H. B. ROBINSON STEAM ELECTRIC PLANT

UNIT NO. 2

REACTOR CONTAINMENT BUILDING
INTEGRATED LEAK RATE TEST

MARCH 1982

CAROLINA POWER AND LIGHT

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TABLE OF CONTENTS

Section	Item	Title	Page
1.0		SYNOPSIS	1
2.0		INTRODUCTION	1
3.0		GENERAL AND TECHNICAL DATA	2
4.0		ACCEPTANCE CRITERIA	3
5.0		TEST INSTRUMENTATION	4
	5.1	SUMMARY OF INSTRUMENTS	4
	5.2	SCHEMATIC ARRANGEMENT	8
	5.3	CALIBRATION CHECKS	9
	5.4	INSTRUMENTATION PERFORMANCE	9
	5.5	SYSTEMATIC ERROR ANALYSIS	10
	5.6	SUPPLEMENTAL VERIFICATION	12
6.0		TEST PROCEDURE	14
	6.1	PREREQUISITES	14
	6.2	GENERAL DISCUSSION	15
	6.3	TEST PERFORMANCE	16
7.0		METHODS OF ANALYSIS	20
	7.1	GENERAL DISCUSSION	20
	7.2	STATISTICAL EVALUATION	22
8.0		DISCUSSION OF RESULTS	23
	8.1	RESULTS AT P_t	23
	8.2	SUPPLEMENTAL TEST RESULTS	24
9.0		TYPE B AND C LEAKAGE RATE HISTORIES	27
10.0		REFERENCES	29

Appendices

A. SCHEMATIC ARRANGEMENT OF TEST INSTRUMENTATION

B. REDUCED LEAKAGE RATE DATA

C. WEIGHT OF CONTAINMENT AIR AND AVERAGE CONTAINMENT TEMPERATURE VERSUS TIME

D. COMPUTER PRINTOUT

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 from March 3, 1982 to March 7, 1982. 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 conformance with the requirements of 10 CFR 50, 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 0.020 percent by weight per day at 21.0 psig. The leakage rate at the upper bound of the 95 percent confidence interval was 0.026 percent by weight per day which is well below the allowable leakage rate of 0.0424 percent by weight per day at 21.0 psig.

The supplemental instrumentation verification at P_t demonstrated an agreement between measured reactor containment building integrated leakage rates of 21.1 percent of L_t which was within the 25 percent requirement of 10 CFR 50, Appendix J, Section III A.3.b.

All testing was performed by Carolina Power and Light Company with the technical assistance of Gilbert Associates, Inc. Procedural and calculational methods were witnessed by Nuclear Regulatory Commission personnel and audited by the Carolina Power and 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 10 CFR 100. For H. B. Robinson Steam Electric Plant Unit No. 2, the maximum allowable integrated leak rate at one half the design basis accident pressure, 21.0 psig (P_t), is 0.057 percent by weight per day (L_t).

Testing was performed in accordance with the procedural requirements as stated in H. B. Robinson Steam Electric Plant Unit No. 2, Integrated Leak Rate Test Procedure CT-3-82. This procedure was approved by the H. B. Robinson Plant Safety Review Committee 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 hours. The 24 hour period was followed by a 9 hour supplemental test for a verification of test instrumentation.

3.0 GENERAL AND TECHNICAL DATA

3.1 GENERAL DATA

Owner:	Carolina Power and 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	March 7, 1982

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	$263^{\circ}F$

4.0 ACCEPANCE CRITERIA

Acceptance criteria established prior to the test and as specified by 10 CFR 50, Appendix J, ANSI N45.4-1972, and the H.B. Robinson Steam Electric Plant Unit No. 2 Technical Specifications are as follows:

a. 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 percent of the maximum allowable leakage rate (L_t),

specified as 0.057 percent 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 = 0.08%/day

P_a = 42.0 psig

P_t = 21.0 psig

Substituting the values for L_a, P_a, and P_t,

L_t = 0.057% per day

and .75 L_t = 0.0424% per day.

b. 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 percent of L_t.

5.0 TEST INSTRUMENTATION

5.1 SUMMARY OF INSTRUMENTS

Test instruments employed are described, by system, in the following subsections. An Instrumentation Selection Guide (ISG) formula, as discussed in Section 5.5 was calculated to be $\pm$ 0.012%/day.

5.1.1 Temperature Indicating System

Components:

a. Resistance Temperature Detectors (sensors)

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

b. Digital Temperature Indicator (Including Bridge Cards)

Quantity	1 Indicator (with 24 input channels)
Manufacturer	Rosemount
Type	Model 2501-4-A10-SF20 with 2506 Switching Units
Range, $^{\circ}$F	0-200 (32° to 120°F maximum accuracy)
Accuracy, $^{\circ}$F	$\pm$0.25
Repeatability, $^{\circ}$F	$\pm$0.10

5.1.2 Dewpoint Indicating System

Components:

a. Dewcell Elements

Quantity	5
Manufacturer	Foxboro
Type	Model 2781
Range, ^{o}F (Dewcell Element)	-50 to 140
Accuracy, ^{o}F	± 1.0
Sensitivity, ^{o}F	± 0.5

b. Dewpoint Recorder

Quantity	1
Manufacturer	Foxboro
Type	Model ERB
Range, ^{o}F (Dewcell Element)	0-200
Accuracy, ^{o}F	± 1.0
Repeatability, ^{o}F	± 0.4

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	0.010% of indication plus 0.002% of full scale
Sensor sensitivity, psia	0.0013% of full scale
Repeatability, psia	$\pm$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 $80^{\circ}F$	0-6
Accuracy, scfm	$\pm$2% of full scale

5.2 SCHEMATIC ARRANGEMENT

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

Temperature sensors were placed throughout the reactor containment building volume to permit monitoring of internal temperature variations at 24 locations. A temperature survey was performed after the sensors were installed which verified there were no large areas of temperature variation. In addition, a weighting factor was assigned to each temperature sensor based on the calculated volume each sensing device monitored. Dewcells were placed in 5 locations. Placement of temperature sensors, dewcells and the temperature sensor weighting factors were as follows:

