BRUNSWICK STEAM ELECTRIC PLANT
UNIT NO. 2

REACTOR CONTAINMENT BUILDING
INTEGRATED LEAK RATE TEST

MARCH 1988

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TABLE OF CONTENTS

TABLE OF CONTENTS (Cont'd)

1.0 SYNOPSIS

The Brunswick Steam Electric Plant Unit No. 2 reactor containment building was subjected to an integrated leak rate test during the period of March 26 to March 28, 1988. The purpose of this test was to demonstrate the acceptability of the building leakage rate at an internal pressure of 49.0 psig (P_a). Testing was performed in accordance with the requirements of 10CFR50 Appendix J, ANSI N45.4-1972, and Brunswick Steam Electric Plant Unit No. 2 Technical Specifications.

The Mass Point method of analysis resulted in a measured leakage rate of 0.307% by weight per day. The leakage rate at the upper bound of the 95% confidence interval was 0.312% by weight per day. A correction factor of 0.017% by weight per day for 12 penetrations which were not vented for the test must be added to the test results. Therefore, the leakage rate at the upper bound of the 95% confidence interval is 0.329% by weight per day which is below the allowable leakage rate of 0.375% by weight per day.

Using the minimum pathway leakage analysis to determine the "as found" reactor containment integrated leakage rate indicates that the acceptance criteria would have been exceeded. This was due to one penetration that could not be pressurized during local leakage rate testing and required maintenance to be performed.

The supplemental instrumentation verification test at P_a demonstrated an agreement between measured reactor containment building integrated leakage rates of 19.6%, using the Mass Point method which is within the 25% requirement of 10CFR50, Appendix J, Section III A.3.b.

Testing was performed by Carolina Power and Light Company with the technical assistance of United Energy Services Corporation. Procedural and calculational methods were witnessed by Nuclear Regulatory Commission personnel.

2.0 INTRODUCTION

The objective of the integrated leak rate test was the establishment of the degree of overall leak tightness of the reactor containment building at the calculated design basis accident pressure of 49.0 psig. The allowable leakage is defined by the design basis accident applied in the safety analysis in accordance with site exposure guidelines specified by 10CFR100. For Brunswick Steam Electric Plant Unit No. 2, the maximum allowable integrated leak rate at the design basis accident pressure of 49.0 psig (P_a) is 0.5% by weight per day (L_a).

Testing was performed in accordance with the procedural requirements as stated in Brunswick Steam Electric Plant Integrated Primary Containment Leak Rate Test Procedure PT-20.5. This procedure received two independent technical safety reviews and was approved by the Manager, Technical Support prior to the commencement of the test.

Leakage rate testing was accomplished at the pressure level of 50.8 psig for a period of 24 hours. The 24 hour period was followed by a 4 hour supplemental test for a verification of test instrumentation.

3.0 GENERAL, TECHNICAL AND TEST DATA

3.1 GENERAL DATA

Owner:	Carolina Power & Light
Docket No.	50-324
Location:	Southport, North Carolina
Type:	Mark 1, BWR-4
Containment Description:	Steel lined, reinforced concrete, 'light bulb' shaped drywell with torus shaped suppression chamber connected by a vent system. Vacuum breakers are provided between the suppression chamber and both the drywell and reactor building.
Date Test Completed:	March 28, 1988

3.2 TECHNICAL DATA

Containment Net Free Volume:	294,981 cubic feet
Design Pressure:	62 psig
Design Temperature:	300^{o}F (drywell), 220^{o}F (suppression chamber)
Calculated Accident Peak Pressure:	49.0 psig
Calculated Accident Peak Temperature:	297^{o}F

3.3 TEST DATA

Test Method:	Absolute
Data Analysis:	Mass Point and Total Time
Test Pressure:	65.5 psia
Max Allowable Leakage Rate (L_a):	0.500 wt % per day
Measured Leakage Rate:	
Mass Point	0.307 wt % per day
Measured Leakage Rate at UCL:	
Mass Point	0.329 wt % per day
Supplemental Test Flow Rate:	0.478 wt % per day
Supplemental Test Measured Leak Rate:	
Mass Point	0.687 wt % per day
Supplemental Test and L_{am} Agreement:	
Mass Point	19.6%

4.0 ACCEPTANCE CRITERIA

Acceptance criteria established prior to the test and as specified by 10CFR50, Appendix J, ANSI N45.4-1972 and the Brunswick Steam Electric Plant Unit No. 2 Technical Specifications are as follows:

1. The measured leakage rate (L_{am}) at the calculated design accident pressure of 49.0 psig (P_a) shall be less than 75% of the maximum allowable leakage rate (L_a), specified as 0.5% by weight of the building atmosphere per day. The acceptance criteria is determined as follows:

   L_a = 0.5%/day

   $0.75\ L_a$ = 0.375%/day

2. The test instrumentation shall be verified by means of a supplemental test. Agreement between the containment leakage measured during the Type A test and the containment leakage measured during the supplemental test shall be within 25% of L_a.

5.0 TEST INSTRUMENTATION

5.1 SUMMARY OF INSTRUMENTS

Test instruments employed are described, by system, in the following subsections.

5.1.1 Temperature Indicating System

Components:

1. Resistance Temperature Detectors:

Quantity	24
Manufacturer	Rosemount
Type	78-S 100 ohm platinum
Range, $^{\circ}F$	0 to 400
Accuracy, $^{\circ}F$	+/- 0.1
Sensitivity, $^{\circ}F$	+/- 0.1

2. Digital Temperature Scanner/Printer:

Quantity	1
Manufacturer	Fluke
Type	Model 2285B
Accuracy, $^{\circ}F$	+/- 0.2
Repeatability, $^{\circ}F$	+/- 0.1

5.1.2 Dewpoint Indicating System

1. Dewcell Elements:

Quantity	10
Manufacturer	Foxboro
Type	Model 2781
Range, $^{\circ}F$	0 - 150 dewpoint
Accuracy, $^{\circ}F$	+/- 2
Sensitivity, $^{\circ}F$	+/- 0.5

2. Digital Temperature Scanner/Printer:

Quantity	1
Manufacturer	Fluke
Type	Model 2285B
Accuracy, $^{\circ}F$	+/- 0.2
Repeatability, $^{\circ}F$	+/- 0.1

5.1.3 Pressure Monitoring System

Precision Pressure Gauges

Quantity	2
Manufacturer	Heise
Type	Series 10 (with angular readout)
Range, psia	0 - 75
Accuracy, psia	0.0005% f.s.+0.0065% of reading
Sensor sensitivity,psia	0.001% of full scale
Repeatability, psia	0.0005% of full scale

5.1.4 Supplemental Test Flow Monitoring System

Flowmeter

Quantity	1
Manufacturer	Brooks
Type	Model 1110
Range, scfm	1.0 - 10.0
Accuracy	+/- 1% of full scale

5.2 SCHEMATIC ARRANGEMENT

The arrangement of the four measuring systems summarized in Section 5.1 is depicted in Appendix A.

Drybulb temperature sensors were placed throughout the reactor containment vessel volume to permit monitoring of internal temperature variations at 24 locations. Dewcells were placed at ten locations to permit monitoring of the reactor containment partial pressure of water vapor.

5.3 CALIBRATION CHECKS

Temperature, dewpoint, and pressure measuring systems were checked for calibration before the test as recommended by ANSI N45.4-1972, Section 6.2 and 6.3. The results of the calibration checks are on file at Brunswick Steam Electric Plant. A containment temperature survey was conducted which verified that there were no unmonitored regional temperature variations. The supplemental test at 50.8 psig confirmed the instrumentation acceptability.

5.4 INSTRUMENTATION PERFORMANCE

During the ILRT, one RTD exhibited abnormal behavior and was not used for the test. The remaining 10 dewcells, 23 RTDs, two precision pressure gauges, and flow meter performed satisfactorily throughout the performance of the integrated leak rate test and provided more than adequate coverage of the containment. A post test inspection revealed that the erratic RTD had fallen to the floor and was sensing metal temperature rather than air temperature.

5.5 VOLUME WEIGHTING FACTORS

Weighting factors were assigned to each drybulb temperature sensor and dewpoint temperature sensor based on the calculated volume of the reactor containment building each sensing device monitored. Drybulb and dewpoint temperature sensors elevation and weighting factors for the test were as follows:

Elevation/ Azimuth	Temperature Element	Weighting Factor
93/0°	TE 1	.0528
93/180°	TE 2	0
78/270°	TE 3	.0187
78/90°	TE 4	.0187
66/0°	TE 5	.0115
66/180°	TE 6	.0115
54/270°	TE 7	.0136
54/90°	TE 8	.0136
46/300°	TE 9	.0194
46/0°	TE 10	.0194
46/180°	TE 11	.0194
33/0°	TE 12	.0500
33/120°	TE 13	.0500
33/240°	TE 14	.0500
16/0°	TE 15	.0577
16/270°	TE 16	.0577
16/180°	TE 17	.0577
16/90°	TE 18	.0577
Torus 0°	TE 19	.0701
Torus/60°	TE 20	.0701
Torus/120°	TE 21	.0701
Torus/180°	TE 22	.0701
Torus/240°	TE 23	.0701
Torus/300°	TE 24	.0701
93/270°	DPE 1	.0527
78/90°	DPE 2	.0489
54/0°	DPE 3	.0386
46/180°	DPE 4	.0583

5.5 VOLUME WEIGHTING FACTORS (Continued)

Elevation/ Azimuth	Temperature Element	Weighting Factor
33/270°	DPE 5	.1502
16/90°	DPE 6	.2309
Torus/0°	DPE 7	.1051
Torus/90°	DPE 8	.1051
Torus/180°	DPE 9	.1051
Torus/270°	DPE 10	.1051

5.6 SYSTEMATIC ERROR ANALYSIS

Systematic error, in this test, is induced by the operation of the temperature indicating system, dewpoint indicating system, and the pressure indicating system.

Justification of instrumentation selection was accomplished, using manufacturer's sensitivity and repeatability tolerances stated in Section 5.1, by computing the instrumentation selection guide (ISG) formula.

Containment leakage determined by the Absolute Method requires accurate measurement of small changes in containment pressure with suitable corrections for temperature and water vapor. Since the Absolute Method utilizes the change in a reading (i.e., pressure and temperature) to calculate leak rate, the repeatability, sensitivity, and readability of the instrument system is of more concern than the accuracy. To perform the ISG calculation, the sensitivity error of the sensor and the repeatability error of the measurement system must be used.

Sensitivity is defined as "the capability of a sensor to respond to change." Sensitivity is usually a function of the system measuring the sensor output. When the sensor energy state is raised or lowered an amount equal to the smallest value which the entire system will process, a change of indication will occur. To determine sensitivity for ILRT sensors, it is necessary to analyze the smallest value of the analog sensor output which will cause a one digit change in the digital display.

Repeatability is defined as "the capability of the measurement system to reproduce a given reading from a constant source."

5.6 SYSTEMATIC ERROR ANALYSIS
(Continued)

Utilizing the methods, techniques, and assumptions in Appendix G to ANS 56.8-1981, the ISG formula was computed for the Absolute Method as follows:

1. Conditions:

L_a = 0.5 wt.%/day

P = 65.5 psia

T = 547.5^{O}R drybulb

T_{dp} = 80.5^{O}F dewpoint

t = 24 hours

2. Total Absolute Pressure: e_p

No. of sensors = 2

Range = 0 - 75 psia

Sensor sensitivity error (E_p) = +/- 0.001% of full scale

Measurement system error (ε_p) = +/- 0.0005% of full scale

$$e_p = +/- \, [(E_p)^2 + (\varepsilon_p)^2]^{1/2} \, /[\text{no. of sensors}]^{1/2}$$

$$e_p = +/- \, [(0.00075)^2 + (0.000375)^2]^{1/2} \, / \, [2]^{1/2}$$

$$e_p = +/- \, 0.0006 \text{ psia}$$

5.6 SYSTEMATIC ERROR ANALYSIS (Continued)

3. Water Vapor Pressure: e_{pv}

No. of sensors = 10

Sensor sensitivity error (E_{pv}) = +/- 0.5°F

Measurement system error (ε_{pv}) excluding sensor = +/- .1°F

At a dewpoint temperature of 80.5°F, the equivalent water vapor pressure change (as determined from steam tables) is 0.0168 psia/°F

E_{pv} = +/- 0.5°F (0.0168 psia/°F)

E_{pv} = +/- 0.00840 psia

ε_{pv} = +/- 0.1°F (0.0168 psia/°F)

ε_{pv} = +/- 0.00168 psia

$e_{pv} = +/- [(E_{pv})^2 + (\varepsilon_{pv})^2]^{1/2}/[\text{no. of sensors}]^{1/2}$

$e_{pv} = +/- [(0.00840)^2 + (0.00168)^2]^{1/2}/[10]^{1/2}$

e_{pv} = +/- 0.00271 psia

4. Temperature: e_T

No. of sensors = 23

Sensor sensitivity error (E_T) = +/- 0.1°F = +/- 0.1°R

Measurement system error (ε_T) excluding sensor = +/- 0.1°F = +/- 0.1°R

$e_T = +/- [(E_T)^2 + (\varepsilon_T)^2]^{1/2} / [\text{no. of sensors}]^{1/2}$

$e_T = +/- [(0.1)^2 + (0.1)^2]^{1/2} / [23]^{1/2}$

e_T = +/- 0.0294°R

5.6 SYSTEMATIC ERROR ANALYSIS (Continued)

5. Instrument Selection Guide (ISG):

$$ISG = +/-\frac{2400}{t}\left[2\left(\frac{e_p}{P}\right)^2 + 2\left(\frac{e_{pv}}{P}\right)^2 + 2\left(\frac{e_T}{T}\right)^2\right]^{1/2}$$

$$ISG = +/-\frac{2400}{24}\left[2\left(\frac{0.0006}{65.5}\right)^2 + 2\left(\frac{0.00271}{65.5}\right)^2 + 2\left(\frac{0.0294}{547.5}\right)^2\right]^{1/2}$$

$$ISG = +/-100[1.678 \times 10^{-10}+3.424 \times 10^{-9}+5.767 \times 10^{-9}]^{1/2}$$

$$ISG = +/- 0.010 \text{ wt.\%/day}$$

The ISG value does not exceed 0.25 L_a (0.125 wt.%/day) and it is therefore concluded that the instrumentation selected was acceptable for use in determining the reactor containment integrated leakage rate.

