# NSP

NORTHERN STATES POWER COMPANY

MINNEAPOLIS, MINNESOTA 55401

March 20, 1978



Director of Nuclear Reactor Regulation
U S Nuclear Regulatory Commission
Washington, DC 20555

MONTICELLO NUCLEAR GENERATING PLANT
Docket No. 50-263 License No. DPR-22

Supplement No. 1 to License Amendment Request
Dated September 2, 1977

On September 2, 1977, Northern States Power Company submitted a License Amendment Request for the Monticello Nuclear Generating Plant. This Request contained proposed changes to the Technical Specifications to permit containment integrated leak rate tests to be terminated in less than 24 hours. The proposed test duration would be at least eight hours, be long enough to accumulate at least 20 sets of data at approximately equal time intervals, and have a duration long enough to accumulate and analyze enough data to verify that the measured leakage rate, at the 95% confidence level, is less than the test acceptance criterion.

On November 2, 1977, the NRC Staff telecopied to us a Request for Additional Information. This request consisted of 11 questions concerning our integrated leak rate test procedures at Monticello and our proposed test completion criteria. The purpose of this supplement to our License Amendment Request is to provide answers to the Staff's questions. These answers are contained in Enclosure (1).

We ask that you complete review of our September 2, 1977 License Amendment Request and issue the necessary Technical Specification changes no later than October 1, 1978. This will permit us to incorporate the new test completion criteria in the integrated leak rate test scheduled for the autumn 1978 refueling outage.

Please contact us if you have any additional questions on this matter or if we can assist in expediting its review.

L. O. Mayer

L O Mayer, PE
Manager of Nuclear Support Services

LOM/DMM/deh



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1/40

cc: J G Keppler
G Charnoff
MPCA-Attn: J W Ferman

Attachment

Enclosure (1)

Letter dated March 20, 1978, L O Mayer, NSP, to Director, NRR, USNRC

RESPONSE TO NOVEMBER 2, 1977 REQUEST FOR ADDITIONAL INFORMATION
MONTICELLO NUCLEAR GENERATING STATION
CONTAINMENT LEAK TEST DURATION

1. Identify the computation procedures used to calculate the containment leakage rate and the upper 95% confidence limit for the purpose of determining the acceptability of a specific containment integrated leakage rate test (CILRT).

Response

The mass plot method is used. Containment mass, $W_i$, is computed using the reference vessel method at approximately equal time intervals.

For the first data point:

$$W_1 = \frac{144 (P_1 - P_{v,1}) V}{RT_1} \quad (1\text{-}1)$$

For subsequent data points:

$$W_i = W_{i-1} (1 - L_i) \quad (1\text{-}2)$$

Where

$$L_i = \frac{(\Delta P_{i-1} - P_{v,i-1}) - (T_{i-1}/T_i)(\Delta P_i - P_{v,i})}{(P_{i-1} - P_{v,i-1})} \quad (1\text{-}3)$$

= Leakage air mass as fraction of total contained air mass

W = Weight of air in the containment

V = Free air volume of containment

R = Gas constant for air

P = Containment absolute pressure

$\Delta P$ = Reference Chamber to containment differential pressure

$P_v$ = Containment weighted average vapor pressure

T = Containment weighted average absolute temperature

i = i th data point, i = 1, 2, ..., n

The leakage rate is determined from the above calculations of the mass of air ($W_i$) at each time point i by applying a linear regression analysis to the data. A linear regression analysis consists of minimizing the squares of the deviations of the data points from a straight line:

$$\bar{W} = At + B \qquad (1\text{-}4)$$

The slope (A) and the intercept (B) of the line are calculated as follows (all summations are from i = 1 to n).

$$A = \frac{\sum t_i W_i - (\sum t_i \sum W_i)/n}{\sum t_i^2 - (\sum t_i)^2/n} \qquad (1\text{-}5)$$

$$B = \frac{\sum W_i - A\sum t_i}{n} \qquad (1\text{-}6)$$

Where

$t_i$ = time of data point i, hours ($t_1$ = 0)

The leakage rate in weight percent per day is:

$$L = -2400\frac{A}{B} \qquad (1\text{-}7)$$

The 95% upper confidence limit for L, UCLL, is calculated using:

$$UCLL \doteq L + \frac{S_A}{B}(2400)\ t_{0.95,n-2} \qquad (1\text{-}8)$$

Where

$$S_A = \frac{\sqrt{n}\ S}{\sqrt{n(\sum t_i^2) - (\sum t_i)^2}}$$

$$S = \sqrt{\frac{\sum (W_i - \bar{W}_i)^2}{n-2}}$$

$$\bar{W} = At_i + B$$

$t_{0.95,n-2}$ = 95th percentile of "t" distribution with n-2 degrees of freedom

We will judge a test acceptable if:

a) $t_n \geq 8$ hours

b) $n \geq 21$ after rejection of spurious data points (see item 2)

c) UCLL $\leq 0.75\ L_a$

Where

$L_a$ is the maximum permitted containment leakage rate at peak accident pressure, $P_a$.

2. Your September 2, 1977 submittal indicates that the point-to-point calculational technique will be used to detect spurious data points. Discuss and justify your proposed criteria for data rejection.

Response

The point-to-point method will be used to calculate a leakage rate, $L_i$, for each data point using equation (1-3).

Point-to-point leakage rates will be subjected to a statistical test. The widely used Chauvenet criterion will be used (Reference 1). A measurement in a set of n data points will be rejected if it deviates from the mean value to the extent that the probability of all such deviations at least as great is less than 1/2n. A Gaussian distribution is assumed.

Analysis of data from the last four Type A tests indicates that none of the data points would have been rejected as spurious.

3. Discuss and justify the methods used to establish the weighting factors or volume assignments for the temperature and dewcel sensors.

