BALTIMORE GAS AND ELECTRIC COMPANY

CALVERT CLIFFS NUCLEAR POWER PLANT

UNIT 1

# PRIMARY REACTOR CONTAINMENT

# INTEGRATED LEAKAGE RATE TEST REPORT

MAY 1985

PREPARED BY

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CONTENTS

## EXECUTIVE SUMMARY

A Primary Containment Integrated Leakage Rate Test (ILRT) was successfully completed at the Calvert Cliffs Nuclear Power Plant, Unit 1, on May 20, 1985. The test met the requirements set forth in 10CFR50, Appendix J.

Listed below is the summary of the test results for both the mass point and total time data analysis techniques. The actual measured leakage ($L_{am}$) and the 95 percent upper confidence limit (UCL), in units of weight percent per day, are compared to the acceptance criteria.

| Mass Point | Test Result | Acceptance Criteria |
|---|---|---|
| ILRT Lam | 0.032 | 0.150 |
| ILRT UCL | 0.035 | 0.150 |
| Verification Test Lam | 0.201 | $0.155 < Lam < 0.255$ |
| **Total Time** | | |
| ILRT Lam | 0.025 | 0.150 |
| ILRT UCL | 0.069 | 0.150 |
| Verification Test Lam | 0.166 | $0.148 < Lam < 0.248$ |

The total local leakage rate measured for the eight penetrations not in the post-LOCA lineup during the ILRT was 0.002%/day.

The chronological summary of events, summary of plant technical data, and discussion of test results are included in portions of this report.

## I. INTRODUCTION

This report presents data, analysis, and conclusions pertaining to the Calvert Cliffs Nuclear Power Plant Unit 1 Integrated Leakage Rate Test (ILRT) performed in May 1985. The Integrated Leakage Rate Test (Type A) is performed periodically to demonstrate that the combined leakage through the reactor containment and those systems penetrating the containment does not exceed the allowable leakage rate specified in the Plant Technical Specifications.

The successful periodic Type A and supplemental verification tests were performed according to the requirements of the Calvert Cliffs Nuclear Power Plant, Unit 1, Technical Specifications and 10CFR50, Appendix J. The Calvert Cliffs Type A test method is the Absolute Method described in ANSI N45.4-1972, "Leakage Rate Testing of Containment Structures for Nuclear Reactors" and ANSI/ANS 56.8-1981, "Containment System Leakage Testing Requirements." The leakage rate was calculated using formulas from the above ANSI Standards and BN-TOP-1, Rev 1, "Testing Criteria for Integrated Leakage Rate Testing of Primary Containment Structures for Nuclear Power Plants." Type A and verification test durations were according to the criteria of BN-TOP-1.

A 95% upper confidence level was calculated for leakage rate data as required by Reference 6. This is to ensure a 95% probability that the calculated leakage rate value is within the acceptance limits. All calculations were done with Bechtel's ILRT computer program described in Appendix A.

The temperature and pressure history and the containment air mass variations were plotted by the computer program and are contained in Appendix E.

## II. TEST SYNOPSIS

Valve line-ups were conducted on all systems to e tablish post-accident conditions except for shutdown cooling, steam generator manways and manholes and three penetrations necessary to conduct the ILRT. The inspection of the containment's accessible interior and exterior surfaces was conducted prior to pressurization. No evidence of structural deterioration was noted which would have affected containment integrity or leak tightness.

Containment pressurization commenced at 1:00 pm, May 18, 1985. At 3:30 pm, pressurization was stopped to investigate an observed 100 inch water level decrease (approximately 3000 gal.) in the pressurizer. At 5:25 pm the pressurizer was refilled and pressurization restarted. At 7:45 pm the sumps were drained due to a high sump water level reading.

Test pressure of 50.5 psig was reached at 2:44 am, May 19, 1985. The pressurization line was vented and the containment coolers and fans were stopped in stages between 3:00 am and 6:40 am. Containment pressure continued to increase due to increasing containment temperature. In order to satisfy procedural requirements on the test pressure, the upper limit on the test pressure was raised from 50.5 psig to 52.0 psig. The temperature stabilization criteria were satisfied during the four hours from 9:30 am to 1:30 pm.

Collection of data to determine the integrated leakage rate commenced at 1:30 pm, May 19, 1985 and was completed at 11:30 pm. The verification flow test was initiated at 0:30 am, May 20, 1985. The verification flow test was completed satisfactorily and depressurization of the containment commenced at 7:40 am, May 20, 1985. After the containment was completely depressurized at 10:30 pm, May 20, 1985, a containment entry was made. Determination was made that no measurable water level changes requiring corrections to the measured leakage rate had occurred during the test. Summary of test phases were as follow:

| Test Phase | Time | Duration hr. | Date |
|---|---|---|---|
| Pressurization | 1300 - 0244 | 14.73 | May 18-19 |
| Stabilization | 0245 - 1315 | 10.5 | May 19 |
| ILRT | 1330 - 2330 | 10.0 | May 19 |
| Verification Initiation | 2345 - 0015 | 0.5 | May 19-20 |
| Verification Stabilization | 0030 - 0130 | 1.0 | May 20 |
| Verification Test | 0130 - 0630 | 5.0 | May 20 |

During the test two temperature sensors were malfunctioning. Temperature sensor 13, located in #11 steam generator cavity indicated a decreasing temperature starting at 9:30 am on May 19. Since all other temperature sensors indicated an increase in temperature, sensor 13 was judged to be malfunctioning and its volume fraction assigned to temperature sensor 6, located in #12 steam generator cavity. Temperature sensor 14 consistently indicated temperatures approximately 6 to 7°F lower than adjacent sensors which was inconsistent with the temperature survey. Sensor 14 was judged to be malfunctioning and its volume fraction assigned to temperature sensor 12, located at the same elevation. The reassigned volume fractions were used to calculate the containment dry air mass during the entire test. Plots of temperature sensors 13 and 14 are in Appendix I.

## III. TEST DATA SUMMARY

### A. Plant Information

| | |
|---|---|
| Owner: | Baltimore Gas and Electric Company |
| Plant: | Calvert Cliffs Nuclear Power Plant Unit 1 |
| Location: | Lusby, Maryland |
| Containment Type: | Post-tensioned concrete |
| Data Test Completed: | May 20, 1985 |
| Docket No.: | 50317 |

### B. Technical Data

| | | |
|---|---|---|
| 1. | Containment Net Free Air Volume | 2,000,000 cu. ft. |
| 2. | Design Pressure | 50 psig |
| 3. | Design Temperature | 276°F |
| 4. | Calculated Peak Accident pressure Pa | 50 psig |
| 5. | Containment ILRT Average Temperature Limits | 60-120°F |

### C. Type A Test Result

| | | |
|---|---|---|
| 1. | Test Method | Absolute |
| 2. | Leakage Rate Data Analysis Techniques | Total Time per BN-TOP-1 and Mass Point per ANSI/ANS 56.8-1981 |
| 3. | Test Pressure | 50.0 psig + 2.0* - 0.0 |
| 4. | Maximum Allowable Leakage Rate, La, per Technical Specification | 0.2%/day |
| 5. | 75% of La | 0.15%/day |

### D. Type A Test Results

| Integrated Leakage Rate | | From Regression Line, %/day (Lam) | At Upper 95% Confidence Limit |
|---|---|---|---|
| a. | Mass Point Analysis | 0.032 | 0.035 |
| b. | Total Time Analysis | 0.025 | 0.069 |

* The upper bound on test pressure was increased from 50.5 to 52.0 psig to allow for increasing pressure due to increasing containment temperature.

E. Verification Test

| | | |
|---|---|---|
| 1. | Imposed flow rate (Li) | 10.75 scfm (0.173%/day) |
| 2. | Verification Test Results | Leakage Rate, %/day |
| | a. Mass Point Analysis | 0.201 |
| | b. Total Time Analysis | 0.166 |
| 3. | Verification Test Limits | Test Limit, %/day |
| | a. Mass Point Analysis | |
| | (1) Upper Limit (Li + Lam + 0.25 La) | 0.255 |
| | (2) Lower Limit (Li + Lam - 0.25 La) | 0.155 |
| | b. Total Time Analysis | |
| | (1) Upper Limit | 0.248 |
| | (2) Lower Limit | 0.148 |

F. Report Printouts

The Report Printouts of the Type A and Verification Test calculations are provided for the Mass Point and Total Time Analysis (Appendices C through F). Stabilization data is also provided (Appendix B).

G. Local Leakage Rate Test Results - Type B and C Tests

1. LLRT Results - The Type B and C leakage tests were conducted prior to the Type A test. The total as left LLRT measurement for Unit 1 was 28,354.03 sccm. This value converts to 0.016%/day which is less than the technical specification limit of .12%/day. An evaluation of "as left" compared to "as found" data is contained in Appendix H.

2. During the ILRT the following penetrations were not in the post accident position. The following is the local leakage rate measurement for these penetrations.

| Penetration | System | As Left, SCCM |
|---|---|---|
| 7A | ILRT Instrumentation | 20.4 |
| 7B | ILRT Instrumentation | 494 |
| 41 | Shutdown Cooling Return | 2376 |
| 50 | ILRT Pressurization | 362 |
| 11 | SG Manway 11-1 | 59.7 |
| 11 | SG Manhole 11-2 | 192 |
| 12 | SG Manway 12-1 | 98.2 |
| 12 | SG Manhole 12-2 | 62.8 |
| | Total: | 3655.1 sccm |
| | %/day: | .002%/day |

3. Periodic Type B and Type C Test Results Since Last ILRT

| Outage Date | LLRT | Acceptance Criteria |
|---|---|---|
| 10/3/83 | 29,886.94 | .6 La = 207,700 sccm |

4. 10CFR50, Appendix J, paragraph V.B.3 requires that leakage test results from Type A, B, and C tests that failed to meet the acceptance criteria of III.A.5(b), III.B.3 and III.C.3, respectively, shall be reported in a separate accompanying summary report that includes an analysis and interpretation of the test data, the least-squares fit analysis of the test data, the instrumentation error analysis, and the structural condition of the containment or components, if any, which contributed to the failure in meeting the acceptance criteria. Since the tests meet the acceptance criteria no further analysis is submitted. Instruments used during local leakage rate testing are calibrated as follows: ± 1% full scale for flowmeters, and ± 0.1% full scale for temperature and pressure gauges. Field checks of flowmeters are performed prior to each test to check calibration.

H. Integrated Leakage Rate Measurement System

The following instrument system was used:

| Description | Data | |
|---|---|---|
| 1. Absolute Pressure | | |
| 2 Precision Pressure Gages | Range: | 0-100 psia |
| Mensor Model 10100 | Accuracy: | 0.02% F.S. |
| | Sensitivity: | 0.001 psia |
| | Repeatability: | 0.001 psia |
| | Calibration Date: | 2/26/85 |

| Description | Data | |
|---|---|---|
| 2. Drybulb Temperature | | |
| 18 Temperature Sensors<br>Volumetrics 100 ohm<br>Platinum RTD, part no.<br>VSTD-347 | Range:<br>Accuracy:<br>Sensitivity:<br>Repeatability:<br>Calibration Date: | 32-120°F<br>0.20°F<br>0.01°F<br>0.01°F<br>2/23/85 |
| 3. Dewpoint Temperature | | |
| 6 Dewpoint Sensors<br>EG&G Model 660 Chilled<br>Mirror Hygrometers | Range:<br>Accuracy:<br>Sensitivity:<br>Repeatability:<br>Calibration Date: | 40-100°F<br>0.54°F<br>0.10° F<br>0.1°F<br>2/25/85 |
| 4. Flowmeters | | |
| 2 Mass Flowmeters<br>(1) TSI Model 2013<br>(2) Model 2014 | Range:<br><br>Accuracy:<br>Sensitivity:<br>Repeatability:<br>Calibration Date: | 0-10 scfm<br>0-20 scfm<br>1% F.S.<br>1% F.S.<br>0.1 scfm<br>3/5/85 |

5. Overall Instrumentation Selection Guide (ISG) Value (from ANSI/ANS 56.8-1981, Appendix G) based on ILRT instrumentation and ten hour minimum test duration = 0.0067%/day. (Calculations Appendix G).

6. Drybulb and Dewpoint Temperature Sensor Volume Fractions - Table 1.

## I. Information Retained at Plant

The following information is available for review at the Facility:

1. Listing of all containment penetrations, including the total number of like penetrations, penetration size and function.

2. Systems lineup (at time of test).

3. A continuous, sequential log of events during the test.

4. Documentation of instrumentation calibration and standards.

5. The working copy of test procedure that would include signature sign-off of procedural steps.

6. The procedure and all data from local leakage rate testing of penetrations and valves.

7. The Quality Assurance audit plan that was used to monitor ILRT.

8. A listing of all test exceptions including changes in containment system boundaries instituted by licensee to conclude successful testing.

9. Description of method of leak rate verification of instrument measuring system (superimposed leakage), with calibration information on flowmeters along with calculations that were used to measure the verification leakage rate.

## IV. ANALYSIS AND INTERPRETATION

The Integrated Leakage Rate Test results at the upper 95% confidence level, are Lam = 0.035%/day (Mass Point analysis) and 0.069%/day (Total Time analysis). The local leakage rate for penetrations not in post-LOCA lineup is 0.002%/day. The sums of the ILRT upper 95% confidence level and LLRT leakage rates, Lam = 0.037%/day (Mass Point analysis) and 0.071%/day (Total Time analysis) satisfy the acceptance criterion. The acceptance criterion is Lam $<$ 0.75 La = 0.150%/day, at Pa = 50 psig (-0 psi, +2.0 psi).

