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United States Nuclear Regulatory Commission
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H. B. ROBINSON STEAM ELECTRIC PLANT, UNIT NO. 2
DOCKET NO. 50-261
LICENSE NO. DPR-23
REACTOR CONTAINMENT BUILDING INTEGRATED LEAK RATE TEST

Dear Sir:

Carolina Power and Light Company is herewith transmitting to NRC the final report of 1987 Containment Integrated Leak Rate Test pursuant to 10CFR50 Appendix J, V.B.1. Please note that the H. B. Robinson containment building successfully passed the Integrated Leak Rate Test.

If you have any questions, please contact my staff.

Very truly yours,

R. E. Morgan
General Manager
H. B. Robinson S. E. Plant

DAS:ac

Enclosure

cc: J. N. Grace
H. E. P. Krug
T. E. Murley

H. B. ROBINSON STEAM ELECTRIC PLANT
UNIT NO. 2

REACTOR CONTAINMENT BUILDING
INTEGRATED LEAK RATE TEST

APRIL 1987

CAROLINA POWER & LIGHT COMPANY

Prepared by: John Blessing

Reviewed by: Robert E. Shirk
ILRT Engineer

Approved by: S. D. Palmer

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APPENDICES

1.0 SYNOPSIS

The H. B. Robinson Steam Electric Plant Unit No. 2 reactor containment building was subjected to a periodic integrated leak rate test during the period of April 6, 1987 to April 8, 1987. The purpose of this test was to demonstrate the acceptability of the building leakage rate at an internal pressure of 21.0 psig (P_t). Testing was performed in accordance with the requirements of 10CFR50 Appendix J, ANSI N45.4-1972, and H. B. Robinson Steam Electric Plant Unit No. 2 Technical Specifications. In addition, the recommendations of ANS 56.8-1981 were considered where appropriate to reduced pressure testing.

The measured leakage rate based on the Mass Point Method of analysis was found to be 0.039 by weight per day at 21.0 psig. The leakage rate at the upper bound of the 95% confidence interval was 0.041% by weight per day which is well below the allowable leakage rate of 0.053% by weight per day at 21.0 psig.

The measured leakage rate based on the Total Time Method of analysis was found to be 0.029% by weight per day at 21.0 psig. The leakage rate at the upper bound of the 95% confidence interval was 0.036% by weight per day which is also well below the allowable leakage rate of 0.053% by weight per day at 21.0 psig.

The integrated leakage rate test was performed at the beginning of the refueling outage prior to the performance of any Type B or C tests. Therefore, the results indicated above are both the 'as found' and 'as left' containment integrated leakage rate.

The supplemental instrumentation verification at P_t demonstrated an agreement between measured reactor containment building integrated leakage rates of 15.6% of L_t by the Mass Point Method which is within the 25% requirement of 10CFR50 Appendix J, Section III A.3.b. The agreement using the Total Time Method slightly exceeded the 25% requirement, refer to Section 8.2 for a more detailed discussion.

All testing was performed by Carolina Power & Light Company with the technical assistance of United Energy Services Corporation. Procedural and calculational methods were witnessed by Nuclear Regulatory Commission personnel and audited by the Carolina Power & Light Company site Quality Control staff.

2.0 INTRODUCTION

The objective of the periodic integrated leak rate test was the verification of the overall leak tightness of the reactor containment building at 21.0 psig, one half the calculated design basis accident pressure. 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 H. B. Robinson Steam Electric Plant Unit No. 2, the maximum allowable integrated leak rate at one half the design basis accident pressure of 21.0 psig (P_t) is 0.0707% by weight per day (L_t).

Testing was performed in accordance with the procedural requirements as stated in H. B. Robinson Steam Electric Plant Integrated Leak Rate Test Procedure EST-085. This procedure was approved by the H. B. Robinson Plant staff prior to the commencement of the test.

Leakage rate testing was accomplished at the pressure level of 21.0 psig for a period of 24.0 hours. The 24.0 hour period was followed by an 11 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.	50-261
Location:	Six miles northwest of Hartsville, South Carolina
Containment Description:	Steel lined, partially insulated reinforced concrete right vertical cylinder with a flat base and a hemispherical dome. The containment wall is prestressed using vertical tendons from the ring girder to the base. The base mat is founded on earth driven piles.
Date Test Completed:	April 8, 1987

3.2 TECHNICAL DATA

Containment Net Free Volume:	1.95×10^6 cubic feet
Design Pressure:	42 psig
Design Temperature:	$263^{\circ}F$
Calculated Accident Peak Pressure:	42 psig
Calculated Accident Peak Temperature:	$263^{\circ}F$

3.3 TEST DATA

Test Method:	Absolute Method
Data Analysis:	Mass Point and Total Time
Test Pressure:	36.5 psia
Max Allowable Leakage Rate (L_t):	0.0707 wt % per day

3.3 TEST DATA (Cont'd)

Measured Leakage Rate:

Mass Point	0.039 wt % per day
Total Time	0.029 wt % per day

Measured Leakage Rate at UCL:

Mass Point	0.041 wt % per day
Total Time	0.036 wt % per day

Supplemental Test Flow Rate: 0.0722 wt % per day

Supplemental Test Measured Leak Rate:

Mass Point	0.100 wt % per day
Total Time	0.122 wt % per day

Supplemental Test and L_{tm} Agreement:

Mass Point	15.6%
* Total Time	29.7%

* Refer to Section 8.2 for a detailed discussion.

4.0 ACCEPTANCE CRITERIA

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

1. The measured leakage rate (L_{tm}) at one half the calculated design basis accident pressure of 21.0 psig (P_t) shall be less than 75% of the maximum allowable leakage rate (L_t) specified as 0.0707% by weight of the building atmosphere per day. The 1974 Integrated leak Rate Test established the L_t/L_{am} ratio was greater than 0.7 and therefore the acceptance criteria is determined as follows:

$$L_t = L_a \left(\frac{P_t}{P_a}\right)^{1/2}$$

Where:

L_a = 0.10%

P_a = 42.0 psig

P_t = 21.0 psig

Substituting the values for L_a, P_a, and P_t,

L_t = 0.0707% per day

and .75 L_t = 0.053% per 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_t.

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

1. Resistance Temperature Detectors (Sensors):

Quantity	24
Manufacturer	Rosemount
Type	Model 78
Range, ^{o}C	-200 to 660
Range, ^{o}F (calibrated)	0 to 400
Accuracy, ^{o}F (interchangeability)	$\pm$0.1
Sensitivity, ^{o}F	$\pm$0.1

2. Digital Temperature Scanner/Printer:

Quantity	1
Manufacturer	Fluke
Type	Model 2285B
Range, ^{o}F	0 to 200 (calibrated from 60^{o}F to 100^{o}F)
Accuracy, ^{o}F	$\pm$0.2
Repeatability, ^{o}F	$\pm$0.1

5.1.2 Dewpoint Indicating System

1. Dewcell Elements:

Quantity	5
Manufacturer	Foxboro
Type	Model 2781
Range, ^{o}F	-50 to 140
Accuracy, ^{o}F	$\pm$2.0
Sensitivity, ^{o}F	$\pm$0.5

2. Digital Temperature Scanner/Printer:

Quantity	1
Manufacturer	Fluke
Type	Model 2285B
Range, ^{o}F	0 to 200 (calibrated from 120^{o}F to 160^{o}F)
Accuracy, ^{o}F	$\pm$0.2
Repeatability, ^{o}F	$\pm$0.1

5.1.3 Pressure Monitoring System

Precision Pressure Gauges:

Quantity	2
Manufacturer	Texas Instruments
Type	Model 145 (with direct readout)
Range, psia	0 - 75
Accuracy, psia	0.015%
Sensor sensitivity, psia	0.0013% of full scale
Repeatability, psia	±0.001% of full scale

5.1.4 Supplemental Test Flow Monitoring System

Flowmeter:

Quantity	1
Manufacturer	Wallace & Tiernan
Type	Model 5210601108
Range, scfm at 1 psig and 80°F	0 to 6
Accuracy, scfm	±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 six locations to permit monitoring of the reactor containment partial pressure of water vapor.

5.3 CALIBRATION CHECKS

Temperature, dewpoint, pressure, and flow measuring systems were checked for calibration before the test in accordance with H. B. Robinson Steam Electric Plant Unit No. 2 ILRT Instrumentation Pre-Test Calibration Procedure EST-095, as recommended by ANSI N45.4-1972, Section 6.2 and 6.3. The results of the calibration checks are on file at H. B. Robinson Steam Electric Plant Unit No. 2. The supplemental test at 21.0 psig confirmed the instrumentation acceptability.

5.4 INSTRUMENTATION PERFORMANCE

During the integrated leak rate test, one dewcell exhibited erratic behavior and had to be rejected. The volume weighting fraction assigned to the defective dewcell was then assigned to the other dewcell on the same elevation and all data points were recalculated. The remaining five dewcells, 24 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.

5.5 VOLUME WEIGHTING FACTORS

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

Elevation/ Coordinate	Temperature Element	Weighting Factor
240'/W	TE-101	.01509
240'/S	TE-106	.01509
240'/N	TE-111	.01509
240'/E	TE-117	.01509
253'/NW	DPTE-6	.19482
263'/S	TE-108	.01909
263'/E	TE-115	.01909
263'/N	TE-122	.01909
252'/Pump Bay	TE-102	.01987
252'/Pump Bay	TE-113	.01986
252'/Pump Bay	TE-121	.01986
252'/S	TE-116	.00879
252'/N	TE-119	.00879
304'/W	DPTE-3	.25511
e04'/E	DPTE-4	.22511
314'/W	TE-103	.06463
314'/S	TE-104	.06463
314'/N	TE-118	.06463
314'/E	TE-123	.06463
335'/W	TE-109	.06293
335'/S	TE-110	.06293
335'/N	TE-112	.06293
335'/E	TE-114	.06293
364'/SW	DPTE-1	.14738
364'/NE	DPTE-2	.14748
375'/W	TE-105	.09832
375'/S	TE-107	.09832
375'/N	TE-120	.09832
375'/E	TE-124	.09832

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."