Elev./ Coordinate	Temperature Element	Dewcell	Weighting Factor
238'/S	TE-111		.017
238'/S	TE-119		.009
238'/N	TE-101		.017
238'/N	TE-116		.009
238'/E	TE-106		.017
238'/W	TE-117		.017
253'/NW		DPTE-6	
253'/SE		DPTE-5	
263'/S	TE-108		.017
263'/S	TE-113		.019
263'/N	TE-122		.017
263'/NE	TE-102		.021
263'/E	TE-115		.017
263'/W	TE-121		.019
295'/S	TE-123		.054
295'/N	TE-103		.054
295'/E	TE-118		.054
295'/W	TE-104		.054

Elev./ Coordinate	Temperature Element	Dewcell	Weighting Factor
304'/E		DPTE-4	
315'/S	TE-114		.054
315'/N	TE-109		.054
335'/E	TE-110		.092
335'/W	TE-112		.092
364'/W	TE-107		.074
364'/W	TE-124		.074
364'/E	TE-105		.074
364'/E	TE-120		.074
364'/NE		DPTE-2	
364'/SW		DPTE-1	

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, CT-2-82, as recommended by ANSI N45.4-1972, Section 6.2 and 6.3 and ANS 56.8-1981, Section 4.2. 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 installation phase of the test equipment one dewcell hookup location could not be located inside the reactor containment and was not used for the test. The remaining five dewcells, 24 temperature sensors, two precision pressure gauges, and one flowmeter performed satisfactorily throughout the performance of the test. No sensor or readout equipment malfunction occurred during the integrated leakage rate test.

5.5 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 4.1, by computing the instrumentation selection guide (ISG) formula.

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

a. Conditions

L_t = 0.057%/day

P = 35.85 psia

T = 65°F = 524.69°R dry bulb

T_{dp} = 56°F

t = 24 hours

b. 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

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

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

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

c. Water Vapor Pressure: e_{pv}

No. of sensors: 5

Range: 0-200°F

Sensor sensitivity error (E): $\pm$ 0.5°F

Measurement system error (ε) excluding sensor: $\pm$ 0.4°F

At a dewpoint temperature of 56°F, the equivalent water vapor pressure change (as determined from the steam tables) is 0.0082 psia/$^{\circ}$F.

$$E_{pv} = \pm 0.5^{\circ}\text{F} \cdot (0.0082 \text{ psia}/^{\circ}\text{F})$$

$$E_{pv} = \pm 0.0041 \text{ psia}$$

$$\varepsilon_{pv} = \pm 0.4^{\circ}\text{F} \cdot (0.0082 \text{ psia}/^{\circ}\text{F})$$

$$\varepsilon_{pv} = \pm 0.00328 \text{ psia}$$

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

$$e_{pv} = \pm \left[(0.0041)^2 + (0.00328)^2 \right]^{\frac{1}{2}} \left[5 \right]^{\frac{1}{2}}$$

$$e_{pv} = \pm 0.0023 \text{ psia}$$

d. Temperature

No. of sensors: 24

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

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

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

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

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

e. Instrumentation Selection Guide (ISG)

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

$$ISG = \pm \frac{2400}{24}\left[2\left(\frac{0.00087}{35.85}\right)^2 + 2\left(\frac{0.0023}{35.85}\right)^2 + 2\left(\frac{0.0288}{524.69}\right)^2\right]^{1/2}$$

$$ISG = \pm 100\left[1.178 \times 10^{-9} + 8.232 \times 10^{-9} + 6.025 \times 10^{-9}\right]^{1/2}$$

$$ISG = \pm 0.012\%/\text{day}$$

The ISG formula does not exceed 0.25 L_t (0.014%/day) and it is therefore concluded that the instrumentation selected was acceptable for use in determining the reactor containment integrated leakage rate.

5.6 SUPPLEMENTAL VERIFICATION

In addition to the calibration checks described in Section 5.2, 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.

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 building leakage rate plus the imposed leakage rate

L_o = imposed leakage rate

L_v' = leakage rate of the reactor 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_{tm}) to determine instrumentation acceptability. Instrumentation is considered acceptable if the difference between the two building leakage rates is within 25 percent 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 basic prerequisites were satisfied:

a. Proper operation of all test instrumentation was verified.

b. All reactor containment building isolation valves were closed using the normal mode of operation. All associated system valves were placed in post-accident positions.

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

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

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

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

   1. Purge Supply

   2. Purge Exhaust

   3. Personnel Access Lock Doors

   4. Equipment Access Hatch

g. Containment recirculation fans were operational.

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

i. 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 3.0 psi per hour. Building pressure, temperature, and the amperage required by the recirculation unit fans (HVH-1,2,3 and 4) were monitored half hourly. Leak rate testing was initiated at the 21.0 psig pressure level. For the duration of the 24 hour leak test and the 9 hour supplemental test, the average internal containment temperature was maintained within a band of $\pm$ 0.2^{o}F by varying the service water flow rate to the containment recirculation fan unit coolers.

During the test the following occurred at half-hour intervals (See Appendix B-Reduced Leakage Data):

a. Pressures indicated by the precision pressure gauges were recorded.

b. The twenty-four RTD temperatures were recorded and the average calculated by use of a weighting factor that was assigned to each RTD.

c. The five dewpoint values were recorded. The average of the five values was converted to vapor pressure using steam tables. This permitted correction of the total pressure to the partial pressure of air by subtracting the vapor pressure.

The use of 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.

The plot of average temperature and weight of air was performed half hourly (See Appendix C).

When convenient, the available half-hourly values of P_{wv}, T and P_T were transmitted via on-site portable computer terminal to the Gilbert Associates, Inc. home office for analysis using the CLERCAL computer program. Computer program results, including at least squares fit of the data, were returned to the site via the terminal. A final computer run was made after data for a full 24 hour period was available.