TABLE 1

DRYBULB AND DEWPOINT TEMPERATURE SENSOR LOCATIONS

| TE No. | Tag No. | Elevation (ft) | Azimuths (degrees) | Distance From Center | Volume Fractions Original | Volume Fractions Reassigned | Reference Drawing |
|---|---|---|---|---|---|---|---|
| 1 | 0-TE-5500 | 175 | 0 | 0 | .081 | .081 | E-292 |
| 2 | 0-TE-5501 | 160 | 180 | 33 | .081 | .081 | E-292 |
| 3 | 0-TE-5502 | 145 | 0 | 33 | .081 | .081 | E-292 |
| 4 | 0-TE-5503 | 130 | 90 | 48 | .073 | .073 | E-292 |
| 5 | 0-TE-5508 | 115 | 0 | 0 | .073 | .073 | E-292 |
| 6 | 0-TE-5511 | 50 | 230 | 50 | .021 | .043 | E-290 |
| 7 | 0-TE-5513 | 104 | 180 | 32 | .073 | .073 | E-275-2 |
| 8 | 0-TE-5504 | 104 | 0 | 30 | .073 | .073 | E-292 |
| 9 | 0-TE-5505 | 75 | 20 | 48 | .058 | .058 | E-292 |
| 10 | 0-TE-5506 | 65 | 0 | 0 | .042 | .042 | E-292 |
| 11 | 0-TE-5517 | 16 | 180 | 45 | .044 | .044 | E-298 |
| 12 | 0-TE-5507 | 50 | 140 | 44 | .044 | .088 | E-295-1 |
| *13 | 0-TE-5509 | 50 | 85 | 40 | .022 | .000 | E-295-1 |
| *14 | 0-TE-5510 | 50 | 320 | 50 | .044 | .000 | E-295-2 |
| 15 | 0-TE-5512 | 75 | 220 | 44 | .058 | .058 | E-295-2 |
| 16 | 0-TE-5514 | 16 | 80 | 50 | .044 | .044 | E-289 |
| 17 | 0-TE-5515 | 16 | 0 | 48 | .044 | .044 | E-289 |
| 18 | 0-TE-5516 | 16 | 270 | 25 | .044 | .044 | E-289 |

DEWCELLS

| AE No. | Tag No. | Elevation (ft) | Azimuths (degrees) | Distance From Center | Volume Fractions Original | Volume Fractions Reassigned | Reference Drawing |
|---|---|---|---|---|---|---|---|
| 1 | 0-AE-5518 | 154 | 0 | 33 | .231 | .231 | E-292 |
| 2 | 0-AE-5519 | 119 | 180 | 33 | .231 | .231 | E-292 |
| 3 | 0-AE-5520 | 75 | 350 | 48 | .231 | .231 | E-292 |
| 4 | 0-AE-5521 | 50 | 320 | 40 | .131 | .131 | E-292-2 |
| 5 | 0-AE-5522 | 16 | 0 | 30 | .088 | .088 | E-289 |
| 6 | 0-AE-5523 | 16 | 180 | 45 | .088 | .088 | E-289 |

* Malfunctioning sensors - not used for leakage rate calculations.

## V. REFERENCES


1. Calvert Cliffs, Unit 1, Plant Technical Specifications.

2. Calvert Cliffs Procedure STP M-662-1, Integrated Leakage Rate Test, Unit 1 Containment.

3. 10CFR50, Appendix J, "Reactor Containment Leakage Testing for Water Cooled Power Reactors."

4. ANSI N45.4-1972, "Leakage Rate Testing of Containment Structures for Nuclear Reactors."

5. ANSI/ANS 56.8-1981, "Containment System Leakage Testing Requirements."

6. Bechtel Topical Report BN-TOP-1, "Testing Criteria for Integrated Leakage Rate Testing of Primary Containment Structures for Nuclear Power Plants." Rev. 1, February 1972.

# APPENDIX A

# DESCRIPTION OF BECHTEL ILRT COMPUTER PROGRAM

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DESCRIPTION OF BECHTEL ILRT COMPUTER PROGRAM

A. Program and Report Description

1. The Bechtel ILRT computer program is used to determine the integrated leakage rate of a nuclear primary containment structure. The program is used to compute leakage rate based on input values of time, free air volume, containment atmosphere total pressure, drybulb temperature, and dewpoint temperature (water vapor pressure). Leakage rate is computed using the Absolute Method as defined in ANSI/ANS 56.8-1981, "Containment System Leakage Testing Requirements" and BN-TOP-1, Rev 1, "Testing Criteria for Integrated Leakage Rate Testing of Primary Containment Structures for Nuclear Power Plants". The program is designed to allow the user to evaluate containment leakage rate test results at the jobsite during containment leakage testing. Current leakage rate values may be obtained at any time during the testing period using one of two computational methods, yielding three different report printouts.

2. In the first printout, the Total Time Report, leakage rate is computed from initial values of free air volume, containment atmosphere drybulb temperature and partial pressure of dry air, the latest values of the same parameters, and elapsed time. These individually computed leakage rates are statistically averaged using linear regression by the method of least squares. The Total Time Method is the computational technique upon which the short duration test criteria of BN-TOP-1, Rev 1, "Testing Criteria for Integrated Leakage Rate Testing of Primary Containment Structures for Nuclear Power Plant," are based.

3. The second printout is the Mass Point Report and is based on the Mass Point Analysis Technique described in ANSI/ANS 56.8-1981, "Containment System Leakage Testing Requirements." The mass of dry air in the containment is computed at each data point (time) using the Equation of State, from current values of containment atmosphere drybulb temperature and partial pressure of dry air. Contained mass is "plotted" versus time and a regression line is fit to the data using the method of least squares. Leakage rate is determined from the statistically derived slope and intercept of the regression line.

4. The third printout, the Trend Report, is a summary of leakage rate values based on Total time and Mass Point computations presented as a function of number of data points and elapsed time (test duration). The Trend Report provides all leakage rate values required for comparision to the acceptance criteria of BN-TOP-1 for conduct of a short duration test.

5. The program is written in a high level language and is designed for use on a micro-computer with direct data input from the data acquisition system. Brief descriptions of program use, formulae

used for leakage rate computations, and program logic are provided in the following paragraphs.

B. Explanation of Program

1. The Bechtel ILRT computer program is written, for use by experienced ILRT personnel, to determine containment integrated leakage rates based on the Absolute Method described in ANSI/ANS 56.8-1981 and BN-TOP-1.

2. Information loaded into the program prior to or at the start of the test:

   a. Number of containment atmosphere drybulb temperature sensors, dewpoint temperature (water vapor pressure) sensors and pressure gages to be used in leakage rate computations for the specific test

   b. Volume fractions assigned to each of the above sensors

   c. Calibration data for above sensors

   d. Test title

   e. Test pressure

   g. Maximum allowable leakage rate at test pressure

3. Data received from the data acquistion system during the test, and used to compute leakage rates:

   a. Time and date

   b. Containment atmosphere drybulb temperatures

   c. Containment atmosphere pressure(s)

   d. Containment atmosphere dewpoint temperatures

   e. Containment free air volume.

4. After all data at a given time are received , a Summary of Measured Data report (refer to "Program Logic," Paragraph D, "Data" option command) is printed.

5. If drybulb and dewpoint temperature sensors should fail during the test, the data from the sensor(s) are not used. The volume fractions for the remaining sensors are recomputed and reloaded into the program for use in ensuing leakage rate computations.

C. Leakage Rate Formulae

1. Computation using the Total Time Method:

a. Measured leakage rate, from data:

$$P_1V_1 = W_1RT_1 \tag{1}$$

$$P_iV_i = W_iRT_i \tag{2}$$

$$L_i = \frac{2400\ (W_1 - W_i)}{\Delta t_i\ W_1} \tag{3}$$

Solving for $W_1$ and $W_i$ and substituting equations (1) and (2) into (3) yields:

$$L_i = \frac{2400}{\Delta t_i}\left(1 - \frac{T_1P_iV_i}{T_iP_1V_1}\right) \tag{4}$$

where,

$W_1$, $W_i$ = Weight of contained mass of dry air at times $t_1$ and $t_i$ respectively, lbm.

$T_1$, $T_i$ = Containment atmosphere drybulb temperature at times $t_1$ and $t_i$ respectively, °R.

$P_1$, $P_i$ = Partial pressure of the dry air component of the containment atmosphere at times $t_1$ and $t_i$ respectively, psia.

$V_1$, $V_i$ = Containment free air volume at times $t_1$ and $t_i$ respectively, (constant or variable during the test), $ft^3$.

$t_1$, $t_i$ = Time at $1^{st}$ and $i^{th}$ data points respectively, hours.

$\Delta t_i$ = Elapsed time from $t_1$ to $t_i$, hours.

$R$ = Specific gas constant for air = 53.35 ft.lbf/lbm.°R.

$L_i$ = Measured leakage rate computed during time interval $t_1$ to $t_i$, wt.%/day.

In order to reduce truncation error, the computer program uses the following equivalent formulation:

$$L_i = \frac{-2400}{\Delta t_i}\ \frac{\Delta W_i}{W_1}$$

where,

$$\frac{\Delta W_i}{W_1} = \frac{W_i - W_1}{W_1}$$

$$= \frac{\frac{\Delta P_i}{P_1} + \frac{\Delta V_i}{V_1} + \frac{\Delta P_i \Delta V_i}{P_1 V_1} - \frac{\Delta T_i}{T_1}}{1 + \frac{\Delta T_i}{T_i}}$$

$$\Delta P_i = P_i - P_1$$
$$\Delta V_i = V_i - V_1$$
$$\Delta T_i = T_i - T_1$$

b. Calculated leakage rate from regression analysis,

$$\bar{L} = a + b \Delta t_N \tag{5}$$

where:

$\bar{L}$ = Calculated leakage rate, wt.%/day, as determined from the regression line.

$$a = (\Sigma L_i - b\Sigma \Delta t_i)/N \tag{6}$$

$$b = \frac{N(\Sigma L_i \Delta t_i) - (\Sigma L_i)(\Sigma \Delta t_i)}{N(\Sigma \Delta t_i^2) - (\Sigma \Delta t_i)^2} \tag{7}$$

N = Number of data points

$$\Sigma = \sum_{i=1}^{N}$$

c. Calculated leakage rate at the 95% confidence level.

$$\bar{L}_{95} = a + b \Delta t_N + S_{\bar{L}} \tag{8}$$

where:

$\bar{L}_{95}$ = Calculated leakage rate at the 95% confidence level, wt.%/day, at elapsed time $\Delta t_N$.

For $\Delta t_N < 24$

$$S_{\bar{L}} = t_{0.025;N-2} \left[(\Sigma L_i^2 - a\Sigma L_i - b\Sigma L_i \Delta t_i)/(N-2)\right]^{1/2} \times \left[1 + \frac{1}{N} + (\Delta t_N - \overline{\Delta t})^2 / (\Sigma \Delta t_i^2 - (\Sigma \Delta t_i)^2/N)\right]^{1/2} \quad (9a)$$

where, $t_{0.025;N-2} = 1.95996 + \frac{2.37226}{N-2} + \frac{2.82250}{(N-2)^2}$ ;

For $\Delta t_N \geq 24$

$$S_{\bar{L}} = t_{0.025;N-2} \left[(\Sigma L_i^2 - a\Sigma L_i - b\Sigma L_i \Delta t_i)/(N-2)\right]^{1/2} \times \left[\frac{1}{N} + (\Delta t_N - \overline{\Delta t})^2 / (\Sigma \Delta t_i^2 - (\Sigma t_i)^2/N)\right]^{1/2} \quad (9b)$$

where, $t_{0.025;N-2} = \dfrac{1.6449(N-2)^2 + 3.5283(N-2) + 0.85602}{(N-2)^2 + 1.2209(N-2) - 1.5162}$

$$\overline{\Delta t} = \frac{\Sigma \Delta t_i}{N}$$

2. Computation using the Mass Point Method

   a. Contained mass of dry air from data:

$$W_i = 144 \frac{P_i V_i}{R T_i} \quad (10)$$

   where:

   All symbols as previously defined.

   b. Calculated leakage rate from regression analysis, $W = a + b\,\Delta t$

$$\overline{L} = -2400 \frac{b}{a} \quad (11)$$

   where:

   $\overline{L}$ = Calculated leakage rate, wt.%/day, as determined from the regression line.

$$a = (\Sigma W_i - b\Sigma\Delta t_i)/N \quad (12)$$

$$b = \frac{N(\Sigma W_i \Delta t_i) - (\Sigma W_i)(\Sigma \Delta t_i)}{N(\Sigma \Delta t_i^2) - (\Sigma \Delta t_i)^2} \quad (13)$$

$\Delta t_i$ = Total elapsed time at time of $i^{th}$ data point, hours

$N$ = Number of data points

$W_i$ = Contained mass of dry air at $i^{th}$ data point, lbm, as computed from equation (10).

$$\Sigma = \sum_{i=1}^{N}$$

Inorder to reduce truncation error, the computer program uses the following equivalent formulation:

$$a = W_1 \left[ 1 + \left( \Sigma \frac{\Delta W_i}{W_1} - \frac{b}{W_1} \Sigma \Delta t_i \right)/N \right]$$

$$b = W_1 \left[ \frac{N \left( \Sigma \frac{\Delta W_i}{W_1} \Delta t_i \right) - \Sigma \frac{\Delta W_i}{W_1} \Sigma \Delta t_i}{N(\Sigma \Delta t_i^2) - (\Sigma \Delta t_i)^2} \right]$$

where, $\frac{\Delta W_i}{W_1}$ is as previously defined.

c. Calculated leakage rate at the 95% confidence level.

$$\bar{L}_{95} = \frac{-2400}{a} (b - S_b) \quad (14)$$

where:

$\bar{L}_{95}$ = Calculated leakage rate at the 95% confidence level, wt.%/day.

$$S_b = t_{0.025;N-2} \frac{SN^{1/2}}{[N\Sigma\Delta t_i^2 - (\Sigma\Delta t_i)^2]^{1/2}} \qquad (15)$$

where, $t_{0.025;N-2} = \dfrac{1.6449(N-2)^2 + 3.5283\ (N-2)^2 + 0.85602}{(N-2)^2 + 1.2209\ (N-2) - 1.5162}$

$$S = \left\{\frac{\Sigma[W_i - (a + b\,\Delta t_i)]^2}{N-2}\right\}^{1/2}$$

$$= W_1 \left\{\frac{1}{N-2}\left[\Sigma(\Delta W_i/W_1)^2 - [\Sigma(\Delta W_i/W_1)]^2/N - \frac{[\Sigma(\Delta W_i/W_1)\,\Delta t_i - \Sigma(\Delta W_i/W_1)(\Sigma\Delta t_i)/N]^2}{\Sigma(\Delta t_i^2) - (\Sigma\,\Delta t_i)^2/N}\right]\right\}^{1/2}$$

