DONALD C. COOK NUCLEAR PLANT UNIT 1

INDIANA & MICHIGAN POWER COMPANY

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REACTOR CONTAINMENT BUILDING
INTEGRATED LEAK RATE TEST
D. C. COOK NUCLEAR PLANT - UNIT #1

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INTRODUCTION

The Pre-Operational Integrated Leakage Rate Test (ILRT) for the Donald C. Cook Nuclear Plant - Unit 1 Reactor Containment was sucessfully completed on November 24, 1974 by members of the Indiana and Michigan Power Company and the American Electric Power Service Corporation.

As per FSAR and Technical Specifications the containment allowable leakage rate L_a is limited to 0.25 percent by weight of the containment air per twenty-four hours at a pressure P_a of 12.0 PSIG. In conformance with the criteria specified in Appendix J of 10CFR 50 this allowable leakage is reduced to 0.75 L_a which is equivalent to 0.1875 percent by weight per day. The measured leakage rate for the Donald C. Cook Nuclear Plant - Unit 1 Reactor Containment was found to be 0.16044 percent by weight per day.

This ILRT is unique in the fact that it is the first such test to be performed on an Ice Condenser equipped reactor containment.

The reactor containment is designed to insure that acceptable limits for leakage to the environment of radioactive materials are not exceeded under conditions resulting from the Design Basis Accident for doses dictated by the 10CFR 100 criteria. The steel-lined, reinforced concrete containment structure, including foundations, accesshatches, and penetrations is designed and constructed to maintain full containment integrity when subjected to accident forces.

The Reactor Containment is divided into three volumes; a lower volume which houses the reactor and Reactor Coolant System, an intermediate volume housing the energy absorbing ice bed and an upper volume which accommodates the air displaced from the other two volumes during the unlikely event of a loss-of-coolant accident.

INTRODUCTION (CONTD.)

The containment design pressure is twelve (12) PSIG.

The ILRT was performed as specified in the I&M approved Pre-Operational Test Procedure PO-033-334 written by AEPSC. The American National Standard - ANSI N45.4-1972-Leakage - Rate Testing of Containment Structures for Nuclear Reactors and 10CFR50; Appendix J were used as a guideline for the procedure. The absolute test method was used to calculate the leakage rate using data taken every thirty minutes for twenty-four hours. The normalized weight of original air remaining in the containment determined from these calculations was plotted against time and a statistically averaged leakage rate in per cent by weight per day was obtained by a linear least-squares fit to the resulting graph. Following the twenty-four hour test, a supplemental test was performed by imposing a known leak on the containment to verify the validity of the measurements made during the twenty-four hour test.

2.0 TEST CRITERIA & RESULTS

A. TEST CRITERIA

As specified in the Acceptance Criteria of the test procedure the test was considered acceptable when the following had been verified:

1. The measured leakage rate (LAM), as determined by a linear least-squares fit to a graph of calculated points, proves to be less than 0.75LA as specified in the D. C. Cook Nuclear Plant Technical Specifications.

2. The accuracy of this test has been verified by performance of the supplemental test. The measured leakage rate (LAM) is validated when the difference between the leakage rate L'AM, determined from the supplemental test, and the leakage rate LAM, determined from the linear least squares fit to the graph of calculated points, is within 0.25 L_A.

B. TEST RESULTS

During the twenty-four hours of the ILRT, computer calculations were performed to determine the leakage rate at thirty minute intervals. These calculations were made using the absolute test method based on weighted individual compartment calculations and volumetric weighting of RTDs for average compartment temperatures.

At the end of the twenty-four hours (which corresponds to computer run number 49) the measured leakage rate was 0.16191% by weight per day. A 95% confidence level was imposed on the calculations to yield a "leakage band" between 0.18564 and 0.13817 per cent per day. Note the higher limit of leakage is still below the allowable limit. With these results the twenty-four hour ILRT was considered acceptable on November 24, 1974 and the go ahead for the Supplemental Test was given. As the Supplemental Test continued the confidence limits for the leakage rate were observed as a basis for termination. A minimum test duration of six hours following the stabilization period is required as per the test procedure. After nine hours elapsed the Supplemental Test was terminated with a measured leakage of 0.33642 per cent per day and confidence limits of 0.37939 to 0.29356 per cent per day.

The known leak imposed on the containment was set to 2.70 SCFM, (flowmeter corrected), which is equivalent to 0.17544 per cent by weight per day. The Supplemental Test was performed in accordance with ANSI 45.4 and 10 CFR 50 Appendix J which state the containment leakage rate is determined by deducting the known leakage rate from the composite leakage rate. The results from the Supplemental Test are acceptable provided the difference between the Supplemental Test Data and the Type "A" test data is within 0.25La.

When the forementioned deduction is made, the difference between the Supplemental Test data and the twenty-four hour ILRT is 0.00093% per day which is well within the 0.25 La margin (0.0625% per day).

With the above results obtained from the twenty-four hour ILRT and the Supplemental Test, all Acceptance Criteria was met and the Pre-Operational Test considered acceptable.

To verify the results obtained during the actual performance of the ILRT were indeed the true leakage rate, all input data was rechecked to locate any errors. A review of the data input did reveal errors caused by handling of the input parameters. These errors were corrected and a new leakage rate of 0.16044 per cent by weight per day was computed as the official leakage rate. It should be noted that by correcting the bad data points the confidence limits were improved to a 0.17097 to 0.14991 per cent by weight per day leakage band. The Supplemental Test Data was also reviewed, corrected and rerun on the computer which calculated the official composite leakage to be 0.31501 per cent by weight per day with the confidence limits at 0.35525 to 0.27477 per cent by weight per day. When the known leak was substracted from the composite leakage rate, the leakage difference is 0.02087 per cent per day, which is well below the 0.25La acceptance.

3.0 CONDUCT OF TEST

A. ORGANIZATION OF TEST

I&M Power Company Performance Engineers were responsible for the Integrated Leak Rate Test. The testing activities were supervised by the test supervisor (1 per 12 hour shift) with support given by various sections as described in Figure 3.1.

Test responsibilities:

(1) Shift Operating Engineer

(a) Ensure that the plant is maintained in a safe condition

(2) Test Supervisor (1 per 12 hour shift)

(a) General conduct of test

(3) AEPSC Support Group (4)

(a) Technical Support to the test supervisor
(b) Test results review responsibility

(4) Timekeeper/Data Analyst (1 per 12 hour shift)

(a) Responsible for coordinating data collection and transforming data to computer input format.
(b) Responsible for preliminary review of data for correctness.

(5) Computer Operator (1 per 12 hour shift)

(a) Responsible to transfer data from computer input sheets to data cards and receiving results printout from the computer.

(6) Data Takers (4 per 12 hour shift)

(a) Responsible to readout and record specific instruments assigned to and apply correction factor to reading, if required.

(7) Startup/Maintenance (On Call)

(a) Responsible to assist and coordinate any repair work that may be required during the test.

(8) Instrument Technician (1 per 12 hour shift)

(a) Responsible for maintaining all test instrumentation in working condition.

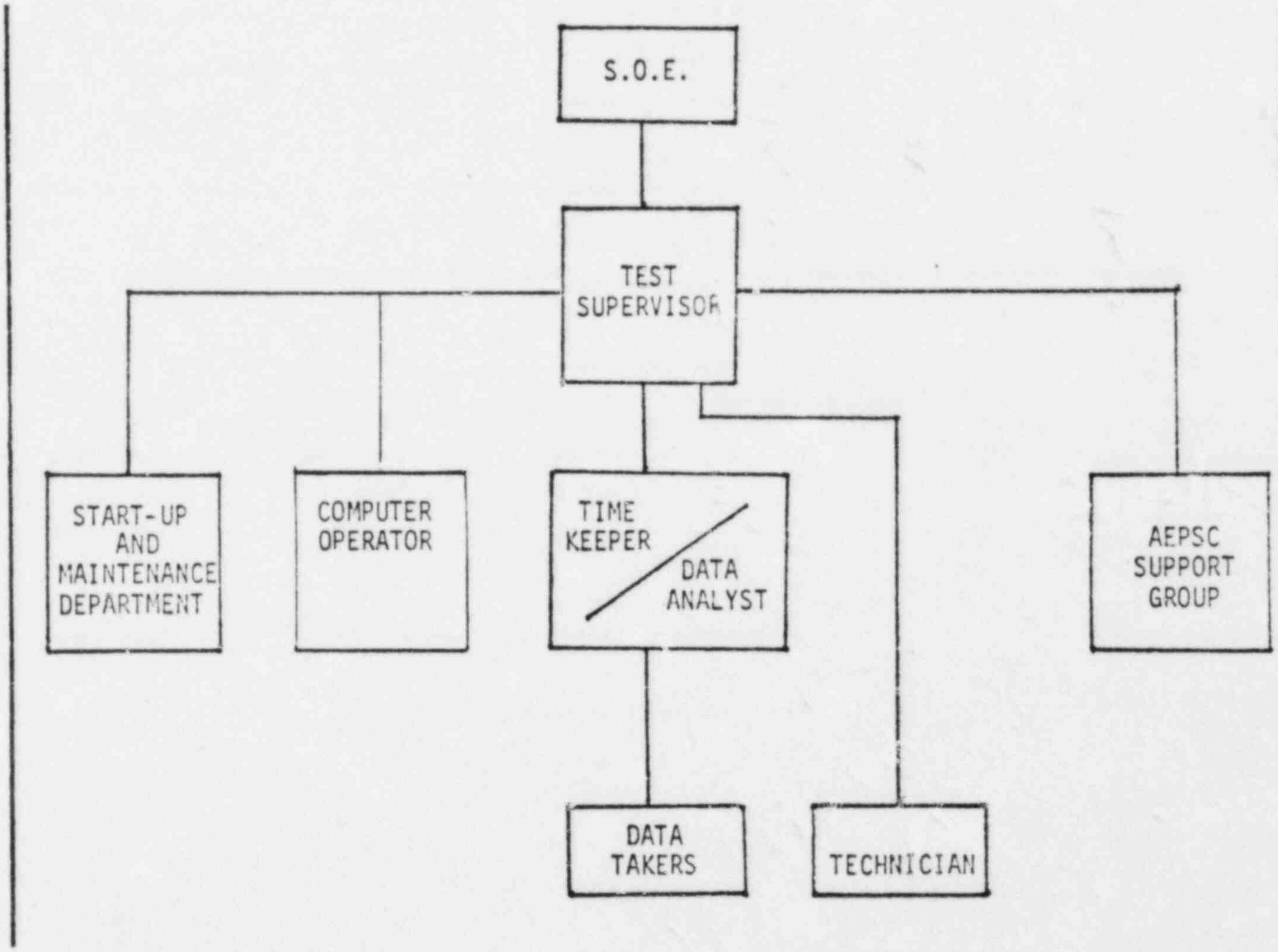

S.O.E.
TEST SUPERVISOR
START-UP AND MAINTENANCE DEPARTMENT
COMPUTER OPERATOR
TIME KEEPER
DATA ANALYST
AEPSC SUPPORT GROUP
DATA TAKERS
TECHNICIAN

FIGURE 3.1

B. LOG OF TIMES AND EVENTS

Prior to containment pressurization an inspection of all accessible interior and exterior surfaces of the Containment Structure was performed to uncover any evidence of structural deterioration. The visual inspection consisted of verifying in the log the condition of containment surfaces elevation by elevation and verifying by check list the integrity of the containment penetrations. The inspection did not uncover any adverse conditions which may have affected the leak-tightness of the containment, therefore, the pressurization of the containment was initiated.