5.7 SUPPLEMENTAL VERIFICATION

In addition to the calibration checks described in Section 5.3, test instrumentation operation was verified by a supplemental test subsequent to the completion of the 24 hour leakage rate test. This test consisted of imposing a known calibrated leakage rate on the reactor containment building. After the flow rate was established, it was not altered for the duration of the test.

5.7 SUPPLEMENTAL VERIFICATION
(Continued)

During the supplemental test, the measured leakage rate was:

$$L_c = L_v' + L_o$$

Where:

L_c = Measured composite leakage rate consisting of the reactor containment building leakage rate plus the imposed leakage rate

L_o = Imposed leakage rate

L_v' = Leakage rate of the reactor containment building during the supplemental test phase

Rearranging the above equation,

$$L_v' = L_c - L_o$$

The reactor containment building leakage during the Supplemental test can be calculated by subtracting the known superimposed leakage rate from the measured composite leakage rate.

The reactor containment building leakage rate during the supplemental test (L_v') was then compared to the measured reactor containment building leakage rate during the preceding 24 hour test (L_{am}) to determine instrumentation acceptability. Instrumentation is considered acceptable if the difference between the two building leakage rates is within 25% of the maximum allowable leakage rate (L_a).

6.0 TEST PROCEDURE

6.1 PREREQUISITES

Prior to commencement of reactor containment building pressurization, the following prerequisites were satisfied:

1. Proper operation of all test instrumentation was verified.
2. All reactor containment building isolation valves were closed using the normal mode of operation. All associated system valves were placed in post-accident positions.
3. Portions of fluid systems, which under post-accident conditions become extensions of the containment boundary, were drained and vented to the extent possible or the Type C penalty taken as appropriate.
4. Type B and C testing was completed with a leakage value less than 0.6 L_a.
5. Containment pressurization system was operational.
6. Potential pressure sources were removed or isolated from the containment.
7. An inspection of the accessible interior and exterior surfaces of the containment was completed.

6.2 GENERAL DISCUSSION

Following the satisfaction of the prerequisites stated in Section 6.1, the reactor containment building pressurization was initiated at a rate of approximately 6.0 psi per hour. After the containment was stabilized, leak rate testing was initiated at the 50.5 psig pressure level. For the duration of the 24 hour leak test and the 4 hour supplemental test, average internal containment temperature slowly increased due to the Residual Heat Removal (Shutdown Cooling) System temperature.

6.2 GENERAL DISCUSSION
(Continued)

During the test the following occurred at 15 minute intervals (see Appendix B - Reduced Leakage Data):

1. Readings indicated by the precision pressure gauges were recorded and entered into the computer.

2. Readings indicated by the 23 RTDs were recorded and entered into the computer. The computer program calculated the weighted average containment building drybulb temperature by use of a weighting factor that was assigned to each RTD. This value was subsequently converted to degrees Rankine for use in the ideal gas law equation to calculate containment building weight of air.

3. Readings indicated by the ten dewpoint temperature sensors were recorded and entered into the computer. The computer program converted the readings to dewpoint temperatures and then calculated the average containment dewpoint temperature by use of a weighting factor assigned to each sensor. This weighted average dewpoint temperature was then converted to a partial pressure of water vapor.

The use of water vapor pressure (P_{wv}), temperature (T), and the total pressure (P_t) is described in more detail in Section 7.1.

Data was entered into an IBM AT Portable Computer located at the leak rate instrumentation room. The ILRT computer program utilized for the test had been previously checked with sample data of known results and certified prior to the test. The computer program then calculated the following at 15 minute intervals:

1. Total weight of containment air.

2. Mass point least squares fit leakage rate.

3. Mass point 95% upper confidence level leakage rate.

4. Observed total time leakage rate.

5. Total time mean leakage rate.

6. Total time least squares fit leakage rate.

7. Total time 95% upper confidence level leakage rate.

6.2 GENERAL DISCUSSION (Continued)

A plot of weighted average containment temperature, containment total pressure, containment average dewpoint temperature, and weight of air was performed for each 15 minute data set (see Appendix C).

Immediately following the 24 hour leak test, a superimposed leakage rate was established for a 4 hour test period. During this time, temperature, pressure, and vapor pressure were monitored as described above.

6.3 TEST PERFORMANCE

6.3.1 Pressurization and Stabilization Phase

Pressurization of the reactor containment building was started at approximately 1920 on March 25, 1988. The pressurization rate was approximately 6 psi per hour. When containment internal pressure reached 50.5 psig at 0443 on March 26, 1988, pressurization was secured. By 0900, on March 26, temperature stabilization criteria had been met.

6.3.2 Integrated Leak Rate Testing Phase

At 0900 on March 26, 1988, 15 minute frequency test data collection was initiated. Initial indications showed a slowly rising leakage rate of approximately 0.33% by weight per day. However, operations was experiencing problems in maintaining a steady residual heat removal (RHR) temperature which caused fluctuations in the reactor vessel level. This introduced some periodic perturbations in the observed containment mass weight points and in the corresponding mass point leakage rate. Additionally, due to the recent completion of the reactor vessel hydrostatic test, the RHR system temperature was fluctuating in the range of 125° F to 135° F. Since this was substantially higher than the containment ambient air temperature, a heat source existed inside containment. Additional influences on the test data were caused by an operational requirement for two loop RHR shutdown cooling when the reactor vessel level dropped below 200 inches and an increase in RHR flow from 5,000 gallons per minute to 7,500 gallons per minute. This caused an additional drop in reactor vessel level resulting in more perturbations of the containment leakage rate. Leak detection and identification teams were dispatched but no major source of containment leakage was

6.3.2 Integrated Leak Rate Testing Phase (Continued)

identified. Three minor packing leaks were identified on the RHR containment spray valve E11-F021A, containment vacuum breaker valve CAC-V17, and the feedwater B loop injection valve B21-F032B.

At this time (1230 on March 26), no repairs were made. By 1355, the containment leakage rate was 0.35% by weight per day and still increasing slowly. However, regression analysis of containment mass weights recorded between the perturbations caused by RHR temperature and reactor vessel level changes indicated a containment leakage rate of approximately 0.31% by weight per day.

At 0745 on March 27, 1988, a decision was made to terminate the integrated leakage rate test. The containment leakage rate had stabilized at approximately 0.39 to 0.40% by weight per day. Based on the regression analysis described above, it was felt that the actual containment leakage rate was lower than .39 to .40% per day and was probably on the order of 0.31% per day. However, due to the changes in RHR temperature and reactor vessel level, this could not be positively confirmed. By 1035 on March 27, reactor vessel level had been raised to 235 inches, single loop RHR shutdown c[illegible]ing had been established, operations had committe[illegible]aintaining better RHR temperature control and the pac[illegible]leaks on valves E11-F021A and CAC-V17 had been repai[illegible]. Containment ambient air temperature changes had been continuously monitored and were still within the temperature stabilization criteria. Containment pressure was well above the required 49 psig criteria at approximately 50.3 psig.

The integrated leakage rate test was officially restarted at 1200 on March 27, 1988. The containment leakage rate exhibited a gradual increasing trend, reaching a maximum value of 0.39% per day at 1930 hours. Leakage detection and identification was again initiated but no areas of significant leakage were observed. From 1930 on March 27 to 1200 on March 28, the containment leakage rate showed a continual and gradual decreasing trend. The containment integrated leakage rate test was concluded at 1200 on March 28, 1988 with an acceptable measured mass point leakage rate value of 0.307% per day. The leakage rate at the upper 95 percent confidence level was 0.312% by weight per day.

6.3.3 Supplemental Leakage Rate Test Phase

Following completion of the 24 hour integrated leak rate test, a leakage rate of 4.36 scfm was imposed on the containment building through a calibrated flow meter at 1200 on March 28. After a fifteen minute stabilization period, leakage rate data was again collected at 15 minute intervals for a period of 4 hours. With an imposed leak rate of 0.478% per day, a measured composite leakage rate of 0.687% per day was obtained using the Mass Point method. This results in a containment building leakage rate agreement of 19.6% of L_a with the results of the 24 hour test. This value is within the acceptance limit of 25% of L_a.

6.3.4 Depressurization Phase

After all required data was obtained and evaluated, containment building depressurization to 0 psig was started. A post test inspection of the containment revealed no unusual findings. The RTD which exhibited erratic behavior (TE-2) was found to have fallen from its test location onto the floor. This explains the sudden and large increase in temperature readings from TE-2 since it was then measuring the floor temperature instead of the containment ambient air temperature.

7.0 METHODS OF ANALYSIS

7.1 ABSOLUTE METHOD

7.1.1 General

The Absolute Method of leakage rate determination was employed during testing at the 49.0 psig pressure level. The ILRT computer code calculates the percent per day leakage rate using both the mass point and total time methods.

7.1.2 Mass Point Analysis

The Mass Point method of computing leakage rates uses the following ideal gas law equation to calculate the weight of air inside containment for each 15 minute interval:

$$W = \frac{144\ PV}{RT} = \frac{KP}{R}$$

Where:

W = Mass of air inside containment, lbm

$K = 144\ V/R$ - [illegible] $\times 10^5\ \frac{lbm - {}^{\circ}R - in.^2}{lbf}$

P = Partial pressure of air, psia

T = Average internal containment temperature, $^{\circ}R$

V = 294,981 ft^3

$R = 53.35\ \frac{lbf - ft}{lbm - {}^{\circ}R}$

The partial pressure of air, P, is calculated as follows:

$$P = P_T - P_{wv}$$

Where:

P_T = Total containment pressure

P_{wv} = Partial pressure of water vapor determined by averaging the nine dewpoint temperatures and converting to partial pressure of water vapor, psia

7.1.2 Mass Point Analysis
(Continued)

The average internal containment temperature, T, is calculated as follows:

$$T = \frac{1}{\sum_i \frac{V_{fi}}{T_i}}$$

Where:

V_{fi} = Volume fraction of the i^{th} sensor

T_i = Absolute temperature of the i^{th} sensor

The weight of air is plotted versus time for the 24 hour test and for the 4 hour supplemental test. The ILRT computer code fits the locus of these points to a straight line using a linear least squares fit. The equation of the linear least squares fit line is of the form $W = A_t + B$, where A is the slope in lbm per hour and B is the initial weight at time zero. The least squares parameters are calculated as follows:

$$A = \frac{N(\Sigma t_i W_i) - (\Sigma t_i)(\Sigma W_i)}{S_{xx}}$$

$$B = \frac{(\Sigma t_i^2)(\Sigma W_i) - (\Sigma t_i)(\Sigma t_i W_i)}{S_{xx}}$$

Where:

$S_{xx} = N (\Sigma t_i^2) - (\Sigma t_i)^2$

N = Number of data points

W_i = Measured mass of containment air

t_i = Time interval

7.1.2 Mass Point Analysis
(Continued)

The weight percent leakage per day can then be determined from the following equation:

$$L_{am} = \frac{-2400\ A}{B}$$

where the negative sign is used since A is a negative slope to express the leakage rate as a positive quantity.

7.2 STATISTICAL EVALUATION

7.2.1 General

After performing the least squares fit, the ILRT computer code calculates the limits of the 95 percent confidence interval for the mass point leakage rate (C_M).

This statistical parameter is then used to determine that the measured leakage rate plus the 95 UCL meets the acceptance criteria.