Response

Rosemount Model 442A ALPHALINE Temperature Transmitters are placed throughout the containment to monitor temperature. The temperature sensing system consisted of twenty individual 2-wire temperature transmitters each connected to a platinum resistance temperature sensor and a regulated DC power supply. Each resistance temperature detector is assigned a weighting factor proportional to the volume monitored for use in calculating the average containment temperature. Tables 3-1 and 3-2 list the resistance temperature detector locations and assigned weighting factors. The RTD signals are transmitted to the plant process computer where a ten minute average of the temperature

at each locale is printed by the computer typer in degrees F.

Foxboro Model 2701 RPG dewcels are used to monitor containment vapor pressure. Each dewcel is assigned a weighting factor proportional to the containment volume monitored for calculation of average vapor pressure. Tables 3-1 and 3-2 list the dewcel locations and assigned weighting factors. The dewcel signals are transmitted to the plant process computer via resistance to current converters and a ten minute average of the vapor pressure is printed in inches of water by the computer typer. Reading of the dewcel resistance and conversion to vapor pressure is accomplished by entering the required calibration curves into the computer memory.

When instrument locations were originally specified, the drywell was divided vertically into four levels and horizontally into four sectors. Sixteen volume assignments resulted. Because of the possibility of temperature stratification near the top of the drywell, smaller volumes were assigned at higher elevations than at the lower elevations to increase the number of temperature sensors in those regions. One temperature transmitter was located in each volume. One dewcel was located in each sector and at each elevation. The torus was divided horizontally into four sectors. Vertical division was not needed. One temperator transmitter was located in each sector and one dewcel was located in every other sector.

As noted in Tables 3-1 and 3-2, generally higher weighting factors result for the torus than the drywell. There are no heat sources in the torus and conditions remain very stable thereby justifying the larger sensing volumes.

A total of twenty temperature transmitters are used. The largest weighting factor is just over ten percent and is assigned to torus sensors. The largest temperature transmitter weighting factor assigned to a sensor in the drywell is just over five percent. The largest dewcel weighting factor is 22%.

During the CILRT, one fan cooler unit is run throughout the test and additional portable fans are located in the torus and the drywell. This guarantees good air circulation and the maintenance of relatively stable temperatures and humidities throughout the containment vessel.

Instrument error analysis indicates the number of sensors used exceeds the minimum number required by approximately 100% in the case of both temperature and humidity sensors.

4. The ability of the CILRT instrumentation to detect a change in the containment atmosphere mass is primarily a function of the number and location of temperature and dewcel sensors. Discuss

and justify the criteria used to establish the number of temperature and dewcel sensors, and the maximum volume fraction that may be assigned to any particular sensor.

Response

See response to question (3) above.

As noted in the response to question (3), the number and location of temperature and humidity sensors was originally determined by attempting to locate a sensor in each major region of the containment. The containment was subdivided into twenty sensing volumes. One temperature sensor was located in each sensing volume. One humidity sensor was located in every fourth sensing volume in the drywell and every other sensing volume in the torus (where vapor pressure is a more significant factor). This philosophy resulted in a total of twenty temperature sensors and six humidity sensors.

Instrument error analysis confirms that this number is more than adequate. An overall figure of merit for the instrumentation system, based on the reference vessel method using a point-to-point leak rate calculation over an eight hour interval, has been computed to be less than one percent of the allowable containment leakage rate.

Refer to the response to question (6) for a discussion of the maximum volume fraction that may be assigned to any sensor in the event of instrument failure and reassignment of weighting factors.

5. Discuss the manner in which the mass plot technique is applied to testing with a reference vessel.

Response

Refer to the response to question (1).

While the mass plot technique is best used with the absolute method, it may also be used with the reference vessel method. Since the reference vessel method actually measures changes in the containment mass over a time interval, the initial containment air mass must be calculated for the first data point if the mass plot method is to be utilized. Equation (1-1) is used for this purpose. P, $P_V$ and T are determined using the CILRT instrumentation. V, the containment free air volume was measured during the 1974 Type A test and was reported in reference (4). The measured volume was in excellent agreement with the design value.

There does not appear to be a statistical advantage in applying the mass plot method to the reference vessel technique. Other

TABLE 3-1 DRYWELL DEWCELS AND RTD's

| Sensor Type | Sensor No. | Location* | | Volume Weighting Factor |
|---|---|---|---|---|
| | | Elevation | Azimuth | |
| Dewcel | 1 | 933 | 0 | 0.2158 |
| | 2 | 951 | 90 | 0.2050 |
| | 3 | 966 | 180 | 0.0787 |
| | 4 | 994 | 270 | 0.0936 |
| RTD | 1 | 933 | 0 | 0.0537 |
| | 2 | 933 | 90 | 0.0537 |
| | 3 | 933 | 180 | 0.0537 |
| | 4 | 933 | 270 | 0.0537 |
| | 5 | 951 | 0 | 0.0513 |
| | 6 | 951 | 90 | 0.0513 |
| | 7 | 951 | 180 | 0.0513 |
| | 8 | 951 | 270 | 0.0513 |
| | 9 | 966 | 0 | 0.0198 |
| | 10 | 966 | 90 | 0.0198 |
| | 11 | 966 | 180 | 0.0198 |
| | 12 | 966 | 270 | 0.0198 |
| | 13 | 994 | 0 | 0.0235 |
| | 14 | 994 | 90 | 0.0235 |
| | 15 | 994 | 180 | 0.0235 |
| | 16 | 994 | 270 | 0.0235 |

TABLE 3-2 TORUS DEWCELS AND RTD's

| Sensor Type | Sensor No. | Location* | | Volume Weighting Factor |
|---|---|---|---|---|
| | | Elevation | Azimuth | |
| Dewcel | 5 | 915 | 0 | 0.2034 |
| | 6 | 915 | 180 | 0.2034 |
| RTD | 17 | 915 | 0 | 0.1017 |
| | 18 | 915 | 90 | 0.1017 |
| | 19 | 915 | 180 | 0.1017 |
| | 20 | 915 | 270 | 0.1017 |

*Referenced to the drywell floor at 9[illegible]0.5 ft, the torus center line at 912.5 ft, and the drywell airlock at 0 degrees.

computational methods, such as the point-to-point method or the total time method, combined with least-squares data analysis, are more directly applicable. The mass plot technique is rapidly becoming the industry standard, however, and we have adopted it in the manner described to permit it to be used with our reference vessel instrumentation. The absolute method may be used in the future.