Pressurization of the Containment Vessel for the Integrated Leakage test began at 23:22 hours on 11/20/74 and continued through 23:04 hours on 11/21/74. Data collection for this period consisted of an hourly log of the average temperatures, pressures, and vapor pressures for the 3 containment compartments. Upon attainment of test pressure, 23:15 hours on 11/21/74, pressurization was discontinued by closing the air supply valve and data collection at 1/2 hour intervals began in a preliminary attempt to determine the leakage rate and to determine if stabilization criteria could be met. After concluding that the preliminary data showed that leakage should be acceptable, the containment pressure was increased to 12.5 psig to ensure sufficient capacity for the 24 hour and supplemental tests. The containment pressurization was isolated by removing the spool piece and installing a blank flange which was leak tested. Formal data collection to verify stabilization criteria began at 12:47 hours on 11/22/74. Data collection for this period consisted of 1/2 hourly readings of forty-six containment temperatures, two ambient temperatures six containment pressures, one ambient pressure, and four dew point temperature readings. After review of the data, it was determined that temperature stabilization criteria for the Ice Condenser could not be achieved due to the cyclic operation of the air handling units causing larger than anticipated temperature deviations in this compartment. The criteria was waived for the Ice Condenser compartment and at 20:17 hours on 11/22/74 the formal 24 hour test data collection commenced. Data collection for this period was the same as for the stabilization period. Raw data was punched on cards and input to the computer for averaging and regression analysis. Final reading for the 24 hour test was recorded at 20:17 on 11/23/74 with the leakage rate equal to .16191% per day. After review of the 24 hour test data and determination of its acceptability, a known leak was introduced to the containment volume through the supplemental test flow meter and the supplemental test stabilization period began. This occured at 21:00 hours on 11/23/74. After sufficient stabilization time the Supplemental Test began at 2:00 hours on 11/24/74 and was terminated at 10:00 on 11/24/74. Data collection for the Supplemental Test was identical to that during the 24 hour test. Review of the data verified the sum of the introduced leak and the containment leakage equal to .33642% which agreed with the measured value within 25%. Therefore, all acceptance critiera were met and the Integrated Leak Rate Test was terminated.

4.0 MEASUREMENTS AND CALCULATIONS

A. TEST EQUIPMENT

The best state of the art pressure, temperature, and vapor pressure instrumentation was employed during the ILRT test. The Ice Condenser reactor containment is unique in the fact that containment design pressure is limited to 12 PSIG. This low pressure requires more accurate instrumentation to detect leakage to the same degree as for conventional containments with design pressures of 50-60 PSIG.

Six prescision Mensor Quartz manometers were used to measure containment absolute pressure. Two sensed lower volume pressure, two upper volume, and two ice condenser pressure. A seventh manometer measured ambient pressure during the test. Each instrument was supplied with an NBS certified calibration correction curve. These correction factors were applied to readings during the test. The direct reading accuracy of the manometers is ±.020% full scale with no corrections applied and ±.010% of reading + .002%F.S. when readings are corrected. The manometers have a resolution capacity of .0001 PSIA. The large resolution capability of this instrument and the fact that six sensors were used resulted in a very precise pressure determination during the ILRT.

Forty six precision RTD sensors were located in the containment for temperature determination. Seven sensors were in the Ice Condenser, twenty four in the lower volume and fifteen in the upper volume. Two sensors were also located external to the containment for an ambient temperature indication. 2,330Ω copper RTD's were used for this application. Copper was selected because its resistance temperature relationship is the quite linear in this temperature range. The high resistance sensor was specified to obtain a large change in resistance for a small change in temperature ($5\Omega/^{o}F$). This resulted in a high resolution capatility. The resistance of each sensor is readout with a Rosemount bridge whose 0-50 mv. output is fed into a Doric Scientific Corporation digital printout device. The Doric printer is programed to accept a linear 0-50 mv. input for an output range of 0-100^{o}F. Each temperature sensor, each bridge, and the Doric printer were supplied with calibrations certified to NBS. Temperature correction factors were applied. The overall temperature sensing accuracy was ±.1^{o}F. Volume fractions were also calculated for each sensor, and these weighting factors were applied to each temperature reading in the computer program.

Four Cambridge Dew Point Hydrometers were used to sense containment humidity during the test. Two units sensed lower volume dew point, one Ice Condenser and one in the upper volume. Each unit is complete with its own sample pump which draws the sample through the mirror surface sensor. The sensor is cooled until vapor is formed on the mirror surface and electronic circuitry is used to maintain an equilibrium condition on the sensor. The sensor temperature is measured by the use of a platinum RTD. Each RTD had certification to NBS. The overall dew-point temperature sensing accuracy is ±.5^{o}F.

A Fisher & Porter flowmeter was used to introduce a known leak during the supplemental verification test. The flowmeter was a rotometer with certification to NBS at 12.0 PSIG and 70^{o}F by the manufacturer. The specified accuracy of the meter is ±2%

The chart shown in Table 4.1 lists identification numbers and specifications of test instrumentation used during the test in tabular form.

INSTRUMENT SPECIFICATIONS

Item	Manufacturer	Type	Model	Serial #	Range	Accuracy
Pressure	Mensor	Quartz Manometer	______	632, 633, 427, 428, 425, 426, 631	0-30 PSIA	.0001 PSIG Resolution ±.010% of Reading+ ±.002% F.S.
Temperature Sensors	Minco	2330 Ω Copper RTD.	S3334	1 thru 101	0-100^{o}F	±.01^{o}F
Temperature Readout	Doric Digitrend	Linear Readout Printer 0-50 MV	210	6789	0-100^{o}F	±.04^{o}F
Temperature (Overall System)	Doric, Bridge & Sensors	______	______	______	0-100^{o}F	±.1^{o}F
Dew Point Temperature	Cambridge	Mirror Surface	992-C1	409, 428, 418, 420	-100 - +200^{o}	±.5^{o}F
Supplemental Leak	Fisher & Porter	Rotometer	10A1735S	7112AA280A1	0-17CFM	±2% f.s.
Pressure Gage	Heise	Bordon Tube	CCM	7870	0-30 PSIG	.1% f.s.

TABLE 4.1

B. SENSOR LOCATIONS

The Test Instrumentation, which included forty-six RTDs, six absolute pressure reading quartz manometers, and six vapor pressure sensing points, was located throughout the containment to give an accurate accounting of the containment environmental conditions during the test. The actual location of each sensor can be seen on the elevation and plan views of the containment found on Figure 4.1 of this report.

In general, the breakdown of sensor locations as per containment volume are as follows:

I. UPPER VOLUME

a) Fifteen Resistance Temperature detectors

1. ETR-101	9. ETR-109
2. ETR-102	10. ETR-110
3. ETR-103	11. ETR-111
4. ETR-104	12. ETR-112
5. ETR-105	13. ETR-114
6. ETR-106	14. ETR-128
7. ETR-107	15. ETR-133
8. ETR-108	

b) Two absolute pressure reading Quartz manometers.

c) One vapor pressure sensing point (one Hygrometer).

II. LOWER VOLUME

a) Twenty-four resistance temperature detectors

1. ETR-113	13. ETR-135
2. ETR-122	14. ETR-136
3. ETR-123	15. ETR-137
4. ETR-124	16. ETR-138
5. ETR-125	17. ETR-139
6. ETR-126	18. ETR-140

II LOWER VOLUME (CONTD.)

7. ETR-127	19. ETR-141
8. ETR-129	20. ETR-142
9. ETR-130	21. ETR-143
10. ETR-131	22. ETR-144
11. ETR-132	23. ETR-145
12. ETR-134	24. ETR-146

b) Two absolute pressure reading Quartz Manometers

c) Four vapor pressure sensing points (two Hygrometers).