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_t = 0.0707%/day

P = 36.45 psia

T = $74^{\circ}F = 533.69^{\circ}R$ drybulb

T_{dp} = $42.5^{\circ}F$

t = 24.0 hours

2. Total Absolute Pressure: e_p

No. of sensors = 2

Range = 0 - 75 psia

Sensor sensitivity error (E) = $\pm$0.0013% of full scale

Measurement system error (ε) = $\pm$0.001% of full scale

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

$$e_p = \pm \left[(0.000975)^2 + (0.00075)^2 \right]^{1/2} / [2]^{1/2}$$

$$e_p = \pm 0.00087 \text{ psia}$$

3. Water Vapor Pressure: e_{pv}

No. of sensors = 5

Sensor sensitivity error (E) = $\pm 0.5^{\circ}F$

Measurement system error (ε), excluding sensor = $\pm .1^{\circ}F$

At a dewpoint temperature of $42.5^{\circ}F$, the equivalent water vapor pressure change (as determined from steam tables) is 0.00052 psia/$^{\circ}F$

$$E_{pv} = \pm 0.5^{\circ}F \ (0.0052 \text{ psia}/^{\circ}F)$$

$$E_{pv} = \pm 0.0026 \text{ psia}$$

$$\varepsilon_{pv} = \pm 0.1^{\circ}F \ (0.0052 \text{ psia}/^{\circ}F)$$

$$\varepsilon_{pv} = \pm 0.00052 \text{psia}$$

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

$$e_{pv} = \pm \left[(0.0026)^2 + (0.00052)^2 \right]^{1/2} / [5]^{1/2}$$

$$e_{pv} = \pm 0.0012 \text{ psia}$$

4. Temperature: e_T

No. of sensors = 24

Sensor sensitivity error (E) $= \pm 0.1^{\circ}F = \pm 0.1^{\circ}R$

Measurement system error (ε), excluding sensor $= \pm 0.1^{\circ}F = \pm 0.1^{\circ}R$

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

$$e_T = \pm \left[(0.1)^2 + (0.1)^2 \right]^{1/2} / [24]^{1/2}$$

$$e_T = \pm 0.0288^{\circ}R$$

5. Instrument Selection Guide (ISG):

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

$$ISG = \pm \frac{2400}{24} \left[2\left(\frac{0.00087}{36.45}\right)^2 + 2\left(\frac{0.0012}{36.45}\right)^2 + 2\left(\frac{0.0288}{533.69}\right)^2 \right]^{1/2}$$

$$ISG = \pm 100 \left[1.139 \times 10^{-9} + 2.168 \times 10^{-9} + 5.824 \times 10^{-9} \right]^{1/2}$$

$$ISG = \pm 0.010\%/\text{day}$$

The ISG formula does not exceed 0.25 L_t (0.0177%/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 24.0 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.

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 24.0 hour test (L_{tm}) 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_t).

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. Equipment within the reactor containment building, subject to damage, was protected from external differential pressures.

4. Portions of fluid systems which, under post-accident conditions become extensions of the containment boundary, were drained and vented.

5. The penetration pressurization and fluid block systems were depressurized and vented for the test.

6. Pressure gauges were installed on the following systems to provide a means of detection for leakage into these systems:

   a. Purge supply

   b. Purge exhaust

   c. Personnel access lock doors

   d. Equipment access hatch

7. Potential pressure sources were removed or isolated from the containment.

8. A general inspection of the accessible interior and exterior areas 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 2.5 psi per hour. Building pressure and temperature were monitored half hourly. Leak rate testing was initiated at the 21.0 psig pressure level. For the duration of the 24.0 hour leak test and the 11.0 hour supplemental test, the average internal containment temperature remained within a band of $\pm 0.3^{\circ}F$.

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

1. Readings indicated by the two precision pressure gauges were recorded and entered into the computer. The computer then calculated the average pressure in psia.

2. Readings indicated by the 24 RTDs were recorded and entered into the computer. The computer program calculated the 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 five dewcells were recorded and entered into the computer. The computer program 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. All original data is on file at H. B. Robinson Steam Electric Plant Unit No. 2.

Data was entered into an IBM AT Portable Computer located at the leak rate panel. The ILRT computer program utilized for the test had been previously checked with sample data of known results and certified prior to the test at H. B. Robinson Unit No. 2. 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 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.

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

Immediately following the 24.0 hour leak test, a superimposed leakage rate was established for an additional 11 hour period. During this time, temperature, pressure, and vapor pressure were monitored as described above.

6.3 TEST PROCEDURE

6.3.1 Pressurization and Stabilization Phase

Pressurization of the reactor containment building was started on April 6 at 0100. The pressurization rate was approximately 2.5 psi per hour. During pressurization at approximately 0430, instrument air valve PCV-1716 was found to be in the incorrect position (open instead of closed). The valve was aligned to its correct closed position. When containment internal pressure reached 21.0 psig at approximately 1125 on April 6, pressurization was secured.

The temperature stabilization criteria was met after the required four hour hold period and at 1600, leakage rate data recording, reduction, and analysis began.

6.3.2 Integrated Leak Rate Testing Phase

Based on the results of the first hour of data recording, it was decided to commence the test starting at 1700 on April 6.

At approximately 2100, valve WD-1966 (sample line vent) was found to be open. This valve is required to be closed per the procedure valve lineup and was subsequently closed. Due to the valve misalignment, a high initial leakage rate ($\sim$.1%/day) over the first four hours of the test was obtained. This had negligible affect on the overall test result and a successful ILRT was concluded at 1700 on April 7.

6.3.3 Supplemental Leakage Rate Test Phase

Following completion of the 24.0 hour integrated leak rate test, a leakage rate of 2.39 scfm was imposed on the containment building through a calibrated flow meter at 1715 on April 7, 1987. Leakage rate data was again collected at 15 minute intervals for a period of 11 hours. The superimposed test was extended from 4 hour to 11 hours because agreement using the total time analysis was not being met. Agreement was obtained using the Mass Point analysis after 4 hours. After 11 hours, it was decided to terminate the superimposed test at 0415 on April 8, 1987. Refer to Section 8.2 for a more detailed discussion.

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 reactor containment building revealed no unusual findings.

6.3.5 Local Testing

Additional leakage rates must be applied to the measured leakage rate at the upper 95% confidence level to account for penetration paths not properly vented during the performance of the integrated leakage rate test. The lines used for the precision pressure gauges and flow verification instruments were tested using local leakage rate methods. The leakage from the instrument lines was measured to be 0 sccm.

7.0 METHODS OF ANALYSIS

The Absolute Method of leakage rate determination was employed during testing at the 21.0 psig pressure level. The United Energy Services Corporation ILRT computer code calculates the percent per day leakage rate (measured and upper confidence level) using both the Mass Point and and Total Time data analysis techniques.

7.1. 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:

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

Where:

W = Mass of air inside containment, lbm

$K = 144\ V/R = 5.26336 \times 10^{6}\ \frac{\text{lbm} - {}^{\circ}\text{R} - \text{in.}^2}{\text{lbf}}$

P = Partial pressure of air, psia

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

$V = 1.95 \times 10^{6}\ \text{ft}^3$

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

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 five dewpoint temperatures and converting to partial pressure of water vapor, psia

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

T = Sum of the products of each RTD x assigned weighting factor + 459.69°R

The weight of air is plotted versus time for the 24.0 hour test and for the 11 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 = At + 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:

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

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

Where:

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

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

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

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

7.2 TOTAL TIME ANALYSIS

The total time method utilizes the following equation to determine the leakage rate of the reactor containment building:

$$L = \frac{2400}{t}\left[1 - \frac{T_1 P_2}{T_2 P_1}\right]$$

Where:

L = Measured leak rate in weight percent per day

t = Time interval, in hours, between measurements

T_1, T_2 = Average internal containment temperature, ^{o}R, at the beginning and end of the test interval respectively.

P_1, P_2 = Average containment pressure (corrected for water vapor pressure) at the beginning and end of the test interval respectively.

The mean total time leakage rate is derived from the above individual total time calculations. The equation for the mean leakage rate is in the form:

$$\bar{L} = \frac{\Sigma_i L_i}{n}$$

Where:

L_i = Individual total time leakage rates

n = Number of total time leakage rates

The individual leakage rates are then plotted against time for the duration of the 24 hour test. The ILRT computer code fits the locus of these points to a straight line using a linear least squares fit. The equation is of the form $L = L_o + L_1 t$ where L_1 is the slope in percent per hour and L_o is the initial leakage rate at time zero. The least squares parameters are calculated as follows:

$$L_o = \frac{\Sigma t_i^2 \, \Sigma L_i - \Sigma t_i \, \Sigma L_i}{S_{xx}}$$

$$L_1 = \frac{N \, \Sigma t_i \, \Sigma L_i - \Sigma t_i \, \Sigma L_i}{S_{xx}}$$

Where:

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

7.3 MASS POINT UPPER CONFIDENCE

The upper 95% confidence limit for the Mass Point leakage rate is calculated as follows:

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

Where:

C_L = Upper 95% 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:

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

Where:

S = Common standard deviation of the weighted from 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% confidence leakage rate as follows:

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

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

7.4 TOTAL TIME UPPER CONFIDENCE

The 95% confidence limit for the total time leakage rate is calculated as follows:

$$C_L = t_{95}\ Se \left[\frac{1}{n} + \frac{(t - \bar{t})^2}{\Sigma (t_i - t)^2}\right]^{1/2}$$

Where:

t = Total time interval

$\bar{t} = \frac{\Sigma t_i}{n}$

t_i = Time interval for each data point

n = Number of individual total time leakage rates

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

Se = Common standard deviation of the leakage rates from the least squares fit line

The common standard deviation (Se) is defined by:

$$Se = \left[\frac{\Sigma (L_i - L)^2}{n-2}\right]^{1/2}$$

Where:

L_i = Observed total time leakage rate

L = Least squares calculated total time leakage rate

8.0 DISCUSSION OF RESULTS

8.1 RESULTS AT P_t

8.1.1 Mass Point Method of Analysis

Data obtained during the leak rate test at P_t indicated the following changes (highest to lowest) during the 24.0 hour test.

Variable	Maximum Change
P_T	0.033 psia
P_{wv}	0.0225 psia
T	0.563^{o}F

The method used in calculating the Mass Point leakage rate is described in Section 7.1. The results of this calculation is a Mass Point leakage rate of 0.039%/day (see Appendix D).

The 95% confidence limit associated with this leakage rate is 0.003% per day. Thus, the leakage rate at the upper bound of the 95% confidence level becomes:

$$UCL = 0.039 + 0.002$$

$$UCL = 0.041\%/day$$

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

System	Type C Leakage (sccm)
ILRT Superimposed FLow	0
ILRT Pressure Sensing	0

During the test, no makeup water was introduced into the reactor coolant system and no level change in the containment sump occurred during the 24.0 hour tests.

The measured leakage rate and the measured leakage rate at the upper bound of the 95% confidence level are well below the acceptance criteria of 0.053%/day (0.75 L_t).

8.1.2 Total Time Method of Analysis

The method used in calculating the total time leakage rates is defined in Section 7.2. The results of these calculations are as follows:

1. The measured total time leakage rate for the 24.0 hour test was 0.029% by weight per day.

2. The 95% confidence limit associated with this leakage rate is 0.007% per day. Thus, the leakage rate at the upper bound of the 95% confidence level becomes:

$$UCL = 0.029 + 0.007$$
$$UCL = 0.036\%/day$$

The total time measured leakage rate and the measured leakage rate at the upper bound of the 95% confidence level are below the acceptance criteria of 0.053%/day.

Therefore, the reactor containment building leakage rate, based on both the Mass Point method and Total Time method of analysis, at the reduced test pressure (P_t) of 21.0 psig is acceptable.

8.2 SUPPLEMENTAL TEST RESULTS

After conclusion of the 24.0 hour test at 21.0 psig (P_t), the flowmeter was placed in service and a flow rate of 2.39 scfm was established. This flow rate is equivalent to a leakage rate of 0.0722% 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 0.100% per day using the Mass Point method of analysis and 0.122% per day using the Total Time method.

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

Mass Point	Total Time
$L_v' = L_c - L_o$	$L_v' = L_c - L_o$
$L_v' = 0.100 - 0.072$	$L_v' = 0.122 - 0.072$
$L_v' = 0.028\%/day$	$L_v' = 0.050\%/day$

Comparing this leakage rate with the building leakage rate measured during the 24.0 hour test yields the following:

$$\text{Mass Point} = \left|\frac{L_{tm} - L_v'}{L_t}\right| = \left|\frac{0.039 - 0.028}{0.0707}\right| = 0.156$$

$$\text{Total Time} = \left|\frac{L_{tm} - L_v'}{L_t}\right| = \left|\frac{0.029 - 0.050}{0.0707}\right| = 0.297$$

The building leakage rates agree within 15.6% of L_t using the Mass Point method which is below the acceptance criteria of 25%.