D. Program Logic

1. The Bechtel ILRT computer program logic flow is controlled by a set of user options. The user options and a brief description of their associated function are presented below.

| OPTION COMMAND | FUNCTION |
|---|---|
| | After starting the program execution, the user either enters the name of the file containing previously entered data or initializes a new data file. |
| DATA | Enables user to enter raw data. When the system requests values of time, volume, temperature, pressure and vapor pressure, the user enters the appropriate data. After completing the data entry, a summary is printed out. The user then verifies that the data were entered correctly. If errors are detected, the user will then be given the opportunity to correct the errors. After the user verifies that the data were entered correctly, a Corrected Data Summary Report of time, data, average temperature, partial pressure of dry air, and water vapor pressure is printed. |
| TREND | A Trend Report is printed. |
| TOTAL | A Total Time Report is printed. |
| MASS | A Mass Point Report is printed. |
| TERM | Enables user to sign-off temporarily or permanently. All data is saved on a file for restarting. |
| CORR | Enables user to correct previously entered data. |
| LIST | A Summary Data Report is printed. |
| READ | Enable the computer to receive the next set of data from the data acquisition system directly. |
| PLOT | Enables user to plot summary data, individual sensor data or air mass versus time. |
| DELETE | Enables user to delete a data point. |
| INSERT | Enables user to reinstate a previously deleted data point. |
| VOLFRA | Enable user to change volume fractions. |

| OPTION COMMAND | FUNCTION |
|---|---|
| TIME | Enable the user to specify the time interval for a report or plot. |
| VERF | Enable the user to input imposed leakage rate and calcaluted ILRT leakage rates at start of verification test. |

## E. COMPUTER REPORT AND DATA PRINTOUT

### MASS POINT REPORT

The Mass Point Report presents leakage rate data (wt%/day) as determined by the Mass Point Method. The "Calculated Leakage Rate" is the value determined from the regression analysis. The "Containment Air Mass" values are the masses of dry air in the containment (lbm). These air masses, determined from the Equation of State, are used in the regression analysis.

### TOTAL TIME REPORT

The Total Time Report presents data leakage rate (wt%/day) as determined by the Total Time Method. The "Calculated Leakage Rate" is the value determined from the regression analysis. The "Measured Leakage Rates" are the leakage rate values determined using Total Time calculations. These values of leakage rate are used in the regression analysis.

### TREND REPORT

The Trend Report presents leakage rates as determined by the Mass Point and Total Time methods in percent of the initial contained mass of dry air per day (wt%/day), versus elapsed time (hours) and number of data points.

### SUMMARY DATA REPORT

The Summary Data report presents the actual data used to calculate leakage rates by the various methods described in the "Computer Program" section of this report. The six column headings are TIME, DATE, TEMP, PRESSURE, VPRS, and VOLUME and contain data defined as follows:

1. TIME: Time in 24-hour notations (hours and minutes).
2. DATE: Calendar date (month and day).
3. TEMP: Containment weighted-average drybulb temperature in absolute units, degrees Rankine (°R).

4. PRESSURE: Partial pressure of the dry air component of the containment atmosphere in absolute units (psia).

5. VPRS: Partial pressure of water vapor of the containment atmosphere in absolute units (psia).

6. VOLUME: Containment free air volume (cu. ft.).

F. SUMMARY OF MEASURED DATA AND SUMMARY OF CORRECTED DATA

The Summary of Measured Data presents the individual containment atmosphere drybulb temperatures, dewpoint temperatures, absolute total pressure and free air volume measured at the time and date.

1. TEMP 1 through TEMP N are the drybulb temperatures, where N = No. of RTD's. The values in the right-hand column are temperatures (°F), multiplied by 100, as read from the data acquisition system (DAS). The values in the left-hand column are the corrected temperatures expressed in absolute units (°R).

2. PRES 1 through PRES N are the total pressures, absolute, were N = No. of pressure sensors. The right-hand value, in parentheses, is a number in counts as read from the DAS. This count value is converted to a value in psia by the computer via the instrument's calibration table, counts versus psia. The left-hand column is the absolute total pressure, psia.

3. VPRS 1 through VPRS N are the dewpoint temperatures (water vapor pressures), where N = No. of dewpoint sensors. The values in the right-hand column are temperatures (°F), multiplied by 100 as read from the DAS. The values in the left-hand column are the water vapor pressures (psia) from the steam tables for saturated steam corresponding to the dewpoint (saturation) temperatures in the center column.

The Summary of Corrected Data presents corrected temperature and pressure values and calculated air mass determined as follows:

1. TEMPERATURE (°R) is the volume weighted average containment atmosphere drybulb temperature derived from TEMP 1 through TEMP N.

2. CORRECTED PRESSURE (psia) is the partial pressure of the dry air component of the containment atmosphere, absolute. The volume weighted average containment atmosphere water vapor pressure is subtracted from the volume weighted average total pressure, yielding the partial pressure of the dry air.

3. VAPOR PRESSURE (psia) is the volume weighted average containment atmosphere water vapor pressure, absolute derived from VPRS 1 through VPRS N.

4. VOLUME (cu. ft.) is the containment free air volume.

5. CONTAINMENT AIR MASS (lbm) is the calculated mass of dry air in the containment. The mass of dry air is calculated using the containment free air volume and the above TEMPERATURE and CORRRECTED PRESSURE of the dry air.

# APPENDIX B

# PRESSURIZATION AND STABILIZATION SUMMARY DATA

CALVERT CLIFFS - UNIT 1 ILRT
SUMMARY DATA

ALMAX = .200
VRATET = .000
VOLUME = 2000000.
VRATEM = .000

| TIME | DATE | TEMP | PRESSURE | VPRS | VOLUME |
|---|---|---|---|---|---|
| 1300 | 518 | 533.975 | 14.1159 | .2823 | 2000000. |
| 1315 | 518 | 536.428 | 15.0083 | .2863 | 2000000. |
| 1330 | 518 | 537.315 | 15.7861 | .2866 | 2000000. |
| 1345 | 518 | 538.152 | 16.8280 | .2874 | 2000000. |
| 1400 | 518 | 538.642 | 17.9541 | .2889 | 2000000. |
| 1415 | 518 | 538.776 | 19.0683 | .2885 | 2000000. |
| 1430 | 518 | 539.014 | 20.2592 | .2875 | 2000000. |
| 1445 | 518 | 539.026 | 21.4598 | .2871 | 2000000. |
| 1500 | 518 | 539.000 | 22.6594 | .2854 | 2000000. |
| 1515 | 518 | 538.953 | 23.8577 | .2859 | 2000000. |
| 1530 | 518 | 538.489 | 24.8620 | .2856 | 2000000. |
| 1545 | 518 | 536.103 | 24.7467 | .2835 | 2000000. |
| 1600 | 518 | 535.353 | 24.6993 | .2868 | 2000000. |
| 1615 | 518 | 534.915 | 24.6719 | .2893 | 2000000. |
| 1630 | 518 | 534.541 | 24.6528 | .2916 | 2000000. |
| 1645 | 518 | 534.320 | 24.6403 | .2928 | 2000000. |
| 1700 | 518 | 534.116 | 24.6325 | .2932 | 2000000. |
| 1715 | 518 | 533.918 | 24.6250 | .2943 | 2000000. |
| 1730 | 518 | 534.576 | 24.9483 | .2972 | 2000000. |
| 1745 | 518 | 536.017 | 25.9970 | .2981 | 2000000. |
| 1800 | 518 | 536.232 | 26.8289 | .2992 | 2000000. |
| 1815 | 518 | 536.317 | 27.5040 | .2996 | 2000000. |
| 1830 | 518 | 536.980 | 28.5827 | .3004 | 2000000. |
| 1845 | 518 | 537.378 | 29.7501 | .3014 | 2000000. |
| 1900 | 518 | 537.542 | 30.9243 | .3021 | 2000000. |
| 1915 | 518 | 537.607 | 32.0990 | .3014 | 2000000. |
| 1930 | 518 | 537.648 | 33.2755 | .3022 | 2000000. |
| 1945 | 518 | 537.575 | 34.4033 | .3031 | 2000000. |
| 2000 | 518 | 537.507 | 35.5741 | .3041 | 2000000. |
| 2015 | 518 | 537.348 | 36.7148 | .3041 | 2000000. |
| 2030 | 518 | 537.174 | 37.8148 | .3045 | 2000000. |
| 2045 | 518 | 537.243 | 39.0155 | .3056 | 2000000. |
| 2100 | 518 | 537.273 | 40.1853 | .3059 | 2000000. |
| 2115 | 518 | 537.555 | 41.3867 | .3074 | 2000000. |
| 2130 | 518 | 537.586 | 42.5785 | .3076 | 2000000. |
| 2145 | 518 | 537.323 | 43.6967 | .3085 | 2000000. |
| 2200 | 518 | 537.063 | 44.7936 | .3098 | 2000000. |
| 2215 | 518 | 536.956 | 45.9585 | .3102 | 2000000. |
| 2230 | 518 | 536.860 | 47.1453 | .3104 | 2000000. |
| 2245 | 518 | 536.790 | 48.2920 | .3117 | 2000000. |
| 2300 | 518 | 536.698 | 49.3890 | .3146 | 2000000. |
| 2315 | 518 | 536.645 | 50.4994 | .3146 | 2000000. |
| 2330 | 518 | 536.515 | 51.6043 | .3149 | 2000000. |
| 2345 | 518 | 536.479 | 52.7082 | .3166 | 2000000. |
| 0 | 519 | 536.421 | 53.8200 | .3164 | 2000000. |
| 15 | 519 | 536.354 | 54.9303 | .3173 | 2000000. |
| 30 | 519 | 536.261 | 56.0341 | .3171 | 2000000. |
| 45 | 519 | 536.212 | 57.1350 | .3178 | 2000000. |
| 100 | 519 | 536.125 | 58.2352 | .3196 | 2000000. |
| 115 | 519 | 536.047 | 59.3282 | .3213 | 2000000. |
| 130 | 519 | 535.938 | 60.4231 | .3221 | 2000000. |
| 145 | 519 | 535.839 | 61.5146 | .3234 | 2000000. |
| 200 | 519 | 535.743 | 62.6034 | .3239 | 2000000. |
| 215 | 519 | 535.610 | 59.8726 | .3255 | 2000000. |
| 230 | 519 | 535.347 | 64.6239 | .3250 | 2000000. |

# CALVERT CLIFFS - UNIT 1 ILRT
## SUMMARY DATA

ALMAX = .200
VRATET = .198

VOLUME = 2000000.
VRATEM = .205

| TIME | DATE | TEMP | PRESSURE | VPRS | VOLUME |
|---|---|---|---|---|---|
| 245 | 519 | 534.619 | 64.7862 | .3243 | 2000000. |
| 300 | 519 | 533.894 | 64.6880 | .3245 | 2000000. |
| 315 | 519 | 535.073 | 64.8181 | .3269 | 2000000. |
| 330 | 519 | 533.953 | 64.6446 | .3295 | 2000000. |
| 345 | 519 | 533.341 | 64.5506 | .3333 | 2000000. |
| 400 | 519 | 532.998 | 64.4927 | .3350 | 2000000. |
| 415 | 519 | 532.471 | 64.4533 | .3344 | 2000000. |
| 430 | 519 | 532.805 | 64.4839 | .3330 | 2000000. |
| 445 | 519 | 532.885 | 64.4957 | .3335 | 2000000. |
| 500 | 519 | 532.936 | 64.5014 | .3327 | 2000000. |
| 515 | 519 | 532.960 | 64.5044 | .3321 | 2000000. |
| 530 | 519 | 533.511 | 64.5678 | .3328 | 2000000. |
| 545 | 519 | 533.752 | 64.5933 | .3329 | 2000000. |
| 600 | 519 | 533.827 | 64.6087 | .3329 | 2000000. |
| 615 | 519 | 533.924 | 64.6157 | .3323 | 2000000. |
| 630 | 519 | 533.954 | 64.6186 | .3318 | 2000000. |
| 700 | 519 | 535.029 | 64.7479 | .3331 | 2000000. |
| 715 | 519 | 535.460 | 64.7963 | .3344 | 2000000. |
| 730 | 519 | 535.768 | 64.8316 | .3356 | 2000000. |
| 745 | 519 | 536.020 | 64.8601 | .3366 | 2000000. |
| 800 | 519 | 536.248 | 64.8848 | .3376 | 2000000. |
| 815 | 519 | 536.438 | 64.9049 | .3386 | 2000000. |
| 830 | 519 | 536.621 | 64.9232 | .3400 | 2000000. |
| 845 | 519 | 536.760 | 64.9401 | .3408 | 2000000. |
| 900 | 519 | 536.885 | 64.9554 | .3417 | 2000000. |
| 915 | 519 | 537.004 | 64.9689 | .3425 | 2000000. |
| 930 | 519 | 537.089 | 64.9822 | .3435 | 2000000. |
| 945 | 519 | 537.179 | 64.9937 | .3443 | 2000000. |
| 1000 | 519 | 537.273 | 65.0040 | .3459 | 2000000. |
| 1015 | 519 | 537.353 | 65.0133 | .3464 | 2000000. |
| 1030 | 519 | 537.449 | 65.0249 | .3467 | 2000000. |
| 1045 | 519 | 537.531 | 65.0347 | .3472 | 2000000. |
| 1100 | 519 | 537.589 | 65.0446 | .3472 | 2000000. |
| 1115 | 519 | 537.674 | 65.0534 | .3477 | 2000000. |
| 1130 | 519 | 537.732 | 65.0623 | .3476 | 2000000. |
| 1145 | 519 | 537.807 | 65.0701 | .3477 | 2000000. |
| 1200 | 519 | 537.853 | 65.0777 | .3479 | 2000000. |
| 1215 | 519 | 537.915 | 65.0848 | .3482 | 2000000. |
| 1230 | 519 | 537.964 | 65.0916 | .3484 | 2000000. |
| 1245 | 519 | 538.013 | 65.0975 | .3483 | 2000000. |
| 1300 | 519 | 538.057 | 65.1044 | .3489 | 2000000. |
| 1315 | 519 | 538.126 | 65.1091 | .3491 | 2000000. |
| 1330 | 519 | 538.167 | 65.1157 | .3494 | 2000000. |