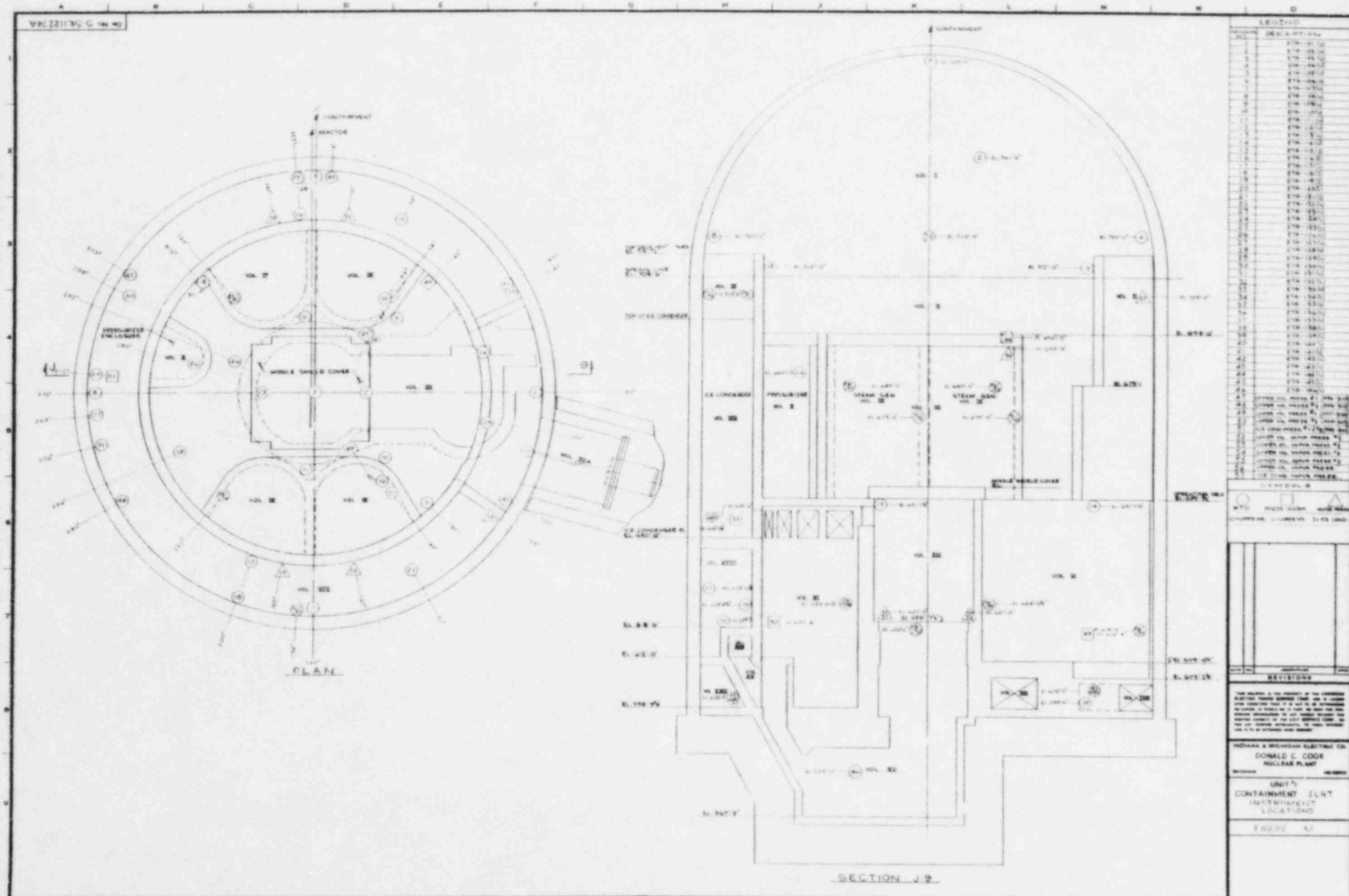
III ICE CONDENSER VOLUME

a) Seven resistance temperature detectors

1. ETR-115	5. ETR-119
2. ETR-116	6. ETR-120
3. ETR-117	7. ETR-121
4. ETR-118	

b) Two absolute pressure reading Quartz Manometers

c) One vapor pressure sensing point (One Hygrometer).


PLAN
SECTION J-J
MISSILE SHIELD COVER
PRESSURIZER ENCLOSURE
CONTAINMENT
REACTOR
ICE CONDENSER
PRESSURIZER
STEAM GEN
TOP OF ICE CONDENSER
LEGEND
DESCRIPTION
SYMBOLS
REVISIONS
INDIANA & MICHIGAN ELECTRIC CO.
DONALD C. COOK
NUCLEAR PLANT
UNIT 1
CONTAINMENT ILRT
INSTRUMENT
LOCATIONS

C. PRESSURIZATION APPARATUS

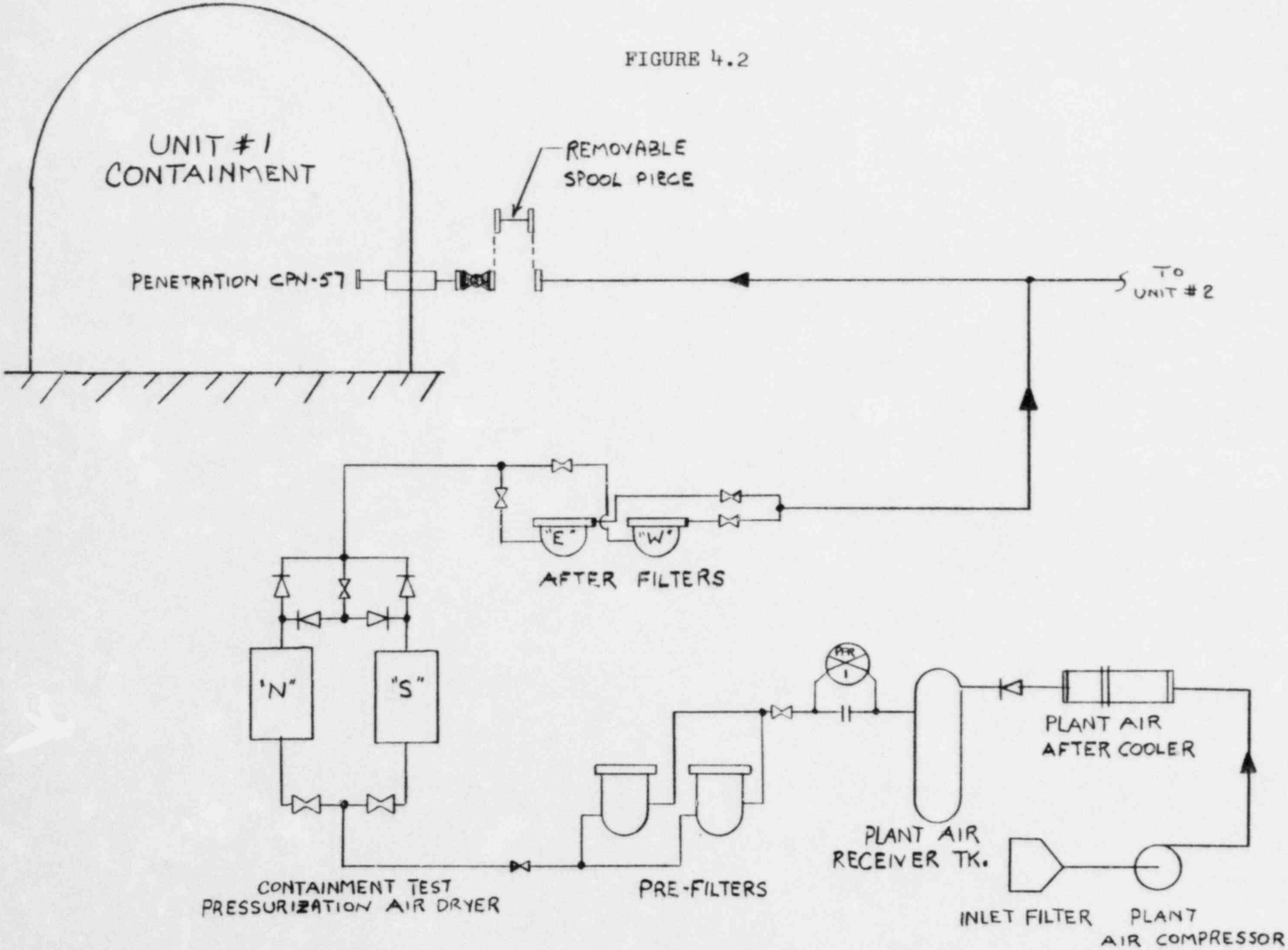
The Plant air system was used to pressurize the ontainment for the Integrated Leakage Rate Test. A three stage centrifugal air compressor located in the turbine room supplies compressed air to the plant air system. The compressor is designed to provide 1500 cfm of oil free compressed air at a discharge pressure of 100 psig continuously. Air discharged from the plant air compressor retains the third stage heat of compression. An aftercooler installed in the discharge line, is designed to cool the air to within 10°F of its inlet cooling water temperature. The condensed moisture resulting from the cooling is removed by a cyclone-type separator installed immediately downstream of the aftercooler. The air discharged from the moisture seperator is fed through the plant air system to the Containment test pressurization filters and dryers. In order to avoid condensing water vapor during the test the plant air supplied is dried to a dew point that is below the coldest temperature anticipated in the Ice Condenser. Two parallel, 100 percent capacity strings of prefilters prevent contamination of the drying dessicants from moisture carryover or scale. Two afterfilters in parallel protect the containment from desicant dusting.

The dried and filtered air is fed through a three inch test line, spool piece, and valve to penetration #CPN-57. This valve was used to throttle the air flow during pressurization and de-pressurization. The spool piece was used to isolate the containment volume from the pressurization system after stabilization was met during the test.

PRESSURIZATION APPARATUS (CONT'D.)

The spool piece was removed after pressurization was complete. A blank flange was installed and leak tested to prevent out leakage from the penetration. See Figure 4.2 for sketch of pressurization apparatus.

FIGURE 4.2


UNIT #1
CONTAINMENT
PENETRATION CPN-57
REMOVABLE
SPOOL PIECE
TO
UNIT #2
"E"
"W"
AFTER FILTERS
'N"
"S"
CONTAINMENT TEST
PRESSURIZATION AIR DRYER
PRE-FILTERS
PLANT AIR
RECEIVER TK.
PLANT AIR
AFTER COOLER
INLET FILTER
PLANT
AIR COMPRESSOR

D. RTD WEIGHTING FACTORS

Calculations for containment leakage were made using individual weightingfactors for each temperature sensing RTD. The RTD weighting factors were computed in two ways; volumetric weighting and mass weighting,with a leakage rate calculation made for both.

I. Volumetric Weighting of RTDs

In computing the weighting factor for RTDs by the volumetric method,each containment volume was sectioned off by elevation and/or structural barriers to form representitive RTD volumes. These volumes were calculated using approved Indiana and Michigan Layout drawings for the D.C. Cook Nuclear Plant. The individual weighting factor for each RTD was computed using the formula:

$$\text{Weighting Factor} = \frac{\text{Representitive RTD Volume}}{\text{Total Compartment Volume}} \times \frac{1}{\text{Number RTDs in Representitive Vol.}}$$

The total of all RTD weighting factors for each containment compartment is equal to one. A listing of all RTD weighting factors determined by the volumetric method can be found on Table 4.2 of this report.

II Mass Weighting of RTDs

In computing the weighting factors for RTDs using the mass weighting method the ideal gas law is applied. In addition, it is concluded, quite naturally, that the total mass of air in each compartment is equal to the sum of the masses in each of the representitive volumes. The representitive RTD volumes are the same as determined for the volumetric weighting method.

II Mass Weighting of RTDs (Contd.)

From the ideal gas law; solving for the total mass W on a compartmental basis we get:

$$W = \frac{PV_T}{RT_{avg}} = \frac{PV_1}{RT_1} + \frac{PV_2}{RT_2} + \cdots$$

Where:

P = Pressure in containment compartment

V_T = Total compartment volume

V_1 = Representative volume for RTD #1

V_2 = Representative volume for RTD #2

R = Gas constant for air

T_{avg} = Average compartment temperature

T_1 = RTD #1 Temperature reading

T_2 = RTD #2 temperature reading

It can be seen from the above equation that each RTD reading is instrumental in calculating the mass in its representative volume.