Immediately following the 24 hour leak test, a superimposed leakage rate was established for an additional 9 hour period. During this time, temperature, pressure and vapor pressure were monitored as described above.

6.3 TEST PERFORMANCE

6.3.1 Pressurization Phase

Pressurization of the reactor building containment was started on March 3, 1982 at 2210. The pressurization rate was approximately 3.0 psi per hour. During pressurization, a slight buildup of pressure was observed in the personnel and equipment hatches and a more substantial pressure buildup was observed between the purge exhaust valves V12-8 and V12-9. The exterior purge exhaust valve was checked and found to be leak tight.

When containment internal pressure reached 21.1 to 21.2 psig, at 0536 on March 4, 1982, pressurization was secured.

6.3.2 Integrated Leak Rate Testing Phase

At 0540 on March 4, 1982, thirty minute frequency test data collection was initiated. At 0940 containment internal temperature appeared to be stabilized at approximately 66.1^{o}F with temperature changes being less than 0.5^{o}F per hour. However, from 0940 until 1540 on March 4, 1982, the reactor building weight data was not stabilized.

At 1532 on March 4, 1982, a leak was discovered at containment pressure transmitter PT-958. No action was taken to stop the leak. At 1540, the reactor building weight data appeared to stabilize and the test was started.

Subsequent to 1540, March 4, 1982, the following sequence of events took place:

a. At 1655, a lineup discrepancy was noted on the N_2 supply to the S.I. accumulators. A TCN was written to procedure CT-3-82 and at 1810 a vent valve on the supply line PI was opened.

b. At 2140, the leakage rate based on six hours of data was 0.004%/day with a 95 percent confidence interval of .058%/day.

c. At 2200 a vent valve (989E) on the sampling system was found closed. The valve was opened at this time and no evidence of leakage was detected.

d. From 1540 on March 4, 1982 until 0910 on March 5, 1982 the leakage rate was acceptable as indicated by the following computer results:

Date	Time Interval	Leakage Rate	95% Confidence Interval
3-4/5	1540-0810	0.023%/day	0.010%/day
3-4/5	1540-0840	0.024%/day	0.010%/day
3-4/5	1540-0910	0.023%/day	0.010%/day

e. At 1110 and again at 1340 on March 5, 1982, a sharp decrease in reactor building weight was indicated. As a result, the reactor building containment integrated leakage rate increased from its stabilized value of 0.023%/day to 0.036%/day based on 22 hours of data from 1540 on March 4, 1982 until 1340 on March 5, 1982.

f. This larger than expected decrease in reactor building weight and corresponding increase in leakage rate continued until 1540. Subsequent to 1540, the slope on the reactor building weight versus time graph appeared to return to the slope exhibited between 1540 on March 4, 1982 and 0910 on March 5, 1982. Subsequent computer results as indicated below confirmed this observation:

Date	Time Interval	Leakage Rate	95% Confidence Interval
3-5/6	1540-0540	0.012%/day	0.017%/day
3-5/6	1540-0810	0.013%/day	0.012%/day
3-5/6	1540-1440	0.018%/day	0.007%/day

g. From analyzing the reactor building weight versus time graph, the excessive leakage trend appeared to have started at approximately 0540 on March 5, 1982. The leakage rate results from 0540 to 1610 on March 5, 1982 indicated a leakage rate of 0.107 percent per day. The following actions were taken subsequent to indications of an excessive leakage rate:

1) A search for possible leakage paths was conducted by operations personnel from 1430 until approximately 1900. Only one leak path (SI Accumulators N_2 supply line PI-855 vent) was thought to be identified but it subsided when the N_2 supply bottles were disconnected.

2) Operations, maintenance and I&C personnel were interviewed to determine if any of their activities during this time frame could have affected the leak rate. No activities were found to be associated with the leakage rate.

3) A careful study of all available data was undertaken by CP&L and Gilbert to try and determine this decrease. One possible explanation was that the relatively large increase in outside air temperature between 0640 and 1540 (temperature went from $45^{o}F$ to $76.4^{o}F$) could have affected the seating characteristics of the purge valves and this may have resulted in the sudden decrease of reactor building weight.

h. Following the sequence of events mentioned in item g above, an acceptable leakage rate of 0.020%/day with an associated 95 percent confidence interval of 0.006 percent by weight per day was obtained from 1540 on March 5, 1982 to 1540 on March 6, 1982.

6.3.3 Supplemental Leakage Rate Test Phase

After the 24 hour integrated leak rate test data was obtained and evaluated, the leakage rate found to be acceptable and a release permit had been obtained, a known leak rate was imposed at 1540 on March 6, 1982, on the reactor containment building. This supplemental test was to last for a period of 6 hours, but due to differences in the expected and calculated leakage rate and doubts about the flowmeter calibration data, it was decided to run the test for 9 hours. A detailed account of these discrepencies is contained in Section 8.2 of this report.

6.3.4 Depressurization Phase

After all required data was obtained and evaluated, the supplemental test results were considered to be acceptable, and permission from

the health physics department was obtained, depressurization of the reactor containment building was started. A post test inspection of the building revealed no unusual findings.

7.0 METHODS OF ANALYSIS

7.1 GENERAL DISCUSSION

The absolute method of leakage rate determination was employed during testing at the 21.0 psig pressure level. The Gilbert Associates, Inc. CLERCAL computer code calculates the percent per day leakage rate using the mass point method of data analysis. The results presented are based on the mass point method.