## CALVERT CLIFFS - UNIT 1 ILRT
## TEMPERATURE STABILIZATION

FROM A STARTING TIME AND DATE OF: 930 519 1985

| TIME (HOURS) | TEMP (°R) | AVE ΔT (4HRS) | ANSI AVE ΔT (1HR) | DIFF | BN-TOP-1 AVE ΔT (2HRS) |
|---|---|---|---|---|---|
| .00 | 537.09 | | | | |
| .25 | 537.18 | | | | |
| .50 | 537.27 | | | | |
| .75 | 537.35 | | | | |
| 1.00 | 537.45 | | | | |
| 1.25 | 537.53 | | | | |
| 1.50 | 537.59 | | | | |
| 1.75 | 537.67 | | | | |
| 2.00 | 537.73 | | | | .322* |
| 2.25 | 537.81 | | | | .314* |
| 2.50 | 537.85 | | | | .290* |
| 2.75 | 537.91 | | | | .281* |
| 3.00 | 537.96 | | | | .258* |
| 3.25 | 538.01 | | | | .241* |
| 3.50 | 538.06 | | | | .234* |
| 3.75 | 538.13 | | | | .226* |
| 4.00 | 538.17 | .269 | .203 | .07* | .109* |

* INDICATES TEMPERATURE STABILIZATION HAS BEEN SATISFIED

# APPENDIX C

# ILRT TREND REPORT

# CALVERT CLIFFS - UNIT 1 ILRT
## TREND REPORT

TIME AND DATE AT START OF TEST: 1330 519 1985

| NO. PTS | END TIME | TOTAL TIME ANALYSIS MEAS. | CALCULATED | UCL | MASS POINT ANALYSIS CALCULATED | UCL |
|---|---|---|---|---|---|---|
| 4 | 1415 | .046 | .062 | .435 | .055 | .175 |
| 5 | 1430 | .096 | .076 | .264 | .080 | .144 |
| 6 | 1445 | .004 | .028 | .174 | .023 | .102 |
| 7 | 1500 | .055 | .031 | .156 | .034 | .088 |
| 8 | 1515 | .043 | .027 | .134 | .033 | .072 |
| 9 | 1530 | .035 | .023 | .116 | .029 | .059 |
| 10 | 1545 | .035 | .020 | .105 | .027 | .051 |
| 11 | 1600 | .018 | .012 | .089 | .019 | .040 |
| 12 | 1615 | .029 | .011 | .084 | .019 | .036 |
| 13 | 1630 | .017 | .007 | .075 | .014 | .029 |
| 14 | 1645 | .036 | .009 | .077 | .018 | .032 |
| 15 | 1700 | .028 | .008 | .074 | .019 | .030 |
| 16 | 1715 | .028 | .008 | .073 | .019 | .029 |
| 17 | 1730 | .034 | .010 | .074 | .022 | .031 |
| 18 | 1745 | .044 | .014 | .078 | .026 | .036 |
| 19 | 1800 | .036 | .015 | .078 | .028 | .037 |
| 20 | 1815 | .045 | .018 | .081 | .032 | .040 |
| 21 | 1830 | .036 | .019 | .080 | .032 | .040 |
| 22 | 1845 | .049 | .022 | .083 | .036 | .044 |
| 23 | 1900 | .034 | .022 | .082 | .035 | .042 |
| 24 | 1915 | .041 | .023 | .082 | .036 | .043 |
| 25 | 1930 | .031 | .023 | .080 | .035 | .041 |
| 26 | 1945 | .037 | .023 | .080 | .035 | .041 |
| 27 | 2000 | .041 | .025 | .080 | .036 | .042 |
| 28 | 2015 | .038 | .025 | .080 | .037 | .042 |
| 29 | 2030 | .033 | .025 | .078 | .036 | .041 |
| 30 | 2045 | .028 | .024 | .076 | .034 | .039 |
| 31 | 2100 | .028 | .024 | .075 | .033 | .038 |
| 32 | 2115 | .036 | .024 | .074 | .033 | .038 |
| 33 | 2130 | .033 | .024 | .073 | .033 | .037 |
| 34 | 2145 | .030 | .024 | .072 | .032 | .036 |
| 35 | 2200 | .043 | .025 | .073 | .034 | .038 |
| 36 | 2215 | .030 | .025 | .072 | .033 | .037 |
| 37 | 2230 | .040 | .025 | .073 | .034 | .038 |
| 38 | 2245 | .032 | .025 | .071 | .033 | .037 |
| 39 | 2300 | .028 | .025 | .070 | .033 | .036 |
| 40 | 2315 | .032 | .025 | .069 | .032 | .036 |
| 41 | 2330 | .032 | .025 | .069 | .032 | .035 |

# APPENDIX D

## ILRT SUMMARY DATA, MASS POINT, AND TOTAL TIME

# CALVERT CLIFFS - UNIT 1 ILRT
## SUMMARY DATA

ALMAX = .200 VOLUME = 2000000.
VRATET = .198 VRATEM = .205

| TIME | DATE | TEMP | PRESSURE | VPRS | VOLUME |
|---|---|---|---|---|---|
| 1330 | 519 | 538.167 | 65.1157 | .3494 | 2000000. |
| 1345 | 519 | 538.220 | 65.1214 | .3491 | 2000000. |
| 1400 | 519 | 538.270 | 65.1265 | .3494 | 2000000. |
| 1415 | 519 | 538.310 | 65.1321 | .3498 | 2000000. |
| 1430 | 519 | 538.363 | 65.1369 | .3499 | 2000000. |
| 1445 | 519 | 538.386 | 65.1421 | .3501 | 2000000. |
| 1500 | 519 | 538.440 | 65.1465 | .3501 | 2000000. |
| 1515 | 519 | 538.477 | 65.1512 | .3504 | 2000000. |
| 1530 | 519 | 538.514 | 65.1558 | .3507 | 2000000. |
| 1545 | 519 | 538.550 | 65.1600 | .3509 | 2000000. |
| 1600 | 519 | 538.580 | 65.1644 | .3509 | 2000000. |
| 1615 | 519 | 538.619 | 65.1682 | .3510 | 2000000. |
| 1630 | 519 | 538.640 | 65.1715 | .3512 | 2000000. |
| 1645 | 519 | 538.685 | 65.1753 | .3514 | 2000000. |
| 1700 | 519 | 538.710 | 65.1788 | .3513 | 2000000. |
| 1715 | 519 | 538.734 | 65.1815 | .3516 | 2000000. |
| 1730 | 519 | 538.771 | 65.1850 | .3515 | 2000000. |
| 1745 | 519 | 538.796 | 65.1868 | .3522 | 2000000. |
| 1800 | 519 | 538.813 | 65.1895 | .3524 | 2000000. |
| 1815 | 519 | 538.855 | 65.1931 | .3523 | 2000000. |
| 1830 | 519 | 538.864 | 65.1952 | .3526 | 2000000. |
| 1845 | 519 | 538.902 | 65.1976 | .3531 | 2000000. |
| 1900 | 519 | 538.915 | 65.2012 | .3526 | 2000000. |
| 1915 | 519 | 538.943 | 65.2032 | .3530 | 2000000. |
| 1930 | 519 | 538.960 | 65.2066 | .3536 | 2000000. |
| 1945 | 519 | 538.990 | 65.2090 | .3531 | 2000000. |
| 2000 | 519 | 539.016 | 65.2112 | .3529 | 2000000. |
| 2015 | 519 | 539.038 | 65.2141 | .3535 | 2000000. |
| 2030 | 519 | 539.049 | 65.2162 | .3532 | 2000000. |
| 2045 | 519 | 539.068 | 65.2193 | .3532 | 2000000. |
| 2100 | 519 | 539.087 | 65.2213 | .3536 | 2000000. |
| 2115 | 519 | 539.117 | 65.2230 | .3539 | 2000000. |
| 2130 | 519 | 539.135 | 65.2257 | .3541 | 2000000. |
| 2145 | 519 | 539.152 | 65.2282 | .3541 | 2000000. |
| 2200 | 519 | 539.194 | 65.2299 | .3543 | 2000000. |
| 2215 | 519 | 539.190 | 65.2323 | .3544 | 2000000. |
| 2230 | 519 | 539.229 | 65.2344 | .3547 | 2000000. |
| 2245 | 519 | 539.238 | 65.2373 | .3549 | 2000000. |
| 2300 | 519 | 539.254 | 65.2400 | .3546 | 2000000. |
| 2315 | 519 | 539.279 | 65.2418 | .3548 | 2000000. |
| 2330 | 519 | 539.298 | 65.2439 | .3551 | 2000000. |

# CALVERT CLIFFS - UNIT 1 ILRT
## LEAKAGE RATE (WEIGHT PERCENT/DAY)
## MASS POINT ANALYSIS

TIME AND DATE AT START OF TEST: 1330 519 1985
TEST DURATION: 10.00 HOURS

| TIME | TEMP (R) | PRESSURE (PSIA) | CTMT. AIR MASS (LBM) | MASS LOSS (LBM) | AVERAGE MASS LOSS (LBM/HR) |
|---|---|---|---|---|---|
| 1330 | 538.167 | 65.1157 | 653172. | | |
| 1345 | 538.220 | 65.1214 | 653164. | 7.5 | 29.9 |
| 1400 | 538.270 | 65.1265 | 653155. | 9.6 | 34.1 |
| 1415 | 538.310 | 65.1321 | 653162. | -7.6 | 12.5 |
| 1430 | 538.363 | 65.1369 | 653145. | 16.7 | 26.1 |
| 1445 | 538.386 | 65.1421 | 653170. | -24.9 | 1.0 |
| 1500 | 538.440 | 65.1465 | 653149. | 21.3 | 15.1 |
| 1515 | 538.477 | 65.1512 | 653151. | -2.2 | 11.6 |
| 1530 | 538.514 | 65.1558 | 653153. | -1.3 | 9.5 |
| 1545 | 538.550 | 65.1600 | 653150. | 2.2 | 9.4 |
| 1600 | 538.580 | 65.1644 | 653159. | -8.8 | 5.0 |
| 1615 | 538.619 | 65.1682 | 653150. | 8.9 | 7.8 |
| 1630 | 538.640 | 65.1715 | 653158. | -7.7 | 4.6 |
| 1645 | 538.685 | 65.1753 | 653140. | 17.7 | 9.7 |
| 1700 | 538.710 | 65.1788 | 653145. | -5.2 | 7.5 |
| 1715 | 538.734 | 65.1815 | 653143. | 2.0 | 7.5 |
| 1730 | 538.771 | 65.1850 | 653134. | 9.1 | 9.3 |
| 1745 | 538.796 | 65.1868 | 653121. | 13.3 | 11.9 |
| 1800 | 538.813 | 65.1895 | 653127. | -6.3 | 9.9 |
| 1815 | 538.855 | 65.1931 | 653113. | 14.1 | 12.3 |
| 1830 | 538.864 | 65.1952 | 653123. | -9.9 | 9.7 |
| 1845 | 538.902 | 65.1976 | 653102. | 21.2 | 13.3 |
| 1900 | 538.915 | 65.2012 | 653121. | -19.6 | 9.1 |
| 1915 | 538.943 | 65.2032 | 653107. | 14.2 | 11.2 |
| 1930 | 538.960 | 65.2066 | 653121. | -13.8 | 8.4 |
| 1945 | 538.990 | 65.2090 | 653108. | 12.8 | 10.1 |
| 2000 | 539.016 | 65.2112 | 653099. | 9.6 | 11.2 |
| 2015 | 539.038 | 65.2141 | 653101. | -2.5 | 10.4 |
| 2030 | 539.049 | 65.2162 | 653110. | -8.4 | 8.9 |
| 2045 | 539.068 | 65.2193 | 653117. | -7.5 | 7.5 |
| 2100 | 539.087 | 65.2213 | 653114. | 2.8 | 7.7 |
| 2115 | 539.117 | 65.2230 | 653095. | 19.2 | 9.9 |
| 2130 | 539.135 | 65.2257 | 653100. | -5.2 | 8.9 |
| 2145 | 539.152 | 65.2282 | 653105. | -4.9 | 8.1 |
| 2200 | 539.194 | 65.2299 | 653071. | 34.0 | 11.8 |
| 2215 | 539.190 | 65.2323 | 653099. | -28.1 | 8.3 |
| 2230 | 539.229 | 65.2344 | 653074. | 24.7 | 10.8 |
| 2245 | 539.238 | 65.2373 | 653092. | -17.0 | 8.7 |
| 2300 | 539.254 | 65.2400 | 653099. | -7.6 | 7.6 |
| 2315 | 539.279 | 65.2418 | 653087. | 11.8 | 8.6 |
| 2330 | 539.298 | 65.2439 | 653085. | 2.3 | 8.7 |

| | |
|---|---|
| FREE AIR VOLUME USED (CU. FT.) | =2000000. |
| REGRESSION LINE | |
| INTERCEPT (LBM) | = 653168. |
| SLOPE (LBM/HR) | = -8.7 |
| MAXIMUM ALLOWABLE LEAKAGE RATE | = .200 |
| 75% OF MAXIMUM ALLOWABLE LEAKAGE RATE | = .150 |
| THE UPPER 95% CONFIDENCE LIMIT | = .035 |
| THE CALCULATED LEAKAGE RATE | = .032 |