6. Identify the criteria used to establish an instrument failure and the maximum number of instruments that may fail before a test is aborted. In addition, discuss the procedures for eliminating the data from failed instruments from the leakage rate calculations, including the replacement of data and recalculation of weighting factors.

<u>Response</u>

Four Type A tests have been conducted at Monticello since the beginning of commercial operation. No test instrument failure has occurred in any of these tests. Special precautions have been taken to assure instrument reliability, both in the selection of top quality sensors and in their installation.

[illegible] instrumentation for those instruments located outside containment will be available during each Type A test (i.e., redundant manometer, pressure gauge, and flow meter). A failure of one of these instruments is not serious. Instruments located inside containment, however, cannot be repaired or replaced during the course of the Type A test. In the event of a temperature or humidity sensor failure, provisions will be made to continue the test by reassigning instrument weighting factors. Because of the large number of sensors used at Monticello, multiple failures can be tolerated and a valid leak rate measurement can still be achieved.

The following criteria will be used:

<u>Instrument Failure</u>

An instrument is considered to have failed if:

a. Out of range high or low
b. Intermittent indication
c. Unexplained departure from trend of previous readings
d. Analysis of a data point rejected using the criteria described in item (2) above indicates an unreasonable sensor reading.

The output of all individual sensors will be scanned at each data point.

Maximum Number of Instrument Failures

Drywell - No more than four temperature sensors will be permitted to fail. The failure of more than two sensors at any one elevation will not be permitted. No more than one humidity sensor will be permitted to fail.

Torus No more than two temperature sensors will be permitted to fail. No more than one humidity sensor will be permitted to fail.

In the event of instrument failures that exceed these numbers, the test will be suspended and repairs made. A new Type A test will be conducted when the minimum number of instruments are again made operable.

Instrument error analysis indicates that the above permitted failures can be tolerated without significantly degrading the figure of merit for the instrumentation system (the figure of merit remains better than 5% $L_a$ - refer to question (4)). Because of its relative insensitivity to temperature sensor error, the reference vessel method can be successfully used with far fewer sensors than other methods.

When an instrument failure occurs, instrument weighting factors will be reassigned and the faulty instrument will no longer be used for computing average containment temperature or vapor pressure. In the event that it is determined that past data may have been affected by an instrument failure, computations based on the faulty instrument can be repeated using the reassigned weighting factors and dropping the faulty instrument readings from the data set.

Weighting factors will be reassigned as shown in Tables 6-1 and 6.2.

7. Discuss the effects of instrument bias as functions of time, temperature, and pressure on the CILRT results. Since the $0.25L_a$ acceptance criteria for the supplemental verification test was established based on a 24-hour test duration, discuss the adequacy of this acceptance criteria as it relates to the identification of systematic instrument errors for a test of shorter duration.

Response

Bias, or systematic error, can arise through faulty instrumentation, calibration procedures, or computational techniques.

TABLE 6-1 RTD WEIGHTING FACTORS TO BE USED AS A RESULT OF RTD FAILURES DURING THE TEST

| Sensor Group | Sensors (Numbers) | Number of Sensor Failures | Remaining Sensors | Weighting factor of remaining sensors |
|---|---|---|---|---|
| RTD 1 | 1,2,3,4 | 1 of 4 | 3 | 0.0716 |
| 1 | 1,2,3,4 | 2 of 4 | 2 | 0.1074 |
| RTD 2 | 5,6,7,8 | 1 of 4 | 3 | 0.0684 |
| 2 | 5,6,7,8 | 2 of 4 | 2 | 0.1026 |
| RTD 3 | 9,10,11,12 | 1 of 4 | 3 | 0.0264 |
| 3 | 9,10,11,12 | 2 of 4 | 2 | 0.0396 |
| RTD 4 | 13,14,15,16 | 1 of 4 | 3 | 0.0313 |
| 4 | 13,14,15,16 | 2 of 4 | 2 | 0.047 |
| RTD 5 | 17,18,19,20 | 1 of 4 | 3 | 0.1356 |
| 5 | 17,18,19,20 | 2 of 4 | 2 | 0.2034 |

TABLE 6-2 DEWCEL WEIGHTING FACTORS TO BE USED AS A RESULT OF DEWCEL FAILURES DURING A TEST

| Sensor | Failed Sensor (Number) | Remaining Sensors (Number) | Weighting Factor (Remaining Sensors) |
|---|---|---|---|
| Dewcel | 1 | 2 | 0.4208 |
| | | 3 | 0.0787 |
| | | 4 | 0.0936 |
| | | 5 | 0.2034 |
| | | 6 | 0.2034 |
| | 2 | 1 | 0.24975 |
| | | 3 | 0.24975 |
| | | 4 | 0.0936 |
| | | 5 | 0.2034 |
| | | 6 | 0.2034 |
| | 3 | 1 | 0.2158 |
| | | 2 | 0.18865 |
| | | 4 | 0.18865 |
| | | 5 | 0.2034 |
| | | 6 | 0.2034 |
| | 4 | 1 | 0.2158 |
| | | 2 | 0.2050 |
| | | 3 | 0.1723 |
| | | 5 | 0.2034 |
| | | 6 | 0.2034 |
| | 5 | 1 | 0.2158 |
| | | 2 | 0.2050 |
| | | 3 | 0.0787 |
| | | 4 | 0.0936 |
| | | 6 | 0.4068 |
| | 6 | 1 | 0.2158 |
| | | 2 | 0.2050 |
| | | 3 | 0.0787 |
| | | 4 | 0.0936 |
| | | 5 | 0.4068 |

Because leak rate computations deal primarily with changes in containment parameters, errors in the measured leak rate due to systematic errors tend to be small.

