

# Reduction of BWR Containment Leakage Rate Test Duration

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## ABSTRACT

Containment leakage rate test (LRT) in Japanese BWR plant is specified on the JEAC 4203-1974 (Japan Electric Association Code) which was based on the American code named 10 CFR50 Appendix J, and LRT is performed by measuring the leakage rate for 24 hours with the reference chamber method. Now, LRT data of each plant are sufficiently accumulated, and those data show good results. So, the theme of the measuring time reduction for LRT has been discussed on the actual plant test data.

As the evaluation result, it is found out that the measuring time of LRT can be reduced to 6 hours from 24 hours, and with this change the measuring interval is reduced to 15 minutes from 60 minutes. This means that the accuracy of LRT data can be held equally by obtaining as the same number of data points as usual.

Finally, by adopting this reduction case, the critical path of the outage period can be reduced to about 1 day.

This test case has been actually adopted in Japan since 1988.

## 1. INTRODUCTION

BWR containment LRT in Japan is specified and is performed on JEAC 4203-1974 "Containment Leakage Rate Test", in which the measuring time of LRT is specified for 24 hours. This measuring time is determined on the following idea:

In Japan, the number of BWR plants and LRT data was small at that time, so the 24 hours test has been specified until the LRT data are accumulated and the measuring time less than 24 hours is judged to be sufficient.

As described before, LRT has been performed for 24 hours, and now the results of each plant are sufficiently accumulated, and those data show good results. Based on these background, the reduction of LRT measuring time has been discussed for the purpose of the outage period rationalization.

## 2. DISCUSSION ABOUT REDUCTION OF LRT MEASURING TIME

### 2.1 LRT Method

The LRT method is based on JEAC 4203, and BWR plants adopt the reference chamber method which is shown below.

- (1) The basic concept of the reference chamber method is shown in Fig. 1.
- (2) The test procedure and schedule based on the reference chamber method is shown in Fig. 2.
- (3) The calculation method of LRT data is shown in Fig. 3.

## 2.2 Reduction Case of LRT Measuring Time

It has been discussed whether the LRT measuring time is sufficient for less than 24 hours, based on the actual plant LRT data in these five years. This examination procedure is shown in Table 1. And the measuring time less than 24 hours is judged to be sufficient, if the following conditions are satisfied:

- (1) In actual plant LRT data, the 95% upper confidence level leakage rate in case of 24 hours measuring time is enough less than the allowable leakage rate 0.45%/day.
- (2) Even if the measuring time is reduced, there is little difference between the measured leakage rate for 24 hours and the calculated leakage rate into 24 hours from 6 hours data.

## 3. RESULT

### 3.1 LRT Data

The distribution of the average leakage rate in Japanese BWR plant for investigation period is shown in Fig. 4. In maximum case of the average leakage rate, the 95% confidence level is also shown in this figure. From this figure, it is found out that the maximum leakage rate is 0.23%/day in case of 24 hours measuring time, and this value is enough less than the allowable leakage rate 0.45%/day.

### 3.2 LRT Data in Case of Measuring Time Reduction

The evaluation procedure to reduce the measuring time based on the actual plant LRT data for investigation period is shown in Table 2, and its result is shown in Table 3. From this table, it is found out that when the measuring time is gradually reduced, there is little difference between the leakage rate for 24 hours and that for not less than 6 hours.

### 3.3 The Measuring Interval in Case of Measuring Time Reduction

One sample of 95% confidence level based on the LRT data measured for one hour interval is shown in Fig. 4. From this figure, it is found out that the shorter the measuring time becomes, the larger the 95% confidence level becomes.

This is caused by the statistical disposal of a few data number. So, if the measuring time is reduced, the measuring interval also should be reduced and the accuracy of 95% confidence level should be improved.

The evaluation sample of 95% confidence level based on the calculated LRT data in reduction case is shown in Fig. 5.

As described before, the accuracy of confidence level can be held as equally as the former case by reducing the measuring interval so as to obtain as the same number of data points as the 24 hours test case.

