Transactions of the Korean Nuclear Society Autumn Meeting
Busan, Korea, October 27-28, 2005

Study on the Risk Contribution Factor for ILRT Interval Extension

M. R. Seo, S. Y. Hong, M. K. Kim, B. S. Chung, H. C. Oh
KEPRI, Nuclear Power Laboratory, 103-16 Munji-Dong Yuseong-Gu, Daejeon, 305-380, Korea, mrseo@kepri.re.kr

1. Introduction

In U.S., the containment Integrated Leakage Rate Test (ILRT) interval was extended from 3 times per 10 years to once per 10 years based on NUREG-1493 "Performance-Based Containment Leak-Test Program" [1] in 1995. In September, 2001, ILRT interval was extended up to once per 15 years based on Nuclear Energy Industry (NEI) provisional guidance "Interim Guidance for Performing Risk Impact Assessments In Support of One-Time Extensions for Containment Integrated Leakage Rate Test Surveillance Intervals" [2].

In Korea, the containment ILRT was performed with 5 year interval. But, in MOST(Ministry of Science and Technology) Notice 2004-15 "Technical Standards of Primary Reactor Containment Leak-Tightness Tests"[3], the extension of the ILRT interval to once per 10 year can be allowed if some conditions are met. So, the safety analysis for the extension of Yonggwang Nuclear (YGN) Unit 1&2 ILRT interval extension to once per 10 years was completed and reviewed by regulatory body, KINS[4]. During the review process by KINS, it was required that some various risk insight or index for risk analysis should be developed. Also, it was recommended that 5% undetectable leakage rate should be used in the risk evaluation instead of 3% undetectable leakage rate. So, we had performed risk analysis based on NEI interim guidance in addition to the methodologies based on NUREG-1493. And, additionally, the justification for using 3% undetectable leakage rate was presented. But, in order to secure the conservatism, the risk according to ILRT extension was evaluated using 5% undetectable leakage rate.

2. Undetectable Leakage Rate

The meaning of the undetectable leakage rate is the fraction of leakage pathways that are detected only by ILRT. According to database in U.S, about 97% of the leakage pathways detected by ILRT are also detectable through Type B & C test (LLRT ; Local Leakage Rate Test). The remaining 3% of leakage pathways that are only detectable through the ILRT are related directly to containment aging and degradation. And in other words, the undetectable leakage rate is the performance indicator of containment integrity and the usefulness of ILRT itself.

According to NUMARC database in NUREG-1493, it was reported that only 4 leakages could be detected only by ILRT among 144 ILRTs for 29 plants. So the undetectable leakage rate was approximately used as 3% using a 95% confidence of a $\chi 2$ distribution. Therefore, in the equation (1) for risk evaluation based on NUREG-1493, the amount of change in probability is calculated as below.

$$\text{Risk} = [\text{Risk(BL)} - \Delta\ \text{Risk(NL)}] + \Delta\ \text{Probability} \times \text{Consequence} \quad \text{----------(1)}$$

$$\Delta\ \text{Probability} = \text{increase of average detection time} \times \text{undetectable leakage rate} \quad \text{----------(2)}$$

In U.S, since they tried to extend ILRT interval from 3 per 10 years to 1 per 10 years, the amount of increase in average detection time was 3.3. So, Δ Probability is calculated 10 % (3.3 × 3), and used as 1.1 in eq. (1)

In NEI Interim guidance, leakage paths are classified as small leak (class 3a, 10La) and large leak (class 3b, 35La). Data collected recently by NEI from 91 nuclear power plants indicates that 38 plants have conducted ILRTs since 1/1/95, with only one failure. This would indicate that the statistical information should be based on 5/182. Rather than using the $\chi 2$ distribution, it has been considered more appropriate to utilize the mean (5/182=0.027) for the class 3a distribution, and Jeffreys non-informative prior distribution for the class 3b distribution:

$$\text{Failure Probability} = \frac{Number\ of\ Failures(0) + 1/2}{Number\ of\ Tests(182) + 1}$$

The number of large failures is zero, so the probability is 0.5/183=0.0027.