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 half hour:

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

where,

W = mass of air inside containment, lbm

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

P = partial pressure of air, psia

T = average internal containment temperature, ^oR

$V = 1.95 \times 10^6\ ft^3$

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

$$P = P_{T1} - P_{wv}$$

where,

P_{T1} = True corrected pressure by averaging PI-201A and PI-201B, psia

P_{wv} = partial pressure of water vapor determined by averaging the five dewpoint temperatures and converting to vapor pressure with the use of steam tables, 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 hour test and for the 9 hour supplemental test. The Gilbert Associates, Inc. CLERCAL 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 $W = W_o + W_1 t$ where W_1 is the slope in lbm per hour and W_o is the weight at time zero and are defined by the following expressions:

$$W_o = \frac{\Sigma\ t_i^2\ \Sigma\ W_i - \Sigma\ t_i\ \Sigma\ t_i\ W_i}{S_{xx}}$$

$$W_1 = \frac{N\ \Sigma\ t_i\ W_i - \Sigma\ t_i\ \Sigma\ W_i}{S_{xx}}$$

where,

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

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

$$\text{wt. \%/day} = \frac{-2400\ W_1}{W_o}$$

where the negative sign is used since W_1 is a negative slope to express the leakage rate as a positive quantity.

7.2 STATISTICAL EVALUATION

After performing the least squares fit, the CLERCAL computer code calculates the following statistical parameters:

a. Standard error of confidence for the curve fit (S_e).

b. Limits of the 95 percent confidence interval for the curve fit.

c. Limits of the 95 percent confidence interval for the leakage rate (C_L).

The significance of the measured leakage rate can then be evaluated in view of the number of data points exceeding the limits of 95 percent confidence interval and by the magnitude of the upper bound of the 95 percent confidence interval for the leakage rate.

Standard error of confidence is defined as follows:

$$S_e = \left[\frac{\Sigma \left[W_i - (W_o + W_1\ t_i)\right]^2}{N-2}\right]^{\frac{1}{2}}$$

where,

W_i = observed mass of air

$(W_o + W_1\ t_i)$ = least squares calculated mass of air

N = number of data points

This parameter is an expression of the difference between an observed and a calculated (least squares) mass point. The 95 percent confidence interval of the fit is twice the standard error of confidence ($2S_e$). The "degree-of-fit" is evaluated by determining the number of data points, W_i, not falling in the interval $(W_o + W_1 t_i) \pm 2S_e$.

The 95 percent confidence interval for the mass leakage rate is calculated as follows:

$$C_L = t_{95} S_e \left[\frac{N}{S_{xx}} + \frac{S_{xx} + (\Sigma t_i)^2}{NS_{xx}} \right]^{\frac{1}{2}}$$

where,

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

This parameter is an expression of the uncertainty in the measured leakage rate. The values of t_{95} used by the CLERCAL program establish a band about the calculated leakage such that there is a 95 percent chance the actual leakage rate is inside the band. There is only a 2.5 percent chance the actual leakage rate exceeds the upper limit.

8.0 DISCUSSION OF RESULTS

8.1 RESULTS AT P_t

Data obtained during the integrated leak rate test at P_t indicated the following maximum changes (highest reading to lowest reading) during the 24 hour test period:

Variable	Maximum Change
P_T	0.012 psia

Variable	Maximum Change
P_{wv}	0.009 psia
T	0.19°F

The method used in calculating the mass point leakage rate is defined in Section 7.0. The results of this calculation is a mass point leakage rate of 0.020%/day.

The 95 percent confidence interval associated with this leakage rate is 0.006 percent per day. Thus, the leakage rate at the upper bound of the 95 percent confidence interval becomes

$$L_{tm} = 0.020 + 0.006$$

$$L_{tm} = 0.026\%/\text{day}$$

The measured leakage rate and the measured leakage rate at the upper bound of the 95 percent confidence level are well below the acceptance criteria of 0.0424 percent per day (0.75 L_t). A comparison of each of the observed weights with the weights calculated using the least squares line reveals only one of the forty-nine data points does not lie within the 95 percent confidence interval. Therefore, reactor containment building leakage at one-half the calculated design basis accident pressure (P_t) of 21.0 psig is considered to be acceptable.

8.2 SUPPLEMENTAL TEST RESULTS

After conclusion of the 24 hour test at 21.0 psig, flowmeter FI-1 was placed in service. Using the calibration data supplied from Gage Laboratories it was calculated that a reading of 3 CFM on FI-1 would result in a flow rate of 1.5 SCFM. This flow rate is equivalent to a leakage rate of 0.0424 percent per day. After the flow was established, it was not altered for the duration of the supplemental test.

As the superimposed test progressed, calculations revealed that a larger than expected leakage rate existed. Data collected tended to favor the original calibration of FI-1 by Wallace & Tiernan rather than that supplied from Gage Laboratories. After 9 hours of data had been collected it was decided to discontinue the superimposed test. FI-1 was removed and sent to Wallace & Tiernan for a post test calibration.

At Wallace & Tiernan the test conditions were duplicated to establish the actual flow rate (L_o) through flowmeter FI-1 during the superimpose test. With an inlet pressure of 8 psig, outlet pressure of 5.3 psig, temperature of 66°F and a rotameter setting of 3 CFM, L_o was determined to be 4.09 SCFM. This flow rate is equivalent to a leakage rate of 0.125 percent per day.

The differences in calibration data that existed between Wallace & Tiernan and Gage Laboratories was a result of the rotameter float being improperly installed by Gage Laboratories during the calibration test. The improper installation of the float was also utilized during the superimposed test.

The measured leakage rate (L_c) during the supplemental test was calculated to be 0.157 percent per day using the mass point method of analysis. The 95 percent confidence interval associated with this leakage rate is 0.016 percent per day. Only one of the 19 data points was outside of the 95 percent confidence interval.

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

$$L_v' = L_c - L_o$$

$$L_v' = 0.157\%/\text{day} - 0.125\%/\text{day}$$

$$L_v' = 0.032\%/\text{day}$$

Comparing this leakage rate with the building leakage rate during the 24 hour test yields the following:

$$\left| \frac{L_{tm} - L_v'}{L_t} \right| = \left| \frac{(0.020)-(0.032)}{0.057} \right| = 0.211$$

The building leakage rates agree within 21.1 percent of L_t which is below the acceptance criteria of 25 percent of L_t.