## 4. EVALUATION

The evaluation for these results are as follows:

- (1) Even if the measuring time is reduced to 6 hours, the maximum leakage rate is enough less than the allowable leakage rate 0.45%/day.
- (2) Even if the measuring time is reduced to 6 hours, the leakage rate in this case has little difference from the leakage rate obtained by measuring for 24 hours.
- (3) The statistical problem in the measuring time reduction case can be dissolved by reducing the measuring interval and by obtaining as the same number of data points as the 24 hours measuring case.

In view of these points, it is possible that the measuring time is reduced to 6 hours.

## 5. CONCLUSION

Japanese BWR containment LRT has been demonstrated that the LRT measuring time is enough for 6 hours. Based on this result, LRT has been performed as follows:

- The LRT measuring time is reduced to 6 hours from 24 hours.
- The measuring interval is reduced to 15 minutes from 60 minutes, so as to obtain the same number of data points as usual.

By adopting this test case, it is considered that the outage critical path can be reduced to about 1 day. (See Fig. 6).

This test case has been actually adopted in Japan since 1988.

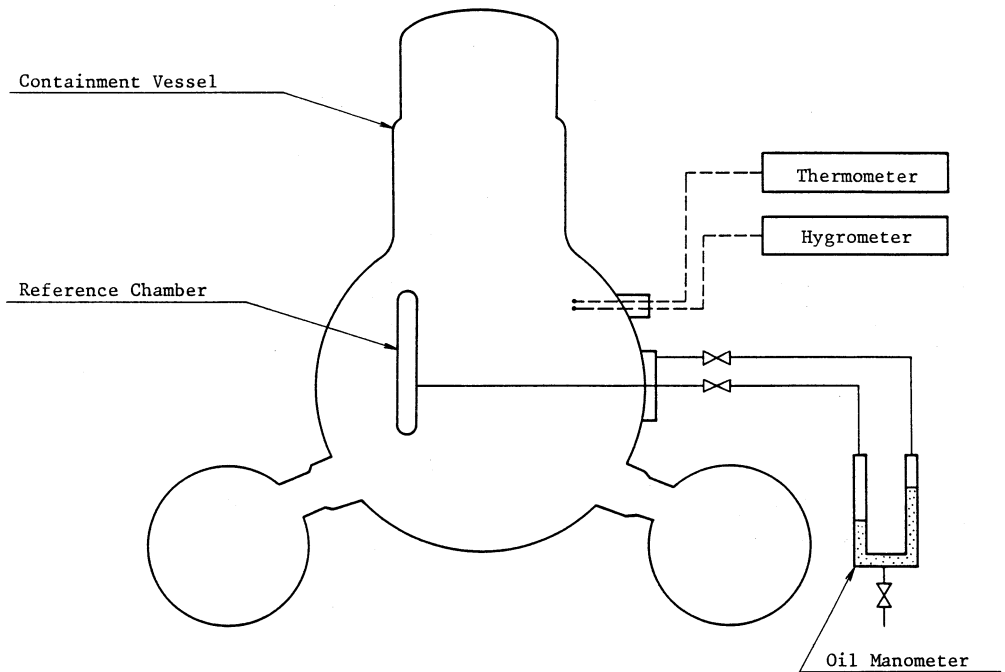


Fig. 1 Outline of Leak Test Installation

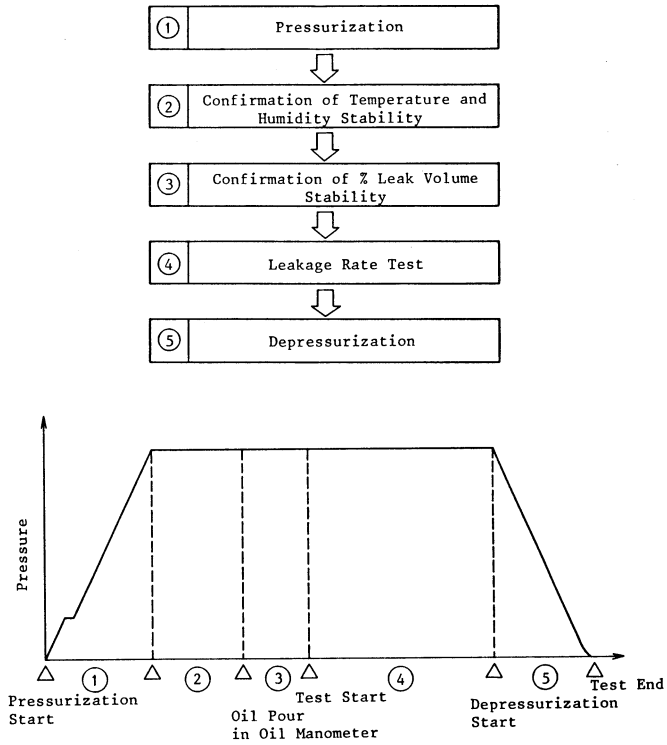


Fig. 2 Leakage Rate Test Procedure

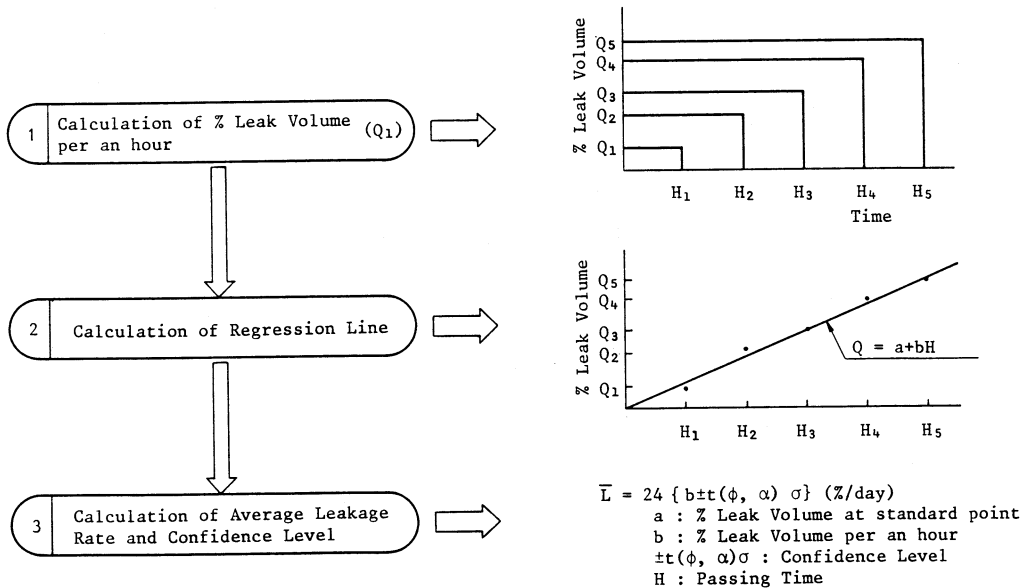


Fig. 3 The Calculation Method of LRT Data

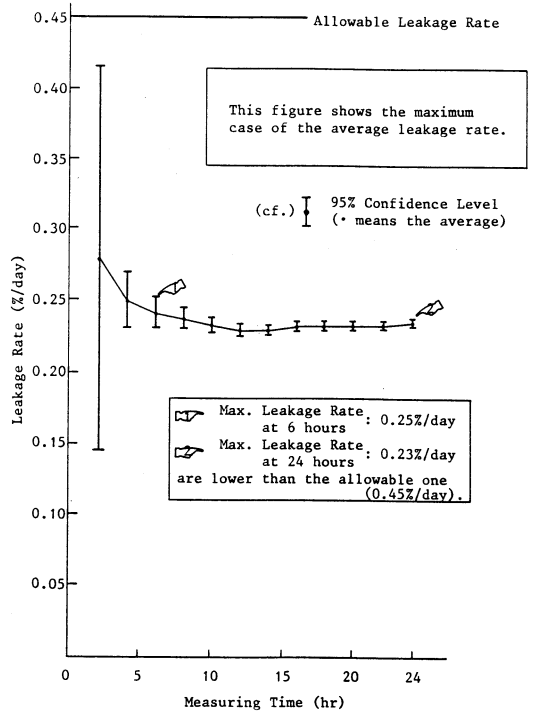
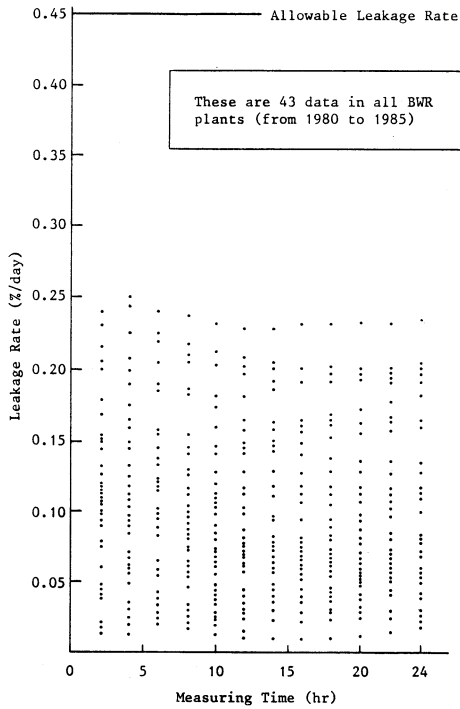


Fig. 4 Leakage Rate Distribution in All BWR Plants

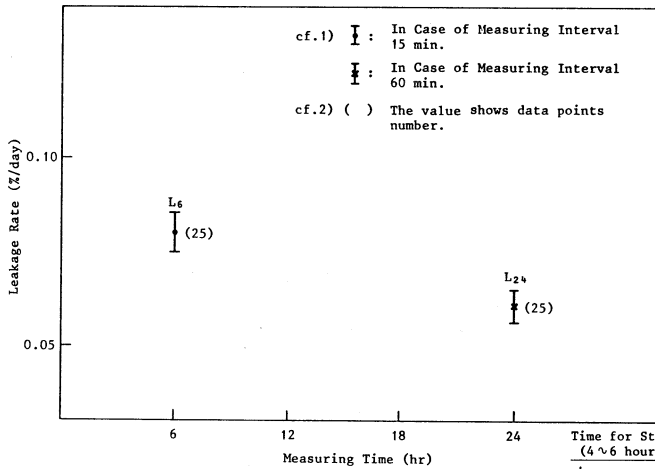