Before a CILRT is begun, all instrumentation is calibrated against standards traceable to the National Bureau of Standards. This guarantees that at the start of the test, systematic error will be held to within very small limits. Following the completion of the CILRT, a verification test is conducted. This verification is a repeat of the CILRT for a short period of time with a known leak rate superimposed on the containment overall leak rate. The CILRT results are acceptable if the verification test confirms the overall containment leak rate measurement to within $0.25L_a$. This places an upper limit on the effects of systematic error which is independent of the length of the CILRT.

To quantify the effects of instrument bias on CILRT results as a function of test duration, a number of calculations have been performed using the 1977 Monticello CILRT data. Using this data, worst case instrument error has been applied as a bias and the effect on CILRT results noted. Using the mass plot method, the leak rate and 95% upper confidence level leak rate were computed for the unbiased data (Table 7-1) and various combinations of biased data. The following cases were evaluated:

a. Pressure instrument bias of 1.71 INWG high and low

b. Temperature instrumentation bias of 0.1°F high and low

c. Dew point instrumentation bias of 0.2 INWG high and low

d. Manometer bias of 0.01 INWG high and low

Instrument bias has the greatest impact for the case of

Pressure instrument bias low
Temperature instrument bias low
Dew point instrumentation bias low
Manometer bias - no effect

This case is shown in Table 7-2 for comparison with the unbiased case shown in Table 7-1. The effect of worst case bias is seen to change the 95% upper confidence level leakage by 0.1% for a test duration of eight hours. The change is 0.5% for a test duration of 24 hours. There is, therefore, no advantage in extending the CILRT to 24 hours to

TABLE 7-1

## 1977 CILRT DATA

| TIME (HR) | PRES(IN) (INWO) | TEMP(R) (INWO) | VAP (IN) (INWO) | DP (IN) (INWO) | MASS (LB) | LEAKAGE WT%/DAY | 95% UCL WT%/DAY |
|---|---|---|---|---|---|---|---|
| 0.0 | 1553.716 | 537.380 | 11.230 | 17.900 | 6.92342E 04 | | |
| 0.500 | 1553.414 | 537.340 | 11.200 | 17.740 | 6.92275E 04 | | |
| 1.000 | 1553.195 | 537.310 | 11.160 | 17.580 | 6.92221E 04 | 4.203E-01 | 5.944E-01 |
| 1.500 | 1553.060 | 537.300 | 11.190 | 17.450 | 6.92158E 04 | 4.212E-01 | 4.565E-01 |
| 2.000 | 1552.783 | 537.280 | 11.180 | 17.340 | 6.92113E 04 | 3.995E-01 | 4.308E-01 |
| 2.500 | 1552.783 | 537.270 | 11.180 | 17.220 | 6.92064E 04 | 3.843E-01 | 4.113E-01 |
| 3.000 | 1552.783 | 537.270 | 11.150 | 17.120 | 6.92028E 04 | 3.652E-01 | 3.939E-01 |
| 3.500 | 1552.234 | 537.260 | 11.150 | 17.010 | 6.91978E 04 | 3.555E-01 | 3.788E-01 |
| 4.000 | 1552.100 | 537.260 | 11.130 | 16.900 | 6.91938E 04 | 3.467E-01 | 3.673E-01 |
| 4.500 | 1552.234 | 537.260 | 11.130 | 16.790 | 6.91886E 04 | 3.429E-01 | 3.599E-01 |
| 5.000 | 1552.234 | 537.270 | 11.130 | 16.690 | 6.91843E 04 | 3.378E-01 | 3.522E-01 |
| 5.500 | 1552.100 | 537.280 | 11.120 | 16.600 | 6.91807E 04 | 3.326E-01 | 3.469E-01 |
| 6.000 | 1551.687 | 537.290 | 11.110 | 16.500 | 6.91766E 04 | 3.276E-01 | 3.399E-01 |