Using the formulation of ANS 56.8-1981,

$$(L_o + L_{tm} - 0.25\ L_t) \leq L_c \leq (L_o + L_{tm} + 0.25\ L_t)$$

$$(0.125 + 0.020 - 0.014) \leq L_c \leq (0.125 + 0.020 + 0.014)$$

$$0.131 \leq L_c \leq 0.159$$

The possible sources of error associated with the determination of L_o are placed by Wallace Tiernan at ± 1% of the actual flow or ± 0.04 SCFM. These flow rates are equivalent to leakage rates of 0.123 and 0.126 percent per day respectively. Utilizing these values, building leakage rate agreement is between 19.3 and 25 percent. Using the formulation of ANS 56.8-1981:

(1) L_o = 0.123 percent per day, then $0.129 \leq L_c \leq 0.157$

(2) L_o = 0.126 percent per day, then $0.132 \leq L_c \leq 0.160$

Since L_c was measured to be 0.157 percent per day, this value falls within the acceptable range for all possible cases. Therefore the test equipment acceptability is considered to have been verified.

9.0 TYPE B AND C LEAKAGE RATE HISTORIES

9.1 Discussion of Type B Tests

Leakage from containment penetrations and some containment isolation valves is constantly monitored by the penetration pressurization system. This surveillance is in lieu of Type B tests for these penetrations and valves. The containment personnel hatch has been tested with dates and test results listed below:

Date	Leakage
April 13, 1979	0.073 SCFM
August 7, 1980	0.2557 SCFM
February 19, 1982	0.5359 SCFM

9.2 Discussion of Type C Tests

The isolation valve seal water system precludes Type C testing on containment isolation valves it serves. The only leakage measurement not subject to the above is the containment pressure manometer line isolation valve leakage measurement. The measured leakage rate for this is as follows:

Date	Leakage
March 7, 1978	0
April 19, 1979	0
September 4, 1980	0

9.3 Discussion of Combined Leakage

The combined leakage measured since the last ILRT are listed below:

Date	Leakage
April, 1979	0.073 SCFM
August, 1980	0.2557 SCFM
February, 1982	0.5359 SCFM

All measurements were well below the acceptance criteria value (0.60 La) of 2.78 SCFM.

10.0 REFERENCES

1) CT-3-82, "Integrated Leak Rate Test Procedure"

2) Code of Federal Regulations, Title 10, Part 50, Appendix J, (1-1-75).

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

4) Steam Tables, American Society of Mechanical Engineers, (1967).

5) CLERCAL, Computer Code, Gilbert Associates, Inc.

6) ANS 56.8-1981, N274, "Containment System Leakage Testing Requirements," American Nuclear Society, (February 19, 1981).

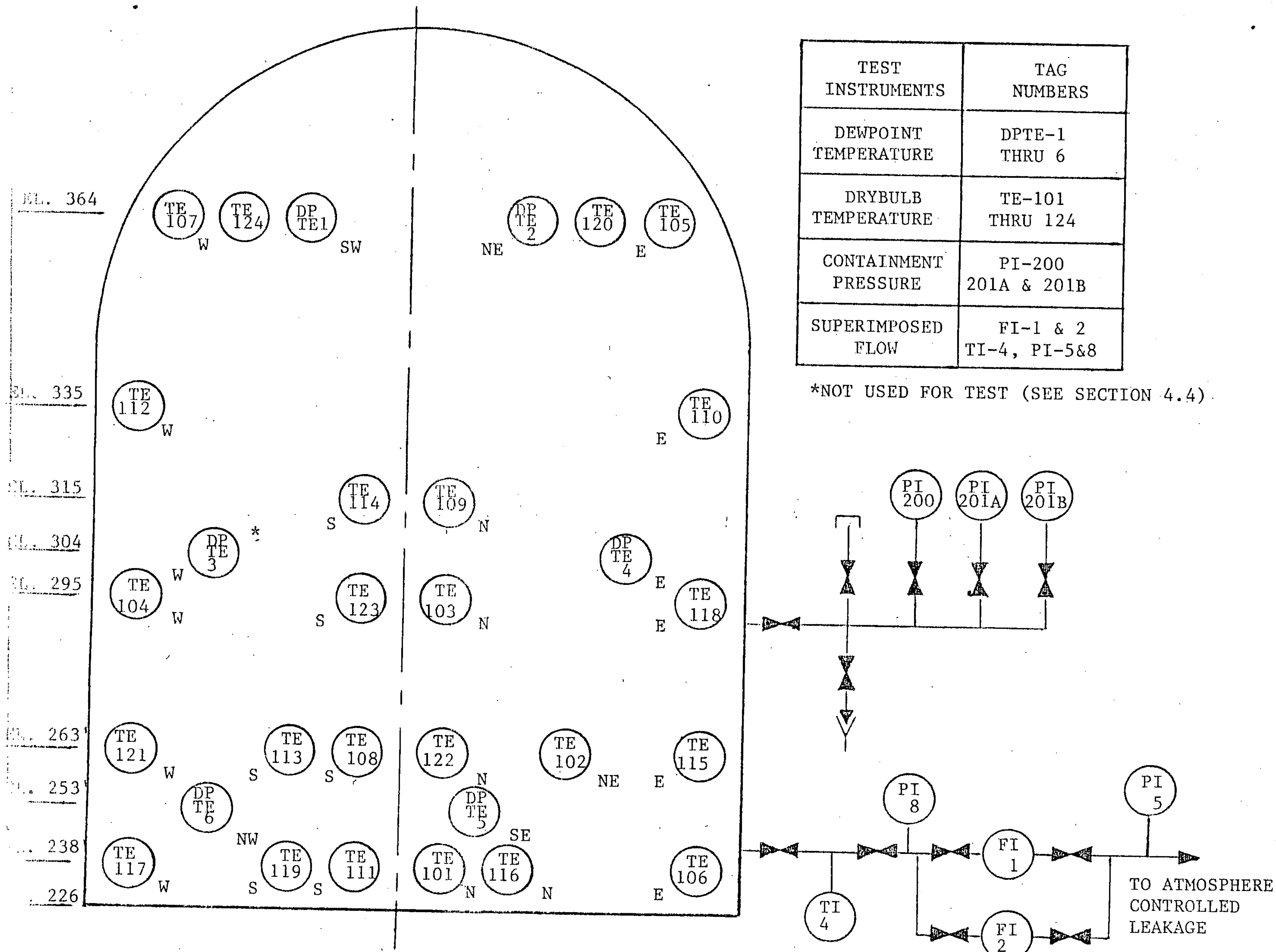
7) "Carolina Power & Light Company" Integrated Leak Rate Test of the Reactor Containment Building, H.B. Robinson Steam Electric Plant Unit No. 2, (February 1978).