7.2.2 Mass Point Confidence

The upper 95 percent confidence limit for the mass point leakage rate is calculated as follows:

$$C_M = 2400\ t_{95}\ (S_A/B)$$

Where:

C_M = Upper 95 percent confidence limit

t_{95} = Student's t distribution with N-2 degrees of freedom

S_A = Standard deviation of the slope of the least squares fit line

B = Intercept of the least squares fit line

The standard deviation of the slope of the least squares fit line (S_A) is calculated as follows:

$$S_A = \frac{S\ (N)^{1/2}}{[N(\Sigma t_i 2) - (\Sigma t_i)^2]^{1/2}}$$

7.2.2 <u>Mass Point Confidence</u>
(Continued)

Where:

S = Common standard deviation of the observed weights from the weights on the least squares fit line

N = Number of data points

t_i = Time interval of the ith data point

The common standard deviation (S) is defined by:

$$S = \left[\frac{\Sigma (W_i - W)^2}{N-2} \right]^{1/2}$$

Where:

W_i = Observed mass of air

W = Least squares calculated mass of air

The ILRT computer code calculates an upper 95 percent confidence leakage rate as follows:

$$UCL = L_{am} + 2400\ t_{95}\ (S_A/B)$$

This UCL value is then used to determine that the measured leakage rate at the upper 95 percent confidence limit meets the acceptance criteria.

8.0 DISCUSSION OF RESULTS

8.1 RESULTS AT P_a

The method used in calculating the Mass Point leakage rate is described in Section 7.1.1. The results of this calculation is a mass point leakage rate of 0.307%/day (see Appendix D).

The 95 percent confidence limit associated with this leakage rate is 0.005% per day. Thus, the leakage rate at the upper bound of the 95 percent confidence level becomes:

$$UCL = .307 + .005$$

$$UCL = 0.312\%/day$$

Additional leakage rates must be applied to the measured leakage rate at the upper 95 percent confidence level to account for penetration paths not exposed to the test pressure and for changes in the net free volume of the containment due to water level changes. Penetration paths not exposed to the test pressure and the corresponding leakage rates based on analysis of minimum pathway local leakage rate testing are as follows:

System	Containment Isolation Valves	Minimum Pathway Local Leakage Rate (SCFH)
Drywell Drains	2-G16-F003/F004	0
Drywell Drains	2-G16-F019/F020	0
Feedwater (RCIC Injection Line B)	2-B21-F032B, 2-E51-V88, 2-B21-F010B,	0
Feedwater (HPCI Injection Line A)	2-B21-F032A, 2-E41-F006, 2-B21-F010A,	0
Reactor Building Cooling Water	2-RCC-V28/V52 RXS-SV1222B/C	0 0
CRD Purge to Reactor Recirc Pumps	2-B32-V24/V22, V30	0
	2-B32-V32/V22, V30	6.35

8.1 RESULTS AT P_a
(Continued)

System	Containment Isolation Valves	Minimum Pathway Local Leakage Rate (SCFH)
Electrical Penetration	101A	0
Recirc Sample	2-B32-F019/F020	0
RHR Suction	2-E11-F008/F009	0
Reactor Water Cleanup	2-G31-F001/F004	2.49

The total applicable local leakage rate is 8.84 scfh which is equivalent to a leakage rate of 0.017%/day.

Water level changes in the containment during the 24 hour integrated leakage rate test are summarized below:

Reactor Vessel Water Level:

1200	3-27-88	235 inches
1200	3-28-88	232 inches

Torus Water Level:

1200	5-19-87	-28.5 inches
1200	5-19-87	-28.5 inches

During the test, no makeup water was introduced into the reactor vessel. Therefore, the volume change associated with the change in reactor vessel water level showed an increase in the net free volume of 64.8 cubic feet. This corresponds to a reduction in the measured containment leakage rate of 0.022% per day. However, it is conservatively assumed that the water level decrease in the reactor vessel was not lost out of containment and therefore no change in net free volume occurred.

8.1 RESULTS AT P_a
(Continued)

The total containment leakage rate at the upper 95 percent confidence level (UCL) is calculated as follows:

UCL = L_{am} + 95 percent confidence limit + Type C leakage + changes in net free volume

UCL = 0.307%/day + 0.005%/day + 0.017%/day + 0.000%/day

UCL = 0.329%/day

This value is below the acceptance criteria leakage rate of 0.375%/day (.75L_a).

Therefore, the reactor containment building leakage rate, based on the mass point method analysis, at the calculated design basis accident pressure (P_a) of 49.0 psig is acceptable.

8.2 SUPPLEMENTAL TEST RESULTS

After conclusion of the 24 hour test at 49.0 psig (P_a), the flowmeter was placed in service and a flow rate of 4.36 scfm was established. This flow rate is equivalent to a leakage rate of 0.478% per day. After the flow rate was established it was not altered for the duration of the supplemental test. The measured leakage rate (L_c) during the supplemental test was calculated to be 0.687% per day using the Mass Point method of analysis.

The building leakage rate during the supplemental test is then determined as follows:

<u>Mass Point</u>

$L_v = L_c - L_o$

$L_v = 0.687 - 0.478$

$L_v = 0.209\%/day$

8.2 SUPPLEMENTAL TEST RESULTS
(Continued)

Comparing this leakage rate with the building leakage rate measured during the 8 hour test yields the following:

$$\text{Mass Point} = \frac{L_{am} - L_v'}{L_a} = \frac{.307 - .209}{0.5} = 0.196$$

The building leakage rates agree within 19.6% of L_a using the Mass Point method which is below the acceptance criteria of 25%.

Using the formulation of ANS 56.8-1981,

$$(L_o + L_{am} - 0.25L_a) \leq L_c \leq (L_o + L_{am} + 0.25L_a)$$

$$(0.478 + 0.307 - 0.125) \leq L_c \leq (0.478 + 0.307 + 0.125)$$

$$0.660 \leq L_c \leq 0.910$$

Since L_c was measured to be 0.687%/day, this value falls within the acceptable range of 0.660% to 0.910% per day. Therefore, the acceptability of the test instrumentation is considered to have been verified.

8.3 AS FOUND ANALYSIS

To determine the as-found containment leakage rate, an analysis was performed to evaluate any leakage savings from repairs or maintenance to containment isolation barriers. Leakage savings are realized when containment isolation barrier repairs result in a lower minimum pathway leakage than that which existed prior to the repair or maintenance.

The results of the analysis are presented in Appendix E. The total leakage savings due to performing Type B and C tests prior to the Type A test indicates that the acceptance criteria (L_a) would have been exceeded due to one penetration (Feedwater B Loop Injection) that could not be pressurized.

The total as left Type B and C leakage rate is 35.275 scfh which is equivalent to a combined leakage rate of 0.066% per day. This is well below the allowable value of 0.6 L_a or 0.300% per day.

8.4 TYPE B AND C TESTING

The results of the Type B and Type C tests conducted during the 1988 Unit 2 refueling outage are shown on Appendix E. Additional Type B and C tests which were conducted subsequent to the last Type A test on May 5, 1986 are listed below.

Date	Item	Leakage Rate (scfh)
05/19/86	CRD Hatch	0
05/23/86	Electrical Penetration X102H	0
06/01/86	N. Torus Hatch	0
06/03/86	Airlock	8.927
06/19/86	CAC-X20A/CAC-V16	0
06/23/86	CRD Hatch	0
07/11/86	B32-F019/B32-F020	0
07/13/85	G31-F001/G31-F004	1.039
10/13/86	CAC-SV-4410-4	0
10/13/86	CAC-SV-4410-3	0
10/13/86	CAC-SV-4410-2	0
10/14/86	CAC-V7 ("O" rings)	0
10/14/86	CAC-V5 ("O" rings)	0
10/14/86	CAC-V16 ("O" rings)	0
10/16/86	CAC-SV-4409-2	0
10/16/86	CAC-SV-4409-3	0
10/16/86	CAC-SV-4409-4	0
10/19/86	B32-F019/B32-F020	WNP
10/19/86	E51-F031	0
10/19/86	E51-F062/E51-F066	1.158
10/19/86	CAC-V9 ("O" rinç ,	0
10/19/86	E51-F019	0
10/23/86	B32-F019/F32-F020	0
10/24/86	N. Torus Hatch	0
10/24/86	CRD Hatch	0
10/27/86	N. Torus Hatch	0
11/05/86	Personnel Airlock	8.753
06/02/87	E21-F001A	9.035
06/17/87	Personnel Airlock	2.558

WNP = Would Not Pressurize

9.0 REFERENCES

1. PT-20.5, Integrated Primary Containment Leak Rate Test.

2. Brunswick Steam Electric Plant Unit No. 2 Final Safety Analysis Report.

3. Code of Federal Regulations, Title 10, Part 50, Appendix J.

4. ANSI N45.4-1972, Leakage Rate Testing of Containment Structures for Nuclear Reactors, American Nuclear Society (March 16, 1972).

5. ANS-56.8-1981, "Containment System Leakage Testing Requirements", American Nuclear Society.

6. ILRT Computer Code, Gilbert/Commonwealth, Inc.

7. Steam Tables, American Society of Mechanical Engineers, 1967.

9. BN-TOP-1, "Testing Criteria for Integrated Leakage Rate Testing of Primary Containment Structures for Nuclear Power Plants", Revision 1, November 1, 1972.

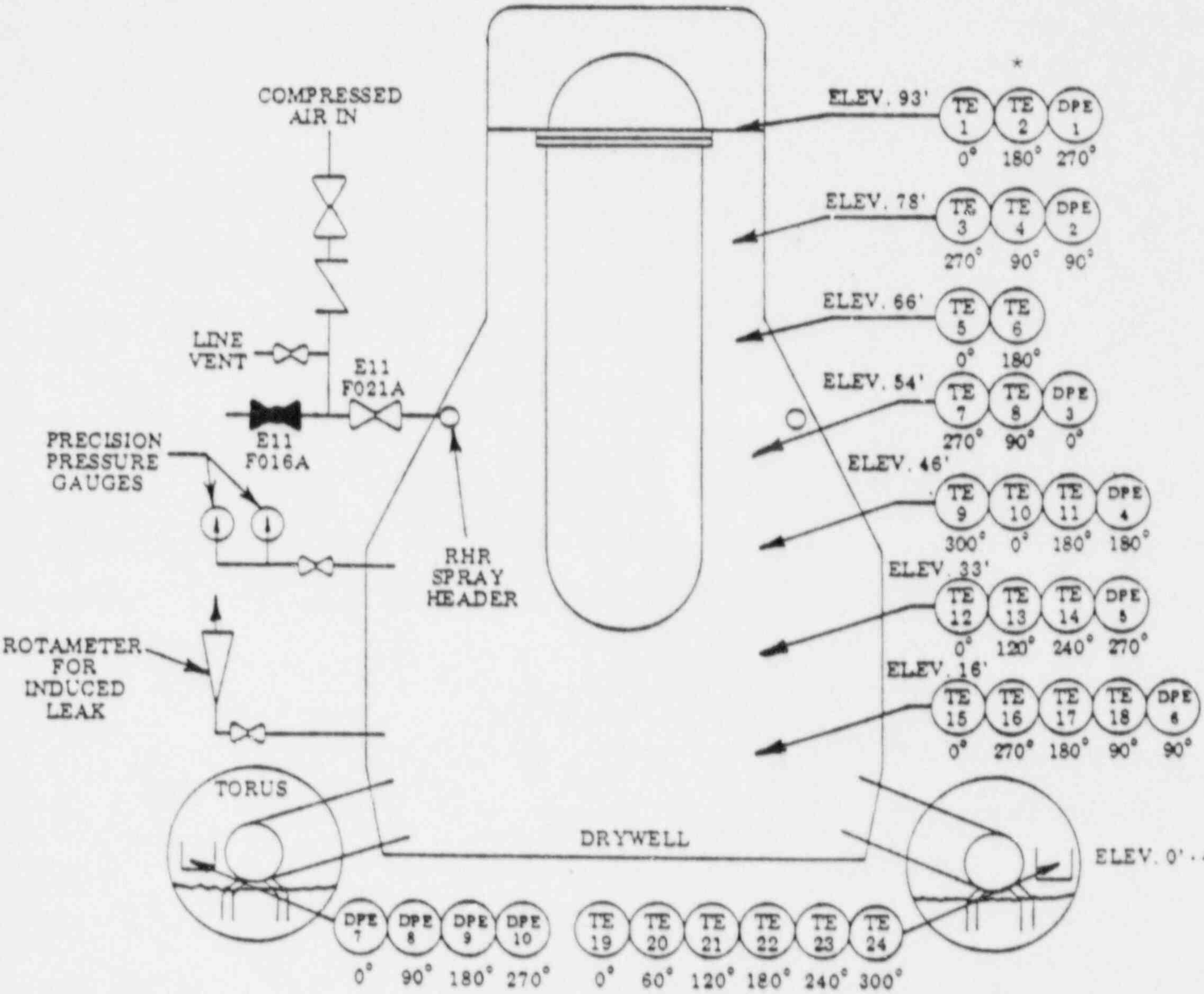
APPENDICES

APPENDIX A

SCHEMATIC ARRANGEMENT OF TEST INSTRUMENTATION

APPENDIX A

IPCLRT SCHEMATIC ARRANGEMENT
(NOT TO SCALE)



