Study on Risk Insight for Additional ILRT Interval Extension

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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 "Standard for the Leak-Rate Test of the Nuclear Reactor Containment", 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 based on the methodology in NUREG-1493. But, during review process by regulatory body, KINS, it was required that some various risk insight or index for risk analysis should be developed. So, we began to study NEI interim report for 15 year ILRT interval extension. As previous analysis based on NUREG-1493, MACCS II (MELCOR Accident Consequence Code System) computer code was used for the risk analysis of the population, and the population dose was selected as a reference index for the risk evaluation.

2. Methodology

In this section, the methodology used in NEI interim guidance for ILRT interval re-extension is described. In this guidance, the methodology for risk impact analysis was consisted of 9 steps as followings.

1. Quantify the base line (nominal 3 year ILRT interval, but in Korea, 5 year interval) risk in terms of frequency per reactor year for the EPRI accident classes of interest. Note that classes 4, 5, and 6 are not affected by changes in ILRT test frequency. Therefore, these classes are not considered in this assessment methodology.
2. Determine the containment leakage rates for applicable cases, 3a and 3b.
3. Develop the baseline population dose (person-rem, from the plant PRA, or calculated based on leakage) for the applicable accident classes.
4. Determine the population dose rate (person-rem/year) by multiplying the dose calculated in step (3) by the associated frequency calculated in step (1). (Note: The method provides for use of the NUREG-1150 population dose methods. If plant-specific values are available, they may be used. The net result is expressed as a percentage change.)
5. Determine the change in probability of leakage detectable only by ILRT, and associated frequency for the new surveillance intervals of interest. Note that with increases in the ILRT surveillance interval, the size of the postulated leak path and the associated leakage rate are assumed not to change, however the probability of leakage detectable only by ILRT does increase.
6. Determine the population dose rate for the new surveillance intervals of interest.
7. Evaluate the risk impact (in terms of population dose rate and percentile change in population dose rate) for the interval extension cases.
8. Evaluate the risk impact in terms of LERF.
9. Evaluate the change in conditional containment failure probability.

The major improvements in NEI methodology as compared to NUREG-1493 are as followings.

1. Leak is classified into 2 classes (small and large) and their pre-existing probabilities were calculated
2. LERF (Large Early Release Frequency) and CCFP (Conditional Containment Failure Probability) can be calculated, so, this assessment methodology suffices as the quantitative basis for a risk informed decision per current NRC practice, namely Regulatory Guide 1.174
3. The recent ILRT Data is statistically represented.

3. Risk Assessment for YGN 1&2

Using this interim assessment methodology employed by NEI, we performed the risk assessment for extension of ILRT surveillance intervals of YGN 1&2.

First of all, the event frequency and the results of off-site consequence analysis should be re-classified into EPRI accident class as shown in Table 1.

The class 1, 2, 7 and 8 can be directly obtained from PSA results [3]. The frequencies for class 3a and 3b are calculated using probability 0.027 and 0.0027 which were suggested by NEI and obtained by statistical approach using recent data in U.S. The class 3a and 3b

corresponds to small leakage (10La) and large leakage (35 La), respectively.

In Table 2, the frequencies for accident class 3a, 3b and 1 can be calculated;

Accident class 3a=0.027×total CDF
=0.027×7.50E-6
Accident class 3b=0.0027×total CDF
=0.0027×7.50E-6
Accident class 1=(base frequency)
- (class 3a frequency + class 3b frequency)
=(4.45E-6)-(2.02E-7+2.02E-8)

As 1La is equivalent to 3.15E+02 [4], so the dose rate of accident class 3a and 3b can be calculated;

Dose rate of accident class 3a
=10×1La = 10×3.15E+02
Dose rate of accident class 3b
=35×1La = 35×3.15E+02

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. This multiplier is the same as raising the detection probability depicted in NUREG-1493. Because this multiplier only affect to frequencies of accident class 3a and 3b, new frequencies for the extension of ILRT surveillance intervals are calculated by multiplying these multiplier to base frequencies. Using these new frequencies, probabilistic population dose rates are calculated.

4. Risk Insight

Table 3 shows the results of risk assessment for the extension of ILRT surveillance intervals of YGN 1&2. The base case is in the case of using internal event frequencies. In the base case, it can be seen that the increase rate of risk (population dose) are 0.006% and 0.012% for the interval extension to 1/10 year and 1/15 year, respectively. And, the amounts of LERF change are 2.02E-08 and 4.05E-08 for the 1 per 10 years and 1 per 15 years ILRT interval extension, respectively. Therefore, in case the ILRT surveillance interval of YGN 1&2 is extended from 1 per 5 years to 1 per 10 and in addition, from 1 per 15 years, the increase rates of risk are very low. Moreover, the amount of changes for LERF for both cases also satisfies the criteria of RG-1.174 of US NRC.

But, in the case of using the all event frequencies (internal event, internal flooding and fire event and seismic event), risk increase rate is lower than that of base case. But, the amount of LERF Change is not satisfied in acceptance criteria in RG 1.174 for the case of 10 year and 15 year interval extension.

5. Conclusion

The risk assessment for the extension of ILRT surveillance intervals of YGN 1&2 is performed based on the methodology described in NEI interim report. According to the results, in case the ILRT surveillance interval of YGN 1&2 is extended from 1 per 5 years to 1 per 10 and in addition, from 1 per 15 years, the increase rates of risk are very low. Moreover, the amount of changes for LERF for both cases also satisfies the criteria of RG-1.174 of US NRC.

But, this methodology shows the risk insight for additional interval extension but also shows the limitation and concern of risk insight for the risk application.

Table 1. Off-site Consequence Analysis Results

PSA	STC	EPRI Class	Internal Event Frequency	Population Dose	Yearly Population Dose Rate
No CF	1,2	1,3a,3b	4.45E-06	3.15E+02	9.72E-04
Iso Fail	15,16	2	3.98E-08	5.64E+05	1.03E-02
ECF	3,13,	7	1.80E-07	3.28E+06	9.55E-02
LCF	4 ~ 12		1.42E-06	8.79E+05	7.25E-02
CFBRB	14		8.69E-07	1.27E+06	1.10E+00
Bypass	17,18	8	5.39E-07	2.34E+06	6.38E-01
Sum			7.50E-06		1.92E+00

Table 2. Base frequencies and base dose rate of YGN 1&2

Accident class	Base frequency for 1/5 year	Base dose	Probabilistic population dose rate
Class 1	4.23E-06	3.15E+02	1.33E-03
Class 2	3.98E-08	5.64E+05	2.24E-02
Class 3a	2.02E-07	3.15E+03	6.37E-04
Class 3b	2.02E-08	1.10E+04	2.23E-04
Class7	2.47E-06	5.42E+06	1.34E+01
Class8	5.39E-07	2.34E+06	1.26E+00
Total CDF	7.50E-06		1.47E+01

Table 3. Risk Insight from risk Assessment for YGN 1&2

	10year Extension		15year Extension	
	Risk Increase Rate (%)	LERF Change	Risk Increase Rate (%)	LERF Change
I.E (Base Case)	**0.006**	**2.02E-8**	**0.012**	**4.05E-8**
All Event	0.003	1.83E-7	0.006	3.65E-7
All Event except Seismic event	0.025	4.15E-8	0.050	8.30E-8

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] "Probabilistic Safety Assessment for YGN Unit 1&2" KOPEC, December 2003.

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