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-4, PI-5&8

*NOT USED FOR TEST (SEE SECTION 4.4)

APPENDIX B

REDUCED LEAKAGE DATA

APPENDIX B

REDUCED TEST DATA

Date	Time	Containment Pressure (psia)	Partial Pressure Of Containment Water Vapor (psia)	Partial Pressure Of Containment Air (psia)	Weighted Average Containment Temperature (°R)	Weight of Containment Air (lbm)
3/5/82	1540	35.862	0.225	35.637	524.87	357,365.37
	1610	35.862	0.225	35.637	524.87	357,365.37
	1640	35.860	0.224	35.636	524.85	357,368.96
	1710	35.860	0.224	35.636	524.87	357,355.34
	1740	35.860	0.225	35.635	524.86	357,352.12
	1810	35.860	0.223	35.637	524.86	357,372.18
	1840	35.858	0.224	35.634	524.84	357,355.77
	1910	35.858	0.228	35.630	524.83	357,322.24
	1940	35.858	0.226	35.632	524.84	357,335.65
	2010	35.858	0.225	35.633	524.84	357,345.68
	2040	35.860	0.222	35.638	524.84	357,395.82
	2110	35.858	0.226	35.632	524.80	357,362.89
	2140	35.856	0.226	35.630	524.82	357,329.21
	2210	35.857	0.225	35.632	524.83	357,342.46
	2240	35.858	0.222	35.636	524.83	357,382.58
	2310	35.859	0.222	35.637	524.84	357,385.79
	2340	35.859	0.224	35.635	524.84	357,365.74
3/6/82	0010	35.860	0.226	35.634	524.84	357,355.71
	0040	35.860	0.225	35.635	524.85	357,358.93
	0110	35.860	0.224	35.636	524.85	357,368.96
	0140	35.860	0.224	35.636	524.85	357,368.96
	0210	35.859	0.223	35.636	524.84	357,375.77
	0240	35.858	0.224	35.634	524.84	357,355.71
	0310	35.856	0.219	35.637	524.81	357,406.22
	0340	35.855	0.224	35.631	524.81	357,346.05
	0410	35.855	0.227	35.628	524.81	357,315.96
	0440	35.852	0.224	35.628	524.79	357,329.58
	0510	35.850	0.224	35.626	524.79	357,309.52
	0540	35.850	0.224	35.626	524.79	357,309.52
	0610	35.850	0.224	35.626	524.80	357,302.71
	0640	35.853	0.222	35.631	524.82	357,339.24
	0710	35.852	0.223	35.629	524.80	357,332.80
	0740	35.853	0.223	35.630	524.81	357,336.02

APPENDIX B (Cont'd)

REDUCED TEST DATA

Time	Containment Pressure (psia)	Partial Pressure Of Containment Water Vapor (psia)	Partial Pressure Of Containment Air (psia)	Weighted Average Containment Temperature (°R)	Weight of Containment Air (lbm)
0810	35.853	0.220	35.633	524.82	357,359.30
0840	35.853	0.223	35.630	524.85	357,308.79
0910	35.851	0.224	35.627	524.81	357,305.9[illegible]
0940	35.851	0.223	35.628	524.83	357,302.35
1010	35.852	0.224	35.628	524.79	357,329.58
1040	35.854	0.228	35.626	524.82	357,289.10
1110	35.857	0.221	35.636	524.88	357,348.53
1140	35.859	0.221	35.638	524.90	357,354.97
1210	35.859	0.223	35.636	524.90	357,334.92
1240	35.859	0.223	35.636	524.92	357,321.30
1310	35.859	0.225	35.634	524.92	357,301.25
1340	35.858	0.226	35.632	524.92	357,281.19
1410	35.859	0.225	35.634	524.93	357,294.44
1440	35.859	0.222	35.637	524.93	357,324.52
1510	35.859	0.225	35.634	524.97	357,267.22
1540	35.861	0.225	35.636	524.98	357,280.46
SUPERIMPOSED TEST					
1540	35.861	0.225	35.636	524.98	357,280.4[illegible]
1610	35.861	0.226	35.635	525.01	357,250.02
1640	35.862	0.226	35.636	525.04	357,239.63
1710	35.864	0.225	35.639	525.06	357,256.10
1740	35.864	0.225	35.639	525.09	357,235.69
1810	35.865	0.224	35.641	525.12	357,235.32
1840	35.864	0.224	35.640	525.12	357,225.30
1910	35.864	0.226	35.638	525.13	357,198.45
1940	35.863	0.224	35.639	525.12	357,215.28
2010	35.860	0.223	35.637	525.13	357,188.43
2040	35.860	0.223	35.637	525.15	357,174.83
2110	35.859	0.224	35.635	525.14	357,161.58
2140	35.858	0.225	35.633	525.12	357,155.14

APPENDIX B (Cont'd)