| 6.500 | 1551.552 | 537.300 | 11.110 | 16.400 | 6.91721E 04 | 3.243E-01 | 3.353E-01 |
| 7.000 | 1551.416 | 537.310 | 11.110 | 16.300 | 6.91676E 04 | 3.219E-01 | 3.318E-01 |
| 7.500 | 1551.416 | 537.310 | 11.120 | 16.200 | 6.91626E 04 | 3.202E-01 | 3.288E-01 |
| 8.000 | 1551.280 | 537.340 | 11.100 | 16.110 | 6.91594E 04 | 3.164E-01 | 3.245E-01 |
| 8.500 | 1551.145 | 537.340 | 11.090 | 16.030 | 6.91563E 04 | 3.125E-01 | 3.206E-01 |
| 9.000 | 1551.145 | 537.360 | 11.100 | 15.960 | 6.91524E 04 | 3.085E-01 | 3.165E-01 |
| 9.500 | 1551.009 | 537.380 | 11.090 | 15.880 | 6.91494E 04 | 3.044E-01 | 3.124E-01 |
| 10.000 | 1551.009 | 537.400 | 11.080 | 15.790 | 6.91458E 04 | 3.000E-01 | 3.082E-01 |
| 10.500 | 1551.009 | 537.410 | 11.100 | 15.700 | 6.91395E 04 | 2.988E-01 | 3.063E-01 |
| 11.000 | 1551.009 | 537.430 | 11.110 | 15.600 | 6.91368E 04 | 2.964E-01 | 3.022E-01 |
| 11.500 | 1551.009 | 537.450 | 11.110 | 15.520 | 6.91327E 04 | 2.946E-01 | 3.019E-01 |
| 12.000 | 1550.374 | 537.470 | 11.120 | 15.430 | 6.91277E 04 | 2.939E-01 | 2.996E-01 |
| 12.500 | 1550.374 | 537.480 | 11.120 | 15.350 | 6.91254E 04 | 2.910E-01 | 2.972E-01 |
| 13.000 | 1550.174 | 537.510 | 11.110 | 15.300 | 6.91223E 04 | 2.893E-01 | 2.953E-01 |
| 13.500 | 1550.679 | 537.520 | 11.120 | 15.230 | 6.91186E 04 | 2.874E-01 | 2.933E-01 |
| 14.000 | 1550.604 | 537.550 | 11.140 | 15.170 | 6.91150E 04 | 2.857E-01 | 2.915E-01 |
| 14.500 | 1550.[illegible] | 537.580 | 11.140 | 15.100 | 6.91110E 04 | 2.831E-01 | 2.889E-01 |
| 15.000 | 1550.196 | 537.590 | 11.140 | 15.030 | 6.91086E 04 | 2.812E-01 | 2.869E-01 |
| 15.500 | 1549.926 | 537.620 | 11.110 | 14.950 | 6.91063E 04 | 2.798E-01 | 2.856E-01 |
| 16.000 | 1550.615 | 537.640 | 11.130 | 14.880 | 6.91023E 04 | 2.774E-01 | 2.831E-01 |
| 16.500 | 1550.068 | 537.660 | 11.160 | 14.820 | 6.90982E 04 | 2.766E-01 | 2.822E-01 |
| 17.000 | 1550.345 | 537.700 | 11.140 | 14.740 | 6.90954E 04 | 2.753E-01 | 2.809E-01 |
| 17.500 | 1549.794 | 537.720 | 11.130 | 14.690 | 6.90936E 04 | 2.730E-01 | 2.787E-01 |
| 18.000 | 1550.209 | 537.740 | 11.160 | 14.640 | 6.90914E 04 | 2.709E-01 | 2.767E-01 |
| 18.500 | 1550.209 | 537.770 | 11.150 | 14.560 | 6.90878E 04 | 2.690E-01 | 2.749E-01 |
| 19.000 | 1550.209 | 537.790 | 11.150 | 14.500 | 6.90850E 04 | 2.673E-01 | 2.732E-01 |
| 19.500 | 1550.073 | 537.810 | 11.110 | 14.400 | 6.90814E 04 | 2.656E-01 | 2.715E-01 |
| 20.000 | 1550.073 | 537.850 | 11.140 | 14.430 | 6.90813E 04 | 2.633E-01 | 2.694E-01 |
| 20.500 | 1550.073 | 537.880 | 11.130 | 14.350 | 6.90781E 04 | 2.611E-01 | 2.673E-01 |
| 21.000 | 1550.040 | 537.910 | 11.140 | 14.280 | 6.90745E 04 | 2.590E-01 | 2.651E-01 |
| 21.500 | 1549.935 | 537.940 | 11.160 | 14.230 | 6.90713E 04 | 2.571E-01 | 2.633E-01 |
| 22.000 | 1549.904 | 537.960 | 11.190 | 14.160 | 6.90668E 04 | 2.558E-01 | 2.619E-01 |
| 22.500 | 1549.938 | 537.970 | 11.200 | 14.100 | 6.90637E 04 | 2.549E-01 | 2.606E-01 |
| 23.000 | 1549.[illegible] | 537.[illegible] | 11.[illegible] | 14.040 | 6.90619E 04 | 2.527E-01 | 2.587E-01 |
| 23.500 | 1549.768 | 537.990 | 11.190 | 13.960 | 6.90578E 04 | 2.515E-01 | 2.573E-01 |
| 24.000 | 1549.768 | 538.020 | 11.200 | 13.900 | 6.90546E 04 | 2.502E-01 | 2.559E-01 |