# CALVERT CLIFFS - UNIT 1 ILRT
## LEAKAGE RATE (WEIGHT PERCENT/DAY)
## TOTAL TIME ANALYSIS

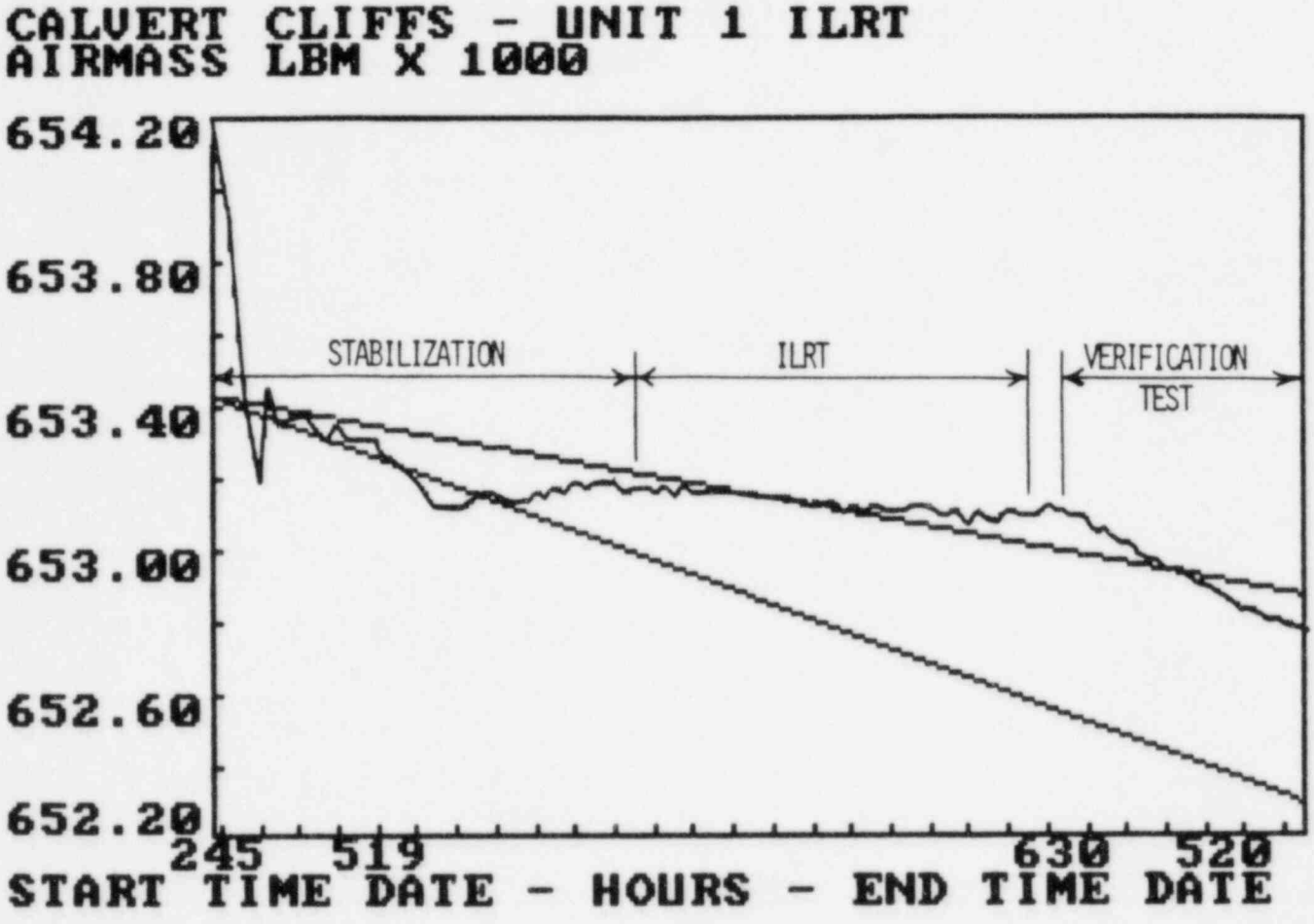
TIME AND DATE AT START OF TEST: 1330 519 1985
TEST DURATION: 10.00 HOURS

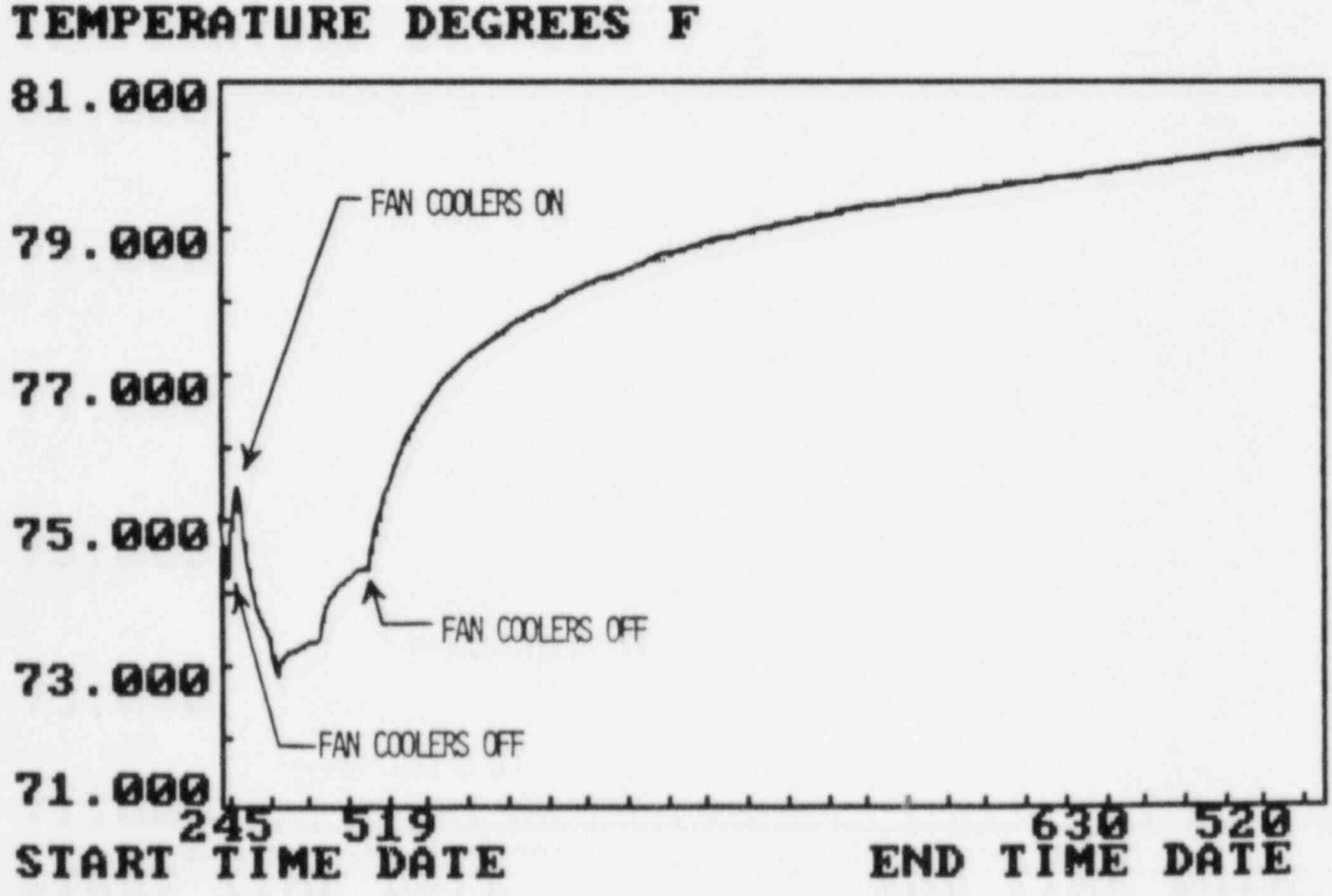
| TIME | TEMP (R) | PRESSURE (PSIA) | MEASURED LEAKAGE RATE |
|---|---|---|---|
| 1330 | 538.167 | 65.1157 | |
| 1345 | 538.220 | 65.1214 | .110 |
| 1400 | 538.270 | 65.1265 | .125 |
| 1415 | 538.310 | 65.1321 | .046 |
| 1430 | 538.363 | 65.1369 | .096 |
| 1445 | 538.386 | 65.1421 | .004 |
| 1500 | 538.440 | 65.1465 | .055 |
| 1515 | 538.477 | 65.1512 | .043 |
| 1530 | 538.514 | 65.1558 | .035 |
| 1545 | 538.550 | 65.1600 | .035 |
| 1600 | 538.580 | 65.1644 | .018 |
| 1615 | 538.619 | 65.1682 | .029 |
| 1630 | 538.640 | 65.1715 | .017 |
| 1645 | 538.685 | 65.1753 | .036 |
| 1700 | 538.710 | 65.1788 | .028 |
| 1715 | 538.734 | 65.1815 | .028 |
| 1730 | 538.771 | 65.1850 | .034 |
| 1745 | 538.796 | 65.1868 | .044 |
| 1800 | 538.813 | 65.1895 | .036 |
| 1815 | 538.855 | 65.1931 | .045 |
| 1830 | 538.864 | 65.1952 | .036 |
| 1845 | 538.902 | 65.1976 | .049 |
| 1900 | 538.915 | 65.2012 | .034 |
| 1915 | 538.943 | 65.2032 | .041 |
| 1930 | 538.960 | 65.2066 | .031 |
| 1945 | 538.990 | 65.2090 | .037 |
| 2000 | 539.016 | 65.2112 | .041 |
| 2015 | 539.038 | 65.2141 | .038 |
| 2030 | 539.049 | 65.2162 | .033 |
| 2045 | 539.068 | 65.2193 | .028 |
| 2100 | 539.087 | 65.2213 | .028 |
| 2115 | 539.117 | 65.2230 | .036 |
| 2130 | 539.135 | 65.2257 | .033 |
| 2145 | 539.152 | 65.2282 | .030 |
| 2200 | 539.194 | 65.2299 | .043 |
| 2215 | 539.190 | 65.2323 | .030 |
| 2230 | 539.229 | 65.2344 | .040 |
| 2245 | 539.238 | 65.2373 | .032 |
| 2300 | 539.254 | 65.2400 | .028 |
| 2315 | 539.279 | 65.2418 | .032 |
| 2330 | 539.298 | 65.2439 | .032 |

| | | |
|---|---|---|
| MEAN OF THE MEASURED LEAKAGE RATES | = | .040 |
| MAXIMUM ALLOWABLE LEAKAGE RATE | = | .200 |
| 75% OF MAXIMUM ALLOWABLE LEAKAGE RATE | = | .150 |
| THE UPPER 95% CONFIDENCE LIMIT | = | .069 |
| THE CALCULATED LEAKAGE RATE | = | .025 |