Fig. 5 95% Confidence Level

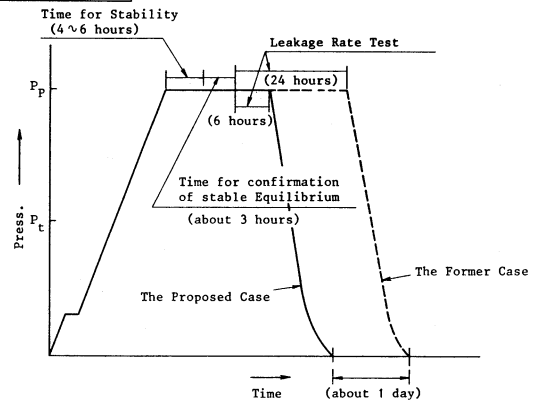


Fig. 6 Standard Schedule of Leakage Rate Test

Table 1 Examination Procedure

|   | Examination Procedure  | Attention Point  |
|---|--|--|
| 1 | Maximum leakage rate for 24 hours measuring case   | To be considerable lower than the allowable leakage rate   |
| 2 | Comparison of the leakage rate for 24 hours measuring case and that for the reduced measuring case | To be little difference between the two leakage rate   |
| 3 | Examination of confidence level in the reduced measuring case                                      | To be little difference between the confidence level in 24 hours measuring case and that in the reduced measuring case |
| 4 | Examination of measuring time  | The examination results obtained from the above item No. 1 ~ 3   |