TABLE 7-2

# WORST-CASE BIASED 1977 CILRT DATA

```
INSTRUMENT BIAS  -  PRESSURE(INWO)      =    -1.71
                 -  TEMPERATURE(F)      =    -0.10
                 -  VAPOR PRES (INWO) =      -0.20
                 -  CNT-REF DP (INWO) =       0.0
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| TIME (HR) | PRES(IN) (INWO) | TEMP(R) (INWO) | VAP (IN) (INWO) | DP (IN) (INWO) | MASS (LB) | LEAKAGE WT%/DAY | 95% UCL WT%/DAY |
|---|---|---|---|---|---|---|---|
| 0.0 | 1552.006 | 537.280 | 11.030 | 17.900 | 6.91794E 04 | | |
| 0.500 | 1551.904 | 537.240 | 11.020 | 17.740 | 6.91706E 04 | | |
| 1.000 | 1551.485 | 537.210 | 10.980 | 17.580 | 6.91673E 04 | 4.006E-01 | 5.949E-01 |
| 1.500 | 1551.350 | 537.200 | 10.990 | 17.450 | 6.91609E 04 | 4.215E-01 | 4.569E-01 |
| 2.000 | 1551.073 | 537.180 | 10.980 | 17.340 | 6.91564E 04 | [illegible] | 4.329E-01 |
| 2.500 | 1551.073 | 537.170 | 10.980 | 17.230 | 6.91515E 04 | 3.841E-01 | 4.106E-01 |
| 3.000 | 1551.073 | 537.170 | 10.950 | 17.120 | 6.91479E 04 | 3.659E-01 | 3.945E-01 |
| 3.500 | 1550.524 | 537.160 | 10.950 | 17.010 | 6.91429E 04 | 3.558E-01 | 3.791E-01 |
| 4.000 | 1550.390 | 537.160 | 10.930 | 16.900 | 6.91389E 04 | 3.469E-01 | 3.676E-01 |
| 4.500 | 1550.524 | 537.160 | 10.930 | 16.790 | 6.91339E 04 | 3.431E-01 | 3.602E-01 |
| 5.000 | 1550.524 | 537.170 | 10.930 | 16.690 | 6.91294E 04 | 3.368E-01 | 3.512E-01 |
| 5.500 | 1550.390 | 537.180 | 10.920 | 16.600 | 6.91258E 04 | 3.309E-01 | 3.461E-01 |
| 6.000 | 1549.977 | 537.190 | 10.910 | 16.500 | 6.91218E 04 | 3.279E-01 | 3.402E-01 |
| 6.500 | 1549.842 | 537.200 | 10.910 | 16.400 | 6.91173E 04 | 3.209E-01 | 3.349E-01 |
| 7.000 | 1549.706 | 537.210 | 10.910 | 16.300 | 6.91129E 04 | 3.217E-01 | 3.316E-01 |
| 7.500 | 1549.706 | [illegible] | 10.920 | 16.200 | 6.91070E 04 | 3.198E-01 | [illegible] |
| 8.000 | 1549.570 | 537.240 | 10.900 | 16.110 | 6.91046E 04 | 3.160E-01 | 3.241E-01 |
| 8.500 | 1549.435 | 537.240 | 10.890 | 16.030 | 6.91014E 04 | 3.119E-01 | 3.189E-01 |
| 9.000 | 1549.435 | [illegible] | [illegible] | 15.960 | [illegible] | [illegible] | 3.145E-01 |
| 9.500 | 1549.299 | [illegible] | 10.890 | 15.860 | 6.90946E 04 | 3.039E-01 | 3.121E-01 |
| 10.000 | 1549.299 | 537.300 | 10.880 | 15.790 | 6.90909E 04 | 2.995E-01 | 3.072E-01 |
| 10.500 | 1549.299 | 537.310 | 10.900 | 15.700 | 6.90846E 04 | 2.982E-01 | 3.051E-01 |
| 11.000 | 1549.299 | 537.330 | 10.910 | 15.620 | 6.90819E 04 | 2.959E-01 | 3.031E-01 |
| 11.500 | 1549.299 | 537.350 | 10.910 | 15.530 | 6.90778E 04 | 2.940E-01 | 3.006E-01 |
| 12.000 | 1549.164 | 537.370 | 10.900 | 15.430 | [illegible] | 2.920E-01 | 2.992E-01 |
| 12.500 | 1549.164 | 537.380 | 10.920 | 15.360 | 6.90706E 04 | 2.905E-01 | 2.970E-01 |
| 13.000 | 1549.164 | 537.410 | 10.910 | 15.300 | 6.90674E 04 | 2.884E-01 | 2.945E-01 |
| 13.500 | 1548.892 | 537.400 | 10.970 | 15.230 | 6.90638E 04 | 2.865E-01 | 2.925E-01 |
| 14.000 | 1548.894 | 537.450 | 10.940 | 15.170 | 6.90601E 04 | 2.847E-01 | 2.906E-01 |
| 14.500 | 1548.622 | 537.460 | 10.940 | 15.100 | 6.90569E 04 | 2.826E-01 | 2.885E-01 |
| 15.000 | 1548.486 | 537.490 | 10.940 | 15.030 | 6.90530E 04 | 2.809E-01 | 2.867E-01 |
| 15.500 | 1548.216 | 537.520 | 10.910 | 14.950 | 6.90514E 04 | 2.784E-01 | 2.842E-01 |
| 16.000 | [illegible] | 537.540 | 10.930 | 14.880 | 6.90474E 04 | 2.768E-01 | 2.825E-01 |
| 16.500 | [illegible] | 537.560 | 10.960 | 14.820 | 6.90433E 04 | 2.755E-01 | 2.812E-01 |
| 17.000 | 1548.635 | 537.600 | 10.940 | 14.740 | 6.90406E 04 | 2.743E-01 | 2.800E-01 |
| 17.500 | 1548.086 | 537.620 | 10.970 | 14.690 | 6.90388E 04 | 2.721E-01 | 2.778E-01 |
| 18.000 | 1548.499 | 537.640 | 10.930 | 14.640 | 6.90365E 04 | 2.696E-01 | 2.755E-01 |
| 18.500 | 1548.499 | 537.670 | 10.950 | 14.580 | 6.90329E 04 | 2.678E-01 | 2.737E-01 |
| 19.000 | 1548.499 | 537.690 | 10.950 | 14.500 | 6.90301E 04 | 2.657E-01 | 2.717E-01 |
| 19.500 | 1548.363 | 537.710 | 10.910 | 14.400 | 6.90265E 04 | 2.641E-01 | 2.701E-01 |
| 20.000 | 1548.363 | [illegible] | 10.940 | 14.430 | 6.90264E 04 | 2.615E-01 | 2.677E-01 |
| 20.500 | 1548.263 | 537.780 | 10.930 | 14.350 | 6.90209E 04 | 2.591E-01 | 2.654E-01 |
| 21.000 | [illegible] | [illegible] | 10.940 | 14.260 | 6.90196E 04 | [illegible] | [illegible] |
| 21.500 | 1548.229 | 537.840 | 10.960 | 14.230 | 6.90164E 04 | 2.557E-01 | 2.620E-01 |
| 22.000 | 1548.194 | 537.860 | 10.990 | 14.160 | 6.90119E 04 | 2.543E-01 | 2.604E-01 |
| 22.500 | [illegible] | 537.770 | 11.000 | 14.100 | 6.90088E 04 | [illegible] | 2.589E-01 |
| 23.000 | 1547.781 | 537.650 | 10.980 | 14.040 | 6.90069E 04 | 2.511E-01 | 2.572E-01 |
| 23.500 | 1548.058 | 537.690 | 10.990 | 13.960 | 6.90029E 04 | 2.500E-01 | 2.559E-01 |
| 24.000 | 1548.058 | 537.920 | 11.000 | 13.900 | 6.89997E 04 | 2.488E-01 | 2.546E-01 |

reduce the effect of systematic error.