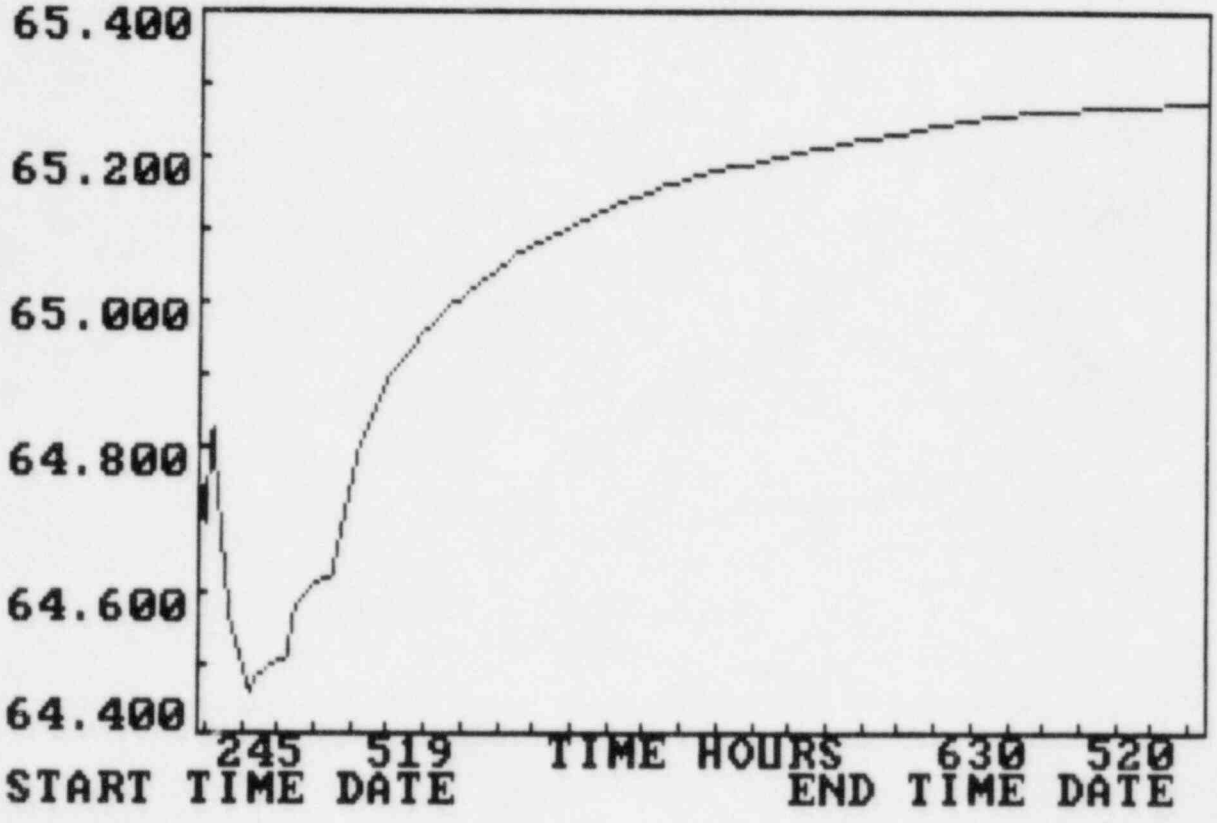
# APPENDIX E

## PLOTS; AIRMASS, TEMPERATURE, PRESSURE, VAPOR PRESSURE, AND LEAKAGE RATE

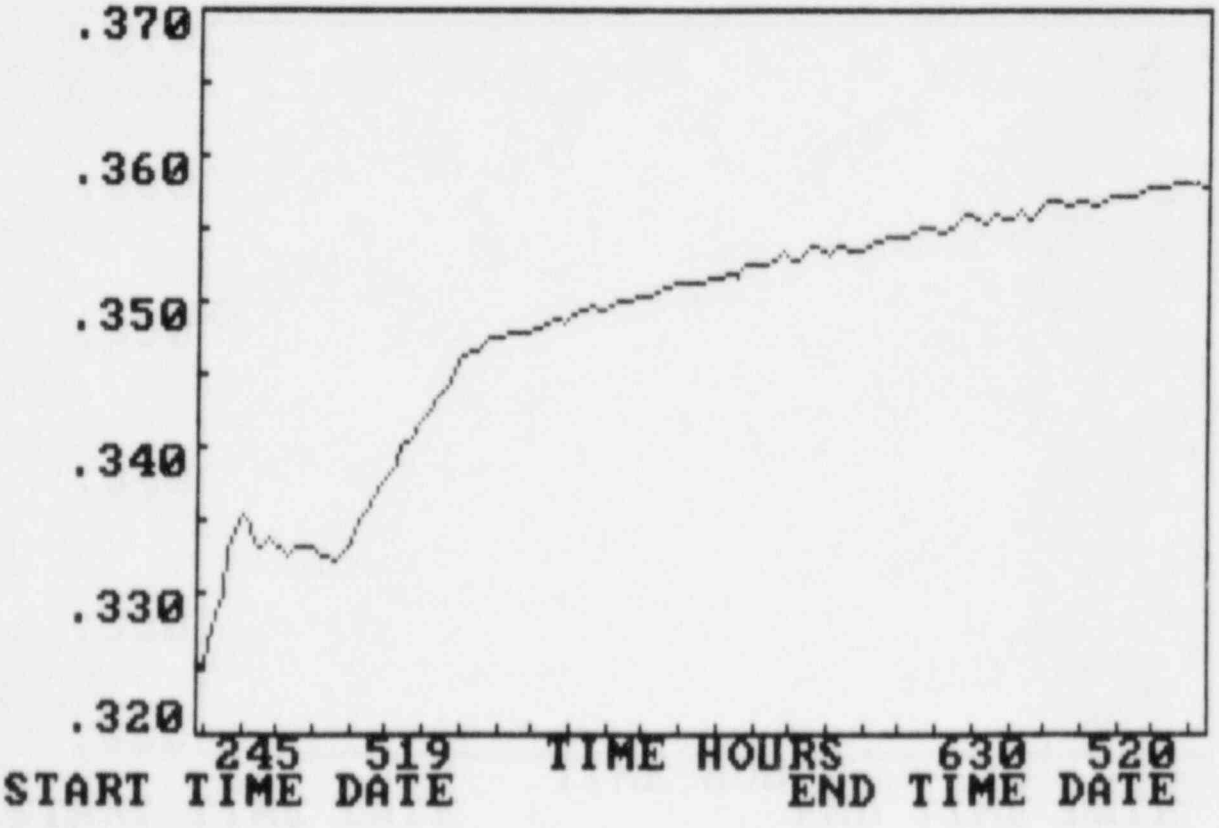

CALVERT CLIFFS - UNIT 1 ILRT
AIRMASS LBM X 1000
654.20
653.80
653.40
653.00
652.60
652.20
STABILIZATION
ILRT
VERIFICATION
TEST
245
519
630
520
START TIME DATE - HOURS - END TIME DATE


TEMPERATURE DEGREES F
81.000
79.000
77.000
75.000
73.000
71.000
FAN COOLERS ON
FAN COOLERS OFF
FAN COOLERS OFF
245
519
630
520
START TIME DATE
END TIME DATE

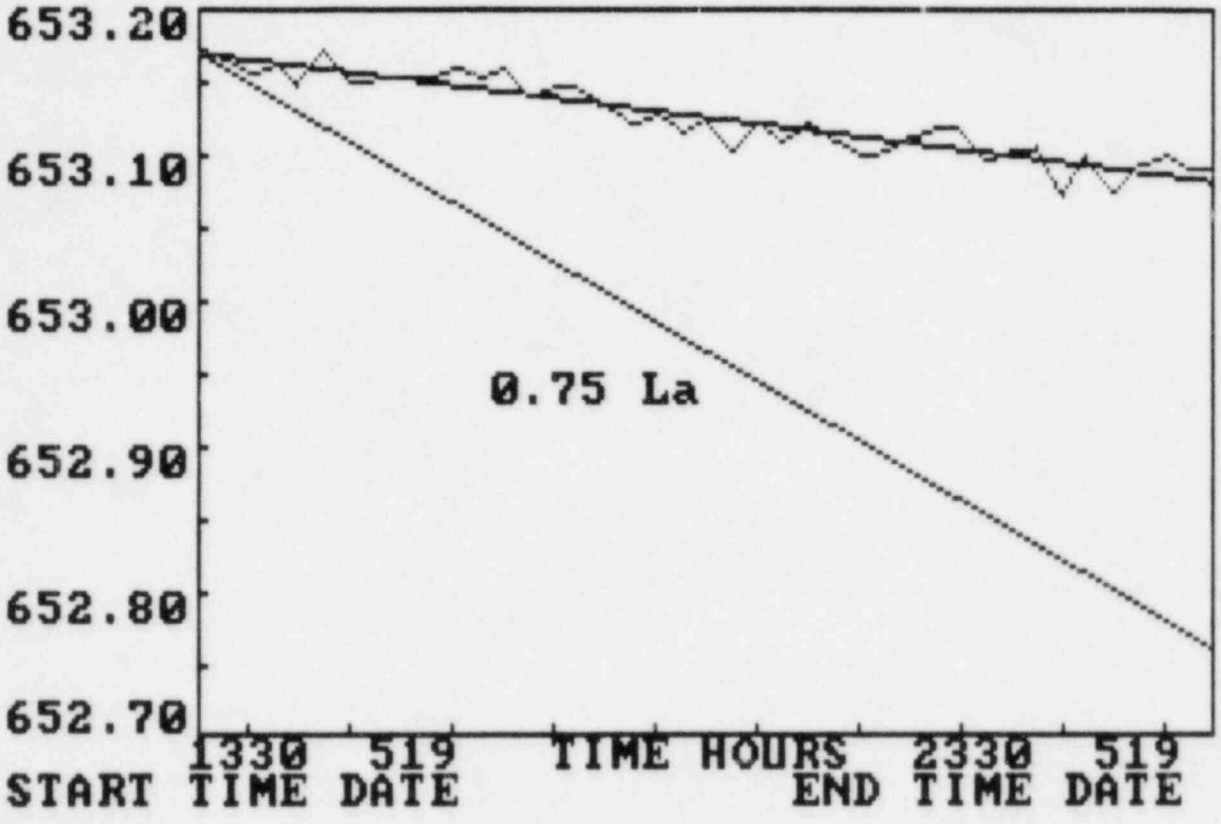
CALVERT CLIFFS - UNIT 1 ILRT
PRESSURE PSIA (DRY AIR)