Rearranging and cancelling like terms we get:

$$\frac{1}{T_{avg}} = \frac{V_1}{V_T}\left(\frac{1}{T_1}\right) + \frac{V_2}{V_T}\left(\frac{1}{T_2}\right) + \cdots$$

This equation is used to compute the weighted average temperature for each particular containment compartment.

TABLE 4.2

VOLUMETRIC WEIGHTING OF RTDs

I UPPER VOLUME

RTD NO.	WEIGHTING FACTOR
ETR-101	0.0651
ETR-102	0.1203
ETR-103	0.0861
ETR-104	0.0861
ETR-105	0.0995
ETR-106	0.0995
ETR-107	0.0995
ETR-108	0.0995
ETR-109	0.0306
ETR-110	0.0306
ETR-111	0.0306
ETR-112	0.0306
ETR-114	0.0938
ETR-128	0.0109
ETR-133	0.0173
TOTAL	1.0000

TABLE 4.2
VOLUMETRIC WEIGHTING OF RTDs

II LOWER VOLUME

RTD NO.	WEIGHTING FACTOR
ETR-113	0.0597
ETR-122	0.0388
ETR-123	0.0388
ETR-124	0.0388
ETR-125	0.0388
ETR-126	0.0130
ETR-127	0.0266
ETR-129	0.0547
ETR-130	0.0080
ETR-131	0.0248
ETR-132	0.0547
ETR-134	0.0976
ETR-135	0.0976
ETR-136	0.0976
ETR-137	0.0976
ETR-138	0.0467
ETR-139	0.0086
ETR-140	0.0228
ETR-141	0.0135
ETR-142	0.0159
ETR-143	0.0232
ETR-144	0.0204
ETR-145	0.0224
ETR-146	0.0394
TOTAL	1.0000

TABLE 4.2
VOLUMETRIC WEIGHTING OF RTDs

III ICE CONDENSER COMPARTMENT

RTD NO.		WEIGHTING FACTOR
ETR-115		0.1442
ETR-116		0.1442
ETR-117		0.1490
ETR-118		0.1490
ETR-119		0.1300
ETR-120		0.1619
ETR-121		0.1217
	TOTAL	1.0000

E. COMPUTER PROGRAM

The program calculates the amount of air in each compartment as based on the fractional amount of air originally in each compartment at the start of the test (Computer Run #1). The fractional amounts of air in each compartment are then combined to yield the fractional amount of air for the entire reactor containment. The program computes the leak rate at a given time from input values of pressure, temperature and vapor pressure. The leak rate, as a function of time, is determined by the least-squares method.

The program is designed to allow evaluation of test results every half-hour after the first 3 sets of data. The print out consists of a summary of all sets of data up to and including the data just submitted. Included are fractional air reports for each compartment, for the containment as a whole, as well as the 24-hr leak rate at the time each set of data was taken. In addition, the upper and lower leakage bounds associated with the 95% confidence limits are printed out.

EXPLANATION OF PROGRAM

Part One (actually a separate program).

Raw data corrected for instrument calibration, for the pressures, temperatures and vapor pressures of each compartment is inputed along with the run number and the elapsed time from the start of the test.

The computer then prints out the corrected data and the volume weighted average temperatures. The output is then examined for correctness of data input. If any incorrect data is detected, new input cards are prepared and the entire data deck for that particular run number re-submitted.

During our subsequent analysis, the entire data deck was rerun with a different program that yielded mass-weighted temperature averages. The difference in results is discussed in the Analysis and Interpretation section of this report.

Part Two (Leak rate on daily basis)

1. The leak rate is given by the Equation:

$$W = \frac{T_1 \, (P_2 - P_{v2})}{T_2 \, (P_1 - P_{v1})}$$

Where W = Fractional amount of air in compartment

T1 = Average temperature of start of test - $^{\circ}R$

T2 = Average temperature at time of run $^{\circ}R$

P1 = Average pressure at start of test - PSIA

P2 = Average pressure at time of run - PSIA

Pv1 = Average vapor pressure at start of test - PSIA

Pv2 = Average vapor pressure at time of run - PSIA

This is calculated three times, once for each compartment.

2. The fractional amounts for the three compartments were combined by:

$$W = \frac{4.2959\left(\frac{P-P_v}{T}\right)_U + 2.2835\left(\frac{P-P_v}{T}\right)_L + \left(\frac{P-P_v}{T}\right)_I}{4.2959\left(\frac{P-P_v}{T}\right)_{UO} + 2.2835\left(\frac{P-P_v}{T}\right)_{LO} + \left(\frac{P-P_v}{T}\right)_{IO}}$$

Where U Stands for upper containment
L Stands for lower containment
I Stands for Ice Condenser
O Stands for reading at the start of the test.

3. Statistical Treatment

A least squares analysis of a plot of the values of W versus time yields a straight line. The slope of this line is the fractional leakage per hour. This is converted to % per day leakage by multiplying by 2400.

The slope of the least squares fit line is

$$b = \frac{(2t+1)\Sigma Wt - \Sigma W \Sigma t}{(2t+1)\Sigma t^2 - (\Sigma t)^2}$$

Where t is time in hours.

In order to check the confidence limits, the following calculations were made:

The vertical intercept

$$a = \frac{\Sigma t^2 \Sigma W - \Sigma t \Sigma Wt}{(2t+1)\Sigma t^2 - (\Sigma t)^2}$$

The variance of W

$$s_w^2 = \frac{\Sigma (W - a - bt)^2}{(2t - 1)}$$

The variance of the slope

$$S_b^2 = \frac{S_w^2}{\Sigma (t - \bar{t})^2}$$

Where $\bar{t}$ = average value of t.

The confidence limits were expressed as

$b \pm K S_b$, where K is taken from a table showing the variation of K with the number of runs completed.

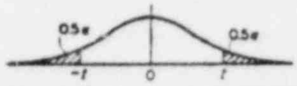


TABLE A-8
Distribution of K

Degrees of freedom ν	Probability α			
	0.10	0.05	0.01	0.001
1	6.314	12.706	63.657	636.619
2	2.920	4.303	9.925	31.598
3	2.353	3.182	5.841	12.941
4	2.132	2.776	4.604	8.610
5	2.015	2.571	4.032	6.859
6	1.943	2.447	3.707	5.959
7	1.895	2.365	3.499	5.405
8	1.860	2.306	3.355	5.041
9	1.833	2.262	3.250	4.781
10	1.812	2.228	3.169	4.587
11	1.796	2.201	3.106	4.437
12	1.782	2.179	3.055	4.318
13	1.771	2.160	3.012	4.221
14	1.761	2.145	2.977	4.140
15	1.753	2.131	2.947	4.073
16	1.746	2.120	2.921	4.015
17	1.740	2.110	2.898	3.965
18	1.734	2.101	2.878	3.922
19	1.729	2.093	2.861	3.883
20	1.725	2.086	2.845	3.850
21	1.721	2.080	2.831	3.819
22	1.717	2.074	2.819	3.792
23	1.714	2.069	2.807	3.767
24	1.711	2.064	2.797	3.745
25	1.708	2.060	2.787	3.725
26	1.706	2.056	2.779	3.707
27	1.703	2.052	2.771	3.690
28	1.701	2.048	2.763	3.674
29	1.699	2.045	2.756	3.659
30	1.697	2.042	2.750	3.646
40	1.684	2.021	2.704	3.551
60	1.671	2.000	2.660	3.460
120	1.658	1.980	2.617	3.373
∞	1.645	1.960	2.576	3.291

This table gives the values of t corresponding to various values of the probability α (level of significance) of a random variable falling inside the shaded areas in the figure, for a given number of degrees of freedom ν available for the estimation of error. For a one-sided test the confidence limits are obtained for $\alpha/2$.

This table is taken from Table III of Fisher & Yates: *Statistical Tables for Biological, Agricultural, and Medical Research* published by Oliver & Boyd Ltd., Edinburgh, by permission of the authors and publishers.