8. Previous testing experience has shown that there are a number of effects which become more pronounced as the CILRT duration decreases. In many cases, these effects are not adequately reflected in the confidence limits of the CILRT results. Demonstrate that the proposed minimum test duration in conjunction with the proposed testing procedure will adequately reflect each of the following effects:

   a) the containment volume change following pressurization;

   b) outgassing and ingassing during and following containment pressurization;

   c) the variation of internal system heat loads; and

   d) diurnal effects relating to variations in the temperature of containment cooling water.

Response

a) Following pressurization and containment atmosphere stabilization, the containment volume will experience a very slight decrease as internal pressure decreases over the course of the CILRT. For the Monticello pressure suppression type containment, the volume can be shown to decrease less than $6ft^3$ for every reduction in pressure of 1 psi.

   Over the course of the CILRT, containment pressure may fall as much as 2 psia. If the period of the CILRT is t hours, this pressure reduction is equivalent to the introduction of air into containment at the rate of 0.76/t scfm. For an eight hour test duration, the equivalent air addition rate is 0.09 scfm. This is less than one percent of $L_a$ and is negligible.

b) Ingassing and outgassing during and following containment pressurization has a small effect on the CILRT results at Monticello. Experience has shown that the effect of ingassing and outgassing on tests of BWR containments is slight because of the small internal surface area compared to a larger PWR type containment. A BWR also has a larger specified value

of $L_a$ because of its smaller containment volume which tends to reduce the effects of ingassing and outgassing. (Reference 2).

The effect of ingassing and outgassing is evident in plots of containment leakage rate versus time. As shown in the plot for the 1977 Monticello CILRT, ingassing generally results in a higher leak rate during the initial phases of the test and outgassing results in a lower leak rate during the final phases of the test. (Figure 8-1). Terminating the test following eight hours of data collection would result in a more conservative leakage rate measurement than the measurement obtained after 24 hours of testing.

c) The variation of internal system heat loads is not a concern during conduct of the CILRT at Monticello.

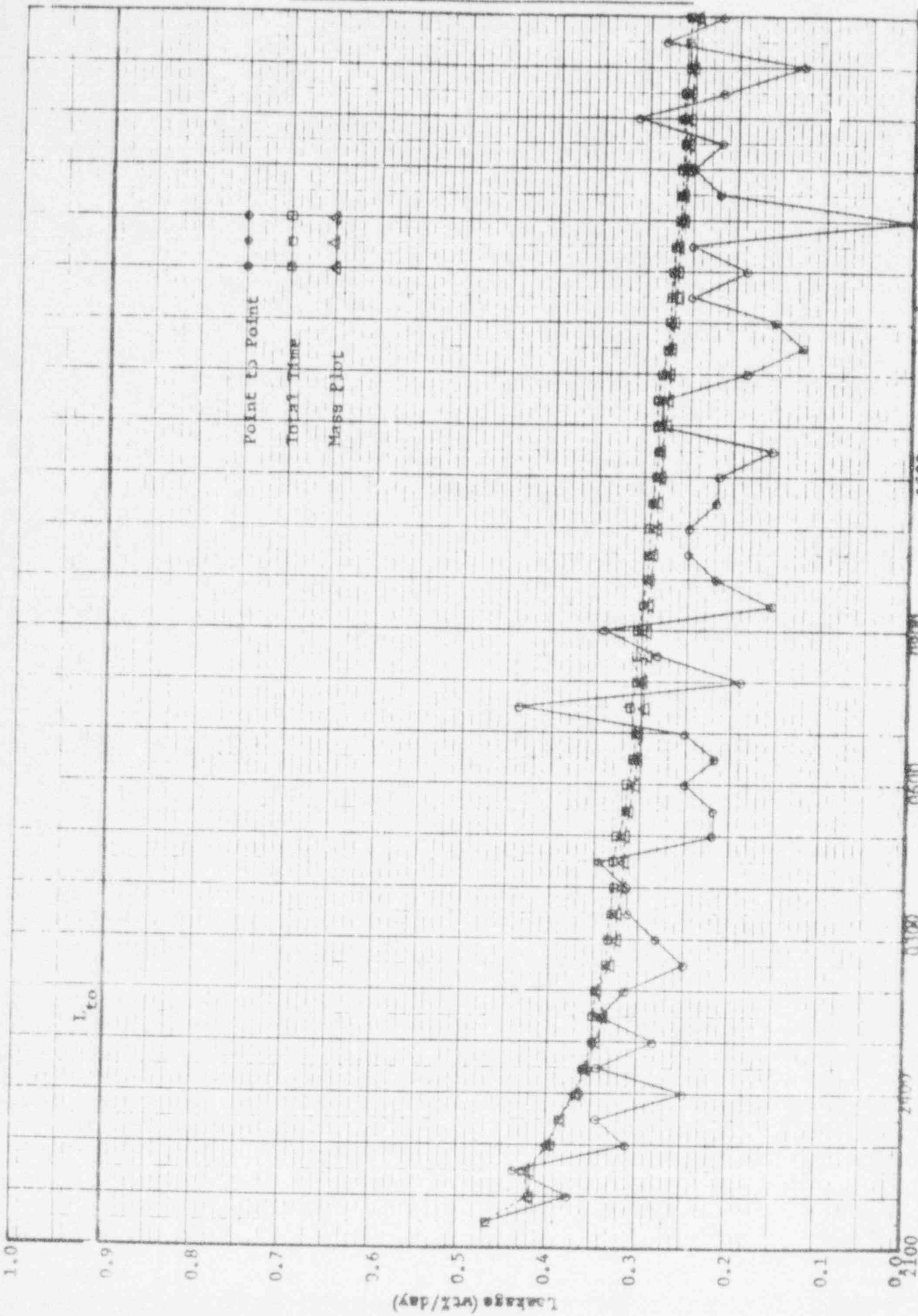
During early CILRT's, some difficulty was experienced in maintaining uniform stable temperatures throughout the drywell. Since then a number of procedural and equipment changes have been made to permit containment temperatures to stabilize rapidly following pressurization and to remain essentially constant during the test. During the 1977 CILRT, over the 24 hour duration of the test, the temperature change amounted to less than 0.7°R. (Table 7-1).

The only significant heat load inside containment during the CILRT is the reactor vessel. Careful regulation of reactor water temperature by adjusting the RHR heat exchanger inlet valve prevents variations in this heat load. Stratification of water within the reactor vessel is prevented by running one recirculation pump at minimum speed throughout the test.

d) Diurnal effects relating to variations in the temperature of containment cooling water are not a concern during the conduct of the CILRT at Monticello. The worst case diurnal variation in river water temperature is ± 3°F during a hot sunny day in July or August. During the autumn, winter, and early spring months, daily temperature variation is less than ± 1°F. CILRT's are conducted during refueling outages which are generally scheduled in late autumn and early spring.

FIGURE 8-1

PL. OF 1977 CILRT MEASURED LEAK RAT.
VERSUS TIME



Daily cooling water temperature variation is therefore small and generally has a negligible effect on RHR heat removal rate or containment fan cooler heat removal rate. In each case, however, these temperatures are closely monitored during the CILRT to prevent significant variation in average containment air temperature.

Since the Monticello containment vessel is entirely enclosed within the Reactor Building, the containment shell is not subjected to diurnal ambient temperature changes. Containment shell temperature remains essentially constant over the course of the test.

We have been unable to detect any diurnal variation in containment leak rate versus time. Refer, for example, to Figure 8-1 which shows no dependence on time of day. Plots of all Monticello CILRT results may be found in References (3) through (7).

9. Discuss and justify the basis for the selection of an eight hour stabilization period.

<u>Response</u>

An eight hour stabilization period will not be used.

Current procedures require a four hour stabilization period and this has generally been adequate during past CILRT's. Future tests will use a temperature stabilization criterion.