Table 2 The Evaluation Procedure of the Average Leakage Rate Difference

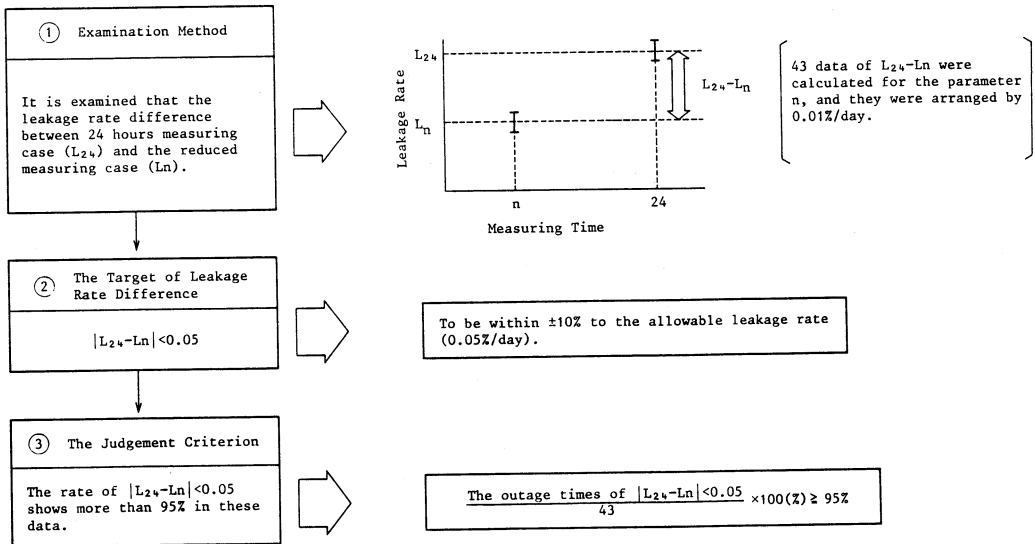


Table 3 Difference Distribution of the Average Leakage Rate

cf) The thick line shows within ±10% to the allowable leakage rate.

| n             | $L_{24}-L_n$   |       |       |       |       |       |       |       |       |    |      |      |      |      |      |      | The outage times of $ L_{24}-L_n  < 0.05$ | The rate of $ L_{24}-L_n  < 0.05$ |
|---------------|--|-------|-------|-------|-------|-------|-------|-------|-------|----|------|------|------|------|------|------|---|-----------------------------------|
|               | -0.09  | -0.08 | -0.07 | -0.06 | -0.05 | -0.04 | -0.03 | -0.02 | -0.01 | 0  | 0.01 | 0.02 | 0.03 | 0.04 | 0.05 | 0.06 |   |                                   |
| n=2           | 1  | 1     | 2     | 4     | 2     | 5     | 4     | 8     | 7     | 2  | 4    | 0    | 2    | 0    | 1    | 0    | 34 times                                  | 79.1%                             |
| n=4           | 0  | 0     | 1     | 2     | 2     | 7     | 4     | 10    | 7     | 2  | 4    | 2    | 1    | 1    | 0    | 0    | 40 times                                  | 93.0%                             |
| n=6           | 0  | 0     | 1     | 1     | 2     | 4     | 5     | 8     | 11    | 5  | 2    | 3    | 1    | 0    | 0    | 0    | 41 times                                  | 95.3%                             |
| n=8           | 0  | 1     | 0     | 0     | 1     | 3     | 5     | 8     | 12    | 6  | 3    | 2    | 2    | 0    | 0    | 0    | 42 times                                  | 97.7%                             |
| n=12          | 0  | 0     | 1     | 0     | 0     | 0     | 2     | 8     | 13    | 11 | 6    | 1    | 0    | 0    | 0    | 0    | 41 times                                  | 97.6%                             |
| n=18          | 0  | 0     | 0     | 0     | 0     | 0     | 1     | 3     | 17    | 19 | 2    | 0    | 1    | 0    | 0    | 0    | 43 times                                  | 100%                              |
| Consideration | Even if the measuring time is reduced to 6 hours, the rate of $ L_{24}-L_n  < 0.05$ shows more than 95%. |       |       |       |       |       |       |       |       |    |      |      |      |      |      |      |   |                                   |