The building leakage rates agree within 29.7% using the Total Time method which is slightly above the acceptance criteria of 25%. This occurred because the start of the superimposed test coincided with a slight upswing in mass weights which may have been due to the initiation of flow through the rotameter, the cyclic nature of the dewpoint measuring system (lithium chloride sensors) or normally occurring fluctuations in the instrumentation. Since the Total Time method calculates a series of leakage rates based upon air mass differences between an initial data point and each individual data point thereafter, this method is extremely sensitive to the accuracy of the initial data point. As a result, the initial observed total time leakage rates (two point leakage rates) were negative and this caused a distortion in the total time least squares fit leakage rate.

If the initial fluctuations are eliminated and the superimposed test started at 1830 on April 7, 1987, the result is a least squares fit total time composite leakage rate of 0.097%/day based on 9 hours and 45 minutes of data. This would be consistent with the mass point least squares fit composite leakage rate of 0.100%/day and result in an agreement of 5.7%. Further evidence supporting this arguement is that the observed total time composite leakage rates (two point leakage rates) stabilized at approximately 0.095%/day over the last four hours of the superimposed test and that the mean total time composite leakage rate over the last five hours (21 data points) was 0.092%/day.

In 1976, an article (reference: 'Containment Leak Rate Testing: Why the Mass-Plot Analysis Method is Preferred,' Power Engineering, February 1976) compared the results of test analyses that were performed using Point-to-Point, Total Time, and Mass-Plot techniques. Subsequently, the Mass-Plot method received NRC staff endorsement and became the staff-recommended method to use. A revision of the Standard (reference: ANSI/ ANSI 56.8-1981, 'Containment System Leakage Testing') specifies the use of Mass-Plot, to the exclusion of the two older methods. The draft revision to Appendix J incorporates the new Standard.

Mass-Plot (also known as Mass Point) is a newer and more accurate method of calculating containment leakage. The Total Time method is extremely sensitive to the accuracy of that initial data point. If, due to any reason (such as instrument error, lack of temperature equilibrium, ingassing or outgassing), the initial data point is not accurate, the results of the test will be affected. Even if the data point is accurate, during the early stages of the test the leakage varies with time; as a result, the initial value and, therefore, the calculated leak rate become time dependent. In the Mass-Plot method, the mass of air in containment is calculated and plotted as a function of time. The slope of the linear least squares fit to the data is the leakage.

Carolina Power and Light Company requested and was granted a waiver to use Mass Plot as the controlling calculational method for the 1987 ILRT.

The ILRT was well within acceptance criteria using either the Total Time or Mass-Plot method. However, during the supplemental accuracy test, initial data fluctuations (as discussed above) caused a data skew in the Total Time method, which caused the test results to fall slightly outside the acceptance criteria by a very small 0.004%/day. Eliminating this erratic initial data would make the Total Time test results very consistent with the technically preferred, more accurate Mass-Plot method, thereby falling well within acceptance criteria.

9.0 TYPE B AND C LEAKAGE RATE HISTORIES SINCE 1984 ILRT REPORT

9.1 DISCUSSION OF TYPE B TESTS

Leakage from containment penetrations and some isolation valves is constantly monitored by the penetration pressurization system. The total leakage from this system is maintained below .3 L_a during normal plant operation. The containment personnel hatch has been tested with dates and results listed below:

Date	Leakage
4-30-85	0 scfm
10-28-85	0 scfm
4-29-86	0.05 scfm
11-3-86	0.44 scfm
3-16-87	0.28 scfm

9.2 DISCUSSION OF TYPE C TESTS

The isolation valve seal water system precludes Type C testing on containment isolation valves it services. The measured leakage from this system was observed to be 20.5 cc/min. water leakage.

The seven lines which are Type C tested had a combined leakage rate of 1122 sccm. This value is equivalent to 0.0396 scfm which is well below the acceptance limit (.3 L_a) of 1.57 scfm.

10.0 REFERENCES

1. Surveillance Test EST-085 Containment Integrated Leak Rate Test.

2. H. B. Robinson Steam Electric Plant Unit No. 2 Updated 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.

APPENDICES

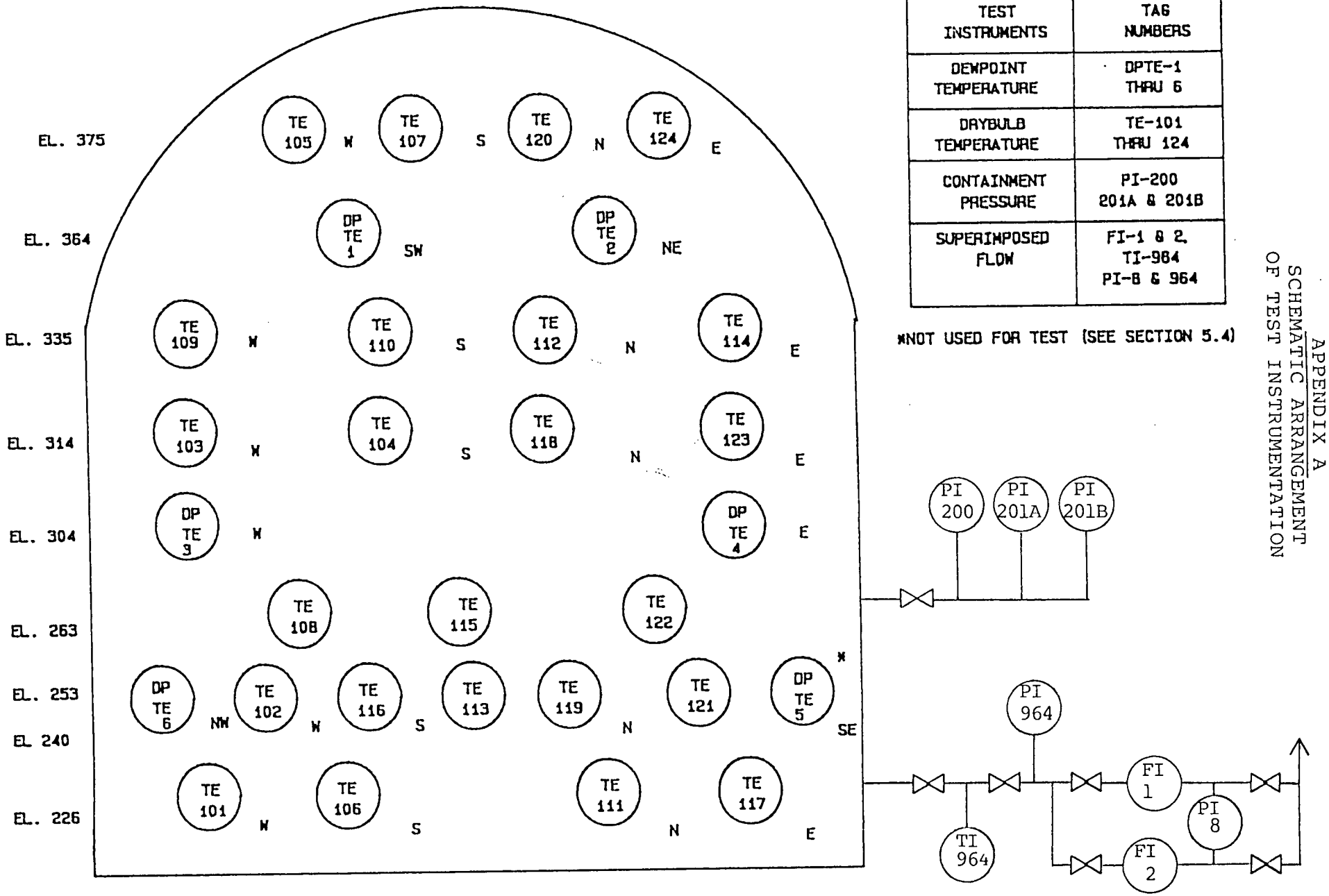
APPENDIX A

SCHEMATIC ARRANGEMENT OF TEST INSTRUMENTATION

APPENDIX A
SCHEMATIC ARRANGEMENT OF TEST INSTRUMENTATION

TEST INSTRUMENTS	TAG NUMBERS
DEWPOINT TEMPERATURE	DPTE-1 THRU 6
DRYBULB TEMPERATURE	TE-101 THRU 124
CONTAINMENT PRESSURE	PI-200 201A & 201B
SUPERIMPOSED FLOW	FI-1 & 2, TI-964 PI-8 & 964

*NOT USED FOR TEST (SEE SECTION 5.4)



APPENDIX B

REDUCED TEST DATA

REDUCED ILRT TEST DATA

DATE	TIME	PAVG	PWV	TAVG	MASS WEIGHT
4- 6-87	1700	36.487	0.1335	74.036	358497.25
	1715	36.484	0.1337	74.005	358490.50
	1730	36.480	0.1339	73.958	358480.75
	1745	36.478	0.1339	73.929	358480.53
	1800	36.477	0.1346	73.894	358482.72
	1815	36.474	0.1344	73.871	358469.81
	1830	36.472	0.1348	73.846	358463.66
	1845	36.470	0.1345	73.805	358474.19
	1900	36.468	0.1348	73.778	358469.41
	1915	36.467	0.1353	73.766	358462.44
	1930	36.465	0.1358	73.753	358447.31
	1945	36.464	0.1357	73.728	358454.91
	2000	36.462	0.1359	73.715	358446.63
	2015	36.461	0.1362	73.701	358438.88
	2030	36.459	0.1361	73.691	358431.09
	2045	36.458	0.1366	73.682	358417.50
	2100	36.458	0.1375	73.665	358420.41
	2115	36.458	0.1371	73.650	358434.00
	2130	36.457	0.1371	73.657	358425.06
	2145	36.457	0.1376	73.644	358428.56
	2200	36.457	0.1380	73.641	358421.06
	2215	36.456	0.1383	73.636	358416.75
	2230	36.456	0.1385	73.621	358424.75
	2245	36.456	0.1386	73.630	358418.16
	2300	36.456	0.1391	73.615	358418.00
	2315	36.456	0.1385	73.621	358425.75
	2330	36.456	0.1393	73.607	358426.06
	2345	36.457	0.1388	73.629	358421.88
4- 7-87	0	36.456	0.1406	73.614	358409.56
	15	36.456	0.1401	73.616	358413.00
	30	36.456	0.1405	73.624	358403.38
	45	36.456	0.1406	73.604	358411.16
	100	36.456	0.1407	73.603	358415.34
	115	36.457	0.1413	73.614	358407.38
	130	36.457	0.1415	73.628	358396.09
	145	36.457	0.1427	73.616	358396.72
	200	36.458	0.1424	73.626	358398.09
	215	36.458	0.1421	73.640	358391.84
	230	36.459	0.1420	73.636	358405.91
	245	36.459	0.1429	73.636	358396.69
	300	36.459	0.1427	73.639	358400.69
	315	36.459	0.1431	73.632	358401.97
	330	36.459	0.1441	73.633	358390.78
	345	36.459	0.1436	73.644	358388.97
	400	36.460	0.1441	73.648	358391.44

