A Study on the Effects of Pipe Thickness in Leak-Before-Break Evaluation for Domestic NPPs

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1. Introduction

The Leak-Before-Break(LBB) concept has been applied to nuclear power plant to exclude the dynamic effects of Double-Ended Guillotine Break(DEGB) and has been implemented into the high-energy portion of the piping which is larger than nominal pipe size 10-inch of safety injection/shutdown cooling system inside containment.

On evaluation of LBB, the various factors should be considered in the analysis, such as piping geometry, material properties, operating conditions and so on. As one of the variables, the piping thickness has contradictory aspect between piping design and LBB evaluation. A thick piping enhances a structural integrity but makes LBB application worse by enlarging the crack size under the condition of the defined flow rate, 10 gpm.

There is a little bit of difference in the piping wall thickness and its size for each discharge piping portion from the safety injection tank in Shin-Kori 3&4(SKN 3&4) and Shin-Wolsong 1&2(SWN 1&2). Specifically, the pipe wall thickness of the section in SKN 3&4 was increased compared to SWN 1&2. This increased wall pipe thickness has adversely affected to the evaluation due to the characteristics of LBB concept assuming virtual cracks.

In this study, the LBB evaluation for the piping of safety injection system is carried out in operating conditions of low temperature and pressure, and the effect by the difference from pipe diameter and wall thickness on LBB evaluation is considered.

2. Evaluation

The LBB evaluation considered piping design information from domestic nuclear power plant, including pipe size, piping load and material properties.

2.1 Evaluation object

The evaluation was conducted for the pipe section between safety injection tank and the first check valve in the safety injection system piping of two plant described above. The material of the pipe section is SA312 TP304, and the piping sizes are 14 inch STD.(30 Sch.) [1] and 12 inch 160 Sch. [2]. The boundary conditions of evaluation were presented as shown in Table 1.

Table 1: Boundary conditions for evaluation case

	Case 1 (SWN 1&2)	Case 2 (SKN 3&4)
Pipe Size	14 inch STD.	12 inch 160 Sch.
Material Properties	SA312 TP304	
Operating Temp.	122 °F	
Operating Pressure	714.7 psia	

2.2 Leakage crack size calculation

The leakage crack size is considered with the normal operation and best-fit data of SA312 TP304 material properties from a domestic nuclear power plant, and the leakage flow rate applies 10 gpm. The computational code used in the leakage crack size is SI-PICEP [3], and the calculation results are as shown in Table 2.

Table 2: Leakage crack size calculation results

Case	Leakage Crack Size	
	inch	θ/π
1	6.705	0.157
2	21.322	0.593

2.3 Crack stability evaluation

The crack stability evaluation for the LBB evaluation applied the faulted load and lower bound of SA312 TP304 material properties of domestic nuclear power plant. For the crack stability evaluation, FLET code [4] was used based on limit load method. The evaluation results are as shown in Table 3.

Table 3: Crack stability evaluation results

Case	Plastic Collapse Load	
	Axial (ksi)	Bending (ksi)
1	27.75	19.95
2	2.94	3.48

3. Results & Discussion

The evaluation was performed for pipe section between the safety injection tank and the first check valve with the same condition except the pipe dimensions. The LBB safety margin was evaluated as shown in Table 4.

Table 4: The LBB safety margin

	LBB safety margin
Case 1 (SWN 1&2)	4.110
Case 2 (SKN 3&4)	1.788

As a result of the LBB evaluation, the LBB safety margin in case 2 was evaluated less than case 1, which resulted from the calculation of the large crack length. The characteristics of the LBB concept, which calculates the leakage rate based on the assumption of leakage cracks are unfavorable to the piping system with thick pipe wall thickness in calculating leakage crack length.

In particular, LBB evaluation requires continuous review and research on the evaluation method under the conditions as low operating temperature, low operating pressure and thick pipe thickness.

REFERENCES

[1] SWN 1&2 Final Safety Analysis Report.
[2] SKN 3&4 Final Safety Analysis Report.
[3] SI-PICEP Version 1.2 User Manual.
[4] EPRI, FLET: Pipe Crack Instability Program.