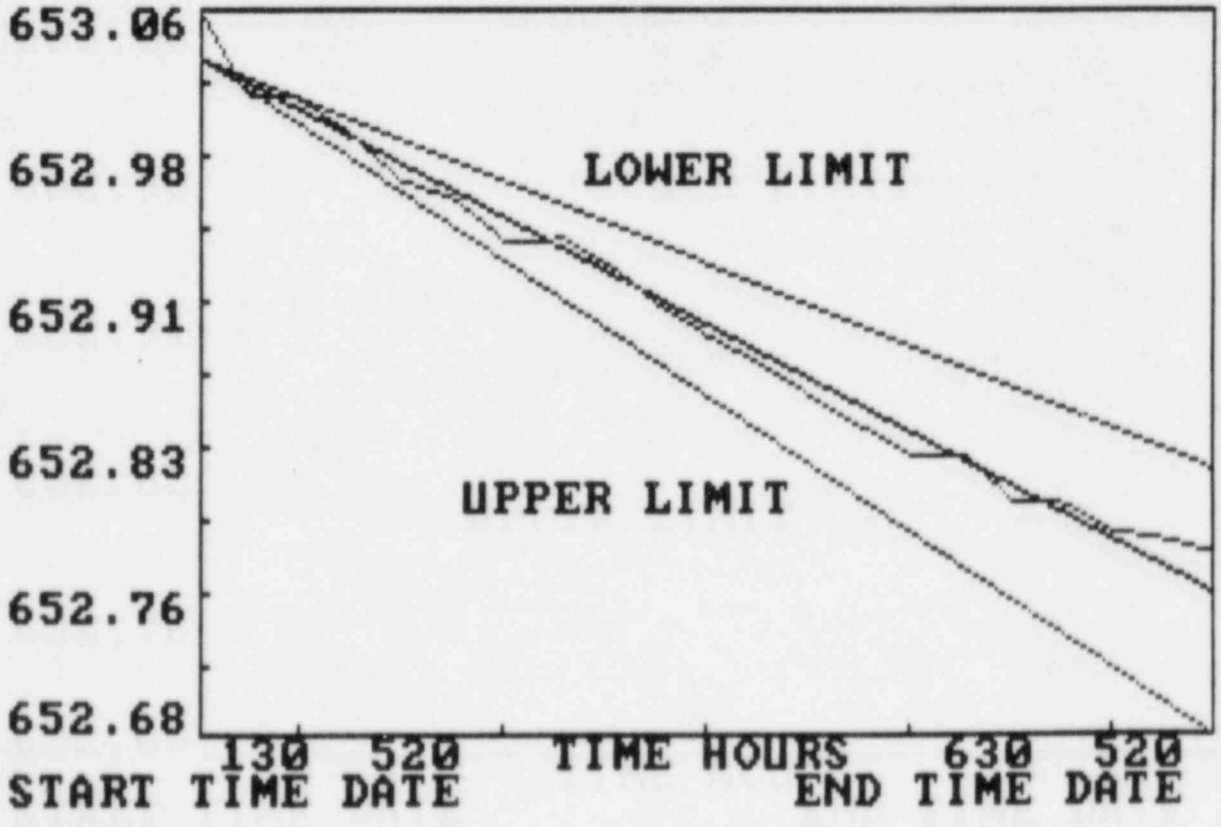

VAPOR PRESSURE PSIA



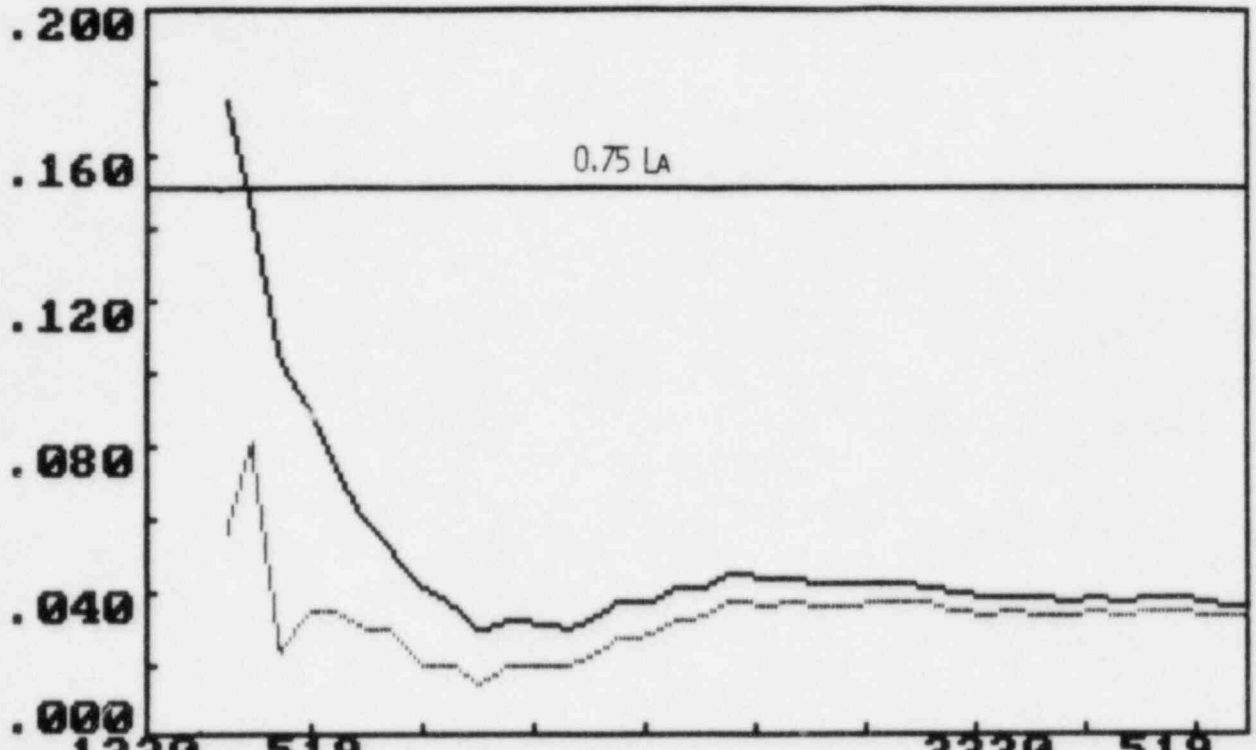
CALVERT CLIFFS - UNIT 1 ILRT
AIRMASS LBM X 1000 AND REGRESSION LINE



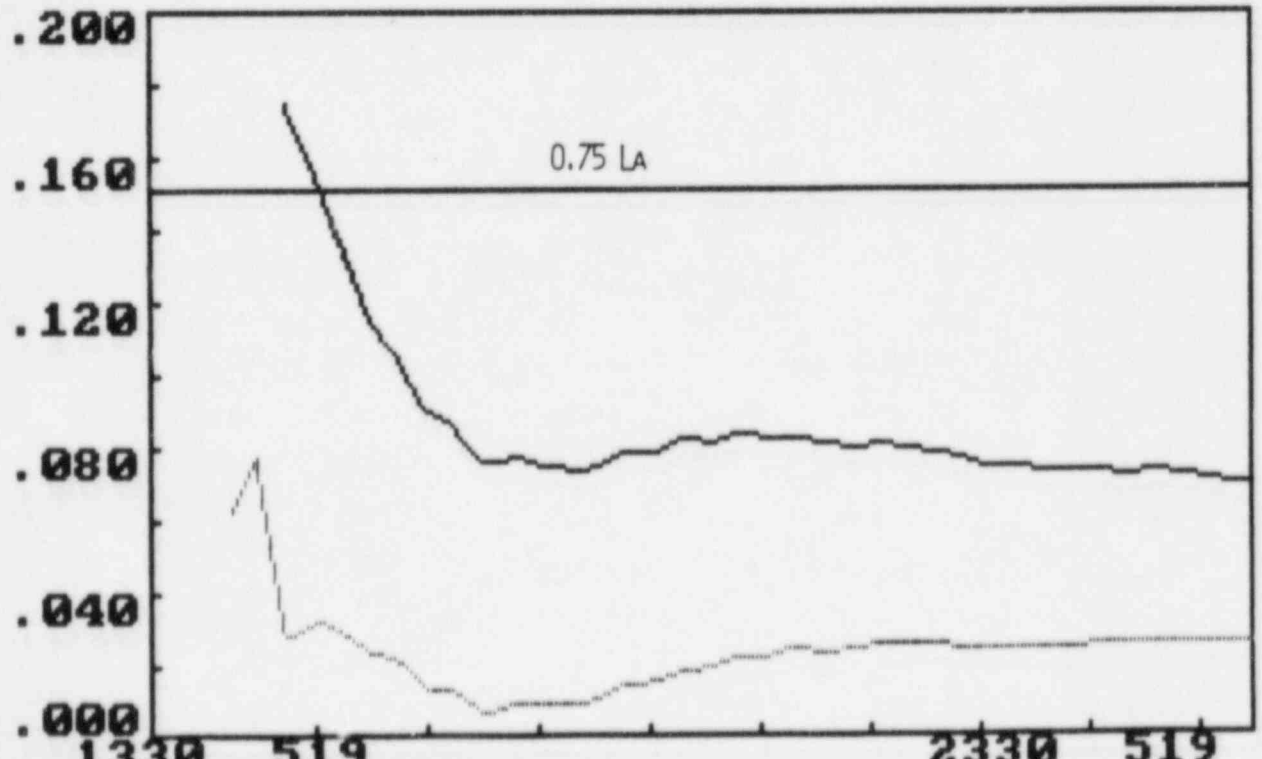

AIRMASS LBM X 1000 VERIFICATION TEST



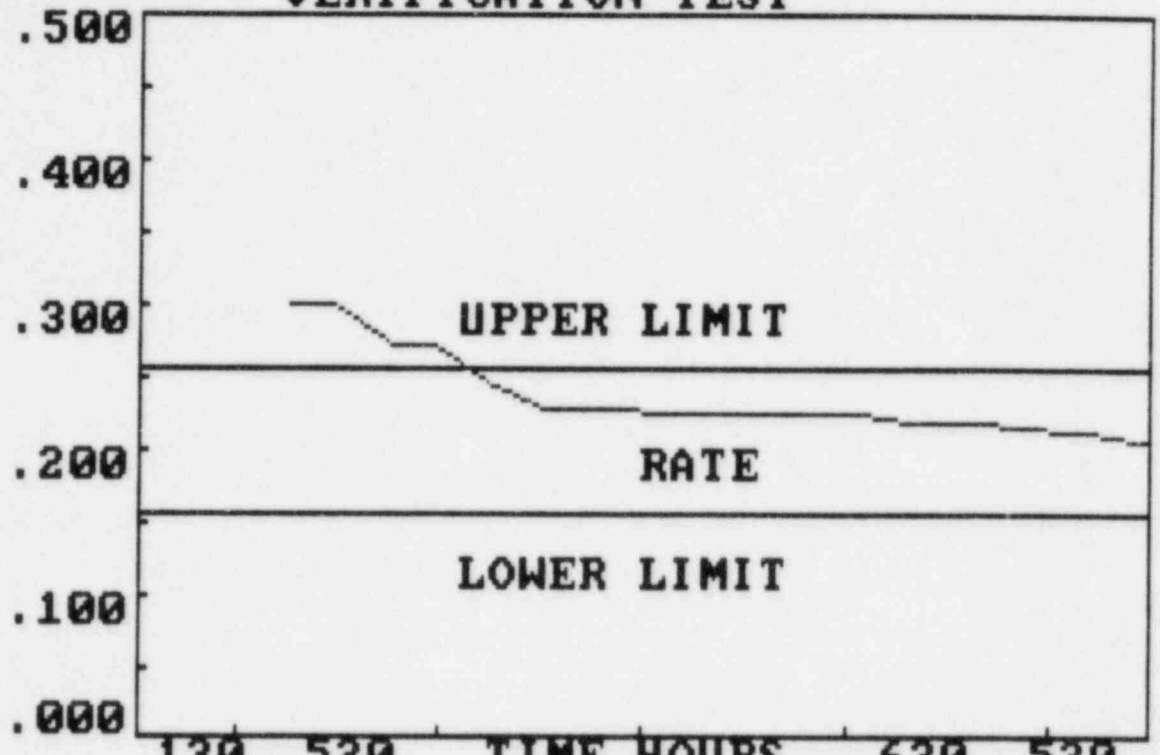
CALVERT CLIFFS - UNIT 1 ILRT
MASS POINT LEAKAGE RATE AND UCL %/DAY



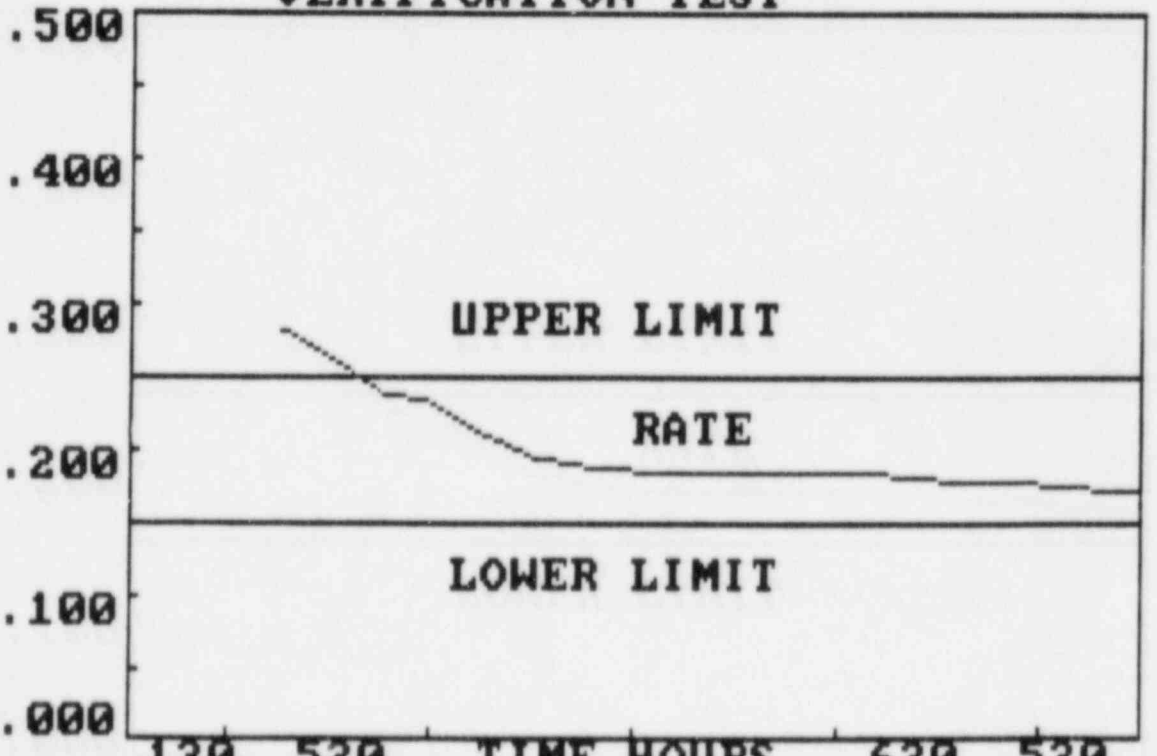

TOTAL TIME LEAKAGE RATE AND UCL %/DAY



CALVERT CLIFFS - UNIT 1 ILRT
MASS POINT LEAKAGE RATE - %/DAY
VERIFICATION TEST




TOTAL TIME LEAKAGE RATE - %/DAY
VERIFICATION TEST



# APPENDIX F

# VERIFICATION FLOW SUMMARY AND DATA

# CALVERT CLIFFS - UNIT 1 ILRT
## SUMMARY DATA

ALMAX = .200
VRATET = .198

VOLUME = 2000000.
VRATEM = .205

| TIME | DATE | TEMP | PRESSURE | VPRS | VOLUME |
|---|---|---|---|---|---|
| 2345 | 519 | 539.304 | 65.2458 | .3557 | 2000000. |
| 0 | 520 | 539.320 | 65.2495 | .3554 | 2000000. |
| 15 | 520 | 539.353 | 65.2519 | .3550 | 2000000. |
| 30 | 520 | 539.373 | 65.2535 | .3558 | 2000000. |
| 45 | 520 | 539.387 | 65.2548 | .3556 | 2000000. |
| 100 | 520 | 539.401 | 65.2558 | .3556 | 2000000. |
| 115 | 520 | 539.438 | 65.2558 | .3560 | 2000000. |
| 130 | 520 | 539.435 | 65.2578 | .3555 | 2000000. |
| 145 | 520 | 539.477 | 65.2582 | .3561 | 2000000. |
| 200 | 520 | 539.480 | 65.2585 | .3568 | 2000000. |
| 215 | 520 | 539.502 | 65.2592 | .3565 | 2000000. |
| 230 | 520 | 539.535 | 65.2609 | .3563 | 2000000. |
| 245 | 520 | 539.543 | 65.2610 | .3567 | 2000000. |
| 300 | 520 | 539.570 | 65.2621 | .3566 | 2000000. |
| 315 | 520 | 539.574 | 65.2627 | .3565 | 2000000. |
| 330 | 520 | 539.595 | 65.2639 | .3568 | 2000000. |
| 345 | 520 | 539.616 | 65.2643 | .3569 | 2000000. |
| 400 | 520 | 539.637 | 65.2653 | .3568 | 2000000. |
| 415 | 520 | 539.657 | 65.2662 | .3570 | 2000000. |
| 430 | 520 | 539.677 | 65.2670 | .3572 | 2000000. |
| 445 | 520 | 539.686 | 65.2666 | .3576 | 2000000. |
| 500 | 520 | 539.701 | 65.2669 | .3577 | 2000000. |
| 515 | 520 | 539.712 | 65.2684 | .3573 | 2000000. |
| 530 | 520 | 539.739 | 65.2692 | .3579 | 2000000. |
| 545 | 520 | 539.750 | 65.2701 | .3579 | 2000000. |
| 600 | 520 | 539.765 | 65.2707 | .3579 | 2000000. |
| 615 | 520 | 539.775 | 65.2714 | .3577 | 2000000. |
| 630 | 520 | 539.782 | 65.2716 | .3579 | 2000000. |

CALVERT CLIFFS - UNIT 1 ILRT
LEAKAGE RATE (WEIGHT PERCENT/DAY)
MASS POINT ANALYSIS

TIME AND DATE AT START OF TEST: 130 520 1985
TEST DURATION: 5.00 HOURS

| TIME | TEMP (R) | PRESSURE (PSIA) | CTMT. AIR MASS (LBM) | MASS LOSS (LBM) | AVERAGE MASS LOSS (LBM/HR) |
|---|---|---|---|---|---|
| 130 | 539.435 | 65.2578 | 653059. | | |
| 145 | 539.477 | 65.2582 | 653012. | 46.7 | 186.8 |
| 200 | 539.480 | 65.2585 | 653010. | 1.6 | 96.7 |
| 215 | 539.502 | 65.2592 | 652991. | 18.9 | 89.6 |
| 230 | 539.535 | 65.2609 | 652969. | 22.5 | 89.7 |
| 245 | 539.543 | 65.2610 | 652960. | 8.9 | 78.9 |
| 300 | 539.570 | 65.2621 | 652938. | 21.9 | 80.3 |
| 315 | 539.574 | 65.2627 | 652939. | -.9 | 68.4 |
| 330 | 539.595 | 65.2639 | 652926. | 13.1 | 66.3 |
| 345 | 539.616 | 65.2643 | 652904. | 21.7 | 68.6 |
| 400 | 539.637 | 65.2653 | 652889. | 15.1 | 67.8 |
| 415 | 539.657 | 65.2662 | 652874. | 15.4 | 67.2 |
| 430 | 539.677 | 65.2670 | 652858. | 15.9 | 66.9 |
| 445 | 539.686 | 65.2666 | 652843. | 15.2 | 66.5 |
| 500 | 539.701 | 65.2669 | 652828. | 14.8 | 65.9 |
| 515 | 539.712 | 65.2684 | 652828. | -.5 | 61.4 |
| 530 | 539.739 | 65.2692 | 652805. | 23.6 | 63.5 |
| 545 | 539.750 | 65.2701 | 652801. | 4.0 | 60.7 |
| 600 | 539.765 | 65.2707 | 652788. | 12.7 | 60.1 |
| 615 | 539.775 | 65.2714 | 652783. | 5.2 | 58.0 |
| 630 | 539.782 | 65.2716 | 652776. | 6.8 | 56.5 |

FREE AIR VOLUME USED (CU. FT.) =2000000.
REGRESSION LINE
INTERCEPT (LBM) = 653031.
SLOPE (LBM/HR) = -54.8
VERIFICATION TEST LEAKAGE RATE UPPER LIMIT = .255
VERIFICATION TEST LEAKAGE RATE LOWER LIMIT = .155
THE CALCULATED LEAKAGE RATE = .201