The above table used to determine the variation of K has been extracted from Basic Statistical Methods For Engineers and Scientists.

```
C              *********************************************
C              *                                           *
C              *      COOK CONTAINMENT VESSEL DATA PROGRAM *
C              *                                           *
C              *         THIS PROGRAM ENTITLED CCVDREP:    *
C              *                                           *
C              *    1.READS RAW INPUT DATA FOR THE LINEAR  *
C              *      REGRESSION ANALYSIS PROGRAM:CCVREPT  *
C              *    2.WRITES THIS DATA AS A MEANS OF       *
C              *      ERROR CHECKING                       *
C              *    3.CALCULATES THE AVERAGE TEMPERATURE   *
C              *      PRESSURE AND VAPOR PRESSURE FOR EACH *
C              *      CHAMBER AND OUTPUTS THESE RESULTS    *
C              *      AS A CUMMULATIVE SUMMARY.            *
C              *    4.CALCULATES A W FOR EACH CHAMBER AS   *
C              *      WELL AS A TOTAL W.THESE CALCULATIONS *
C              *      ARE SAVED ON A DISK DATA SET TO BE   *
C              *      USED AS THE DATA  FOR THE REGRESSION *
C              *      ANALYSIS PROGRAM                     *
C              *    5.THE OUTPUT OF THIS PROGRAM SERVES    *
C              *      AS THE FINAL FORMAT FOR PRESENTATION *
C              *      TO THE A.E.C.                        *
C              *                                           *
C              *********************************************
      DIMENSION TEMPUC(15),PRESUC(2),TEMPLC(24),PRESLC(2)
      DIMENSION VPRELC(2),TEMPIC(7),PRESIC(2)
      INTEGER*2 NR,NRR,N2R
      REAL*8 WUCDEM,WLCDEM,WICDEM,WDEM,WUC(99),WLC(99),WIC(99),W(99)
      REAL*8 TIME(98),ATUC,ATLC,ATIC,APUC,APLC,APIC
      REAL*8 AVPUC,AVPLC,AVPIC,D5,D2
      REAL*8 WUCNUM,WLCNUM,WICNUM,WNUM
      DEFINE FILE 4(99,146,L,ID)
   13 READ(5,100,END=12)NR,TIME(NR)
  100 FORMAT(I2,1X,F5.2)
      WRITE(6,200)NR,TIME(NR)
  200 FORMAT(1H1,44X,'*** THIS IS A CHECK OF THE INPUT DATA ***'///1H ,'
     *RUN #',5X,'TIME',21X,'TEMPERATURE READINGS',11X,'PRESSURE READINGS
     *',11X,'VAPOR PRESSURE READINGS'/1H ,1X,I2,6X,F6.2,26X,'OF UPPER',2
     *2X,'OF UPPER',24X,'OF UPPER'/1H ,38X,'CONTAINMENT',19X,'CONTAINMEN
     *T',21X,'CONTAINMENT'/)
      READ(5,101)(TEMPUC(I),I=1,15),(PRESUC(I),I=1,2),VPREUC
  101 FORMAT(10(F5.2,1X)/5(F5.2,1X),2(F7.4,1X),F6.4)
      WRITE(6,201)TEMPUC(1),PRESUC(1),VPREUC
  201 FORMAT(1H ,40X,F6.2,24X,F8.4,22X,F7.4)
      WRITE(6,202)TEMPUC(2),PRESUC(2)
  202 FORMAT(1H ,40X,F6.2,24X,F8.4)
      WRITE(6,203)(TEMPUC(I),I=3,15)
  203 FORMAT(1H ,40X,F6.2)
      WRITE(6,204)
  204 FORMAT(1H0,35X,'TEMPERATURE READINGS',11X,'PRESSURE READINGS',11X,
     *'VAPOR PRESSURE READINGS'/1H ,40X,'OF LOWER',22X,'OF LOWER',24X,'O
     *F LOWER'/1H ,38X,'CONTAINMENT',19X,'CONTAINMENT',21X,'CONTAINMENT'
```

```
     */)
      READ(5,102)(TEMPLC(I),I=1,24),(PRESLC(I),I=1,2),(VPRELC(I),I=1,2)
  102 FORMAT(12(F5.2,1X)/12(F5.2,1X)/2(F7.4,1X),2(F6.4,1X))
      WRITE(6,201)(TEMPLC(I),PRESLC(I),VPRELC(I),I=1,2)
      WRITE(6,203)(TEMPLC(I),I=3,24)
      WRITE(6,206)
  206 FORMAT(1H1,35X,'TEMPERATURE READINGS',11X,'PRESSURE READINGS',11X,
     *'VAPOR PRESSURE READINGS'/1H ,40X,'OF ICE',24X,'OF ICE',28X,'OF IC
     *E'/1H ,38X,'CONDENSER',21X,'CONDENSER',25X,'CONDENSER'/)
      READ(5,103)(TEMPIC(I),I=1,7),(PRESIC(I),I=1,2),VPREIC
  103 FORMAT(7(F5.2,1X),2(F7.4,1X),F6.4)
      WRITE(6,201)TEMPIC(1),PRESIC(1),VPREIC
      WRITE(6,202)TEMPIC(2),PRESIC(2)
      WRITE(6,203)(TEMPIC(I),I=3,7)
      REAL*8 WTUP(15)/.0651,.1203,2*.0861,4*.0995,4*.0306,.0938,.0109,.0
     *173/
      REAL*8 WTLOW(24)/.0597,4*.0388,.0130,.0266,.0547,.0080,.0248,.0547
     *,4*.0976,.0467,.0086,.0228,.0135,.0159,.0232,.0204,.0224,.0394/
      REAL*8 WTICE(7)/.1442,2*.1490,.1300,.1619,.1217,.1442/
      REAL*8 TMSMUC,PRSMUC,TMSMLC,PRSMLC,VPSMLC,TMSMIC,PRSMIC
      TMSMUC=0.
      DO 1 J=1,15
    1 TMSMUC=TMSMUC+(TEMPUC(J)+459.7)*WTUP(J)
      ATUC=TMSMUC
      PRSMUC=0.
      DO 2 K=1,2
    2 PRSMUC=PRSMUC+PRESUC(K)
      APUC=PRSMUC/2.
      AVPUC=VPREUC
      WRITE(6,207)ATUC,APUC,AVPUC
  207 FORMAT(1H-,36X,'AVG TEMP UPPER CONT',8X,'AVG PRESSURE UPPER CONT',
     *8X,'AVG V PRESSURE UPPER CONT'//1H ,39X,F9.4,18X,F9.4,24X,F9.4/)
      TMSMLC=0.
      DO 3 L=1,24
    3 TMSMLC=TMSMLC+(TEMPLC(L)+459.7)*WTLOW(L)
      ATLC=TMSMLC
      PRSMLC=0.
      DO 4 M=1,2
    4 PRSMLC=PRSMLC+PRESLC(M)
      APLC=PRSMLC/2.
      VPSMLC=0.
      DO 5 IN=1,2
    5 VPSMLC=VPSMLC+VPRELC(IN)
      AVPLC=VPSMLC/2.
      WRITE(6,208)ATLC,APLC,AVPLC
  208 FORMAT(1H-,36X,'AVG TEMP LOWER CONT',8X,'AVG PRESSURE LOWER CONT',
     *8X,'AVG V PRESSURE LOWER CONT'//1H ,39X,F9.4,18X,F9.4,24X,F9.4/)
      TMSMIC=0.
      DO 6 IT=1,7
    6 TMSMIC=TMSMIC+(TEMPIC(IT)+459.7)*WTICE(IT)
      ATIC=TMSMIC
      PRSMIC=0.
      DO 7 JJ=1,2
    7 PRSMIC=PRSMIC+PRESIC(JJ)
      APIC=PRSMIC/2.
      AVPIC=VPREIC
      WRITE(6,209)ATIC,APIC,AVPIC
  209 FORMAT(1H-,36X,'AVG TEMP ICE CONDEN',8X,'AVG PRESSURE ICE CONDEN',
```

```
     *8X,'AVG V PRESSURE ICE CONDEN'//1H ,39X,F9.4,18X,F9.4,24X,F9.4)
      D5=4.2959
      D2=2.2835
      IF(NR-1)8,8,9
    8 WUCDEM=(APUC-AVPUC)/ATUC
      WLCDEM=(APLC-AVPLC)/ATLC
      WICDEM=(APIC-AVPIC)/ATIC
      WDEM=WICDEM+D5*WUCDEM+D2*WLCDEM
      N2R=NR
      WRITE(4'1)N2R,TIME(N2R),WUCDEM,WLCDEM,WICDEM,WDEM
      NRR=NR
      WRITE(4'99)NRR
    9 READ(4'1)N2R,TIME(N2R),WUCDEM,WLCDEM,WICDEM,WDEM
      WUCNUM=(APUC-AVPUC)/ATUC
      WUC(NR)=WUCNUM/WUCDEM
      WLCNUM=(APLC-AVPLC)/ATLC
      WLC(NR)=WLCNUM/WLCDEM
      WICNUM=(APIC-AVPIC)/ATIC
      WIC(NR)=WICNUM/WICDEM
      WNUM=WICNUM+D5*WUCNUM+D2*WLCNUM
      W(NR)=WNUM/WDEM
      IF(NR-1)10,10,11
   10 N2R=NR
      WRITE(4'1)N2R,TIME(N2R),WUCDEM,WLCDEM,WICDEM,WDEM,ATUC,APUC,AVPUC,
     *ATLC,APLC,AVPLC,ATIC,APIC,AVPIC,WUC(N2R),WLC(N2R),WIC(N2R),W(N2R)
      GO TO 13
   11 WRITE(4'NR)NR,TIME(NR),ATUC,APUC,AVPUC,ATLC,APLC,AVPLC,ATIC,APIC,A
     *VPIC,WUC(NR),WLC(NR),WIC(NR),W(NR)
      READ(4'99)NRR
      IF(NR-NRR)13,13,14
   14 NRR=NR
      WRITE(4'99)NRR
      GO TO 13
   12 STOP
      END
```

```
C          ************************************************
C          *                                              *
C          *  COOK CONTAINMENT VESSEL REGRESSION PROGRAM  *
C          *                                              *
C          *     THIS PROGRAM ENTITLED CCVREPT:           *
C          *                                              *
C          *   1.READS THE DISK DATA SET THAT             *
C          *     WAS CREATED BY THE CCVDREP PROGRAM       *
C          *   2.PERFORMS A LINEAR REGRESSION             *
C          *     ANALYSIS TEST ON THESE DATA POINTS       *
C          *   3.THE ANALYSIS IS PERFORMED ON THE         *
C          *     CURRENT MAXIMUM NUMBER OF DATA POINTS.   *
C          *   4.THE W EXPERIMENTAL,THE W REGRESSION,     *
C          *     THE LEAKAGE RATE,CONFIDENCE LIMITS       *
C          *     FOR THE RATE,AS WELL AS THE INTERCEPT    *
C          *     ARE ALL OUTPUTED.                        *
C          *   5.THE OUTPUT OF THIS PROGRAM SERVES AS     *
C          *     THE FINAL FORMAT TO BE PRESENTED TO      *
C          *     THE A.E.C.                               *
C          *                                              *
C          ************************************************
      REAL*8 ATUC,APUC,AVPUC,ATLC,APLC,AVPLC,ATIC,APIC,AVPIC
      REAL*8 WUC(99),WLC(99),WIC(99),W(99),TIME(98)
      REAL*8 WR(99),WLR(99),WUR(99),ATAB(99)
      INTEGER*2 NR,NRR,N2R
      DIMENSION TABLE(96)
      REAL*8 A,B,BL,BH
      REAL*8 WUCDEM,WLCDEM,WICDEM,WDEM
      DEFINE FILE 4(99,146,L,ID)
      REAL*8 TSS,TS,WS,TS2W,ANUM,ADEM,BNUM,EK,WSUM,SIGMAB,XNRR,SIGMA
      REAL*8 AT,ATTN,EKK,TOT,F2,F1,F,FF
      READ(4'99)NRR
      IF(NRR-3)1,2,2
    1 WRITE(6,200)
  200 FORMAT(1H1,10X,'INSUFFICIENT NUMBER OF DATA POINTS FOR A MEANINGFU
     *L ANALYSIS TO BE RUN.MORE DATA POINTS ARE NEEDED')
      GO TO 3
    2 NRR1=2
  847 NRR1=NRR1+1
      TSS=0.0
      TS=0.0
      DO 4 I=2,NRR1
      READ(4'I)NR,TIME(I),ATUC,APUC,AVPUC,ATLC,APLC,AVPLC,ATIC,APIC,AVPI
     *C,WUC(I),WLC(I),WIC(I),W(I)
      TSS=TSS+TIME(I)**2
    4 TS=TS+TIME(I)
      READ(4'1)N2R,TIME(N2R),WUCDEM,WLCDEM,WICDEM,WDEM,ATUC,APUC,AVPUC,A
     *TLC,APLC,AVPLC,ATIC,APIC,AVPIC,WUC(N2R),WLC(N2R),WIC(N2R),W(N2R)
      WS=W(N2R)
      DO 5 J=2,NRR1
      READ(4'J)NR,TIME(J),ATUC,APUC,AVPUC,ATLC,APLC,AVPLC,ATIC,APIC,AVPI
     *C,WUC(J),WLC(J),WIC(J),W(J)
```

```
5 WS=WS+W(J)
  TS2W=0.0
  DO 6 K=2,NRR1
  READ(4'K)NR,TIME(K),ATUC,APUC,AVPUC,ATLC,APLC,AVPLC,ATIC,APIC,AVPI
 *C,WUC(K),WLC(K),WIC(K),W(K)
6 TS2W=TS2W+TIME(K)*W(K)
  ANUM=TSS*WS-TS*TS2W
  XNRR=NRR1
  ADEM=XNRR*TSS-TS**2
  A=ANUM/ADEM
  BNUM=XNRR*TS2W-TS*WS
  B=BNUM/ADEM
  DATA TABLE/12.706,4.303,3.182,2.776,2.571,2.447,2.365,2.306,2.262,
 *2.228,2.201,2.179,2.160,2.145,2.131,2.120,2.110,2.101,2.093,2.086,
 *2.080,2.074,2.069,2.064,2.060,2.056,2.052,2.048,2.045,2.042,2.040,
 *2.038,2.036,2.034,2.032,2.030,2.027,2.025,2.023,2.021,2.020,2.019,
 *2.018,2.017,2.016,2.015,2.014,2.013,2.012,2.011,2.009,2.008,2.007,
 *2.006,2.005,2.004,2.003,2.002,2.001,2*2.000,3*1.999,3*1.998,3*1.99
 *7,3*1.996,3*1.995,3*1.994,3*1.993,3*1.992,3*1.991,3*1.990,3*1.989,
 *2*1.988/
  WR(1)=A
  READ(4'2)NR,TIME(2),ATUC,APUC,AVPUC,ATLC,APLC,AVPLC,ATIC,APIC,AVPI
 *C,WUC(2),WLC(2),WIC(2),W(2)
  WR(2)=A+B*TIME(2)
  DO 7 II=3,NRR1
  READ(4'II)NR,TIME(II),ATUC,APUC,AVPUC,ATLC,APLC,AVPLC,ATIC,APIC,AV
 *PIC,WUC(II),WLC(II),WIC(II),W(II)
  WR(II)=A+B*TIME(II)
  EK=TABLE(II-2)
  READ(4'1)N2R,TIME(N2R),WUCDEM,WLCDEM,WICDEM,WDEM,ATUC,APUC,AVPUC,A
 *TLC,APLC,AVPLC,ATIC,APIC,AVPIC,WUC(1),WLC(1),WIC(1),W(1)
  WSUM=(W(1)-A)**2
  DO 8 L=2,NRR1
  READ(4'L)NR,TIME(L),ATUC,APUC,AVPUC,ATLC,APLC,AVPLC,ATIC,APIC,AVPI
 *C,WUC(L),WLC(L),WIC(L),W(L)
8 WSUM=WSUM+(W(L)-A-B*TIME(L))**2
  SIGMA=DSQRT((1./XNRR)*WSUM)
  AT=TS/XNRR
  READ(4'II)NR,TIME(II),ATUC,APUC,AVPUC,ATLC,APLC,AVPLC,ATIC,APIC,AV
 *PIC,WUC(II),WLC(II),WIC(II),W(II)
  ATTN=(TIME(II)-AT)**2
  TOT=AT**2
  DO 9 M=2,NRR1
  READ(4'M)NR,TIME(M),ATUC,APUC,AVPUC,ATLC,APLC,AVPLC,ATIC,APIC,AVPI
 *C,WUC(M),WLC(M),WIC(M),W(M)
9 TOT=TOT+(TIME(M)-AT)**2
  F2=ATTN/TOT
  F1=(XNRR+1.)/XNRR
  F=F1+F2
  FF=F*(XNRR/(XNRR-2.))
  ATAB(II)=DSQRT(FF)*SIGMA
  WLR(II)=WR(II)-EK*ATAB(II)
  WUR(II)=WR(II)+EK*ATAB(II)
7 CONTINUE
  B=B*2400.
  SIGMAB=DSQRT(WSUM/((XNRR-2.)*TOT))
  EKK=TABLE(NRR1-2)
  BL=B-(EKK*SIGMAB)*2400.
```

```
      BH=B+(EKK*SIGMAB)*2400.
      READ(4'NRR1)NR,TIME(NR),ATUC,APUC,AVPUC,ATLC,APLC,AVPLC,ATIC,APIC,
     *AVPIC,WUC(NR),WLC(NR),WIC(NR),W(NR)
      WRITE(4'NRR1)NR,TIME(NR),ATUC,APUC,AVPUC,ATLC,APLC,AVPLC,ATIC,APIC
     *,AVPIC,WUC(NR),WLC(NR),WIC(NR),W(NR),BL,B,BH,A
      WRITE(6,201)
  201 FORMAT(1H1,48X,'SUMMARY OF  AVERAGES'///1H ,2X,'RUN #',2X,'ELAPSED
     *',2X,3(34HAVG TEMP  AVG PRESS  AVG V PRESS  )/1H ,10X,'TIME',6X,'U
     *PPER',5X,'UPPER',7X,'UPPER',7X,'LOWER',5X,'LOWER',6X,'LOWER',8X,'I
     *CE',7X,'ICE',9X,'ICE'/)
      READ(4'1)N2R,TIME(N2R),WUCDEM,WLCDEM,WICDEM,WDEM,ATUC,APUC,AVPUC,A
     *TLC,APLC,AVPLC,ATIC,APIC,AVPIC
      ATUC=ATUC-459.7
      ATLC=ATLC-459.7
      ATIC=ATIC-459.7
      WRITE(6,202)N2R,TIME(N2R),ATUC,APUC,AVPUC,ATLC,APLC,AVPLC,ATIC,API
     *C,AVPIC
  202 FORMAT(1H ,2X,I3,4X,F6.2,2X,3(F9.4,2X,F9.4,3X,F9.4,2X))
      DO 846 JG=2,NRR1
      READ(4'JG)NR,TIME(NR),ATUC,APUC,AVPUC,ATLC,APLC,AVPLC,ATIC,APIC,AV
     *PIC
      ATUC=ATUC-459.7
      ATLC=ATLC-459.7
      ATIC=ATIC-459.7
  846 WRITE(6,202)NR,TIME(NR),ATUC,APUC,AVPUC,ATLC,APLC,AVPLC,ATIC,APIC,
     *AVPIC
      WRITE(6,205)
  205 FORMAT(1H1,34X,'RESULTS OF THE LINEAR REGRESSION ANALYSIS TEST'///
     *1H ,2X,'RUN #',8X,'W',11X,'LEAKAGE RATE',9X,'LEAKAGE',9X,'LEAKAGE
     *RATE',8X,'W UPPER',7X,'W LOWER',9X,'W ICE'/1H ,10X,'EXPERIMENTAL',
     *6X,'LOWER LIMIT',11X,'RATE',11X,'UPPER LIMIT',5X,'CONTAINMENT',3X,
     *'CONTAINMENT',5X,'CONDENSER'/)
      DO 845 JG2=3,NRR1
      READ(4'JG2)NR,TIME(JG2),ATUC,APUC,AVPUC,ATLC,APLC,AVPLC,ATIC,APIC,
     *AVPIC,WUC(JG2),WLC(JG2),WIC(JG2),W(JG2),BL,B,BH,A
  845 WRITE(6,206)NR,W(JG2),BL,B,BH,WUC(JG2),WLC(JG2),WIC(JG2)
  206 FORMAT(1H ,3X,I3,4X,F9.5,9X,F9.5,9X,F9.5,10X,F9.5,8X,F9.5,5X,F9.5,
     *6X,F9.5)
      READ(4'99)NRR
      IF(NRR1-NRR)847,844,844
  844 READ(4'NRR1)NR,TIME(NR),ATUC,APUC,AVPUC,ATLC,APLC,AVPLC,ATIC,APIC,
     *AVPIC,WUC(NR),WLC(NR),WIC(NR),W(NR),BL,B,BH,A
      WRITE(6,203)B,A
  203 FORMAT(1H0,21X,'FINAL LEAKAGE RATE (% PER DAY) =',F9.5,5X,'INTERCE
     *PT=',F9.5)
      WRITE(6,204)BL,BH
  204 FORMAT(1H0,21X,'FINAL CONFIDENCE LIMITS FOR THE RATE ARE ',F9.5,'
     *TO ',F9.5)
    3 STOP
      END
```