REDUCED ILRT TEST DATA

DATE	TIME	PAVG	PWV	TAVG	MASS WEIGHT
4- 7-87	415	36.461	0.1446	73.654	358387.41
	430	36.461	0.1449	73.653	358384.41
	445	36.461	0.1446	73.653	358388.66
	500	36.461	0.1455	73.640	358387.56
	515	36.461	0.1456	73.656	358376.81
	530	36.461	0.1451	73.646	358387.50
	545	36.461	0.1466	73.659	358364.44
	600	36.461	0.1458	73.654	358380.06
	615	36.461	0.1461	73.653	358377.91
	630	36.462	0.1466	73.651	358379.09
	645	36.461	0.1468	73.651	358372.81
	700	36.461	0.1464	73.650	358371.25
	715	36.462	0.1472	73.671	358364.81
	730	36.462	0.1473	73.653	358371.00
	745	36.462	0.1476	73.639	358377.81
	800	36.462	0.1470	73.639	358383.25
	815	36.462	0.1480	73.648	358367.63
	830	36.462	0.1476	73.651	358370.19
	845	36.462	0.1485	73.637	358369.69
	900	36.461	0.1485	73.634	358367.25
	915	36.461	0.1491	73.638	358358.88
	930	36.461	0.1486	73.626	358371.94
	945	36.461	0.1497	73.626	358355.50
	1000	36.461	0.1493	73.613	358368.06
	1015	36.460	0.1498	73.602	358365.81
	1030	36.460	0.1495	73.607	358365.50
	1045	36.460	0.1503	73.596	358359.69
	1100	36.460	0.1509	73.589	358359.41
	1115	36.459	0.1511	73.589	358352.31
	1130	36.459	0.1512	73.585	358353.50
	1145	36.459	0.1513	73.581	358355.03
	1200	36.459	0.1514	73.568	358358.78
	1215	36.459	0.1523	73.564	358351.69
	1230	36.458	0.1530	73.563	358340.31
	1245	36.458	0.1524	73.554	358347.75
	1300	36.458	0.1529	73.547	358347.63
	1315	36.457	0.1525	73.537	358353.13
	1330	36.457	0.1528	73.537	358350.56
	1345	36.457	0.1532	73.530	358351.00
	1400	36.457	0.1537	73.518	358349.56
	1415	36.456	0.1533	73.521	358346.38
	1430	36.455	0.1541	73.504	358340.00
	1445	36.455	0.1549	73.502	358333.53
	1500	36.455	0.1549	73.496	358337.72
	1515	36.455	0.1545	73.487	358347.13

REDUCED ILRT TEST DATA

DATE	TIME	PAVG	PWV	TAVG	MASS WEIGHT
4- 7-87	1530	36.455	0.1558	73.488	358328.47
	1545	36.455	0.1558	73.478	358335.75
	1600	36.455	0.1556	73.489	358330.25
	1615	36.455	0.1560	73.473	358337.41
	1630	36.454	0.1559	73.464	358339.13
	1645	36.454	0.1560	73.473	358331.97
	1700	36.454	0.1560	73.474	358331.06

VERIFICATION TEST DATA

	1715	36.454	0.1575	73.465	358322.72
	1730	36.454	0.1569	73.466	358328.13
	1745	36.454	0.1569	73.463	358329.63
	1800	36.454	0.1573	73.456	358330.31
	1815	36.454	0.1588	73.461	358312.69
	1830	36.454	0.1578	73.464	358320.50
	1845	36.454	0.1579	73.467	358317.34
	1900	36.454	0.1588	73.464	358306.03
	1915	36.454	0.1586	73.468	358305.41
	1930	36.454	0.1591	73.469	358299.44
	1945	36.453	0.1588	73.482	358288.28
	2000	36.454	0.1597	73.470	358292.16
	2015	36.454	0.1602	73.467	358294.97
	2030	36.454	0.1607	73.476	358284.06
	2045	36.455	0.1602	73.486	358287.06
	2100	36.455	0.1601	73.491	358284.31
	2115	36.455	0.1611	73.500	358268.53
	2130	36.455	0.1614	73.503	358264.03
	2145	36.456	0.1609	73.514	358270.97
	2200	36.456	0.1612	73.520	358264.22
	2215	36.456	0.1620	73.521	358260.50
	2230	36.457	0.1619	73.530	358259.88
	2245	36.457	0.1627	73.532	358256.50
	2300	36.457	0.1620	73.551	358250.09
	2315	36.457	0.1624	73.560	358240.25
	2330	36.457	0.1630	73.563	358232.50
	2345	36.459	0.1637	73.565	358238.22
4- 8-87	0	36.459	0.1635	73.578	358232.56
	15	36.459	0.1642	73.585	358220.78
	30	36.459	0.1638	73.591	358225.09
	45	36.460	0.1643	73.598	358221.22
	100	36.460	0.1647	73.608	358210.06

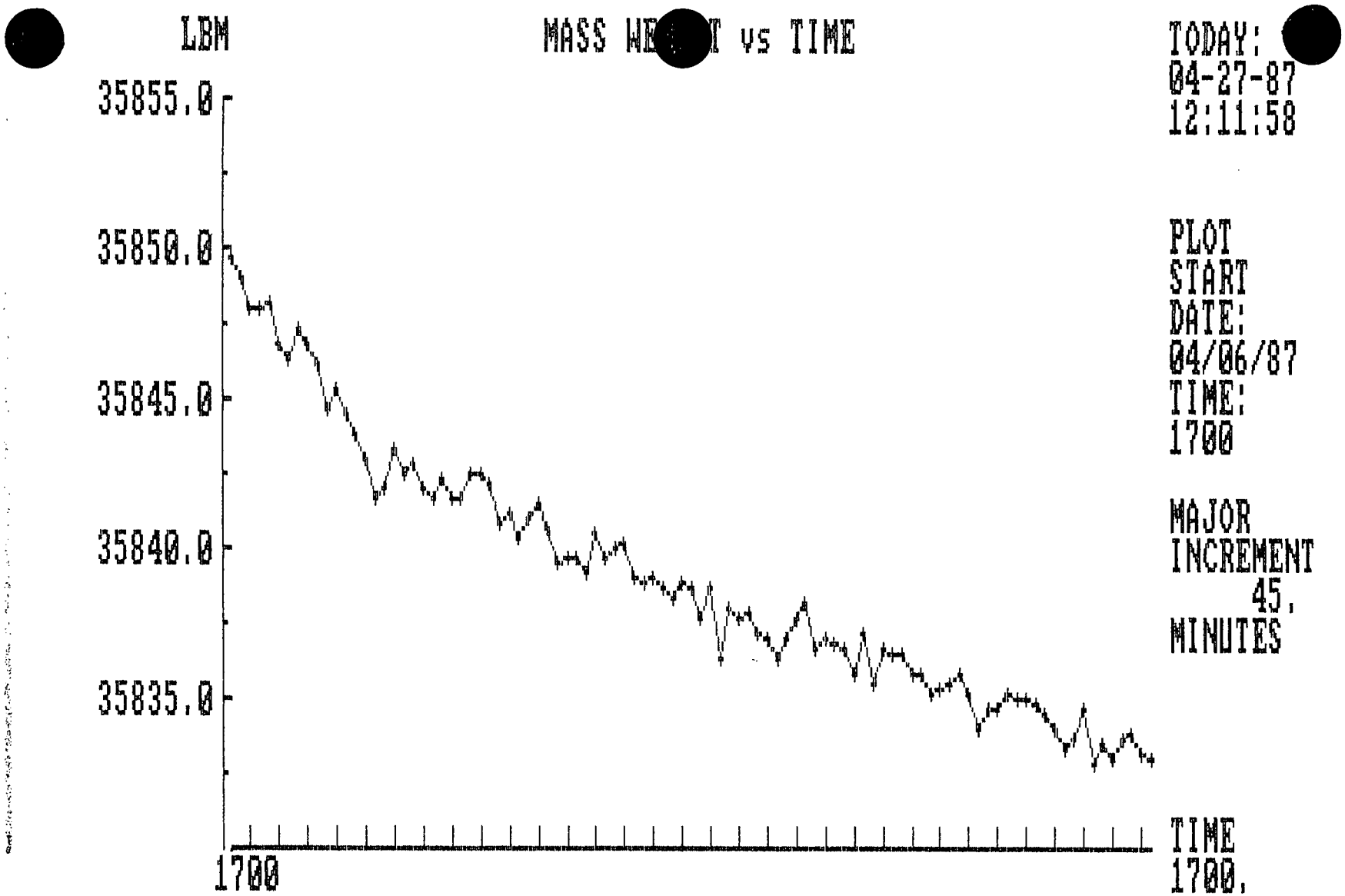
VERIFICATION TEST DATA

DATE	TIME	PAVG	PWV	TAVG	MASS WEIGHT
4- 8-87	115	36.460	0.1649	73.607	358213.38
	130	36.460	0.1653	73.612	358206.22
	145	36.460	0.1656	73.620	358197.91
	200	36.460	0.1648	73.618	358207.22
	215	36.461	0.1659	73.621	358199.59
	230	36.461	0.1657	73.633	358193.28
	245	36.461	0.1656	73.630	358201.28
	300	36.461	0.1662	73.626	358198.19
	315	36.461	0.1672	73.641	358177.47
	330	36.461	0.1670	73.646	358176.38
	345	36.462	0.1671	73.649	358177.97
	400	36.462	0.1673	73.659	358170.38
	415	36.462	0.1677	73.644	358176.56

APPENDIX C

LEAKAGE RATE TEST GRAPHS

24 HOUR ILRT



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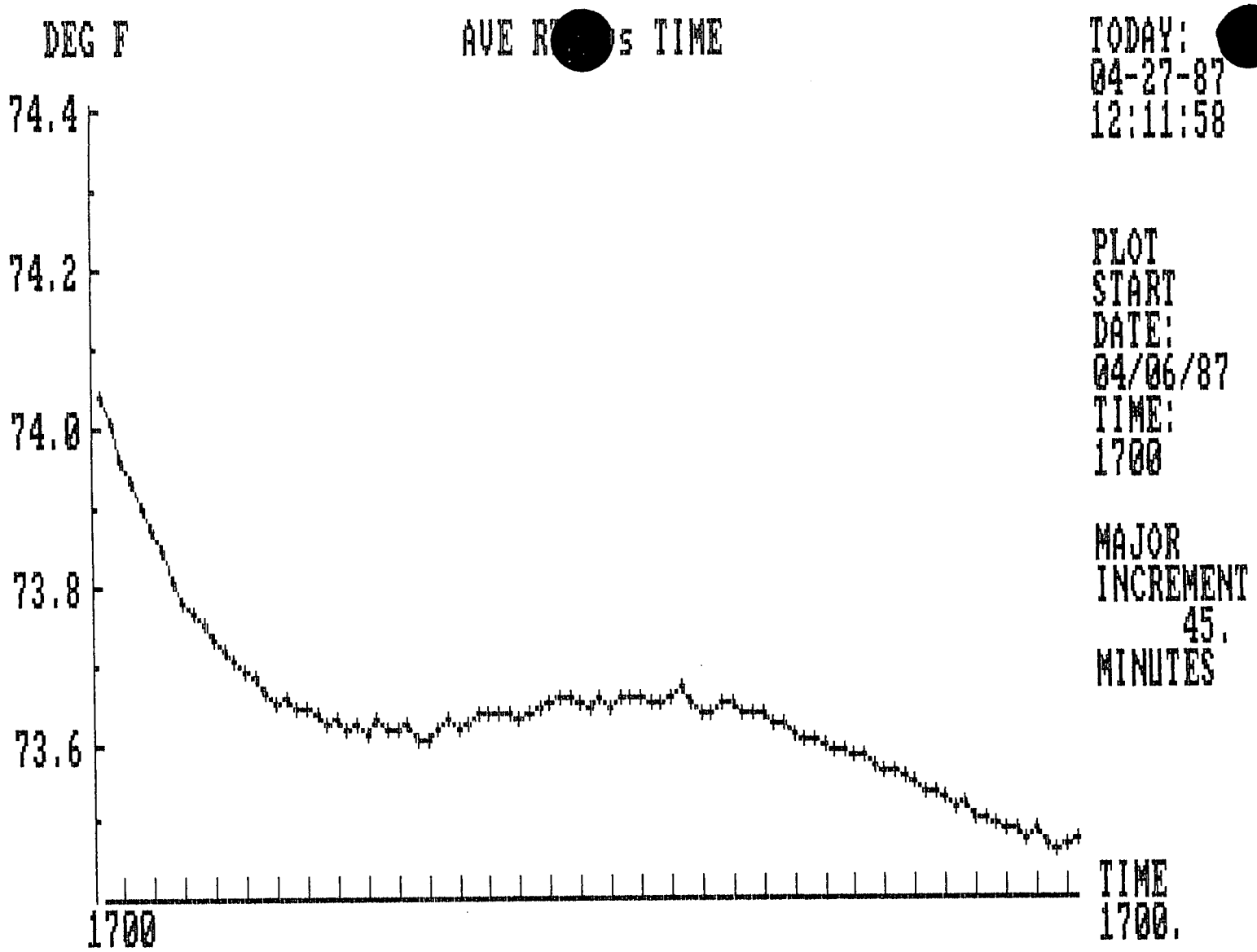