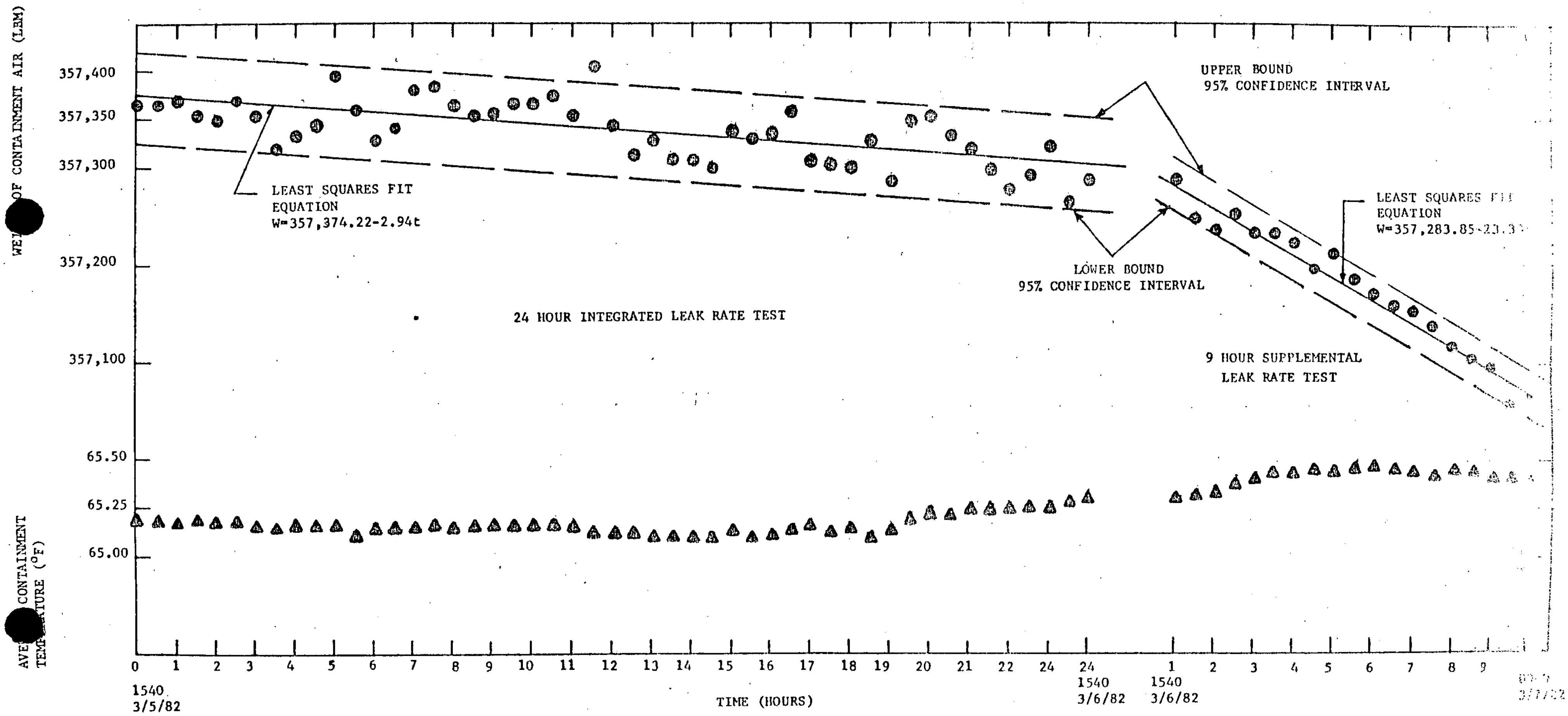
REDUCED TEST DATA

	Time	Containment Pressure (psia)	Partial Pressure Of Containment Water Vapor (psia)	Partial Pressure Of Containment Air (psia)	Weighted Average Containment Temperature (°R)	Weight of Containment Air (lbm)
	2210	35.856	0.225	35.631	525.11	357,141.89
	2240	35.854	0.224	35.630	525.13	357,118.27
	2310	35.852	0.224	35.628	525.12	357,105.0[illegible]
	2340	35.850	0.224	35.626	525.10	357,098.58
3/7/82	0010	35.849	0.227	35.622	525.10	357,058.48
	0040	35.846	0.224	35.622	525.09	357,065.28