5.0 ANALYSIS AND INTERPRETATION

The previous sections of this report described the method of measuring and computing the containment leakage rate. This section will present the observations, discuss the problems encountered and the conclusions drawn from the performance and analysis of this ILRT.

A. DISCUSSION OF GRAPHICAL DATA

Figures 5.1 and 5.2 are the graphical representations of the calculated leakage rates as determined from the twenty-four hour ILRT and the Supplemental Test respectively. The axis of these graphs are the normalized weight of original air remaining in the containment versus time (or run). The slope of the least squares line is the leakage rate.

In reviewing these graphs it is observed that the normalized value of the weight of original air remaining in the containment tends to cyclic. The cycling of normalized weight is experienced throughout the entire twenty-four hour ILRT and is also present in the Supplementary Test. This behavior is directly influenced by the cycling value of the normalized weight of air remaining in the Ice Condenser Compartment. This is in turn related to the cycling temperature experienced in this compartment (see Figure 5.5) caused by the periodic defrosting of the Ice Condenser air handler cooling coils.

The average vapor pressure plot for each compartment, found in Figure 5.4, indicates a steady increase for both Upper and Lower Compartments while the Ice Condenser Compartment tends to cycle slightly while increasing. Again the Ice Condenser's abnormal behavior was influenced by the periodic operation of the air handler's defrost mode which in turn caused the Ice Condenser temperature to cycle. It is important to note at this time that, due to what was thought to be a malfunction in the Ice Condenser's dew point sensing hygrometer, it was decided that the Ice Condenser vapor pressure would be determined using the average compartment temperature and hygrometric tables prepared by the Smithsonian Institution for the saturation vapor pressure over ice. Subsequent inspection of the sampling line, from the Ice Condenser Compartment to the hygrometer, revealed that the line was open at approximately El. 670 ft. and was actually sampling Upper Compartment atmosphere.

Figure 5.3 shows a plot of the absolute pressure in each compartment during the twenty-four hours of the ILRT. The graph indicates a steady decay of pressure in the containment with slight fluctuations, the largest of which is approximately 0.002 psi. The extreme accuracy in which the Quarz Manometers can measure the change in pressure can be seen in the tabulation of data found in Section 6.0. When the initial and final absolute pressure readings of the Upper, Lower and Ice Condenser compartments are compared, the measured change in pressure is 0.0509, 0.0505 and 0.0500 psi respectively. It was therefore concluded that the Quartz manometers gave an accurate indication of containment pressure.