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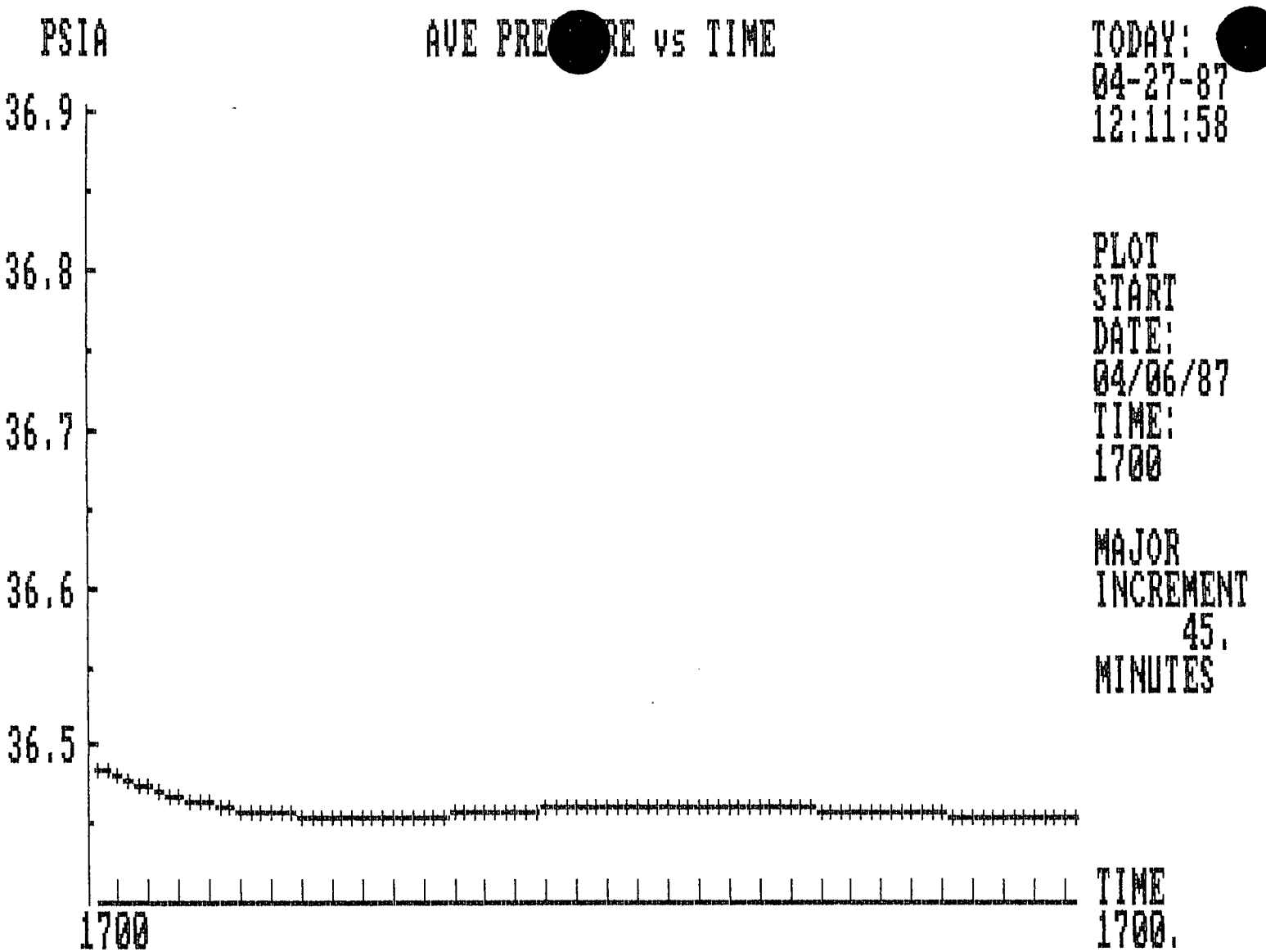

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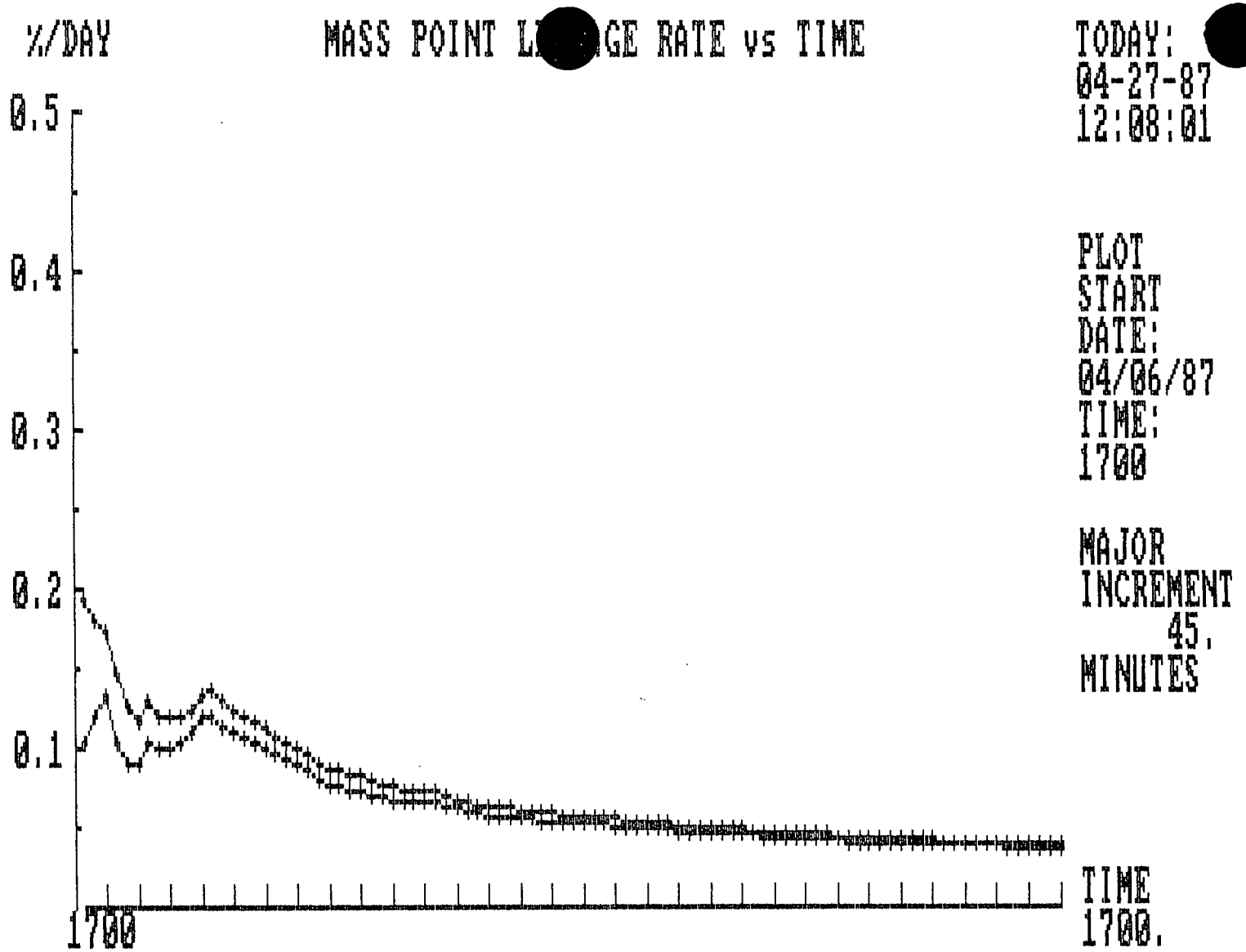

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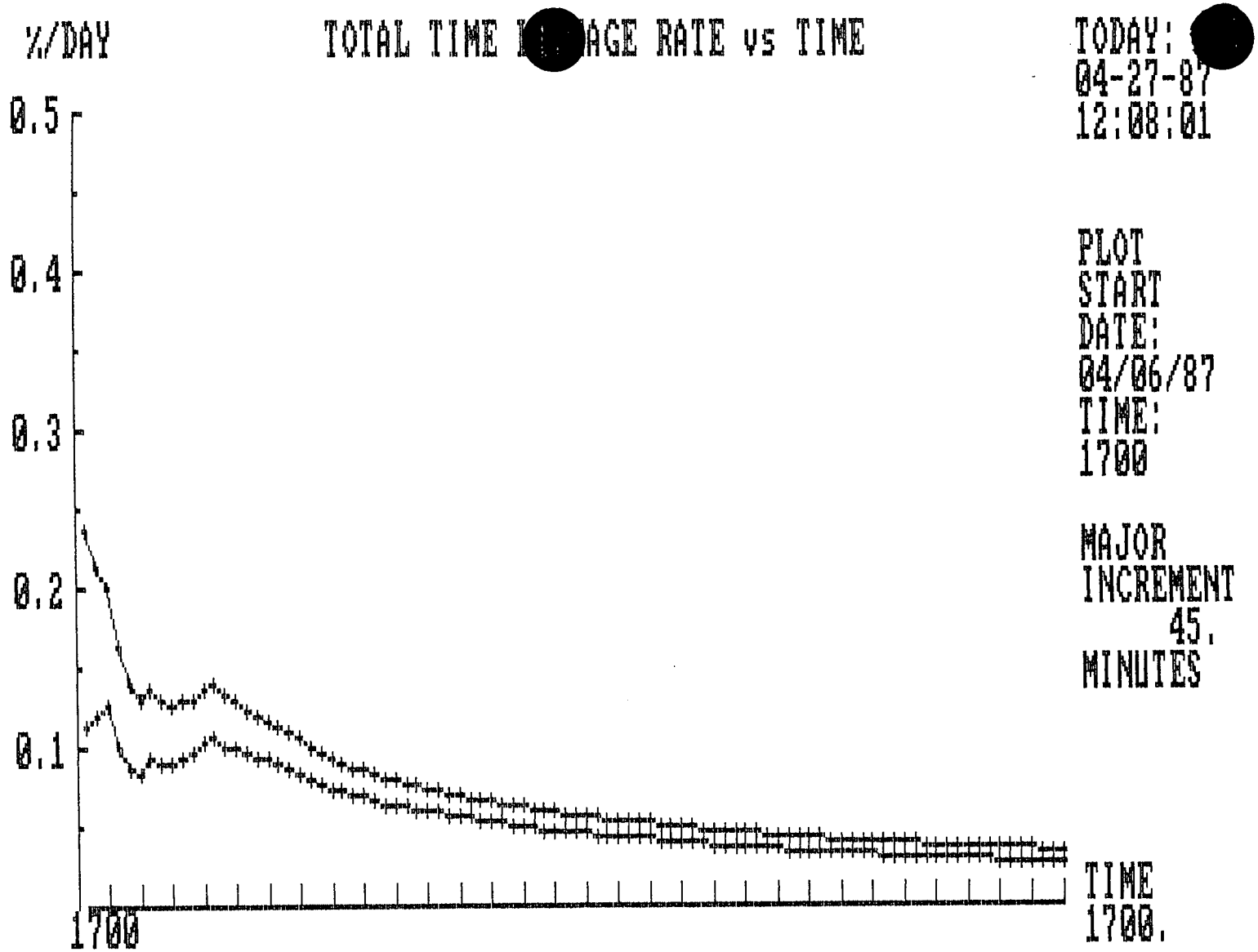