APPENDIX C

WEIGHT OF CONTAINMENT AIR AND AVERAGE CONTAINMENT TEMPERATURE VERSUS TIME

APPENDIX C
WEIGHT OF CONTAINMENT AIR AND
AVERAGE CONTAINMENT TEMPERATURE VERSUS TIME



APPENDIX D

COMPUTER PRINTOUT

APPENDIX D

COMPUTER PRINTOUT

[illegible]BISON ILRT TEST 3/5/82 1540 THRU 3/6/82 1540

LEAST SQUARES RESULTS BASED ON 49 DATA POINTS

TIME PERIOD		OBSERVED WEIGHT (LB)	95% CONFIDENCE LIMIT MINUS (LB)	CALCULATED (LB)	PLUS (LB)	OBS.MINUS CALC. (LB)
0.0		357365.10	357326.41	357374.22	357422.04	-9.12
0.5		357365.10	357324.94	357372.75	357420.56	-7.65
1.0		357368.69	357323.47	357371.28	357419.09	-2.59
1.5		357355.07	357322.00	357369.81	357417.62	-14.73
2.0		357351.86	357320.52	357368.34	357416.15	-16.48
2.5		357371.91	357319.05	357366.86	357414.68	5.05
3.0		357355.44	357317.58	357365.39	357413.20	-9.95
3.5		357322.14	357316.11	357363.92	357411.73	-41.78
4.0		357335.39	357314.64	357362.45	357410.26	-27.06
4.5		357345.42	357313.16	357360.98	357408.79	-15.56
5.0		357395.56	357311.69	357359.50	357407.32	36.05
5.5		357362.62	357310.22	357358.03	357405.84	4.59
6.0		357328.95	357308.75	357356.56	357404.37	-27.61
6.5		357342.20	357307.27	357355.09	357402.90	-12.89
7.0		357382.31	357305.80	357353.61	357401.43	28.70
7.5		357385.53	357304.33	357352.14	357399.96	33.39
8.0		357365.47	357302.86	357350.67	357398.48	14.80
8.5		357355.44	357301.39	357349.20	357397.01	6.25
9.0		357358.66	357299.91	357347.73	357395.54	10.94
9.5		357368.69	357298.44	357346.25	357394.07	22.44
10.0		357368.69	357296.97	357344.78	357392.59	23.91
10.5		357375.50	357295.50	357343.31	357391.12	32.19
11.0		357355.44	357294.03	357341.84	357389.65	13.61
11.5	*	357405.96	357292.55	357340.37	357388.18	65.59
12.0		357345.78	357291.08	357338.89	357386.71	6.89
12.5		357315.70	357289.61	357337.42	357385.23	-21.72
13.0		357329.32	357288.14	357335.95	357383.76	-6.63
13.5		357309.26	357286.67	357334.48	357382.29	-25.22
14.0		357309.26	357285.19	357333.01	357380.82	-23.75
14.5		357302.45	357283.72	357331.53	357379.35	-29.09
15.0		357338.98	357282.25	357330.06	357377.87	8.92
15.5		357332.54	357280.78	357328.59	357376.40	3.95
16.0		357335.76	357279.30	357327.12	357374.93	8.64

* - INDICATES VALUE OUTSIDE OF 95% CONFIDENCE

APPENDIX D (Cont'd)

COMPUTER PRINTOUT

ROBISON ILRT TEST 3/5/82 1540 THRU 3/6/82 1540

LEAST SQUARES RESULTS BASED ON 49 DATA POINTS

TIME PERIOD	OBSERVED WEIGHT (LB)	95% CONFIDENCE LIMIT MINUS (LB)	CALCULATED (LB)	PLUS (LB)	OBS.MINUS CALC. (LB)
16.5	357359.03	357277.83	357325.64	357373.46	33.39
17.0	357308.52	357276.36	357324.17	357371.98	-15.65
17.5	357305.67	357274.89	357322.70	357370.51	-17.03
18.0	357302.08	357273.42	357321.23	357369.04	-19.15
18.5	357329.32	357271.94	357319.76	357367.57	9.56
19.0	357288.83	357270.47	357318.28	357366.10	-29.45
19.5	357348.27	357269.00	357316.81	357364.62	31.45
20.0	357354.71	357267.53	357315.34	357363.15	39.37
20.5	357334.65	357266.06	357313.87	357361.68	20.78
21.0	357321.04	357264.58	357312.40	357360.21	8.64
21.5	357300.98	357263.11	357310.92	357358.74	-9.94
22.0	357280.93	357261.64	357309.45	357357.26	-28.52
22.5	357294.18	357260.17	357307.98	357355.79	-13.80
23.0	357324.26	357258.69	357306.51	357354.32	17.75
23.5	357266.95	357257.22	357305.03	357352.85	-38.08
24.0	357280.20	357255.75	357303.56	357351.37	-23.36

* - INDICATES VALUE OUTSIDE OF 95% CONFIDENCE

THE LEAST SQUARES EQUATION IS   W = W0 + W1 * T

W0 = 357374.22 LB
W1 = -2.94 LB/HR
95% CONFIDENCE LIMIT FOR W0 = 13.19 LB
95% CONFIDENCE LIMIT FOR W1 = 0.95 LB/HR
STANDARD ERROR OF CONFIDENCE = 23.91 LB
95% CONFIDENCE LEAKAGE RATE = 0.006 % PER DAY
LEAKAGE RATE = 0.020 % PER DAY

ROBISON SUPERIMPOSED ILRT 3/6/82 1540 TO 3/7/82 0040

LEAST SQUARES RESULTS BASED ON 19 DATA POINTS

TIME PERIOD	OBSERVED WEIGHT (LB)	95% CONFIDENCE LIMIT MINUS (LB)	CALCULATED (LB)	PLUS (LB)	OBS.MINUS CALC. (LB)
0.0	357280.20	357256.93	357283.85	357310.78	-3.66
0.5	357249.76	357245.27	357272.19	357299.11	-22.43
1.0	357239.37	357233.60	357260.53	357287.45	-21.16
1.5	357255.83	357221.94	357248.86	357275.79	6.97
2.0	357235.42	357210.28	357237.20	357264.12	-1.78
2.5	357235.06	357198.61	357225.54	357252.46	9.52
3.0	357225.04	357186.95	357213.87	357240.80	11.17
3.5	357198.19	357175.28	357202.21	357229.13	-4.02
4.0	357215.01	357163.62	357190.55	357217.47	24.47
4.5	357188.17	357151.96	357178.88	357205.81	9.28
5.0	357174.56	357140.29	357167.22	357194.14	7.34
5.5	357161.32	357128.63	357155.55	357182.48	5.76
6.0	357154.88	357116.97	357143.89	357170.81	10.98
6.5	357141.63	357105.30	357132.23	357159.15	9.40
7.0	357118.01	357093.64	357120.56	357147.49	-2.56
7.5	357104.76	357081.98	357108.90	357135.82	-4.14
8.0	357098.31	357070.31	357097.24	357124.16	1.08
8.5 *	357058.22	357058.65	357085.57	357112.50	-27.35
9.0	357065.02	357046.99	357073.91	357100.83	-8.89

* - INDICATES VALUE OUTSIDE OF 95% CONFIDENCE

THE LEAST SQUARES EQUATION IS W = W0 + W1 * T

W0 = 357283.85 LB
W1 = -23.33 LB/HR
95% CONFIDENCE LIMIT FOR W0 = 12.53 LB
95% CONFIDENCE LIMIT FOR W1 = 2.38 LB/HR
STANDARD ERROR OF CONFIDENCE = 13.46 LB
95% CONFIDENCE LEAKAGE RATE = 0.016 % PER DAY
LEAKAGE RATE = 0.157 % PER DAY