A review of the average temperature plot, found in Figure 5.5, indicates a relatively stable trend for both upper and lower compartments. The Upper Compartment experienced a defective RTD (ETR-103) just prior to the start of the test. Therefore, for the purpose of calculating temperature in the Upper Compartment, the reading of an RTD (ETR-102) in same general vicinity with the same weighting factor was substituted for the defective one. The problem RTD was demonstrated as being defective, after the completion of the test, by measuring its resistance which proved to be far above the manufactured specification. The temperature plot also indicates that the Ice Condenser's average temperature tends to cycle. This cycling of temperature was brought on by the periodic defrosting of the Ice Condenser air handler cooling coils. For this reason, it was impossible for the Ice Condenser Compartment to meet the temperature stablization criteria set forth in the test procedure.

B. COMPARISON OF ONE VOLUME WITH THREE VOLUME METHOD

The method employed in this report was based on calculating the weight of air in each of the three compartments, combining them into the weight of air in one compartment, and then normalizing the result. The purpose of this section of the report is to explore the possibility of considering the entire containment as one compartment.

The pressures at all points in the containment should be the same. An average of all six pressure readings would give an adequate figure for substitution into a one volume formula.

However, since there is no reason for the temperatures to be the same, we must be careful about the method for calculating the average temperature to be used for substitution in a one volume formula.

Since the whole equals the sum of its parts:

$$W = W_1 + W_2 + W_3 + \cdots$$

$$\frac{PV}{RT} = \frac{P_1 V_1}{R T_1} + \frac{P_2 V_2}{R T_2} + \frac{P_3 V_3}{R T_3} + \cdots$$

We can eliminate R and all the values of P from this equation since $P = P_1 = P_2 = P_3 = \cdots$

$$\frac{V}{T} = \frac{V_1}{T_1} + \frac{V_2}{T_2} + \frac{V_3}{T_3} + \cdots$$

$$\frac{1}{T} = \frac{1}{T_1}\left(\frac{V_1}{V}\right) + \frac{1}{T_2}\left(\frac{V_2}{V}\right) + \frac{1}{T_3}\left(\frac{V_3}{V}\right) + \cdots$$

If we substitute "upper" for "1", "lower" for "2", "ice" for "3", and use "0" to designate original values we can solve:

W (Normalized) =

$$\frac{W}{W_o} = \frac{\frac{PV}{RT}}{\frac{P_o V_o}{R T_o}} = \frac{\frac{P}{R}\left[\left(\frac{V}{T}\right)_U + \left(\frac{V}{T}\right)_L + \left(\frac{V}{T}\right)_I\right]}{\frac{P_o}{R}\left[\left(\frac{V}{T}\right)_{OU} + \left(\frac{V}{T}\right)_{LO} + \left(\frac{V}{T}\right)_{IO}\right]}$$

But this is a variation of the formula that we used to combine the three volumes into one in the 3 volume method.

In conclusion, the act of determining a weighted average for the temperature forces us to go through the same steps, and leads to the same result, as calculating masses in the three separate compartments and then combining the masses into one.

C. ERROR ANALYSIS

The following Error Analysis is based on the parameters measured during the actual ILRT.

Leakage during the test resulted in a drop in pressure of about 0.05 psi. Temperature and vapor pressure were measured but were not directly related to leakage.

Since the total pressure should be essentially the same throughout the containment, all six pressure gages should show the same change in pressure throughout the test. The actual measurements show:

Mean Change: 0.0504 psi

Std. Deviation: ± 0.00053 psi

Probable Error: ± 0.00036 psi

At time zero (beginning of test) the probable error of the mean temperature was:

± 0.19 °F Upper Containment

± 0.27 °F Lower Containment

± 0.80 °F Ice Compartment

and after 24 hours was:

± 0.20 °F Upper Containment

± 0.27 °F Lower Containment

± 1.07 °F Ice Compartment

The measurement of vapor pressure employed a cooled mirror, the temperature of which was accurate to ±0.5F. Multiplying this by $\frac{\partial P}{\partial T}$ yields the probable error for measurements made in each compartment.

Upper compartment-for a temperature of 62F the probable error is:

$$0.5F\ (0.01\ psi/F) = 0.005\ psi$$

Lower compartment-for a temperature of 73F the probable error is:

$$0.5F\left(\frac{0.01373\ psi/F}{\sqrt{2}}\right) = 0.005\ psi$$

Ice condenser-as was previously mentioned the dew point hygrometer was not sensing Ice Condenser atmosphere. Since the water vapor should be at saturation pressure using the mean temperature of the seven RTD's in the ice condenser yields

$$1.07F\ (0.0017\ psi/F) = 0.0018\ psi$$

It is interesting to note that the large probable error in the temperature is more than offset by the low $\frac{\partial P}{\partial T}$, giving a smaller probable error for this vapor pressure than for either of the other two vapor pressure measurements.

Probable error for combined quantities.

$$W = \frac{4.2959\left(\frac{P-P_v}{T}\right)_U + 2.2835\left(\frac{P-P_v}{T}\right)_L + \left(\frac{P-P_v}{T}\right)_I}{4.2959\left(\frac{P-P_v}{T}\right)_{UO} + 2.2835\left(\frac{P-P_v}{T}\right)_{LO} + \left(\frac{P-P_v}{T}\right)_{IO}}$$

Where P = Total pressure - PSIA

P_v = Vapor pressure - PSIA

T = Temperature - ^oR

U = Upper Containment

L = Lower Containment

I = Ice Containment

O An O added to a subscript refers to measurements made at time zero (the start of the test).

W = Fractional weight of air remaining

In order to evaluate the probable error of the above equation, it is best to use a step-by-step approach. If E represents the probable error, we calculate:

1. E^2 for $P-P_v$
2. E^2 for $\frac{P-P_v}{T}$
3. E^2 for the numerator of the fraction
4. E^2 for W, and finally E for W

The two types of formulas used are:

1. If A = B - C

$$E_A^2 = E_B^2 + E_C^2$$

2. If A = B/C

$$\frac{E_A^2}{A^2} = \left(\frac{E_B^2}{B^2} + \frac{E_C^2}{C^2}\right) \text{ OR } E_A^2 = \left(\frac{E_B^2}{B^2} + \frac{E_C^2}{C^2}\right) A^2$$

Solutions for $E^2_{P-P_v}$

1.a. Upper Containment

$$E^2 = E_P^2 + E_{Pv}^2 = (0.00036)^2 + (0.005)^2 = 3.47 \times 10^{-8}$$

b. Lower Containment

$$E^2 = E_P^2 + E_{Pv}^2 = (0.00036)^2 + (0.005)^2 = 3.47 \times 10^{-8}$$

c. Ice Containment

$$E^2 = E_P^2 + E_{Pv} = (0.00036)^2 + (0.0018)^2 = 0.47 \times 10^{-8}$$

2. Solution for $\frac{P-P_v}{T}$

2.a. Upper Containment

$$E^2 = \left[\frac{3.47 \times 10^{-8}}{(26.9)^2} + \frac{20 \times 10^{-2}}{(522)^2}\right]\left(\frac{26.9}{522}\right)^2 = 4.82 \times 10^{-10}$$

2.b. Lower Containment

$$E^2 = \left[\frac{3.47 \times 10^{-8}}{(26.9)^2} + \left(\frac{27 \times 10^{-2}}{(532)}\right)^2\right]\left(\frac{26.9}{532}\right)^2 = 7.43 \times 10^{-10}$$

2.c Ice Containment

$$E^2 = \left[\frac{0.47 \times 10^{-8}}{(72)^2} + \left(\frac{(1.07)}{478} \right)^2 \right] \left(\frac{27}{478} \right)^2 = 160.5 \times 10^{-10}$$

3. Solution for the numerator

$$E^2 = (4.2959)^2 (4.82 \times 10^{-10}) + (2.2835)^2 (7.43 \times 10^{-10}) + 160.5 \times 10^{-10}$$

$$E^2 = 287.53 \times 10^{-10}$$

4. Solution for W

$$E^2 = \left[\frac{287.53 \times 10^{-10}}{(0.3946)^2} + \frac{287.53 \times 10^{-10}}{(0.3946)^2} \right] (1)$$

$$E^2 = 3693.63 \times 10^{-10}$$

$$\boxed{E = 60.77 \times 10^{-5} = 0.061\ \%}$$

This is the probable error of one point on a graph of weight of air in the containment (normalized) plotted against time. The straight line representing the least-squares fit of all 49 points had a slope of 0.16044% ± 0.01053% with a confidence limit of 95%.

Conclusion

It has been shown that any one reading has a probable error of 0.061%. When all the points are used to determine a least-squares-line, we have a 95% confidence limt of ± 0.01053%.

It can be shown that, for a normal distribution, a 50% confidence limit is the same as the probable error.