TE = TEMPERATURE ELEMENT (RTD)
DPE = DEWPOINT ELEMENT (DEWCELL)

* NOT USED FOR TEST

APPENDIX B

REDUCED TEST DATA

REDUCED ILRT TEST DATA

DATE	TIME	PAVG	PWV	TAVG	MASS WEIGHT
3-27-88	1200	65.339	0.4819	84.479	94895.64
	1215	65.351	0.4839	84.566	94893.17
	1230	65.363	0.4859	84.631	94894.94
	1245	65.373	0.4871	84.748	94894.21
	1300	65.388	0.4886	84.849	94893.53
	1315	65.401	0.4895	84.957	94892.00
	1330	[illegible]	0.4897	85.057	94891.13
	1345	65.423	0.4899	85.155	94889.13
	1400	65.430	0.4911	85.244	94882.20
	1415	65.437	0.4911	85.321	94879.13
	1430	65.443	0.4913	85.392	94875.30
	1445	65.448	0.4927	85.463	94867.88
	1500	65.452	0.4922	85.520	94864.78
	1515	65.456	0.4927	85.577	94860.05
	1530	65.460	0.4928	85.632	94855.93
	1545	65.464	0.4933	85.681	94851.45
	1600	65.466	0.4937	85.727	94846.80
	1615	65.469	0.4942	85.771	94842.84
	1630	65.471	0.4941	85.814	94838.80
	1645	65.473	0.4944	85.851	94834.58
	1700	65.475	0.4955	85.889	94828.95
	1715	65.477	0.4949	85.927	94825.50
	1730	65.478	0.4958	85.955	94821.44
	1745	65.480	0.4965	85.995	94815.79
	1800	65.481	0.4958	86.024	94813.88
	1815	65.482	0.4964	86.052	94809.34
	1830	65.483	0.4964	86.079	94806.82
	1845	65.484	0.4962	86.112	94802.48
	1900	65.486	0.4964	86.138	94799.80
	1915	65.486	0.4962	86.165	94796.47
	1930	65.487	0.4967	86.192	94792.09
	1945	65.488	0.4972	86.213	94788.84
	2000	65.489	0.4958	86.238	94787.64
	2015	65.489	0.4958	86.263	94784.45
	2030	65.490	0.4967	86.280	94780.23
	2045	65.490	0.4963	86.310	94776.62
	2100	65.491	0.4978	86.328	94772.38
	2115	65.492	0.4979	86.351	94769.32
	2130	65.492	0.4984	86.370	94765.88
	2145	65.493	0.4994	86.391	94761.91
	2200	65.493	0.4992	86.420	94757.70
	2215	65.494	0.5002	86.439	94754.2[illegible]
	2230	65.495	0.5004	86.453	94752.41
	2245	65.495	0.5001	86.480	94749.28
	2300	65.496	0.5002	86.496	94747.26

REDUCED ILRT TEST DATA

DATE	TIME	PAVG	PWV	TAVG	MASS WEIGHT
3-27-88	[illegible]	65.497	0.5003	86.517	94744.77
	[illegible]	65.497	0.5001	86.536	94741.70
	[illegible]	65.197	0.5005	86.555	94737.88
3-28-88	[illegible]	65.498	0.5011	86.577	94734.24
	[illegible]	65.498	0.5009	86.594	94732.61
	30	65.499	0.5010	86.615	94729.90
	45	65.499	0.5011	86.635	94726.75
	100	65.500	0.5017	86.656	94722.85
	115	65.501	0.5021	86.670	94720.95
	130	65.501	0.5021	86.691	94717.22
	145	65.501	0.5013	86.713	94715.77
	200	65.502	0.5027	86.729	94712.02
	215	65.502	0.5030	86.749	94708.00
	230	65.503	0.5034	86.770	94704.93
	245	65.504	0.5030	86.787	94703.74
	300	65.504	0.5045	86.808	94698.55
	315	65.505	0.5037	86.828	94697.09
	330	65.505	0.5046	86.849	94693.38
	345	65.506	0.5037	86.860	94693.85
	400	65.507	0.5047	86.885	94689.20
	415	65.508	0.5043	86.908	94686.73
	430	65.508	0.5054	86.920	94684.18
	445	65.509	0.5044	86.939	94683.56
	500	65.510	0.5051	86.961	94679.79
	515	65.511	0.5048	86.973	94679.18
	530	65.511	0.5052	86.993	94676.22
	545	65.512	0.5057	87.019	94672.68
	600	65.513	0.5054	87.033	94671.59
	615	65.514	0.5060	87.047	94669.10
	630	65.514	0.5058	87.065	94667.20
	645	65.515	0.5061	87.086	94664.17
	700	65.516	0.5066	87.100	94662.22
	715	65.517	0.5064	87.120	94660.02
	730	65.517	0.5074	87.136	94656.94
	745	65.518	0.5078	87.160	94653.32
	800	65.519	0.5079	87.177	94651.19
	815	65.520	0.5087	87.199	94648.47
	830	65.522	0.5086	87.216	94647.89
	845	65.523	0.5089	87.236	94646.26
	900	65.524	0.5094	87.253	94644.23
	915	65.526	0.5090	87.273	94642.98
	930	65.526	0.5092	87.292	94639.93
	945	65.527	0.5097	87.309	94637.30
	1000	65.527	0.5101	87.326	94634.84
	1015	65.528	0.5095	87.346	94633.25

REDUCED ILRT TEST DATA

DATE	TIME	PAVG	PWV	TAVG	MASS WEIGHT
3-28-88	1030	65.529	0.5105	87.367	94629.27
	1045	65.529	0.5099	87.383	94628.00
	1100	65.530	0.5110	87.404	94624.43
	1115	65.532	0.5110	87.425	94622.39
	1130	65.532	0.5109	87.444	94620.33
	1145	65.533	0.5116	87.460	94617.69
	1200	65.535	0.5116	87.482	94615.91

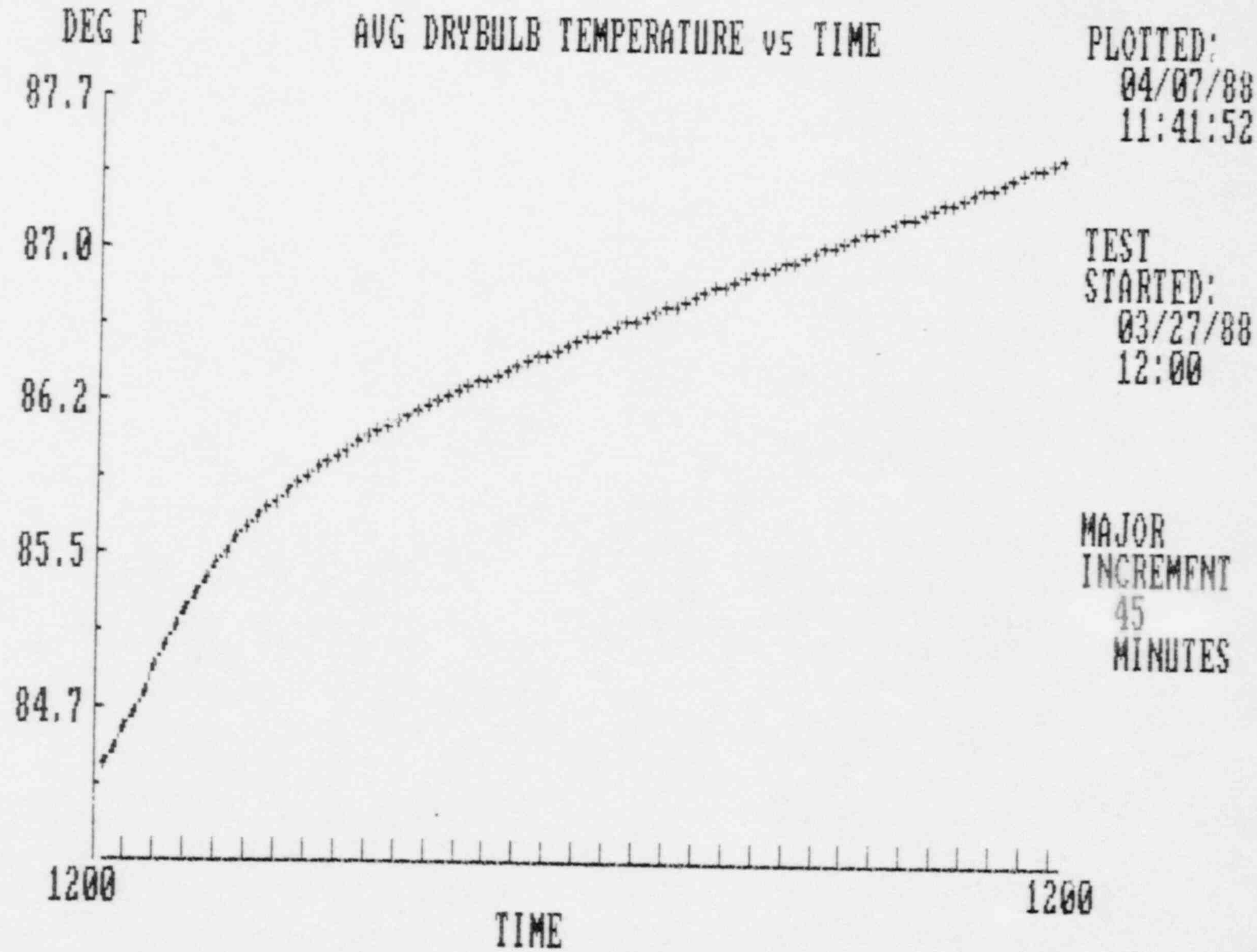
VERIFICATION TEST DATA

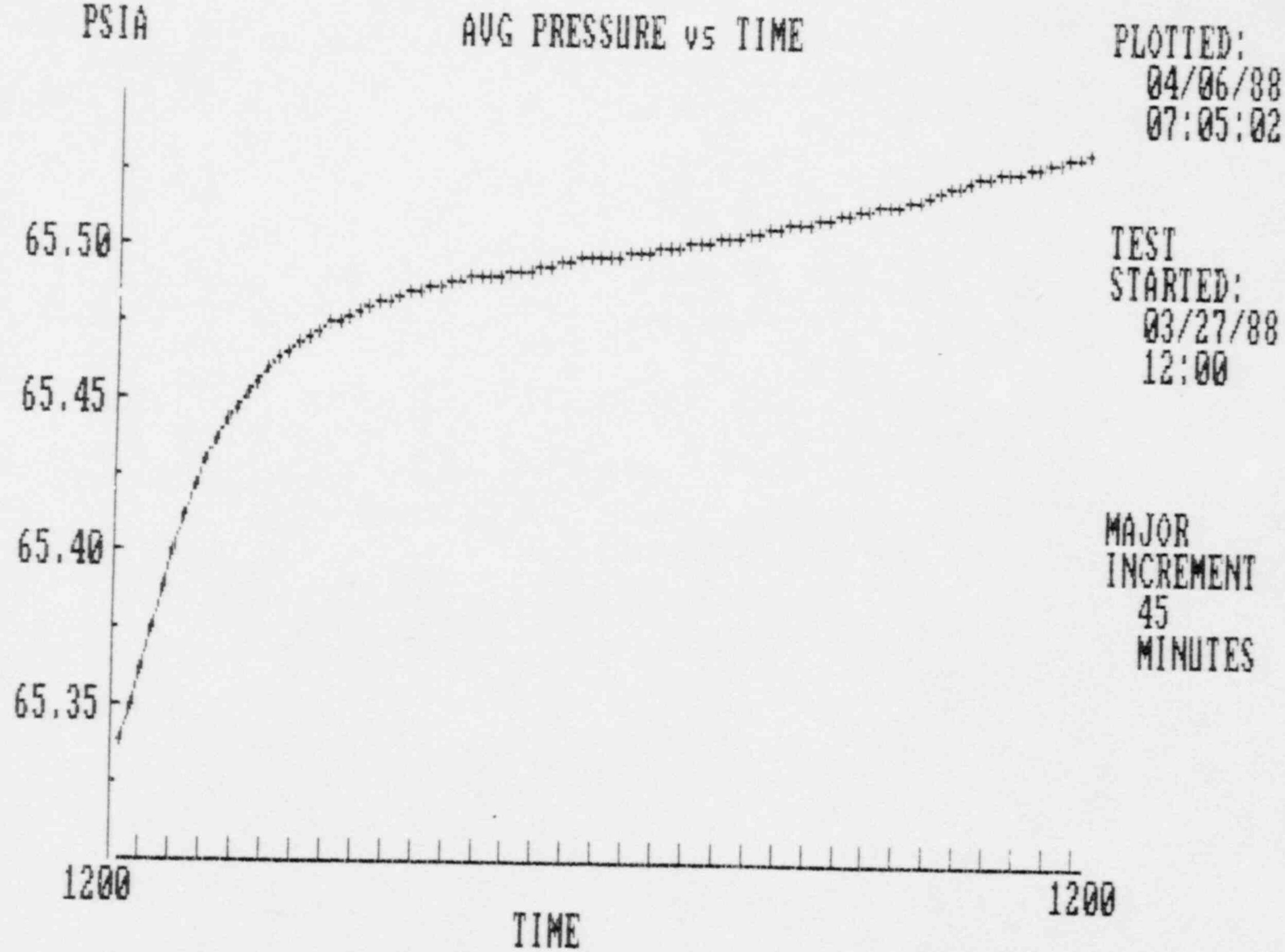
1215	65.533	0.5117	87.503	94609.49
1230	65.530	0.5118	87.518	94602.85
1245	65.529	0.5121	87.541	94596.48
1300	65.526	0.5125	87.558	94589.63
1315	65.524	0.5130	87.576	94582.49
1330	65.522	0.5131	87.604	94574.16
1345	65.520	0.5123	87.619	94570.11
1400	65.518	0.5127	87.640	94563.21
1415	65.516	0.5140	87.662	94554.80
1430	65.514	0.5137	87.685	94548.52
1445	65.512	0.5140	87.700	94542.30
1500	65.510	0.5143	87.722	94535.28
1515	65.508	0.5153	87.743	94527.45
1530	65.506	0.5144	87.763	94522.00
1545	65.504	0.5153	87.784	94514.42
1600	65.502	0.5149	87.800	94509.51
1615	65.501	0.5157	87.828	94500.68