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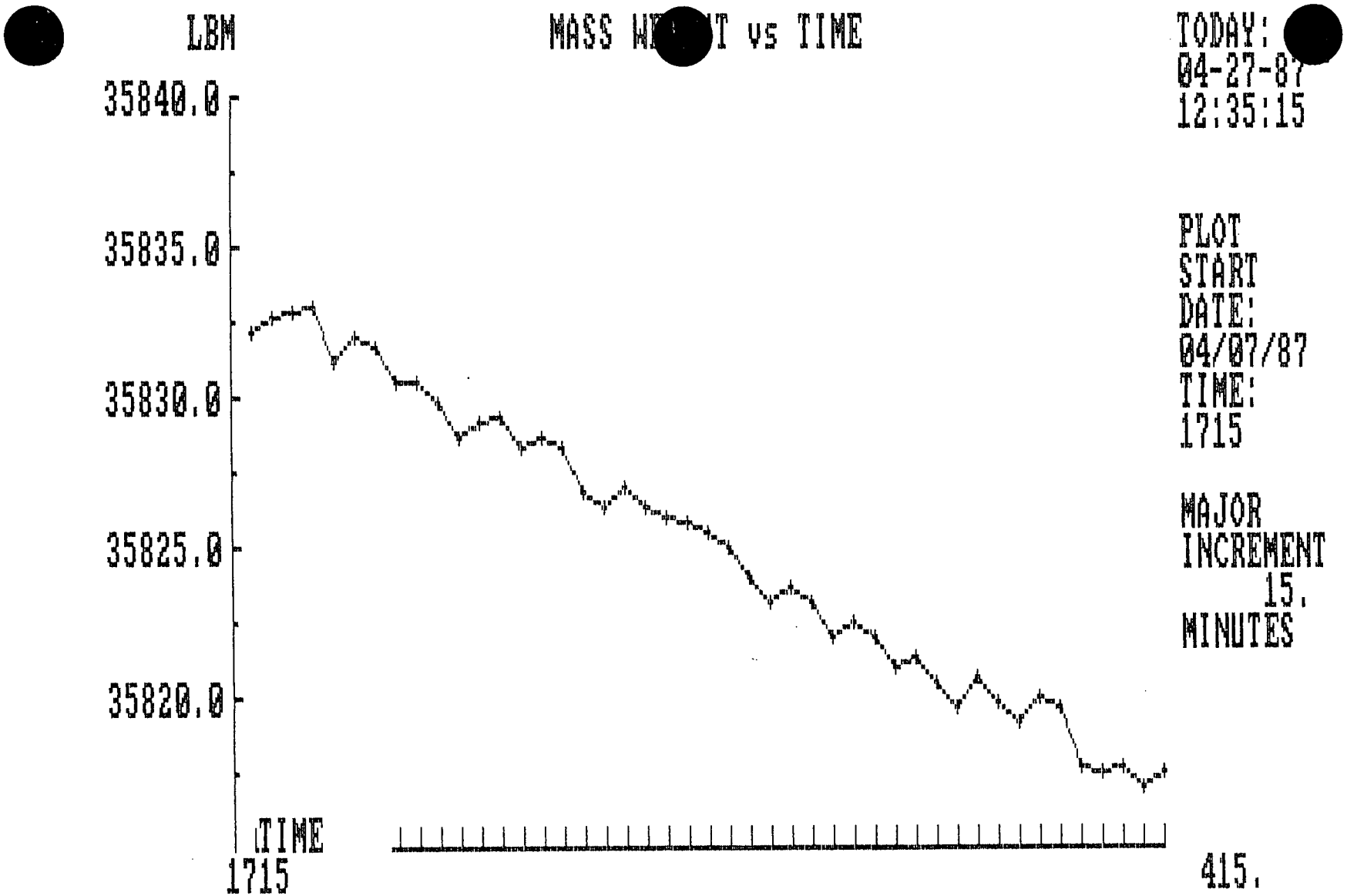
11 HOUR SUPERIMPOSED



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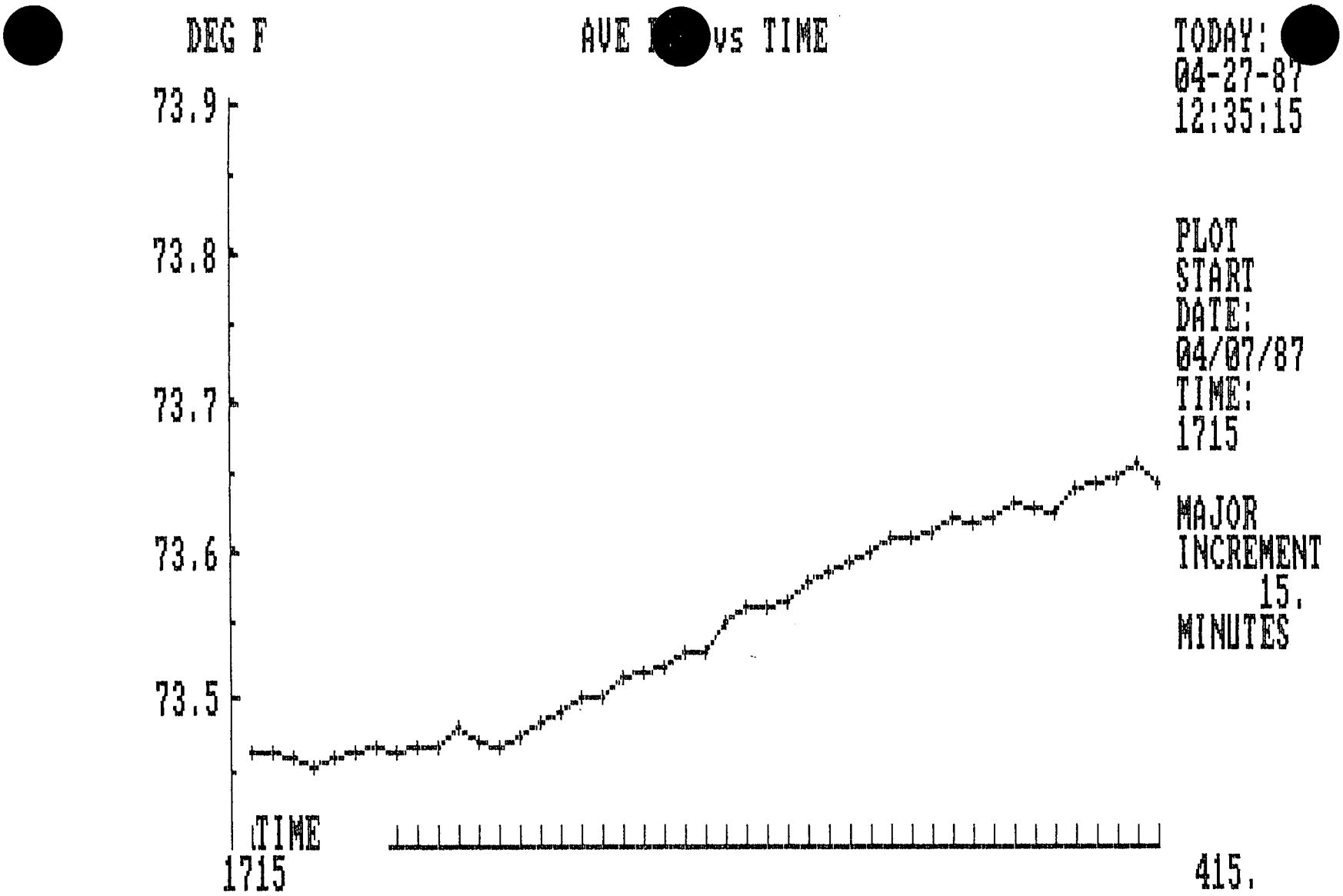

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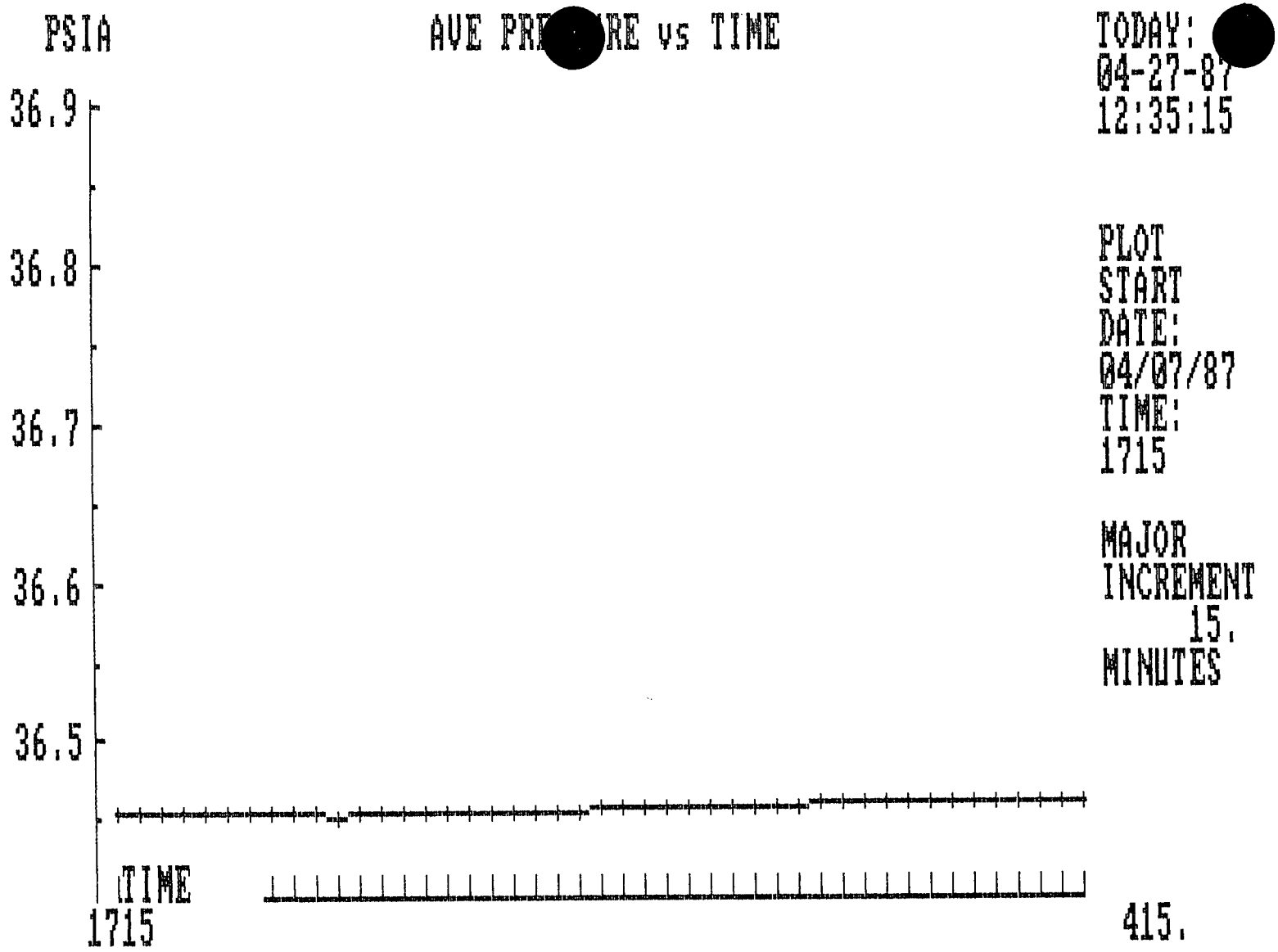

