. Level of Water:

$$H = (1.968\times10^{-4})(V - 3694) + 6 \quad (3694 \le V < 12990.4)$$
$$H = (2.008\times10^{-4})(V - 12990.4) + 7.83 \quad (12990.4 \le V < 63637)$$
$$H = (1.881\times10^{-2})(V - 63637) + 18 \quad (63637 \le V < 63743.32)$$
$$H = (1.546\times10^{-4})(V - 63743.32) + 20 \quad (63743.32 \le V < 83144.32)$$

2) Correlation for Max. Level of Water:

$$H = (2.078\times10^{-4})(V - 3525) + 6 \quad (3525 \le V < 12329.13)$$
$$H = (2.115\times10^{-4})(V - 12329.13) + 7.83 \quad (12329.13 \le V < 34404.22)$$
$$H = (2.164\times10^{-4})(V - 34404.22) + 12.5 \quad (34404.22 \le V < 59819.72)$$
$$H = (1.881\times10^{-2})(V - 59819.72) + 18 \quad (59819.72 \le V < 59926.04)$$
$$H = (1.546\times10^{-4})(V - 59926.04) + 20 \quad (59926.04 \le V < 79327.04)$$

Fig.1 and Fig.2 show level vs. water volume related with the correlations.

4. Results

In cases of LBLOCA, the calculated min. and max. water levels are 9.423ft and 14.036ft, respectively. Table 1 shows the summary of the analysis results. In the evaluation of NPSH margin of the pumps, min. level value of the LBLOCA is used and NPSH margin is well guaranteed.

Table 1. Summary of Results

Min. Level (ft)		Max. Level (ft)	
LBLOCA	9.423	LBLOCA	14.036
MBLOCA	8.934		
SBLOCA	8.432		

ACKNOWLEDGMENTS

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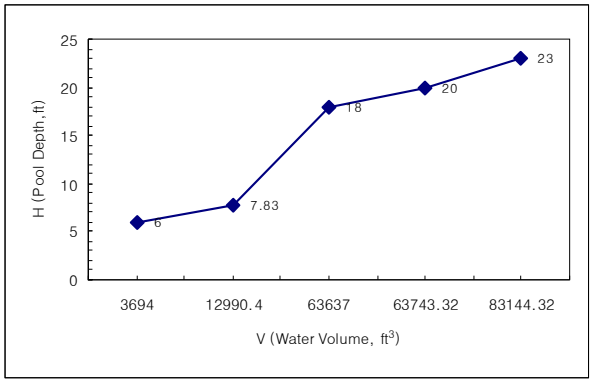

Fig. 1 Level vs. Water Volume (Min. Level Case)

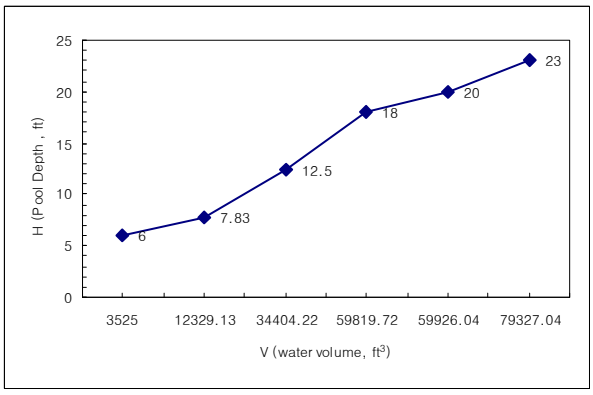

Fig. 2 Level vs. Water Volume (Max. Level Case)