Calculation of Failure Probabilities for Multiple Pipe Size Segments in Risk-Informed In-service Inspection

Baek Soon Jeong[a], Si Yeon Bae[b]
Power Generation Laboratory, KEPCO Research Institute, 105 Munji-Ro, Yuseong-Gu, Daejeon, 305-760 Korea
jungbas@kepco.co.kr[a] and sybae@kepco.co.kr[b]

1. Introduction

Topical report for risk-informed in-service inspection discusses how to estimate the structural reliability and risk assessment failure probabilities for segments. Based on the information presented, there are two methods that can be used for calculating the SRRA failure probability for a multiple pipe size segment. Firstly, a failure probability is calculated for every pipe size in the segment since some of the input parameters used by the SRRA code vary based on the pipe diameter. Secondly, all of the degradation mechanisms in the segment being evaluated are included on a single weld. This paper presents generic discussion and plant-specific example that confirm that both methods are acceptable by demonstrating that there is essentially no difference in the number of examinations between the two methods or that any difference in the number of examinations would result in an insignificant impact.

2. Evaluating Potential Difference by Splitting a HSS Multiple Pipe Size Segment

In the second method, if the failure probability for a HSS multiple size pipe segments are overly conservative, the segment should be split into separate segments and the failure probabilities for these new segments recalculated. If a HSS multiple pipe size segment is split into separated segments based on pipe size and more than one pipe size is categorized as HSS, the minimum number of examinations may increase from one to the number of segment pipe sizes that are categorized as HSS. There are several reasons why a multiple pipe size segment would not need to be split or why there would be no difference in the number of examinations. The following paragraphs explain on a qualitative basis the instances where there would be no difference in the number of examinations.

2.1 Increases in the segment failure probability that is not overly conservative

If the failure probability in a multiple pipe size segment is determined by using SRRA inputs specific to each pipe size, then, in some cases, using the most limiting SRRA inputs from all the pipe sizes will result in an increase in the failure probability for the segment that is not overly conservative. Generally any increase that is less than an order of magnitude is considered not to be overly conservative. If the sum of the failure probabilities from the individual pipe sizes are approximately the same or little higher than the failure probability based on the most limiting SRRA inputs from all the pipe sizes, then the effect on other segment is negligible or conservative. To get a decrease in a segment's RRW from 1.005 to 1.004, the base CDF must increase by appropriately 25 percent. Thus, there is no need to split the segment and there is no difference in the number of examinations.

2.2 The only difference in SRRA inputs is the nominal pipe size or thickness-to-outside diameter ratio

Since the nominal pipe size and thick-to-outside diameter ratios are inputs to the SRRA code and since multiple pipe size segments are acceptable, it can be concluded that differences in the nominal pipe size and the thickness-to-outside diameter ratios are acceptable. Therefore, if the only difference in the SRRA inputs for a HSS multiple pipe size segments are the physical pipe dimensions, there is no need to split the segment, and there is no difference in the number of examinations.

2.3 Segments comprised of butt and socket welded piping where the only difference in SRRA inputs is between the butt and socket welded portions

The number of examinations on the butt welded piping would be based upon any active degradation mechanism and the Perdue Model statistical analysis. The Perdue Model analysis for the butt welded segment would be based on data from the butt welded portion of the piping, resulting in no change in the way the examinations are determined for the combined segment. Therefore, for HSS multiple pipe size segments containing butt welded piping and socket welded piping, there is no difference in the number of examinations.

2.4 Only one size remains when splitting a HSS multiple pipe size segment

If the multiple pipe size segment has no an active degradation mechanism, there is no difference in the minimum number of examinations.

2.5 No difference in the failure probability used to represent the segment

For HSS multiple pipe size segments where the failure probability from the combined limiting

degradation mechanisms for the various pipe sizes in a multiple segment are appropriately the same as the failure probabilities from the various pipe sizes, there is no difference in the number of examinations.

2.6 Segment composed of socket welded piping

If a multiple pipe size segment is split based on pipe size, each of the new segments would be examined via a VT-2 examination. Therefore, for HSS socket welded multiple pipe size segments where there is no externally generated degradation; there is no difference in the number of examination.

2.7 Increase in the segment failure probability that is potentially overly conservative

The first method properly identifies those piping segments with active degradation and moderate to high safety consequences. The calculation of failure probabilities for segments with multiple sizes does not impact the areas involving active degradation mechanisms, but instead impacts areas where inspection sampling is used to address.

3. Summary of Evaluation of Ulchin 3, 4 Multiple Pipe Size Segments

The piping failure probability of Ulchin Unit 3, 4 multiple pipe size segments of 16 segments are described in table 1. And the piping failure probabilities calculation results of table 1 are evaluated based on the criteria described above. There is no difference in number of examinations. Table 2 described the examination number review results of Ulchin Unit 3, 4 multiple pipe size segments.

Table 1. Piping failure probability evaluation results of Ulchin 3, 4 multiple pipe size segments

Segment ID of system	Piping diameter (inch)	Piping Failure Probability
HS-294, 295	1	1.21E-07
	2	3.80E-08
ST-005 ~ 008	1	0.00E00
	2	5.87E-07
PX-031 ~ 034	0.75	1.06E-06
	1	1.06E-06
PX-051, 054	0.375	0.00E00
	0.75	1.85E-06
CIPS-1, 2	0.375	2.05E-05
	0.75	7.75E-06
CIPS-5, 6	0.375	5.58E-06
	0.75	8.50E-06

HS; High pressure safety injection system
ST; Safety injection tank
PX; Primary sampling system
CIPS; Containment purging system (penetration)

Table 2. Examination number review results of Ulchin 3, 4 multiple pipe size segments

No. of multiple pipe size segments	Potentional difference in No. of examinations	Basis
16	0	Only differences are NPS/thickness ratio
0	0	Segments of socket welded piping
0	0	Butt and socket welded portion
0	0	No difference in failure probability
0	0	Only one size remains HSS
0	0	Increase but not overly conservative
0	0	Increases potentially overly conservative

4. Conclusions

Two methods in topical report can be used for calculating the SRRA failure probability for a multiple pipe size segment. Since both methods are acceptable by demonstrating that there is essentially no difference in the number of examinations between the two methods or that any difference in the number of examinations would result in an insignificant impact.

REFERENCES

[1] Westinghouse, "Westinghouse Owners Group Application of Risk-Informed Methods to Piping Inservice Inspection Topical Report Clarifications", WCAP-14572 Revision 1-NP-A Supplement 2, pp. 2-1 ~ 2-16, 2004.
[2] Baek-Soon Jeong, RI-ISI Report of Ulchin Unit 3, pp. 52, 2008
[3] KHNP, "Topical Report for Risk-Informed In-service Inspection for Piping", pp. 35~53, 2008