Following containment pressurization to $P_a$ plus one psi, containment temperature sensors will be read every 10 minutes. The containment atmosphere will be considered stabilized when the change in weighted average air temperature averaged over an hour does not deviate by more than 0.5°R/hour from the average rate of change of temperature measured over the previous four hours. This is a widely used criterion for determining the time when stabilization is essentially complete.

10. The acceptance criteria proposed in your September 2, 1977 submittal is based on a point-in-time measurement. Discuss the manner by which leakage rate trends will be reflected in the acceptance criteria.

<u>Response</u>

The mass plot method of computing CILRT leakage rate is rapidly becoming the standard in the industry. The method

has a number of advantages over older methods. The method generally results in narrower confidence intervals for leakage since maximum use is made of all measured data.

The mass plot method involves the assumption of a linear relationship between the containment air mass, W, and time, t. This is equivalent to assuming a constant rate of change of containment air mass. This rate of change is the containment overall leak rate, L.

L is, in fact, a function of the differential pressure across the containment shell and penetrations. It may also be influenced to some extent by other factors such as temperature. In actual tests of a reactor containment vessel, however, these effects were shown to be very small. (Reference 8).

During a CILRT, pressure will stay within 2% of $P_a$. Assuming a conservative laminar flow through leakage paths, this variation in test pressure results in a 2% change in L. This change is within the statistical uncertainty of the mass plot method. Temperature effects on the measured value of L are negligible since temperature remains constant within 1°R throughout the test. Because of the slight dependence of L on test pressure, a larger value of L will be measured if the test duration is short.

To summarize, the mass plot method assumes a constant containment leak rate, L. In actuality, there is a slight dependence of L on test pressure. This could be taken into account by fitting a higher order polynomial to the W versus t data at the expense of complicating the statistical analysis of the data. This is unnecessary, however, because of the very small departure of the W versus t relationship from a straight line. The linear assumption for the relationship yields conservative values of L if the test is terminated before test pressure falls below $P_a$.

11. Identify the procedures that will be used when excessive leakage is encountered during the performance of a CILRT.

Response

The Monticello Technical Specifications state:

> If leak repairs are necessary to meet the allowable (CILRT) leak rate, the integrated leak rate test need not be repeated provided local leak measurements are conducted and the leak rate differences prior to and after repairs, when corrected to $P_t$ and deducted from the integrated leak rate measurements, yield a leakage rate

value not in excess of the allowable operational leak rate $L_{to}$.

Appendix J to 10 CFR 50 currently requires a Type A test to be repeated in the event repairs are necessary to reduce leakage to an acceptable rate. Therefore, the current Technical Specifications and Appendix J are in conflict on this point

We believe that if, during the CILRT, excessive leakage is identified through a testable penetration, the leakage may be isolated and the CILRT continued. Type B or Type C tests made before and after repairs to the leakage path can be applied to the CILRT leak rate to determine the as-found and as-left overall containment leak rate. A request for exemption from this requirement of Appendix J will be submitted to permit the course of action described to be followed. This will be included in a supplement to our submittal dated May 5, 1976, "Request for Exemption from Certain Requirements of 10 CFR 50, Appendix J."

REFERENCES


1. Wang Lau, L., "Data Analysis During Containment Leak Rate Test," Power Engineering, February, 1974, p. 46.

2. Fleshood, David L, Carolina Power & Light Co., "Containment Leak Rate Testing: Why the Mass-Plot Analysis Method is Preferred," Power Engineering, February, 1976, p. 56.

3. Reactor Containment Building Integrated Leak Test - May, 1973, submitted by NSP for NRC review August 3, 1973.

4. Reactor Containment Building Integrated Leak Test - May, 1974, submitted by NSP for NRC review August 12, 1974.

5. Reactor Containment Building Integrated Leak Test - November, 1975, submitted by NSP for NRC review January 23, 1976

6. Supplement No. 1 to Report of Containment Building Integrated Leak Test - November, 1976, submitted by NSP for NRC review March 16, 1976.

7. Reactor Containment Building Integrated Leak Test - November, 1977, submitted by NSP for NRC review February 8, 1978

8. Bingham, G. E., Final Results of the Carolinas Virginia Tube Reactor Containment Leakage Rate Tests, IN-1399, June, 1970 (TID-4500)