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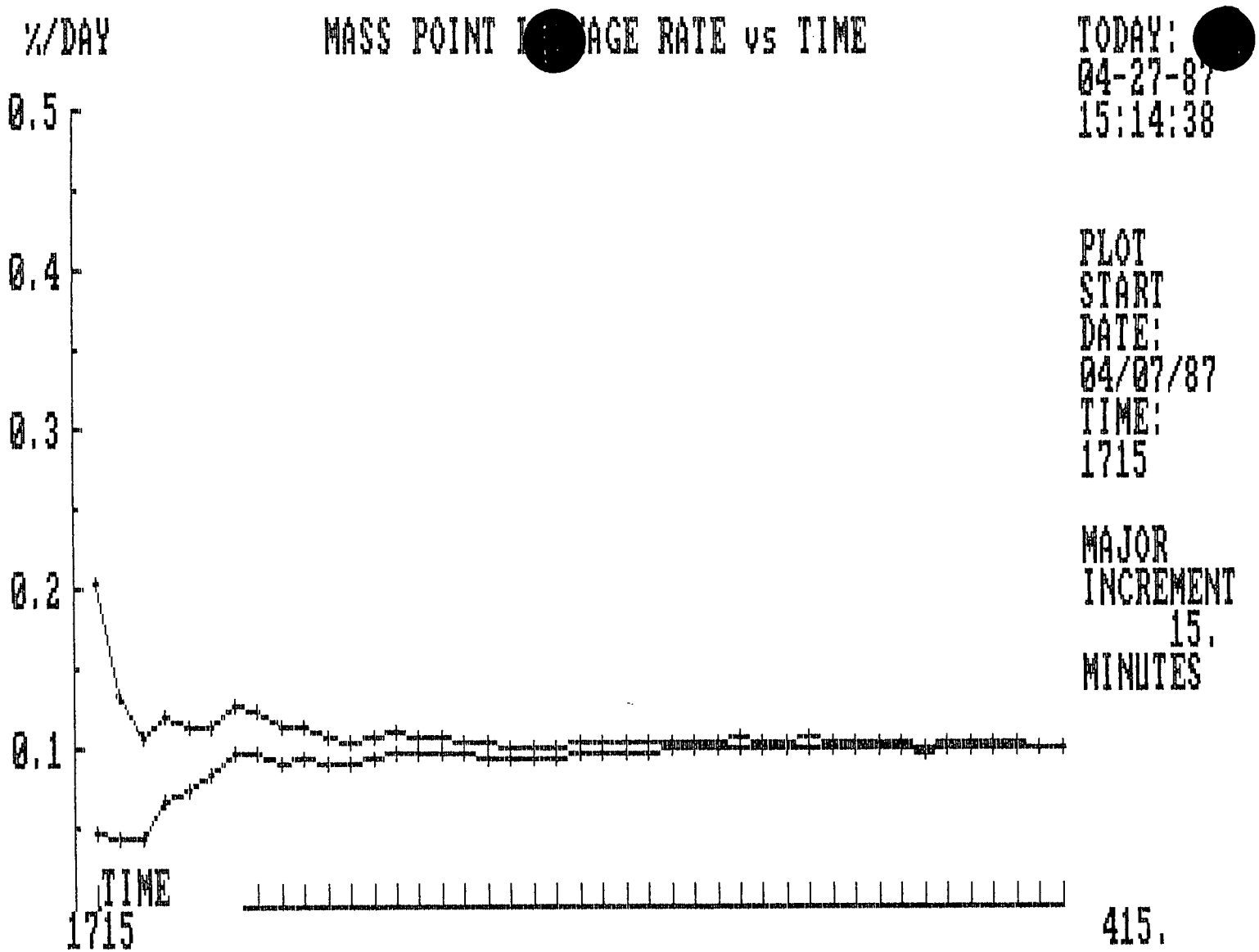

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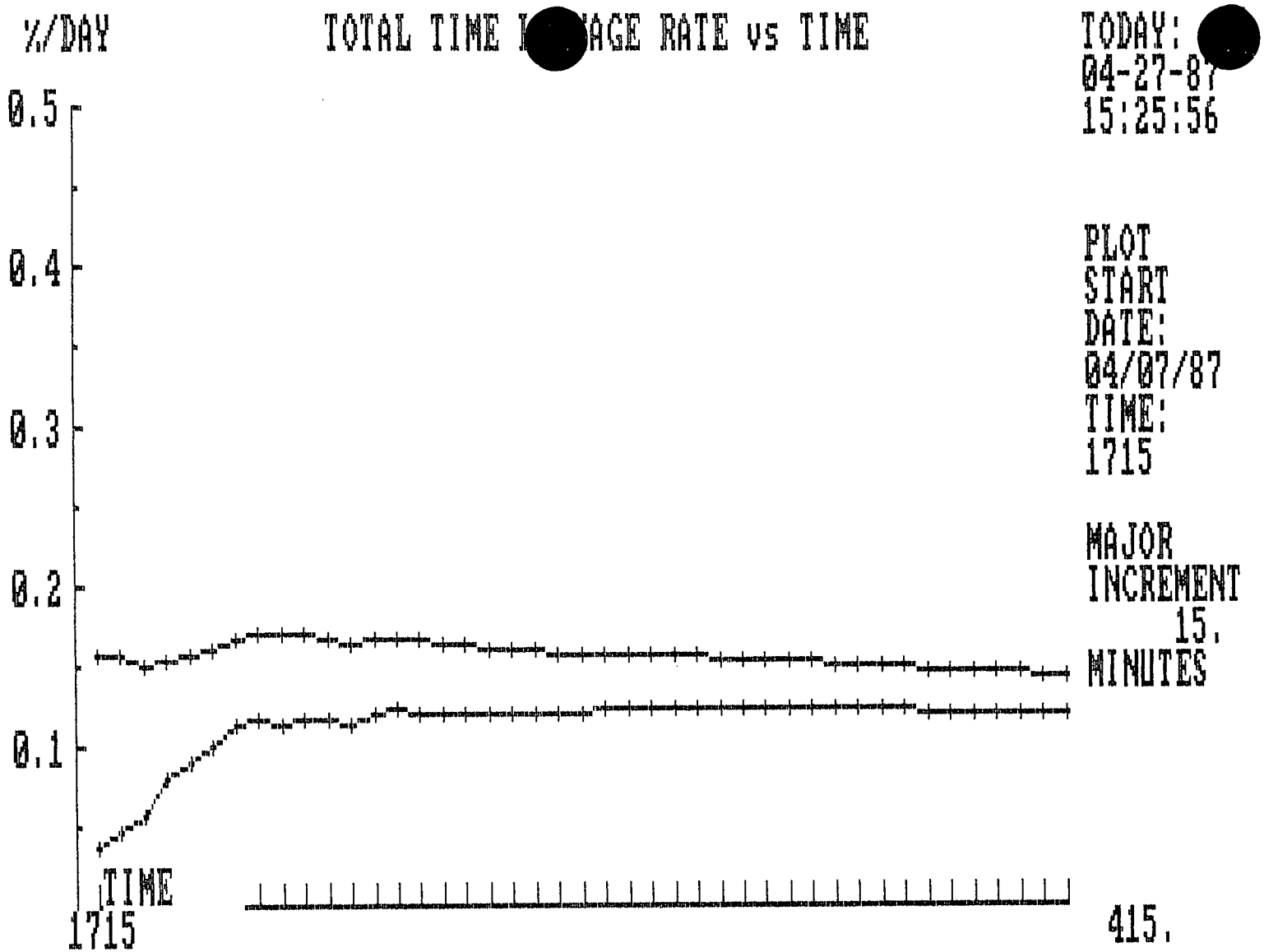

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APPENDIX D

COMPUTER RESULTS

24 HOUR ILRT

INTEGRATED LEAK RATE TEST RESULTS
by GILBERT/COMMONWEALTH INC.

DATE : 04-07-87 TIME : 1700

MASS POINT ANALYSIS

TIME INTERVAL	OBS. WEIGHT (LB)	OBS. MIN. CALC. (LB)
0	358497.3	35.65817641489412
.25	358490.5	30.36501987231895
.5	358480.8	22.07186332973652
.75	358480.5	23.3099567871613 5
1	358482.7	26.95430024457892
1.25	358469.8	15.50489370200376
1.5	358463.7	10.80548715942132
1.75	358474.2	22.79358061684616
2	358469.4	19.46917407426372
2.25	358462.5	13.95726753168856
2.5	358447.3	.2891109891133965
2.75	358454.9	9.339704446530959
3	358446.6	2.515297903955798
3.25	358438.9	-3.77785863862664
3.5	358431.1	-10.1022651812018
3.75	358417.5	-22.23917172378424
4	358420.4	-17.8760782663594
4.25	358434	-2.825484808941837
4.5	358425.1	-10.306141351517
[illegible]75	358428.6	-5.34929789409216
[illegible]	358421.1	-11.3924544366746
5.25	358416.8	-14.24811097924976
5.5	358424.8	-4.791267521832197
5.75	358418.2	-9.928174064407358
6	358418	-8.627580606989795
6.25	358425.8	.5792628504350432
6.5	358426.1	2.348606307859882
6.75	358421.9	-.3820502347225556
7	358409.6	-11.237706777297 72
7.25	358413	-6.343363319880155
7.5	358403.4	-14.51151986245532
7.75	358411.2	-5.273426405037753
8	358415.4	.3709170523870853
8.25	358407.4	-6.140989490195352
8.5	358396.1	-15.96539603277051
8.75	358396.7	-13.88355257534568
9	358398.1	-11.05170911792811
9.25	358391.9	-15.84486566050327
9.5	358405.9	-.3255522030857112
9.75	358396.7	-8.087428745660873
10	358400.7	-2.63058528824331
10.25	358402	.1075081691815285
10.5	358390.8	-9.623148373400909
10.75	358389	-9.97880491597607
11	358391.5	-6.053211458551232
[illegible].25	358387.4	-8.627618001133669
[illegible]5	358384.4	-10.17077454370883
11.75	358388.7	-4.463931086291268
12	358387.6	-4.100837628866429
12.25	358376.8	-13.39399417144887