APPENDIX C

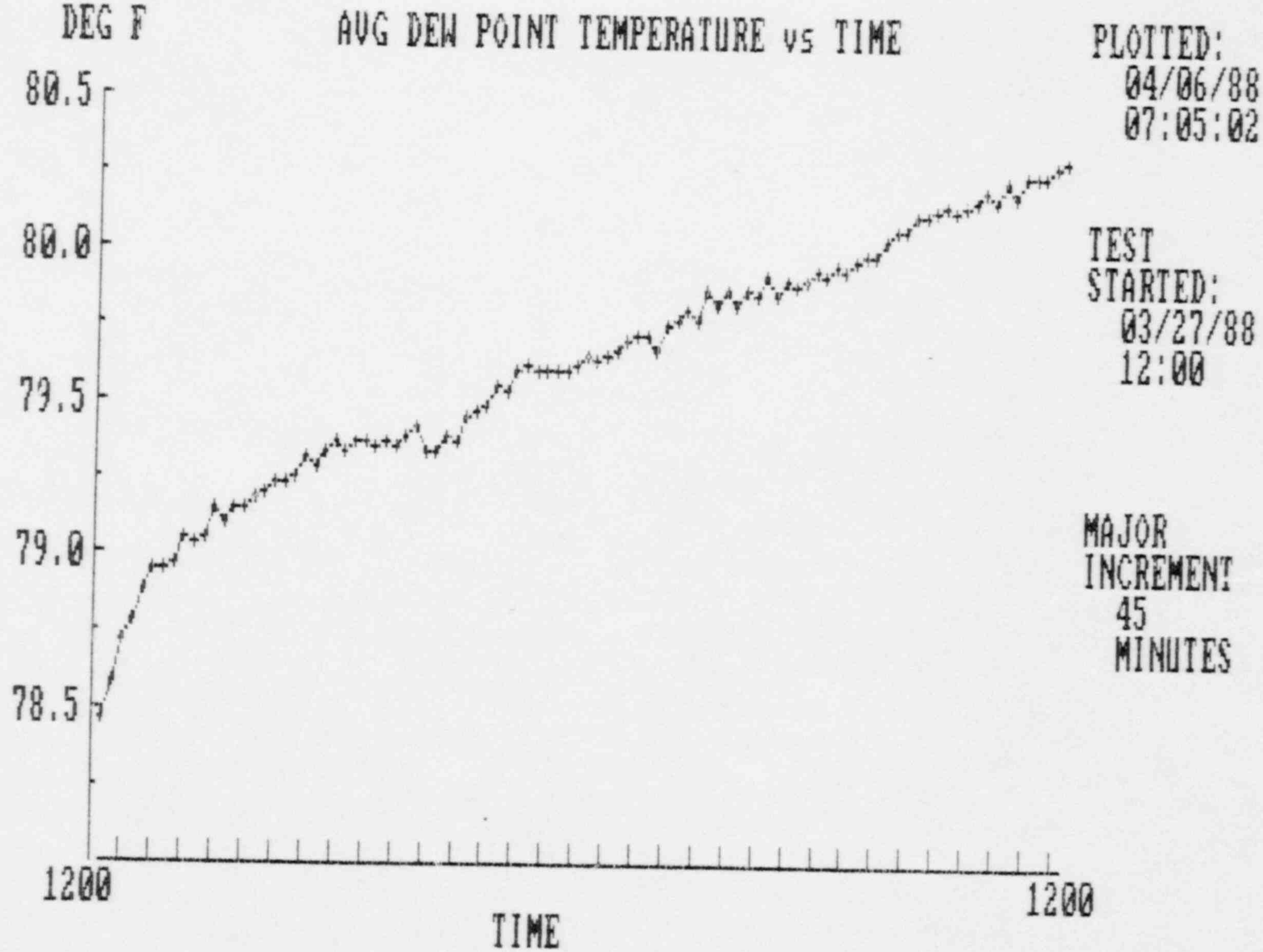
LEAKAGE RATE TEST GRAPHS

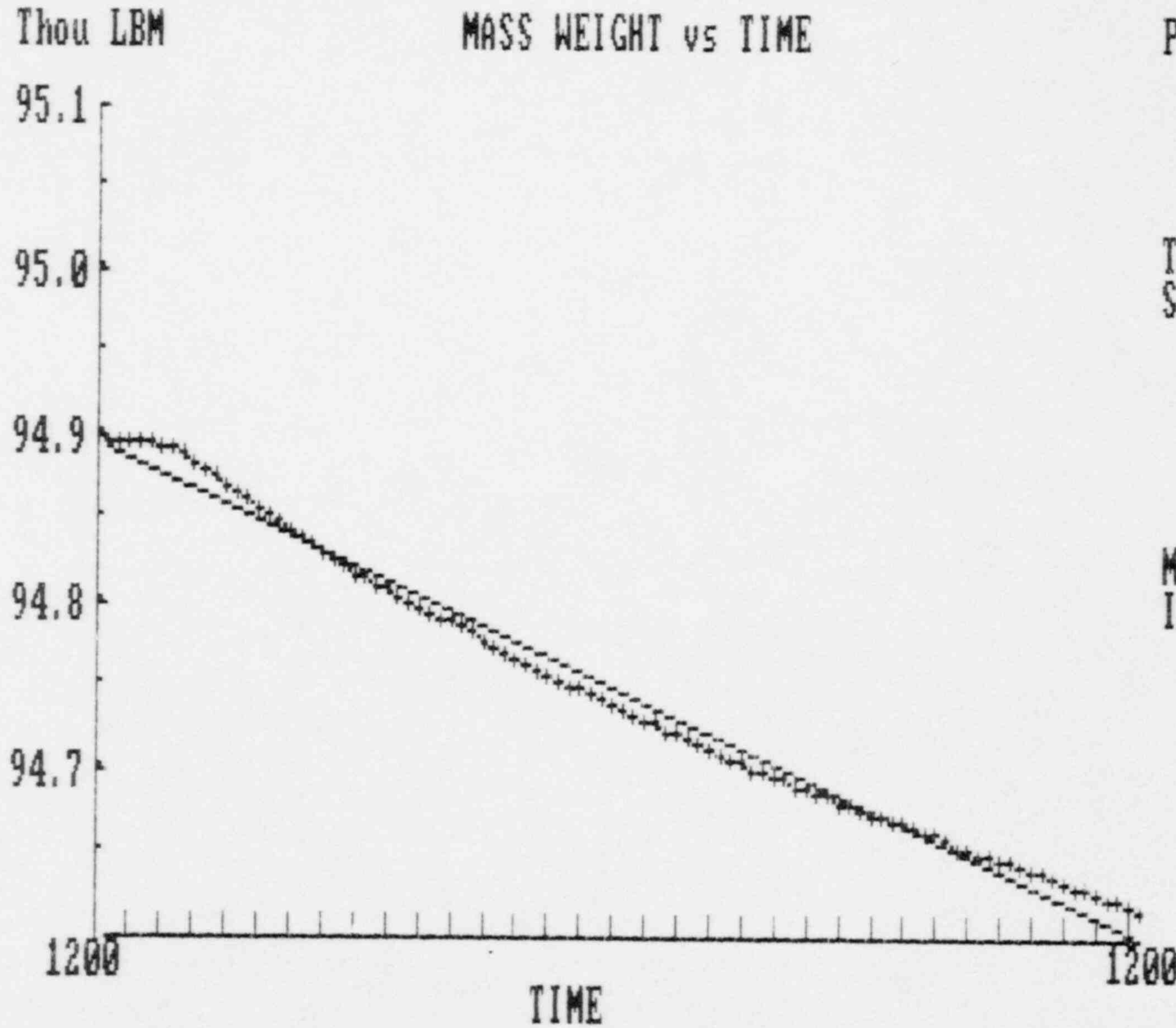
24 HOUR TEST


DEG F
AVG DRYBULB TEMPERATURE vs TIME
PLOTTED:
04/07/88
11:41:52
TEST
STARTED:
03/27/88
12:00
MAJOR
INCREMENT
45
MINUTES
87.7
87.0
86.2
85.5
84.7
1200
1200
TIME



PSIA
AVG PRESSURE vs TIME
PLOTTED:
04/06/88
07:05:02
65.50
65.45
65.40
65.35
TEST
STARTED:
03/27/88
12:00
MAJOR
INCREMENT
45
MINUTES
1200
1200
TIME

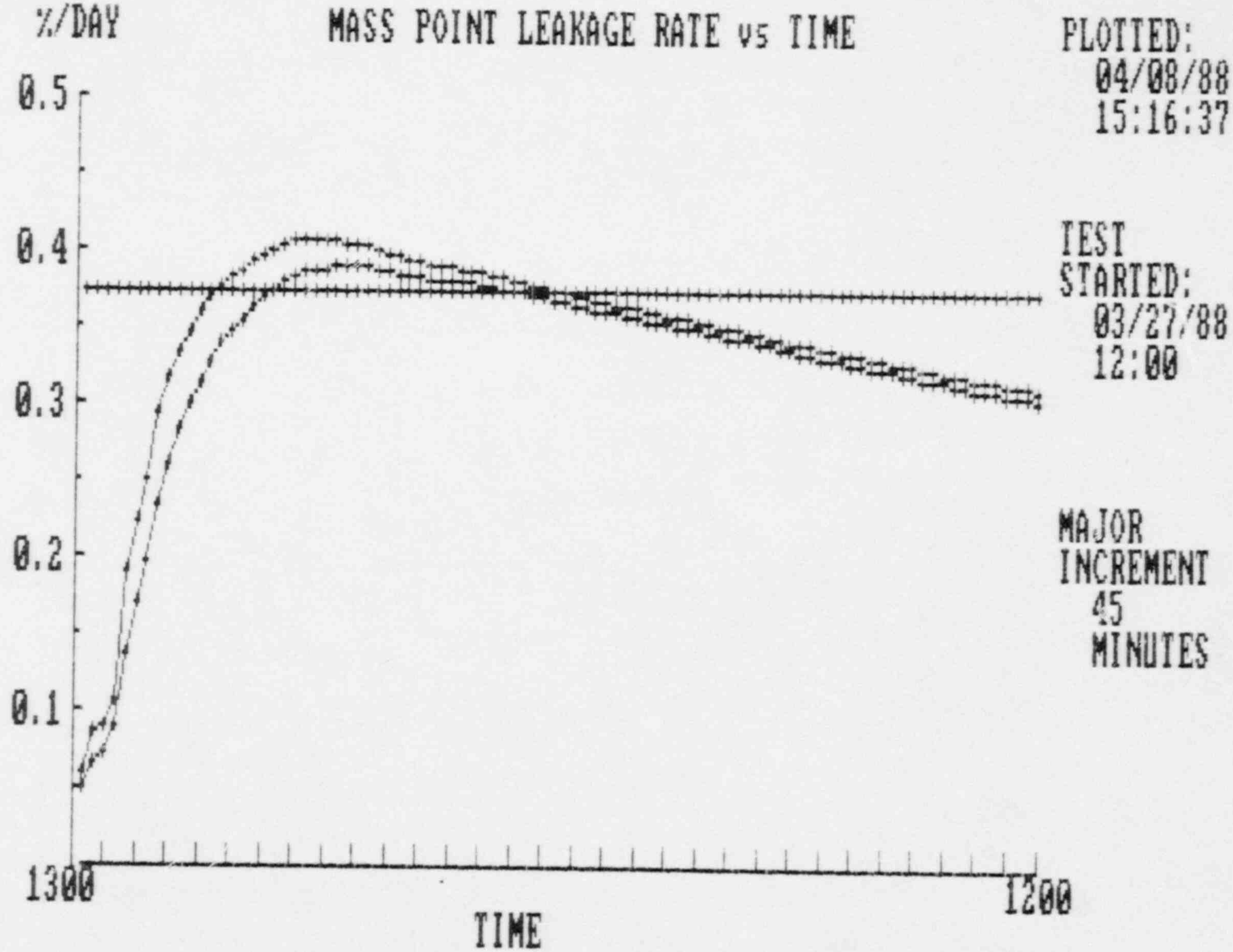

DEG F
AVG DEW POINT TEMPERATURE vs TIME
PLOTTED:
04/06/88
07:05:02
80.5
80.0
79.5
79.0
78.5
TEST
STARTED:
03/27/88
12:00
MAJOR
INCREMENT
45
MINUTES
1200
1200
TIME