CALVERT CLIFFS - UNIT 1 ILRT
LEAKAGE RATE (WEIGHT PERCENT/DAY)
TOTAL TIME ANALYSIS

TIME AND DATE AT START OF TEST: 130 520 1985
TEST DURATION: 5.00 HOURS

| TIME | TEMP (R) | PRESSURE (PSIA) | MEASURED LEAKAGE RATE |
|---|---|---|---|
| 130 | 539.435 | 65.2578 | |
| 145 | 539.477 | 65.2582 | .687 |
| 200 | 539.480 | 65.2585 | .355 |
| 215 | 539.502 | 65.2592 | .329 |
| 230 | 539.535 | 65.2609 | .330 |
| 245 | 539.543 | 65.2610 | .290 |
| 300 | 539.570 | 65.2621 | .295 |
| 315 | 539.574 | 65.2627 | .251 |
| 330 | 539.595 | 65.2639 | .244 |
| 345 | 539.616 | 65.2643 | .252 |
| 400 | 539.637 | 65.2653 | .249 |
| 415 | 539.657 | 65.2662 | .247 |
| 430 | 539.677 | 65.2670 | .246 |
| 445 | 539.686 | 65.2666 | .244 |
| 500 | 539.701 | 65.2669 | .242 |
| 515 | 539.712 | 65.2684 | .226 |
| 530 | 539.739 | 65.2692 | .233 |
| 545 | 539.750 | 65.2701 | .223 |
| 600 | 539.765 | 65.2707 | .221 |
| 615 | 539.775 | 65.2714 | .213 |
| 630 | 539.782 | 65.2716 | .208 |

| | | |
|---|---|---|
| MEAN OF THE MEASURED LEAKAGE RATES | = | .279 |
| VERIFICATION TEST LEAKAGE RATE UPPER LIMIT | = | .248 |
| VERIFICATION TEST LEAKAGE RATE LOWER LIMIT | = | .148 |
| THE CALCULATED LEAKAGE RATE | = | .166 |

# APPENDIX G

# ISG CALCULATIONS

# ISG CALCULATION
## ( ANSI/ANS 56.8 - 1981 )

CALIBRATION DATA

| | # OF SENSORS | SENSITIVITY(E) | REPEATABILITY(r) |
|---|---|---|---|
| TEMPERATURE(T) | 16 | 0.0100 deg. F | 0.0100 deg. F |
| PRESSURE(P) | 2 | 0.0010 psia | 0.0010 psia |
| VAPOR PRESS(Pv) | 6 | 0.1000 deg. F | 0.1000 deg. F |

Length of Test(t) 10.0 hrs

Test Pressure(P) 50.8 psig ==> 65.5 psia

From Steam Table 0.0120 psi/deg. F (at 69 deg. F)

La 0.2000 wt%/day

INSTRUMENT MEASUREMENT ERRORS

$$eT = [(ET)^2 + (rT)^2]^{1/2} / [\#\ of\ sensors]^{1/2}$$

eT = 0.0035 deg. F

$$eP = [(EP)^2 + (rP)^2]^{1/2} / [\#\ of\ sensors]^{1/2}$$

eP = 0.0010 psia

$$ePv = [(EPv)^2 + (rPv)^2]^{1/2} / [\#\ of\ sensors]^{1/2}$$

ePv = 0.0007 psia

INSTRUMENT SELECTION GUIDE

$$ISG = 2400/t[\ 2(eP/P)^2 + 2(ePv/P)^2 + 2(eT/T)^2\ ]^{1/2}$$

ISG = 0.0067 wt%/day

25% of La 0.0500 wt%/day

# APPENDIX H

# LOCAL LEAKAGE RATE TEST EVALUATION

APPENDIX H

LOCAL LEAKAGE RATE TESTING EVALUATION

During refueling outages, local leakage rate testing (LLRT) is commenced at the beginning of the outage and completed in approximately six to eight weeks. The ILRT, if scheduled for that outage, is conducted after the completion of the LLRT.

During the LLRT, repairs and adjustments are made to some systems which may change that penetration's leak rate. The term "As Found" indicates the leak rate before repairs and adjustments and the term "As Left" is the leak rate after repairs and adjustments. An evaluation of the difference between "As Found" and "As Left" can give only some indication of what the ILRT results would be if conducted prior to repairs and adjustments.

Table 1 is a comparison of the "As Found" and "As Left" data for those penetrations which had repairs and adjustments performed during the LLRT. Units of measured leak rate are standard cubic centimeters per minute (sccm).

APPENDIX H

LOCAL LEAKAGE RATE TEST RESULTS
REPAIRS AND ADJUSTMENTS

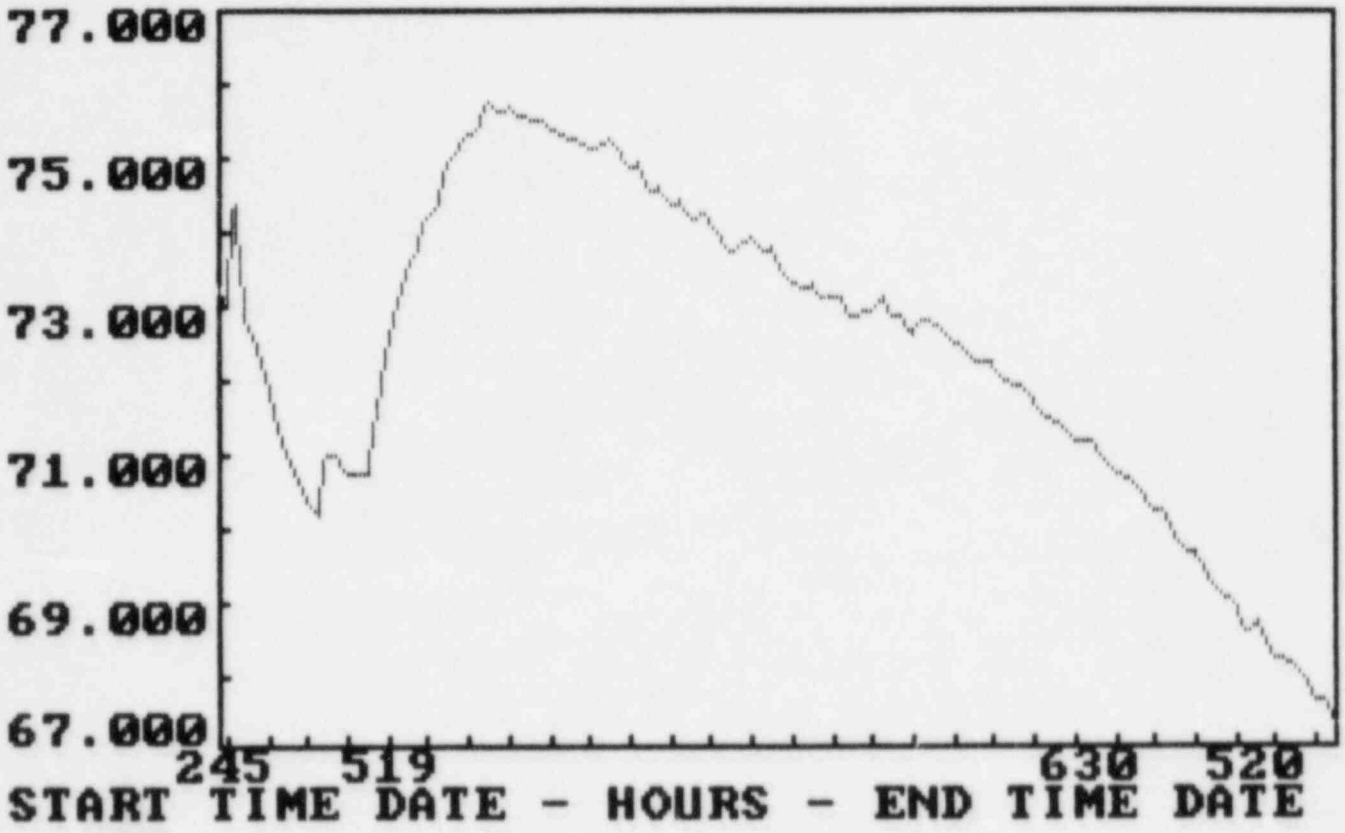
| PENETRATION | "AS FOUND" | "AS LEFT" |
|---|---|---|
| 1A | 65 | 48.5 |
| 1B | 903 | 199 |
| 1D | 6.0 | 24.6 |
| 2A | 2510 | 1950 |
| 2B | 3912.2 | 106.10 |
| 7A | 25.2 | 20.4 |
| 7B | 670 | 494 |
| 8 | 86.3 | 510 |
| 13 | 486.15 | 486.16 |
| 14 | 416.77 | 2500.6 |
| 19A | 1292 | 206 |
| 20A | 3270 | 1711 |
| 20B | 390 | 365 |
| 23 | 826 | 807 |
| 24 | 15.6 | 7.9 |
| 42 | 2420 | 36.5 |
| 47A | 97.1 | 182.3 |
| 47B | 13.5 | 19.2 |
| 47C | 224 | 18.8 |
| 47D | 44.1 | 6.0 |
| 49A | 48.1 | 3[illegible].1 |
| 49B | 19.2 | 16.7 |
| 49C | 21.1 | 15.6 |
| 50 | 40.2 | 362 |
| 53 ZEB1 | 192 | 2.0 |
| ZEB2 | 43.5 | 9.9 |
| 54 ZWB1 | 107.4 | 6.0 |
| 62 | 1810 | 22.4 |
| 64 | 4900 | 125.9 |
| 67 | 73.6 | 18.2 |
| 68 | 3698.94 | 7397.87 |
| 69 | 7397.9 | 925.7 |
| | 36024.86 | 18632.43 |

TOTAL SYSTEM - "AS FOUND" ..... 45,105.26
- "AS LEFT" ..... 28,354.03

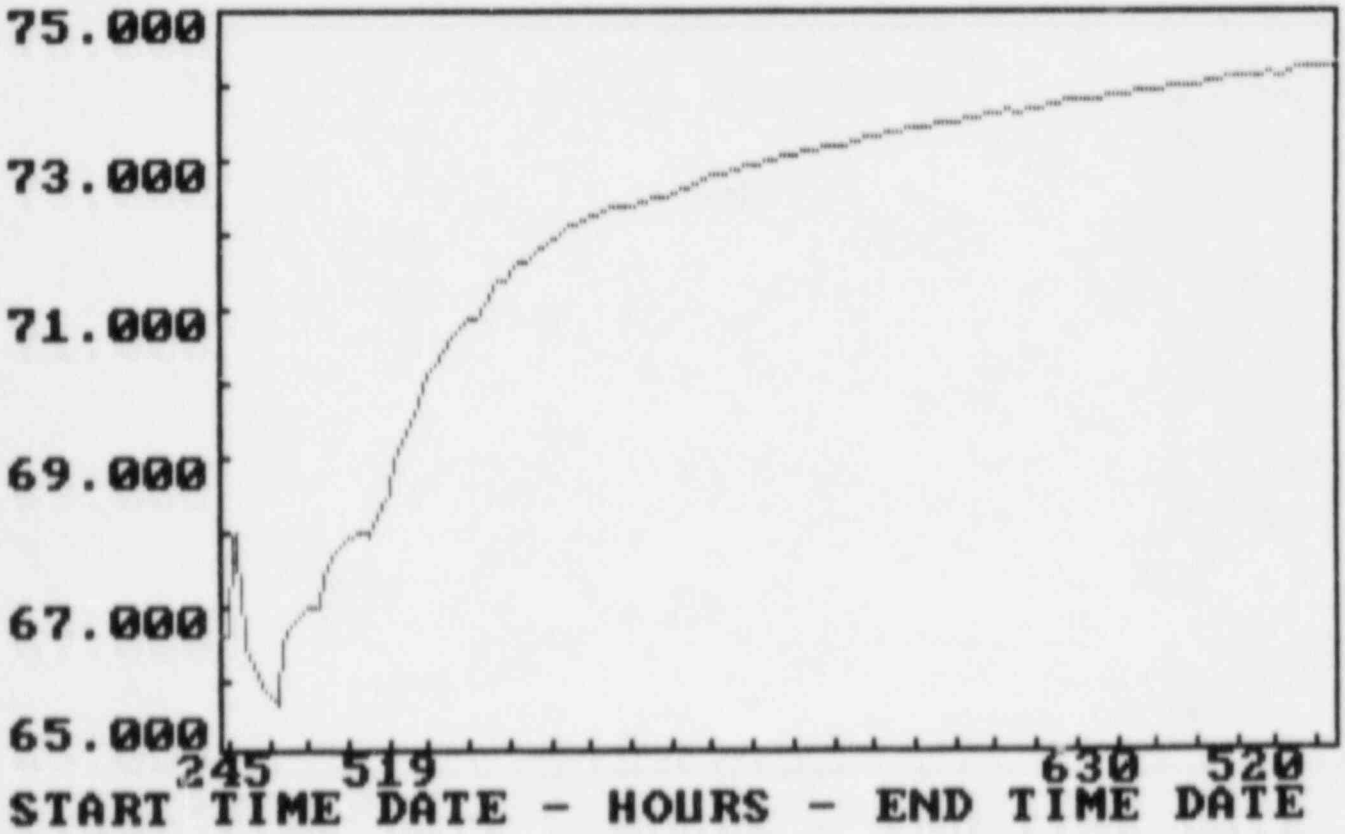
# APPENDIX I

## MALFUNCTIONING SENSOR PLOTS

CALVERT CLIFFS - UNIT 1 ILRT
TEMPERATURE SENSOR 13 DEGREES F




TEMPERATURE SENSOR 14 DEGREES F



BALTIMORE
GAS AND
ELECTRIC

CHARLES CENTER · P. O. BOX 1475 · BALTIMORE, MARYLAND 21203

ARTHUR E. LUNDVALL, JR.
VICE PRESIDENT
SUPPLY

August 5, 1985

U.S. Nuclear Regulatory Commission
Office of Nuclear Reactor Regulation
Washington, D.C. 20555

ATTENTION: Mr. Edward J. Butcher, Jr., Acting Chief
Operating Reactors Branch #3

SUBJECT: Calvert Cliffs Nuclear Power Plant
Unit Nos. 1; Docket No. 50-317
Reactor Containment Building
Integrated Leakage Rate Test Report

REFERENCE: (1) 10 CFR 50, Appendix J

Gentlemen:

A successful periodic Reactor Containment Building Integrated Leak Rate Test, in accordance with Reference (1), was performed on May 20, 1985, on Unit No. 1. Twelve copies of this test report are herewith forwarded for your review, as required by Section V of Reference (1).

Very truly yours,

A. E. Lundvall, Jr.

AEL/OPB/bat

Enclosures (12)

cc: D.A. Brune, Esquire
G.F. Trowbridge, Esquire
T. Foley, NRC
D.H. Jaffe, NRC