But, since these data was collected based on 3 per 10 years test interval, the Korean regulatory body pointed that application of 3% undetectable leakage rate to Korean NPP is not appropriate. At present, since ILRT interval in Korea is 1 per 5 years, they insist that the probability of pre-existing leak is bigger than that in the case of U.S. So, it was recommended that 5% should be used as the undetectable leakage rate. Although the basis for 5% undetectable leakage rate is not the statistics but engineering judgments, we choose that value as a undetectable leakage rate in risk evaluation for ILRT extension of YGN 1&2

3. Risk Assessment for YGN 1&2

Since the risk evaluation methodologies for ILRT interval extension were introduced in previous conference [5][6], the major differences and the results

by application of 5 % undetectable leakage rate were described in this paper.

According to application of 5 % undetectable leakage rate, the equation for risk evaluation in NUREG-1493 was changed as followings. The amount of increase in average detection time was 2 because we tried to extend ILRT interval from 1 per 5 years to 1 per 10 years. So, ΔProbability is calculated 10 % (2 × 5), and used as 1.1 in equation (1) instead of 1.06 for YGN 1&2. Originally, in case of using 3 % undetectable leakage rate, the risk increase rate was 0.057. But, the risk increase rate was recalculated as 0.061 according to application of 5% undetectable leakage rate. At this case, it is judged that the risk impact due to ILRT interval extension is negligible.

Using this interim assessment methodology employed by NEI, the frequencies for class 3a (small leak, 10La) and 3b (large leak, 35 La) should be determined. The frequency for class 3a and 3b was recalculated as Table 1 as the results of application of 5% undetectable leakage rate. When the ILRT surveillance interval for YGN 1&2 is extended from 1 per 5 years to 1 per 10 years, the multiplier related to leakage detection becomes 2. If the time is extended to 1 per 15 years, then the multiplier becomes 3.

Table 1. Multiplier for 5% undetectable leakage rate

Class	**Leak rate**	**Frequency**		
		1/5 yr	1/10 yr	1/15 yr
A	10 La	0.0455	0.091	0.1365
B	35 La	0.0045	0.009	0.0135

Table 2 shows the results of risk assessment for the extension of ILRT surveillance intervals of YGN 1&2 using 5% undetectable leakage rate.

Table 2. Results of Risk Assessment for YGN 1&2

	10year Extension		15year Extension	
	Risk Increase Rate (%)	LERF Change	Risk Increase Rate (%)	LERF Change
3%	0.006	2.02E-8	0.012	4.05E-8
5%	0.010	3.37E-8	0.020	6.75E-8

The Table 2 shows that the increase rate of risk (population dose) changes from 0.006% to 0.01 and the amounts of LERF change are from 2.02E-08 to 3.37E-08 according to application of 5% undetectable leakage rate. for the 1 per 10 years and 1 per 15 years ILRT interval extension, respectively. So, it is judged that the risk impact due to ILRT interval extension is negligible and the amount of changes for LERF also satisfies the criteria of RG-1.174 of US NRC.

4. Conclusion

The risk assessment for the extension of ILRT surveillance intervals of YGN 1&2 is performed using 5% undetectable leakage rate. According to the results, the risk impact due to ILRT interval extension using 5% undetectable leakage rate is negligible. Although, the basis for 5% undetectable leakage rate is not a statistical one, it can be used as a risk contribution factor from the point of view of securing conservatism.

REFERENCES

[1] "Performance-Based Containment Leak-Test Program," NUREG-1493, January 1995.

[2] "Interim Guidance for Performing Risk Impact Assessments In Support of One-Time Extensions for Containment Integrated Leakage Rate Test Surveillance Intervals," NEI Memo, September, 2001

[3] Notice 2004-15 of the Minister of Science and Technology, Technical Standards of Primary Reactor Containment Leak-Tightness Tests, 2004.

[4] "Risk evaluation of YGN Unit 1&2 according to ILRT interval extension," KEPRI, TM.S01.P2005.027, January 2005.

[5] "Study on Risk Insight for Additional ILRT Interval Extension", Korean Nuclear Society Spring Meeting, May, 2005.

[6] "Risk Assessment for the Containment ILRT Interval Extension of Yonggwang Unit 1&2", ICAPP05, May, 2005.