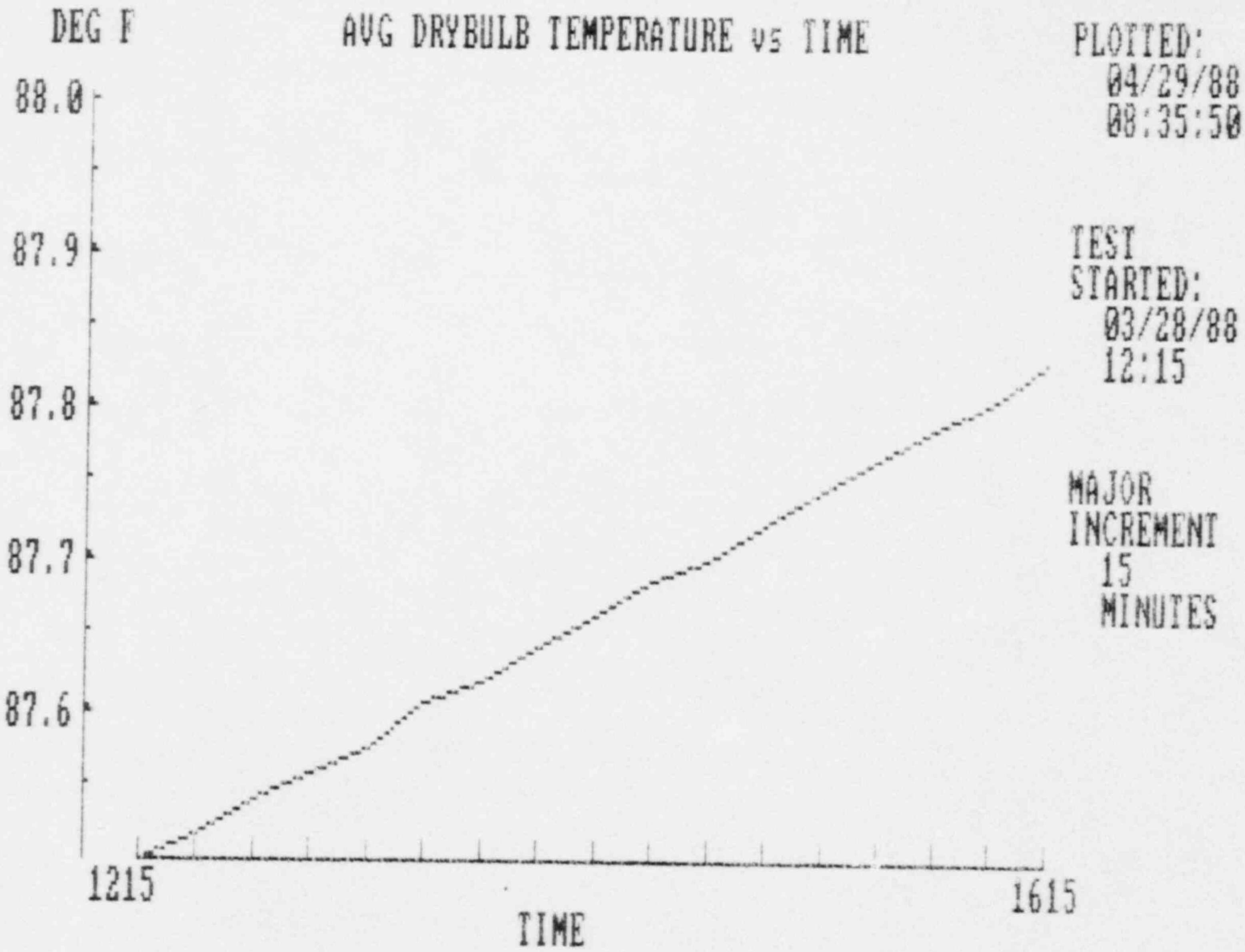
PLOTTED:
04/08/88
15:16:37

TEST
STARTED:
03/27/88
12:00

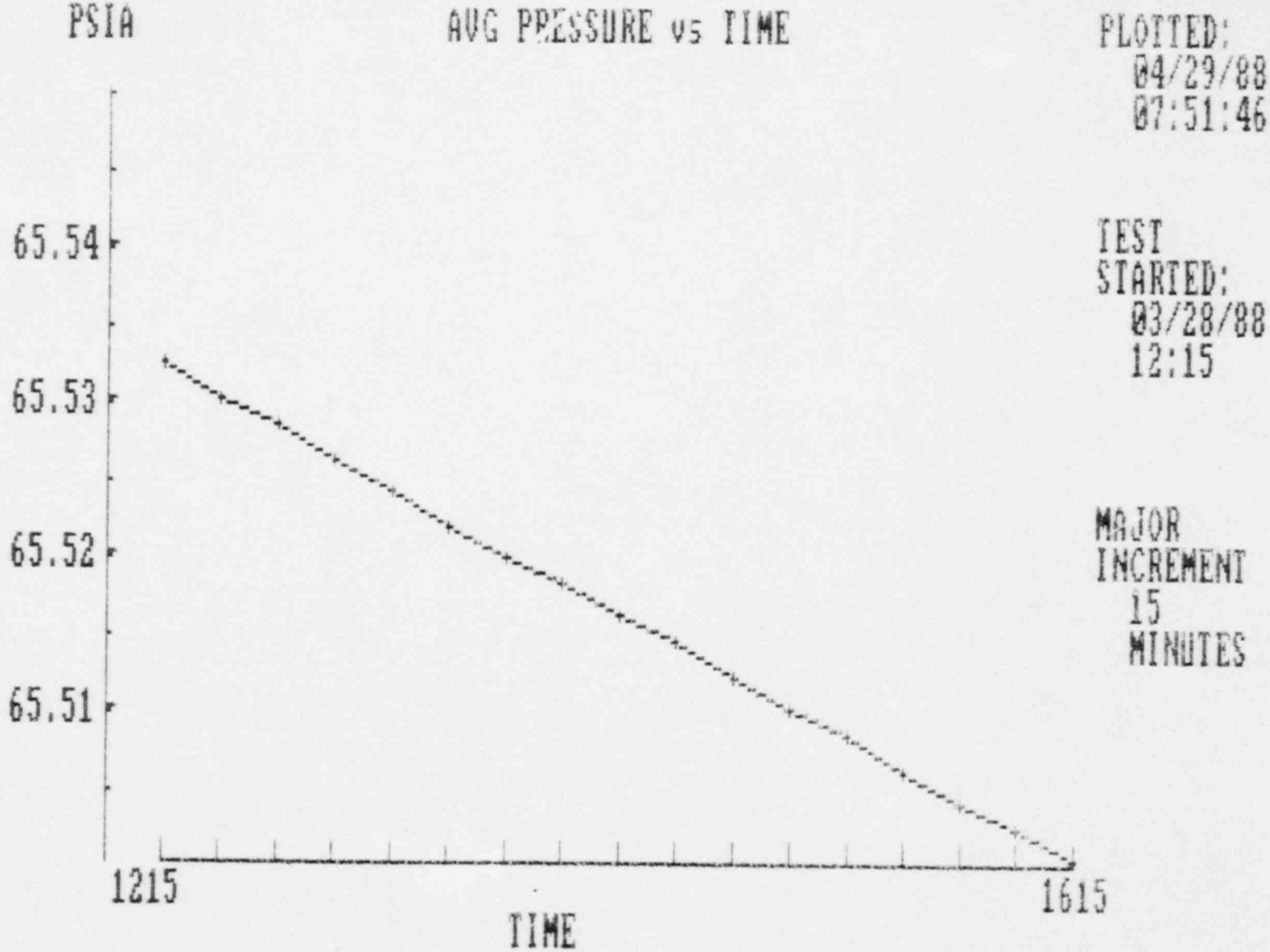
MAJOR
INCREMENT
45
MINUTES

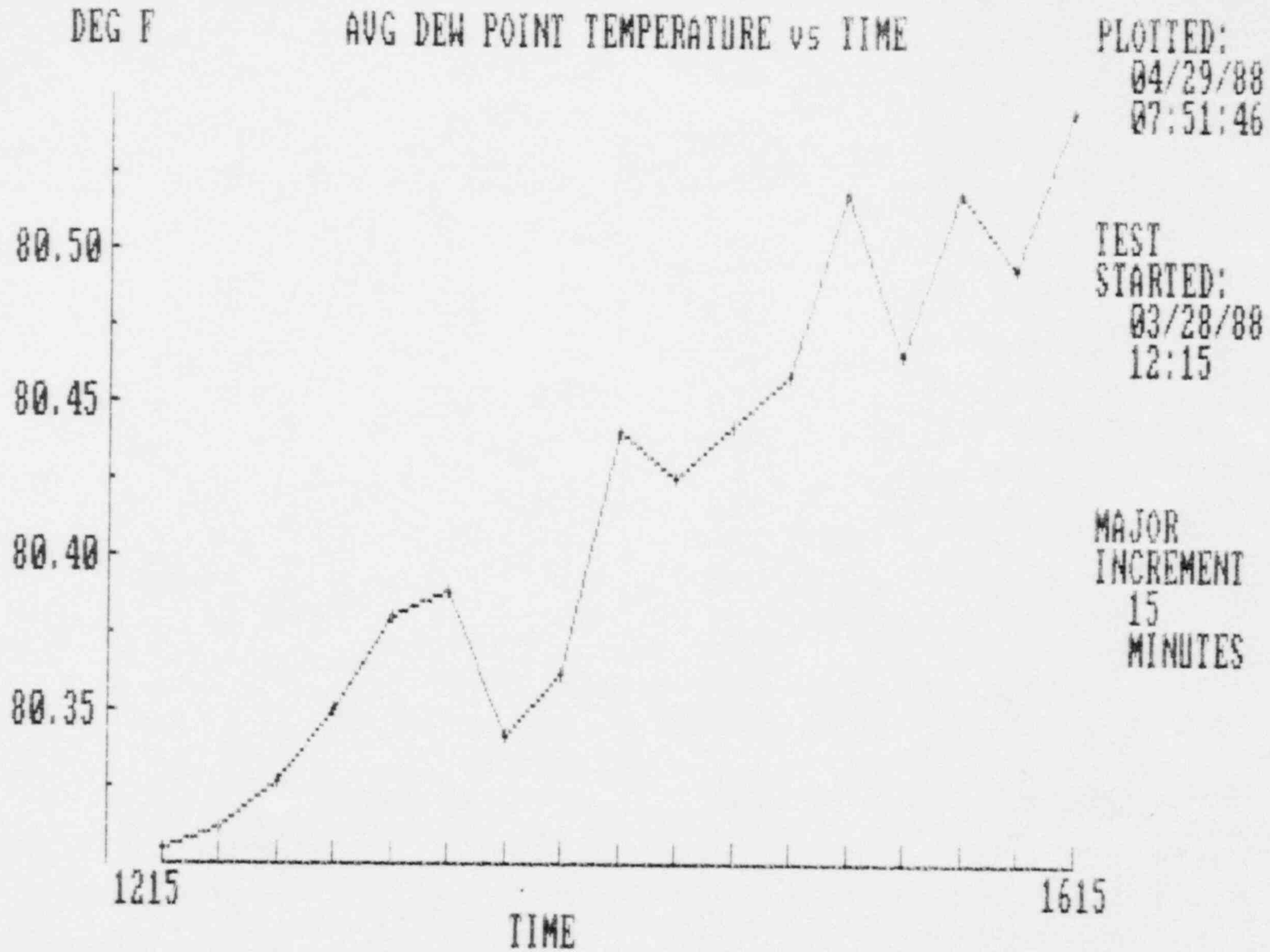

%/DAY
MASS POINT LEAKAGE RATE vs TIME
PLOTTED:
04/08/88
15:16:37
0.5
0.4
0.3
0.2
0.1
TEST
STARTED:
03/27/88
12:00
MAJOR
INCREMENT
45
MINUTES
1300
1200
TIME