12.5	358387.5	-1.2496507140240 28
12.75	358364.5	-22.855307256606 47
13	358380.1	-5.7734637991816 27
13.25	358377.9	-6.4728703417567 89
13.5	358379.1	-3.8285268843392 26
13.75	358372.8	-8.6529334269143 87
14	358371.3	-8.7585899694968 25
14.25	358364.8	-13.739246512071 99
14.5	358371	-6.0949030546544 24
14.75	358377.8	2.1744404027704 15
15	358383.3	9.0687838601952 54
15.25	358367.6	-5.0993726823871 84
15.5	358370.2	-1.0800292249623 45
15.75	358369.7	-.12318576754478 27
16	358367.3	-1.1038423101199 44
16.25	358358.9	-8.0219988527023 82
16.5	358372	6.4973446047224 57
16.75	358355.5	-8.483311937859 98
17	358368.1	5.536031519564858
17.25	358365.8	4.742874976989697
17.5	358365.5	5.887218434407259
17.75	358359.7	1.531561891832098
18	358359.4	2.707155349249661
18.25	358352.3	-2.929751193325501
18.5	358353.5	-.28540773590793 83
18.75	358355	2.702685721516 9
19	358358.8	7.909529178934463
19.25	358351.7	2.272622636359301
19.5	358340.3	-7.64555390621586
19.75	358347.8	1.248809551201703
20	358347.6	2.580653008626541
20.25	358353.1	9.537496466044104
20.5	358350.6	8.431839923468942
20.75	358351	10.32618338088 65
21	358349.6	10.34552683831134
21.25	358346.4	8.614870295728906
21.5	358340	3.696713753153745
21.75	358333.5	-1.315192789421417
22	358337.7	4.329150667996146
22.25	358347.1	15.19224412542098
22.5	358328.5	-2.007162417161453
22.75	358335.8	6.730931040263386
23	358330.3	2.687774497680948
23.25	358337.4	11.30086795510579
23.5	358339.1	14.47646141253063
23.75	358332	8.777054869948188
24	358331.1	9.327648327373027

W0 = 358461.5918235851 LB
W1 = -5.827373829686514 LB/HR

LEAKAGE RATE = 3.901589E-02 % PER DAY
UPPER LIMIT OF THE 95% CONFIDENCE LEVEL = 4.081887E-02 % PER DAY
(INCLUDES LEAKAGE RATE)

*** TOTAL -- TIME ANALYSIS ***

X	OBS. LEAKAGE RATE(LB)
.25	.1807545246162334
.5	.2209221967532704
.75	.1492340596755071
1	9.728108095667931D-02
1.25	.1469467339010322
1.5	.1499314150945397
1.75	8.822542272938375D-02
2	9.320155175527867D-02
2.25	.1035805249087159
2.5	.133724875155945
2.75	.1030818101241989
3	.1129715778851903
3.25	.120245531333O673
3.5	.1265401218957304
3.75	.1423720823521002
4	.1286097731572566
4.25	9.963157892793895D-02
4.5	.1073927345328333
4.75	9.680761333007613D-02
5	.1020091506978082
5.25	.102650717683326O
5.5	8.824715848270563D-02
5.75	9.208729907485051D-02
6	8.842466713482322D-02
6.25	7.658636154112664D-02
6.5	7.331887590383237D-02
6.75	.0747565009215566
7	.0838619702502208
7.25	7.779600867904417D-02
7.5	8.379422715237173D-02
7.75	7.436958114066671D-02
8	6.854132074932129D-02
8.25	7.293069764260161D-02
8.5	7.967080558046735D-02
8.75	7.691631027653832D-02
9	7.375695815425853D-02
9.25	7.628691335470076D-02
9.5	6.436957546947187D-02
9.75	6.904891503030086D-02
10	6.464484734541087D-02
10.25	6.223131724876695D-02
10.5	6.788256893883185D-02
10.75	6.743264726480076D-02
11	6.439760315138629D-02
11.25	.0653654479450901
11.5	6.569088047397816D-02
11.75	6.187174675350972D-02
12	.0611929380211429
12.25	6.581896616319166D-02

12.5	5.87786935604102ID-02
12.75	6.97355419044352ID-02
13	6.03480651096072ID-02
13.25	6.02988757433299ID-02
[illegible].5	5.85933519868156ID-02
[illegible].75	6.05862388065737ID-02
14	6.02515082054317ID-02
14.25	6.22187845454740ID-02
14.5	.0582892943366733
14.75	5.42093371848310ID-02
15	5.08790513734758ID-02
15.25	5.69042021940191ID-02
15.5	5.48796219451804ID-02
15.75	5.42210442007449ID-02
16	5.43937226854605ID-02
16.25	5.70071962251402ID-02
16.5	.0508435496430527
16.75	5.66544032379437ID-02
17	.0508741288646354
17.25	5.10100329130530ID-02
17.5	5.04008648004169ID-02
17.75	5.18832431769011ID-02
18	5.12672458900779ID-02
18.25	.0531671413730584
18.5	5.20189447719569ID-02
18.75	.050778632193134 5
19	4.87891872913508ID-02
19.25	5.06225694842897ID-02
19.5	.0538787525298576
19.75	5.06756707550610ID-02
[illegible]	5.00840661957657ID-02
[illegible].25	4.76474547056682ID-02
20.5	4.79032146877208ID-02
20.75	4.71849160644957ID-02
21	4.70814530057658ID-02
21.25	4.75317453620630ID-02
21.5	4.89640809576443ID-02
21.75	5.03923453844599ID-02
22	4.85454465575655ID-02
22.25	4.51698260641221ID-02
22.5	5.02188882434480ID-02
22.75	4.75243886455544ID-02
23	4.86087046874752ID-02
23.25	4.60254576569278ID-02
23.5	4.50461926003972ID-02
23.75	4.65892144588502ID-02
24	4.63567014809734ID-02

L0 = .1206078910784282 LB
L1 = -3.836440173996333D-03 LB

LEAKAGE RATE = 2.853333E-02
< 24 HRS UPPER LIMIT OF THE 95% CONFIDENCE LEVEL = 6.560248E-02 % PER DAY
(INCLUDES LEAKAGE RATE)
[illegible]24 HRS UPPER LIMIT OF THE 95% CONFIDENCE LEVEL = 3.589189E-02 % PER DAY
[illegible]NCLUDES LEAKAGE RATE)

11 HOUR SUPERIMPOSED

INTEGRATED LEAK RATE TEST RESULTS
by GILBERT/COMMONWEALTH INC.

DATE : 04-08-87 TIME : 415

*** MASS POINT ANALYSIS ***

TIME INTERVAL	OBS. WEIGHT (LB)	OBS. MIN. CALC. (LB)
0	358322.7	-11.031219806762 24
.25	358328.1	-1.88305198726448
.5	358329.6	3.358865832233278
.75	358330.3	7.788283651738311
1	358312.7	-6.094798528763931
1.25	358320.5	5.459619290733826
1.5	358317.4	6.045287110231584
1.75	358306	-1.525295070263383
2	358305.4	1.591622749234375
2.25	358299.5	-.6352094312678673
2.5	358288.3	-8.04954161177011
2.75	358292.2	-.4326237922723522
3	358295	6.121794027232681
[illegible]25	358284.1	-1.042538153269561
[illegible]	358287.1	5.699379666228197
[illegible]75	358284.3	6.691297485725954
4	358268.5	-5.348034694776288
4.25	358264	-6.106116875271255
4.5	358271	4.573300944226503
4.75	358264.2	1.565218763724261
5	358260.5	1.588386583222018
5.25	358259.9	4.705304402727052
5.5	358256.5	5.072222222224809
5.75	358250.1	2.407890041722567
6	358240.3	-3.693942138779676
6.25	358232.5	-7.702024319281918
6.5	358238.2	1.758643500223116
6.75	358232.6	-.1556886802791269
7	358220.8	-8.195020860781369
7.25	358225.1	-.1406030412836117
7.5	358221.2	-.2736852217785781
7.75	358210.1	-7.688017402280821
8	358213.4	-.6335995827830629
8.25	358206.2	-4.047931763285305
8.5	358197.9	-8.618513943787548
8.75	358207.2	4.435903875717486
9	358199.6	.5528216952152434
9.25	358193.3	-2.017760485286999
9.5	358201.3	9.724157334210759
9.75	358198.2	10.37232515370852

	358177.5	-6.60450702678645
.25	358176.4	-3.956339207288693
10.5	358178	1.379328612209065
10.75	358170.4	-2.472503568293178
11	358176.6	7.456914251211856

W0 = 358333.7499698068 LB
W1 = -14.96767127799736 LB/HR

LEAKAGE RATE = .1002485 % PER DAY
UPPER LIMIT OF THE 95% CONFIDENCE LEVEL = .1030632 % PER DAY
(INCLUDES LEAKAGE RATE)

*** TOTAL - TIME ANALYSIS ***

X	OBS. LEAKAGE RATE(LB)
.25	-.1448414998107772
.5	-9.251436837622862D-02
.75	-6.781596233915721D-02
1	6.718803676190044D-02
1.25	1.188872426190812D-02
1.5	2.400071095129963D-02
1.75	6.386900156805098D-02
2	5.797846162942655D-02
2.25	6.930437852214292D-02
2.5	9.226319814532147D-02
2.75	7.443772297155427D-02
3	6.195532361845668D-02
3.25	7.966604502705434D-02
3.5	6.823457939059617D-02
3.75	6.859738083520917D-02
4	9.073524590743065D-02
4.25	9.248974384376062D-02
4.5	7.702553747159039D-02
4.75	8.248959161717476D-02
[illegible]	8.334665494887705D-02
[illegible]25	8.017513243031412D-02
[illegible].5	8.064086655252015D-02
5.75	8.459704588089693D-02
6	.092060866570437
6.25	9.668379420890361D-02
6.5	8.707234670701609D-02
6.75	8.946001433394931D-02
7	9.753777299391483D-02
7.25	9.019032198697191D-02
7.5	9.064454554627677D-02
7.75	9.736222390781392D-02
8	9.154631644466282D-02
8.25	9.458208290318899D-02
8.5	9.835038256442849D-02
8.75	8.841192127173793D-02
9	9.163062126753182D-02
9.25	9.372496363317279D-02
9.5	8.561820326504532D-02
9.75	8.554815128882104D-02
10	9.728660276302814D-02
10.25	9.562847083230422D-02
10.5	9.233496106842828D-02
10.75	9.491898260212387D-02
11	8.899417953424385D-02

L0 = 1.393529426313884D-02 LB
L1 = 9.826853858283695D-03 LB

LEAKAGE RATE = .1220307
< 24 HRS UPPER LIMIT OF THE 95% CONFIDENCE LEVEL = .2065014 % PER DAY
(INCLUDES LEAKAGE RATE)
> 24 HRS UPPER LIMIT OF THE 95% CONFIDENCE LEVEL = .1460388 % PER DAY
(INCLUDES LEAKAGE RATE)