Review of ILRT Experience during Atmosphere Stabilization Period

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1. Introduction

Containment has a principal function of leakage barrier, after the reactor coolant pressure boundary, to control the release of radioactive materials from the fuel in the reactor core under accident conditions. Therefore the containment shall be tested periodically to ensure the leak-tight integrity under design basis conditions. Containment leakage test methods include three types; Integrated Leakage Rate Test (ILRT or Type A test), Local Leakage Rate Test (LLRT or Type B and Type C tests). ILRT is the test to measure the containment system overall integrated leakage rate under conditions representing Design Basis Accident (DBA) containment pressure and system alignments. Type C test is intended to measure the leakage rate of containment isolation valves under DBA pressure. Type B test is for the leakage limiting boundaries other than isolation valves, such as personnel doors, equipment hatch and so on. [1, 2] For ILRT, it usually takes several days to finish the test and there may be some moments to make difficult decisions during test, for example when to finish the atmosphere stabilization. Hence, in this paper, the results of past ILRTs in Korea are reviewed to find some insights that can help in making such decisions.

2. Regulatory requirements for ILRT

Korea has the regulatory requirements related with the containment leakage rate tests; Notice of the Ministry of Education Science and Technology No.2009-39 “Standards for Leakage Rate Tests of Reactor Containment” and Inspection Guidelines IV.7.4 “Containment Leakage Rate Tests”. U.S. NRC’s 10 CFR 50 APP. J "Reactor Containment Leakage Testing for Water-Cooled Power Reactors" and ANSI/ANS-56.8-1994 "Containment System Leakage Testing Requirements" also can be applied to the tests.

Typical requirements applied to the ILRT are described as follows. More detailed requirements would be found in the references.

- Visual inspection of the interior and exterior surface of containment and components shall be performed prior to the ILRT pressurization.
- Containment should be pressurized with air that is clean, relatively dry and free of contaminants.
- The ILRT pressure shall not be less than 0.96 accident pressure nor exceed design pressure.
- The atmosphere stabilization period shall be maintained longer than four hours and this period completes when meets the criteria.
- The main test duration of ILRT shall be at least 24 hours and completes when meets the termination limits.
- The minimum number of sensors shall be operable during the test.
- The results of the ILRT shall be verified using known leakage rate.
- The integrated leakage rate shall not exceed 0.75 La.

3. Investigation of ILRT parameters during atmosphere stabilization period

3.1 Relationship between air mass and other variables

As shown in Figure 1, the dry air mass in containment can be calculated utilizing the ideal gas law based on the measured three variables during the test; pressure, temperature and humidity.

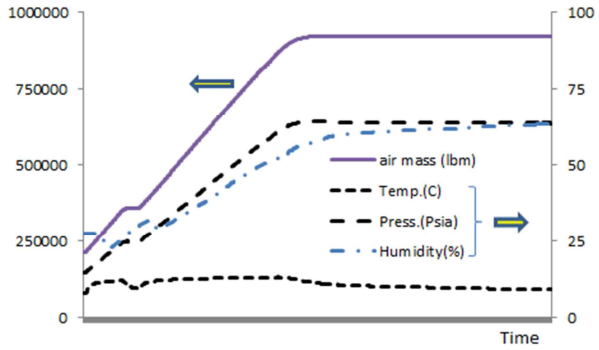

Figure 1. Typical ILRT result

For the atmosphere stabilization period, the relationship between air mass and other measured variables are investigated. Statistical coefficients of correlation for these variables (e.g., air mass vs. humidity, temperature, pressure) are evaluated over 0.9. It shows that these variables have very close relationships. This evaluation is performed for 5 selected plants data.

3.2 Temperature and humidity difference

Table 1 shows the temperature and humidity difference (i.e., difference between maximum and minimum values at same time in the containment) trend during the atmosphere stabilization period. Average values (of 5 values) for the temperature and humidity difference at the end of this period are around 2.2 ℃ and 5.4 %, respectively. It is noticeable that the average

ratios of end values to beginning values are around 0.5 for both temperature and humidity differences. This gives us the insight that you may finish the atmosphere stabilization period when the average ratios of end values to beginning values are around 0.5 for both temperature and humidity differences.

Table 1. Temperature and humidity differences during atmosphere stabilization period

Plant	I	II	III	IV
A	1.66	3.52	3.76	5.84
B	1.54	2.62	2.54	5.88
C	1.40	4.75	6.28	11.50
D	3.90	6.17	11.93	17.95
E	2.60	3.55	2.58	8.70

I: Temperature difference at the end of atmosphere stabilization (℃)
II: Temperature difference at the beginning of atmosphere stabilization (℃)
III: Humidity difference at the end of atmosphere stabilization (%)
IV: Humidity difference at the beginning of atmosphere stabilization (%)

3.3 Average temperature and humidity

Table 2 describes the relationship between duration of atmosphere stabilization period and average temperature or humidity. Except the plant E case, higher average humidity case has longer duration of atmosphere stabilization period. For the average temperature, however, it doesn't show the similar behavior. Therefore, this gives us insight that you have to control the humidity, rather than temperature, in order to have shorter ILRT.

Table 2. Duration of atmosphere stabilization period vs. average temperature and humidity

Plant	I	II	III
A	14	9.7	61
B	7	24.3	55
C	21	27.5	91
D	4	19.7	10
E	4	23.1	84

I: Duration of atmosphere stabilization period (hours)
II: Average temperature at the end of atmosphere stabilization (℃)
III: Average humidity at the end of atmosphere stabilization (%)

4. Conclusions

In this paper, past ILRT results, especially the atmosphere stabilization period are reviewed to find some insights that can help in performing ILRT. Three insights are found during the study.

- Air mass and other measured variables (pressure, temperature and humidity) have very close relationships.
- At the end of atmosphere stabilization period, the average ratios of end values to beginning values are around 0.5 for both temperature and humidity differences.
- Higher average humidity induces longer duration of atmosphere stabilization period.

This paper shows preliminary assessment of ILRT experience on atmosphere stabilization period with limited data. Future work includes more data collection and further investigations on main and verification test periods.

REFERENCES

[1] Containment System Leakage Testing Requirements, ANSI/ANS-56.8-1994
[2] Performance-Based Containment Leak-Test Program, NUREG-1493, NRC
[3] Standards for Leakage Rate Tests of Reactor Containment, Notice of the Ministry of Education Science and Technology No. 2009-37