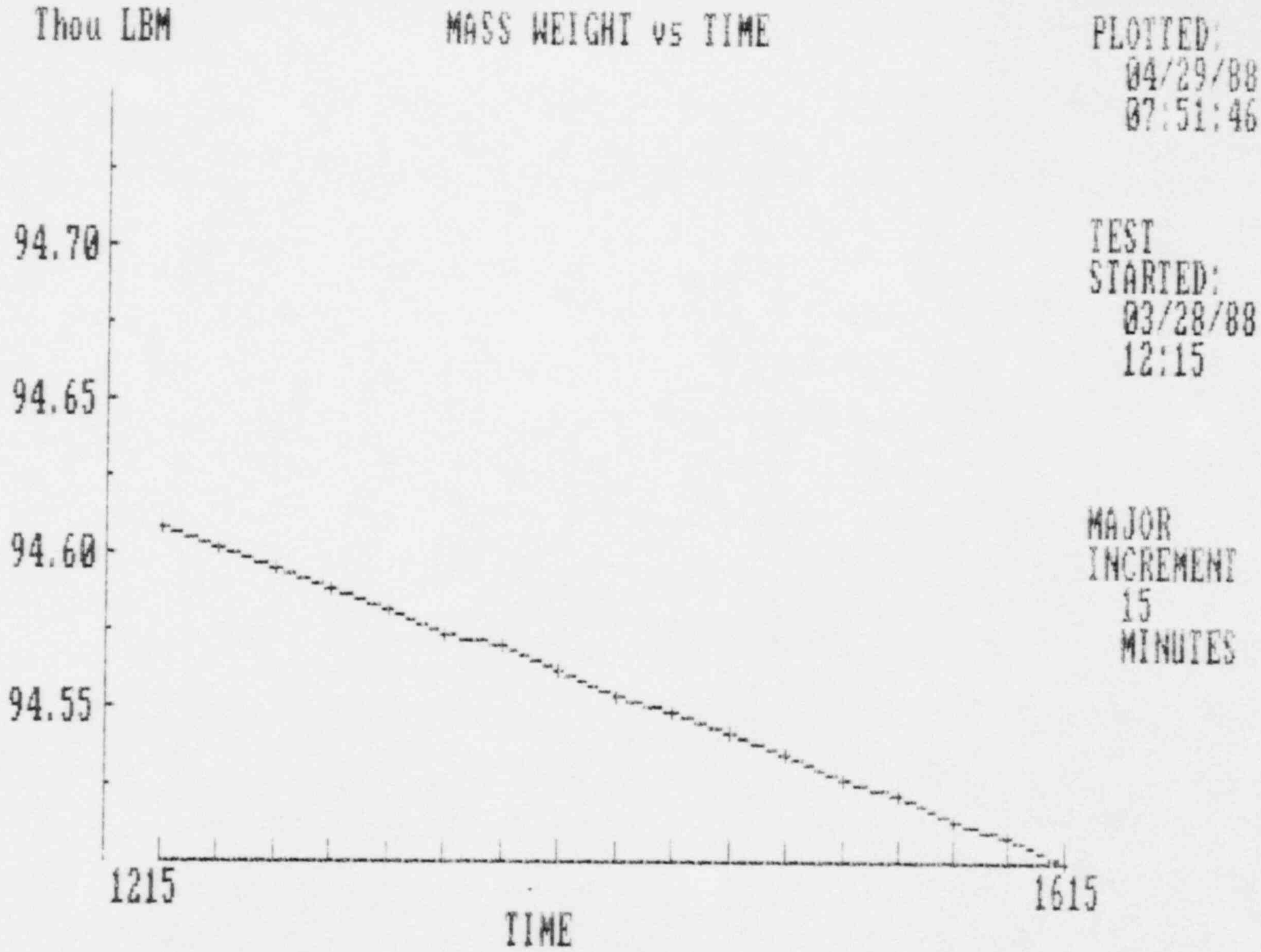
4 HOUR VERIFICATION



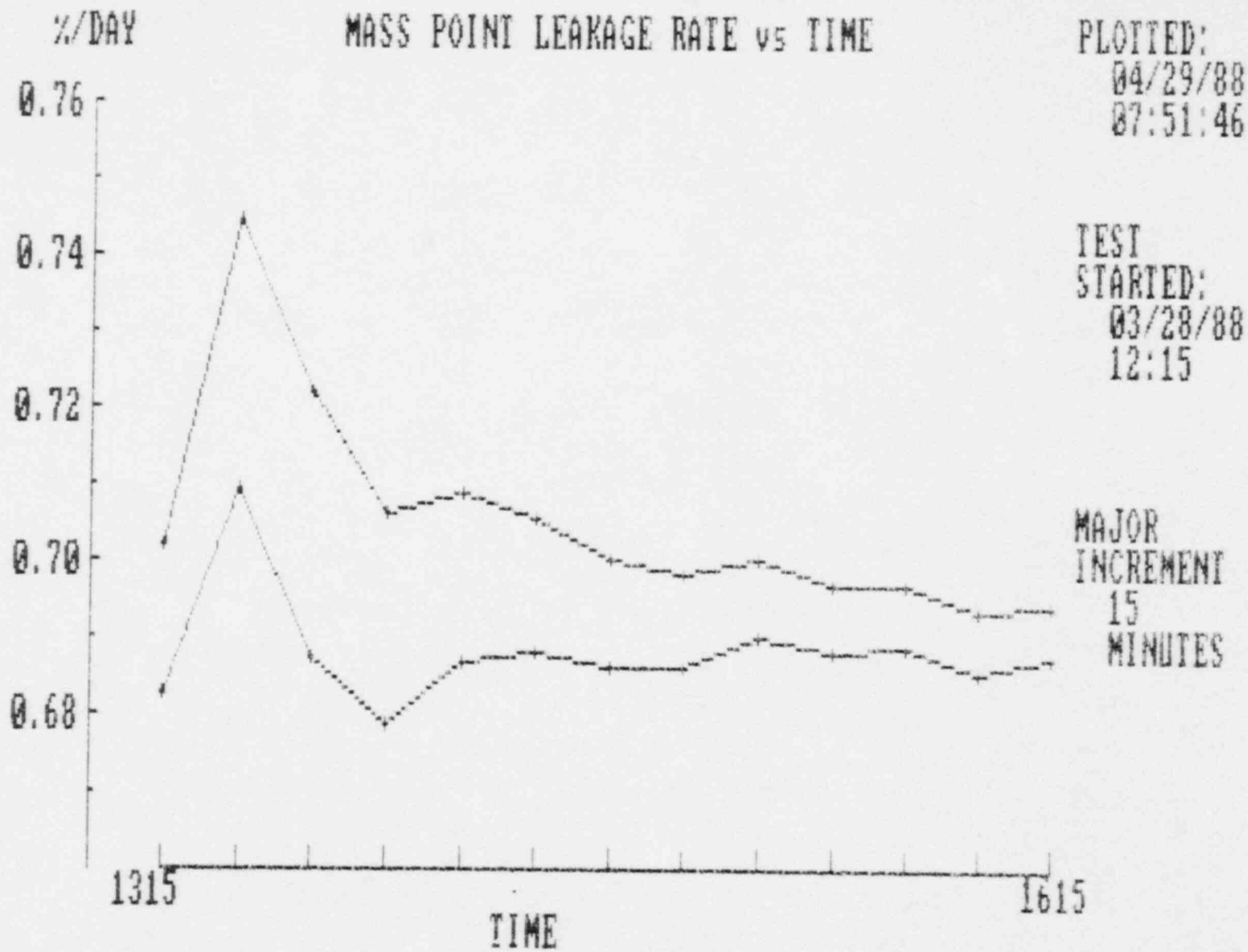
DEG F
AVG DRYBULB TEMPERATURE vs TIME
PLOTTED:
04/29/88
08:35:50
88.0
87.9
87.8
87.7
87.6
TEST
STARTED:
03/28/88
12:15
MAJOR
INCREMENT
15
MINUTES
1215
1615
TIME


PSIA
AVG PRESSURE vs TIME
PLOTTED:
04/29/88
07:51:46
65.54
65.53
65.52
65.51
TEST
STARTED:
03/28/88
12:15
MAJOR
INCREMENT
15
MINUTES
1215
1615
TIME


DEG F
AVG DEW POINT TEMPERATURE vs TIME
PLOTTED:
04/29/88
07:51:46
TEST
STARTED:
03/28/88
12:15
MAJOR
INCREMENT
15
MINUTES
80.50
80.45
80.40
80.35
1215
1615
TIME



Thou LBM
MASS WEIGHT vs TIME
94.70
94.65
94.60
94.55
1215
1615
TIME
PLOTTED:
04/29/88
07:51:46
TEST
STARTED:
03/28/88
12:15
MAJOR
INCREMENT
15
MINUTES



%/DAY
MASS POINT LEAKAGE RATE vs TIME
PLOTTED:
04/29/88
07:51:46
0.76
0.74
0.72
0.70
0.68
TEST
STARTED:
03/28/88
12:15
MAJOR
INCREMENT
15
MINUTES
1315
1615
TIME

APPENDIX D

COMPUTER RESULTS

24 HOUR TEST

INTEGRATED LEAK RATE TEST RESULTS
by GILBERT/COMMONWEALTH INC.

CURRENT DATE : 04-06-1988 CURRENT TIME : 13:06
TIME OF LAST READING : 1200

*** MASS POINT ANALYSIS ***

TIME INTERVAL	OBS. WEIGHT (LB)	OBS. MIN. CALC. (LB)
0	94895.64	5.005141
.25	94895.17	7.566677
.5	94894.84	10.26804
.75	94894.21	12.66631
1	94893.53	15.01691
1.25	94892	16.51594
1.5	94891.13	18.67123
1.75	94889.13	19.70152
2	94882.2	15.80211
2.25	94879.13	15.7699
2.5	94875.31	14.97206
2.75	94867.88	10.58047
3	94864.78	10.50919
3.25	94860.05	8.805102
3.5	94855.93	7.7182
3.75	94851.45	6.271924
4	94846.8	4.645959
4.25	94842.84	3.723119
4.5	94838.8	2.70653
4.75	94834.58	1.518065
5	94828.95	-1.076649
5.25	94825.5	-1.499489
5.5	94821.44	-2.531704
5.75	94815.79	-5.149856
6	94813.88	-4.02582
6.25	94809.34	-5.542409
6.5	94806.82	-5.027749
6.75	94802.48	-6.341214
7	94799.81	-5.982803
7.25	94796.47	-6.288456
7.5	94792.09	-7.640982
7.75	94788.84	-7.860697
8	94787.64	-6.025724
8.25	94784.45	-6.182939
8.5	94780.23	-7.371403
8.75	94776.62	-7.958305
9	94772.38	-9.170207
9.25	94769.32	-9.194609
9.5	94765.88	-9.609636
9.75	94761.91	-10.54029

10	94757.7	-11.72875
10.25	94754.2	-12.19847
10.5	94752.41	-10.94943
10.75	94749.28	-11.05196
11	94747.26	-10.04511
11.25	94744.77	-9.499201
11.5	94741.7	-9.54704
11.75	94737.88	-10.32925
12	94734.24	-10.93959
12.25	94732.61	-9.542121
12.5	94729.8	-9.324336
12.75	94726.75	-9.340925
13	94722.85	-10.20908
13.25	94720.95	-9.085042
13.5	94717.22	-9.781319
13.75	94715.77	-8.204159
14	94712.02	-8.91606
14.25	94708	-9.909212
14.5	94704.93	-9.94924
14.75	94703.74	-8.106454
15	94698.55	-10.27148
15.25	94697.09	-8.694321
15.5	94693.38	-9.374972
15.75	94693.85	-5.875937
16	94689.2	-7.494089
16.25	94686.73	-6.932554
16.5	94684.18	-6.456956
16.75	94683.56	-4.043858
17	94679.79	-4.78701
17.25	94679.18	-2.366099
17.5	94676.22	-2.296752
17.75	94672.68	-2.805529
18	94671.59	-.8611806
18.25	94669.1	-.3230827
18.5	94667.2	.8087653
18.75	94664.17	.8078008
19	94662.22	1.884961
19.25	94660.02	2.719934
19.5	94656.94	2.664282
19.75	94653.32	2.07738

20	94651.19	2.974853
20.25	94648.47	3.286388
20.5	94647.89	5.738549
20.75	94646.26	7.136022
21	94644.23	8.14287
21.25	94642.98	9.923156
21.5	94639.93	9.898753
21.75	94637.31	10.30404
22	94634.84	10.87339
22.25	94633.25	12.30992
22.5	94629.27	11.35583
22.75	94628	13.12049
23	94624.43	12.58017
23.25	94622.39	13.57169
23.5	94620.33	14.53947
23.75	94617.69	14.92914
24	94615.91	16.17817

W0 = 94890.63548351041 LB
W1 = -12.12114182818746 LB/HR

LEAKAGE RATE = .3065713 % PER DAY
UPPER LIMIT OF THE 95% CONFIDENCE LEVEL = 5.684446E-03 % PER DAY
UPPER LIMIT OF THE 95% CONFIDENCE LEVEL = .3122557 % PER DAY
(INCLUDES LEAKAGE RATE)

4 HOUR VERIFICATION

INTEGRATED LEAK RATE TEST RESULTS
by GILBERT/COMMONWEALTH INC.

CURRENT DATE : 04-06-1988   CURRENT TIME : 13:14
TIME OF LAST READING : 1615

*** MASS POINT ANALYSIS ***

TIME INTERVAL	OBS. WEIGHT (LB)	OBS. MIN. CALC. (LB)
0	94609.49	-.1482843
.25	94602.85	-2.054611E-02
.5	94596.48	.3806296
.75	94589.63	.2896178
1	94582.49	-7.483149E-02
1.25	94574.16	-1.642406
1.5	94570.11	1.079082
1.75	94563.21	.9490081
2	94554.81	-.6888787
2.25	94548.52	-.209578
2.5	94542.31	.3478477
2.75	94535.28	9.277344E-02
3	94527.45	-.9669884
3.25	94522	.3482499
3.5	94514.42	-.4615119
3.75	94509.51	1.392789
4	94500.68	-.6669731

W0 = 94609.64047181373 LB
W1 = -27.07345281862745 LB/HR

LEAKAGE RATE = .686783 % PER DAY
UPPER LIMIT OF THE 95% CONFIDENCE LEVEL = 6.942185E-03 % PER DAY
UPPER LIMIT OF THE 95% CONFIDENCE LEVEL = .6937252 % PER DAY
(INCLUDES LEAKAGE RATE)

APPENDIX E

TYPE B & C TESTING

Pen	Valves	TYPE B ANALYSIS As Found	TYPE B ANALYSIS As Left	TYPE B ANALYSIS As Left Pen Leakage	MINIMUM PATH ANALYSIS As Found	MINIMUM PATH ANALYSIS As Left	MINIMUM PATH ANALYSIS Savings	NOTES
100A	ELECTRICAL	0	0	0	0	0	0	
100B	ELECTRICAL	0	0	0	0	0	0	
100C	ELECTRICAL	0	0	0	0	0	0	
103A	ELECTRICAL	0	0	0	0	0	0	
100D	ELECTRICAL	0	0	0	0	0	0	
104A	ELECTRICAL	1.616	0	0	1.616	0	1.616	
102A	ELECTRICAL	0	0	0	0	0	0	
104B	ELECTRICAL	0	0	0	0	0	0	
102B	ELECTRICAL	0	0	0	0	0	0	
101A	ELECTRICAL	0	0	0	0	0	0	(a)
101C	ELECTRICAL	0	0	0	0	0	0	
105D	ELECTRICAL	0	0	0	0	0	0	
105E	ELECTRICAL	0	0	0	0	0	0	
102C	ELECTRICAL	0	0	0	0	0	0	
104C	ELECTRICAL	0	0	0	0	0	0	
105H	ELECTRICAL	0	0	0	0	0	0	
105G	ELECTRICAL	0	0	0	0	0	0	
102E	ELECTRICAL	0	0	0	0	0	0	
104E	ELECTRICAL	0	0	0	0	0	0	
100F	ELECTRICAL	0	0	0	0	0	0	
100E	ELECTRICAL	0	0	0	0	0	0	
100G	ELECTRICAL	0	0	0	0	0	0	
100H	ELECTRICAL	0	0	0	0	0	0	
102F	ELECTRICAL	0	0	0	0	0	0	
104F	ELECTRICAL	0	0	0	0	0	0	
103B	ELECTRICAL	0	0	0	0	0	0	
104G	ELECTRICAL	0	0	0	0	0	0	
102H	ELECTRICAL	0	0	0	0	0	0	

		TYPE B ANALYSIS			MINIMUM PATH ANALYSIS			
Pen	Valves	As Found	As Left	As Left Pen Leakage	As Found	As Left	Savings	NOTES
105J	ELECTRICAL	0	0	0	0	0	0	
105K	ELECTRICAL	0	0	0	0	0	0	
101F	ELECTRICAL	0	0	0	0	0	0	
101D	ELECTRICAL	0	0	0	0	0	0	
105C	ELECTRICAL	0	0	0	0	0	0	
105B	ELECTRICAL	0	0	0	0	0	0	
232B	ELECTRICAL	0	0	0	0	0	0	
232C	ELECTRICAL	0	0	0	0	0	0	
232A	ELECTRICAL	0	0	0	0	0	0	
232D	ELECTRICAL	0	0	0	0	0	0	
1	EQPT HATCH	0	0	0	0	0	0	
2	LINER SEAL	0	0	0	0	0	0	
3	DW HD BLANK	0	0	0	0	0	0	
4	DW HD HATCH	0	0	0	0	0	0	
6	CRD HATCH	0	0	0	0	0	0	
200A	S. TORUS	0	0	0	0	0	0	
200B	N. TORUS	0	0	0	0	0	0	
-	HEAD SEAL	WNP	0	0	0	0	0	(b)
3B	V49-0 RING	0	0	0	0	0	0	
205	V5-0 RING	0	0	0	0	0	0	
25	V6-0 RING	0	0	0	0	0	0	
220	V7-0 RING	0	0	0	0	0	0	
26	V9-0 RING	0	0	0	0	0	0	
205	V16-0 RING	0	0	0	0	0	0	
205	V17-0 RING	0	0	0	0	0	0	

		TYPE C ANALYSIS			MINIMUM PATH ANALYSIS			
Pen	Valves	As Found	As Left	As Left Pen Leakage	As Found	As Left	Savings	NOTES
3B	CAC-49	0	0					
	CAC-50	0	0	0	0	0	0	
7A	B21-F022A							
	B21-F028A	16.45	9.53	9.53				See Note 3
7B	B21-F022B							
	B21-F028B	7.763	7.763	7.763				See Note 3
7C	B21-F022C							
	B21-F028C	19.848	9.558	9.558				See Note 3
7D	B21-F022D							
	B21-F028D	47.697	9.594	9.594				See Note 3
8	B21-F016							
	B21-F019	19.829	0	0	9.915	0	9.915	Tested in parallel
	B21-F010A	WNP	0					
9A	B21-F032A							
	E41-F006	4.269	4.269	0	4.269	4.269	0	
	B21-F010B	WNP	0					
	B21-F032B							
9B	E51-V88	WNP	0	0	WNP	0	Indeterminate	See Note (c)
	E51-F013							
	G31-F042	0	0					
10	E51-F007							
	E51-F008	16.62	0	0	8.31	0	8.31	Tested in parallel
11	E41-F002							
	E41-F003	3.138	0	0	1.569	0	1.569	Tested in parallel
12	E11-F008							
	E11-F009	0	0	0	0	0	0	Tested in parallel
13A	E11-F015A	0	1.32					
	E11-F017A	0	0	1.32	0	1.32	0	

Pen	Valves	TYPE C ANALYSIS As Found	TYPE C ANALYSIS As Left	TYPE C ANALYSIS As Left Pen Leakage	MINIMUM PATH ANALYSIS As Found	MINIMUM PATH ANALYSIS As Left	MINIMUM PATH ANALYSIS Savings	NOTES
13B	E11-F015B	0	0					
	E11-F017B	0	0	0	0	0	0	
14	G31-F001							
	G31-F004	.364	2.49	2.49	.182	1.25	0	Tested in parallel
16A	E21-F004A	0	0					
	E21-F005A	0	.820	.820	0	.820	0	
16B	E21-F004B	0	0					
	E21-F005B	0	0	0	0	0	0	
17	E11-F022							
	E11-F023	0	0	0	0	0	0	Tested in parallel
18	G16-F003							
	G16-F004	0	0	0	0	0	0	Tested in parallel
19	G16-F019							
	G16-F020	0	0	0	0	0	0	Tested in parallel
23	RCC-V52							
& 24	RCC-V28	0	0		0	0	0	Tested in parallel
	CAC-V6, V15							
	V-4,V-5	9.849	9.82	9.82	4.925	4.91	.015	Tested in parallel
	CAC-V17							
	X20B	43.146	1.91	1.91	1.91	0	1.91	
25	CAC-V16							
&	X20A	WNP	0	0	0	0	0	See Note (d)
205	160, 162, 170	1.428	1.428	1.428	1.428	1.428	0	
	171, 163, 161	0	0	0	0	0	0	
	55, 56	.824	.824	.824	.824	.824	0	
26	CAC-V9							
	CAC-V10							
	CAC-V23	34.44	1.422	1.422	17.22	0.711	16.509	Tested in parallel
35A	TIP-V1	0	0	0	0	0	0	
35B	TIP-V2	0	0	0	0	0	0	

Pen	Valves	TYPE C ANALYSIS As Found	TYPE C ANALYSIS As Left	TYPE C ANALYSIS As Left Pen Leakage	MINIMUM PATH ANALYSIS As Found	MINIMUM PATH ANALYSIS As Left	MINIMUM PATH ANALYSIS Savings	NOTES
35C	TIP-V3	0	0	0	0	0	0	
35D	TIP-V4	0	0	0	0	0	0	
35E	TIP-Nitrogen ChK	0	0	0	0	0	0	
39A	E11-F016A							
	E11-F021A	0	0	0	0	0	0	Tested in parallel
39B	E11-F016B							
	E11-F021B	0	0	0	0	0	0	Tested in parallel
42	C41-F006	1.725	0					
	C41-F007	19.81	1.22	1.22	1.725	0	1.725	
49B	CAC-SV-1200B	.825	.825	.825				
	CAC-SV-1261	0	0		0	0	0	
52A	IA-SV-5253	1.174	1.174	1.174	1.174	1.174	0	
54E	CAC-SV-1211E	.307	.307					
	CAC-SV-3439	.307	.307	.307	.307	.307	0	
54F	CAC-SV-1211F	0	0					
	CAC-SV-1261	0	0	0	0	0	0	
55	IA-SV-5262	0	0	0	0	0	0	
56E	B32-F019							
	B32-F020	0	0	0	0	0	0	Tested in parallel
62A	B32-V22	34.522	0					
	B32-V24	0	0	0	0	0	0	
71	IA-SV-5261	0	0	0	0	0	0	
77B	RXS-SV-1222B	0	0	0	0	0	0	
77C	RXS-SV-1222C	0	0	0	0	0	0	
78A	B32-V30	34.522	0					
	B32-V32	12.981	6.35	6.35	12.981	0	12.981	
83D	IA-SV-5251	0	0					
209	RXS-SV-4186	0	0				0	
A/B	RXS-SV-4187	0	0		0	0	0	

		TYPE C ANALYSIS			MINIMUM PATH ANALYSIS			
Pen	Valves	As Found	As Left	As Left Pen Leakage	As Found	As Left	Savings	NOTES
209	RXS-SV-4188	0	0					
A/D	RXS-SV-4189	0	0		0	0	0	
211A	E11-F027A							
	E11-F028A	0	0	0	0	0	0	Tested in parallel
211B	E11-F027B							
	E11-F028B	1.320	1.320	1.320	.660	.660	0	Tested in parallel
216	E51-F062							
	E51-F066	1.493	1.493	1.493	.747	.747	0	Tested in parallel
218	E41-F075							
	E41-F079	0	0	0	0	0	0	Tested in parallel
	CAC-V22	1.121	1.121					
220	CAC-V172	.411	.411					
	CAC-V7							
	CAC-V8	1.02	1.02	2.552	.921	.921	0	Tested in parallel

NOTES

General

1. All values are given in scfh.

2. The MPL assignment to penetrations that have valves tested in parallel is 1/2 the Type C value unless otherwise noted.

3. Leakage from Main Steam Isolation Valves (MSIV) is considered a separate source term from containment leakage in the accident analyses. Technical specification acceptance criteria for MSIV's is 11.5 scfh per valve. These valves are not included in the as found analysis.

NOTES

Specific

a. Tubing and pressure gauge from test connection on electrical penetration 101A damaged. Connection plugged for performance of ILRT.

b. Visual inspection of seals indicated damage to outer seal but no damage observed to inner seal. Further visual inspection and testing of seals indicated integrity of inner seal was maintained.

c. As found leakage could not be quantified. Therefore, leakage is assumed to be greater than L_a and the as found ILRT leakage would be greater than L_a.

d. Maintenance performed on CAC-V16 only.