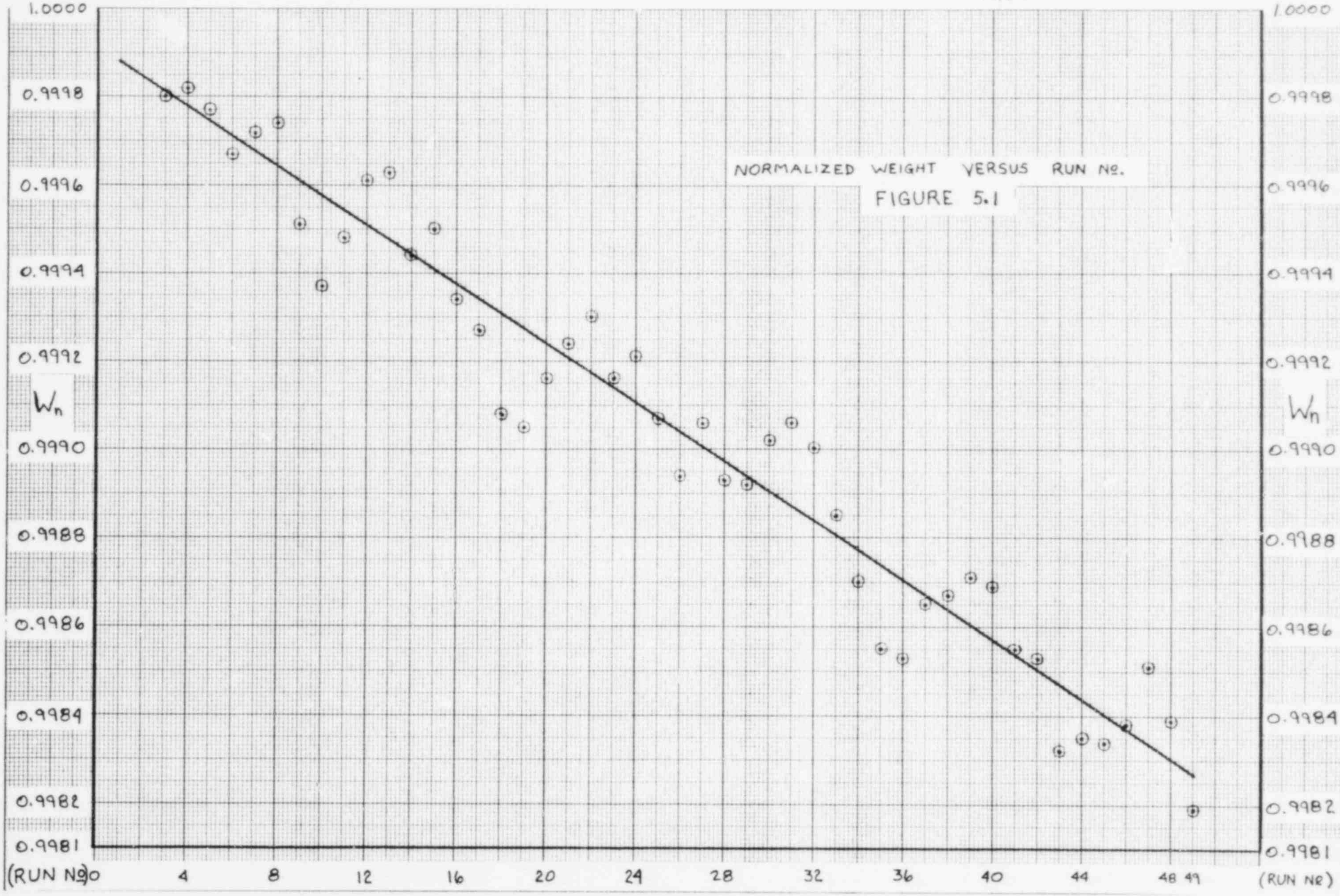
(0.16044 ± 0.01053)%	95% Confidence
(0.16044 ± 0.00363)%	50% Confidence

D. DISCUSSION OF AIR PARTICULATE DETECTOR LEAKAGE

During the course of the ILRT it was found that the air particulate detector sample line used to measure the air borne contamination of the lower Volume was experiencing out-leakage through a flow control mixing valve. The extent of the leakage was measured to be 10.2 SCFH.

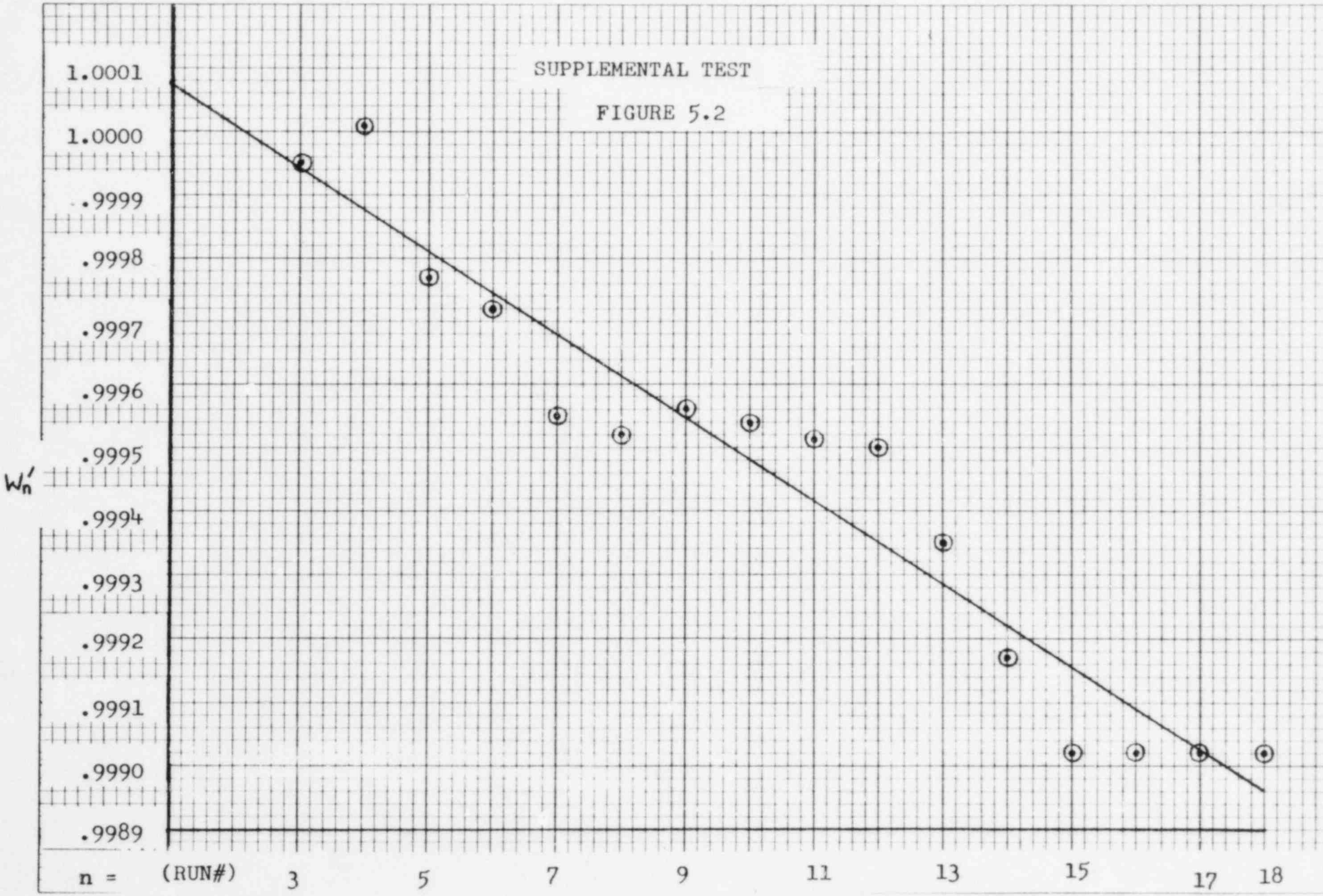
This flow control mixing valve is used during normal operation to manually throttle the correct sample flow-rate to the detector. When the sample pump is not in operation, as was the case during the ILRT, the flow control mixing valve acts as a vent from which the containment air escaped.

Provisions will be taken to eliminate this source of leakage by modifying the present air particulate sampling system. It is important to note that the acceptable leakage rate reported in this text includes the leakage through the flow control mixing valve.



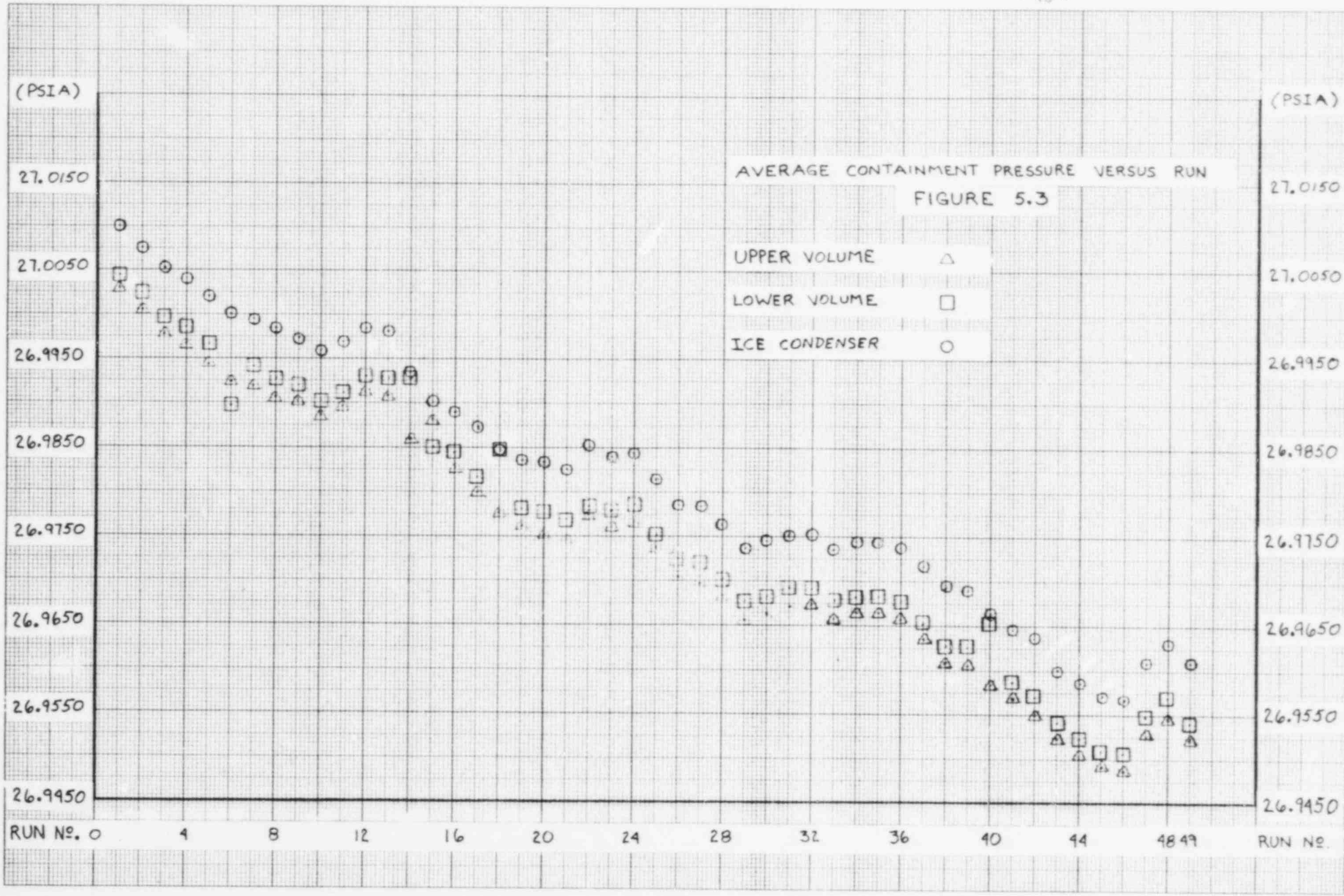
NORMALIZED WEIGHT VERSUS RUN No.

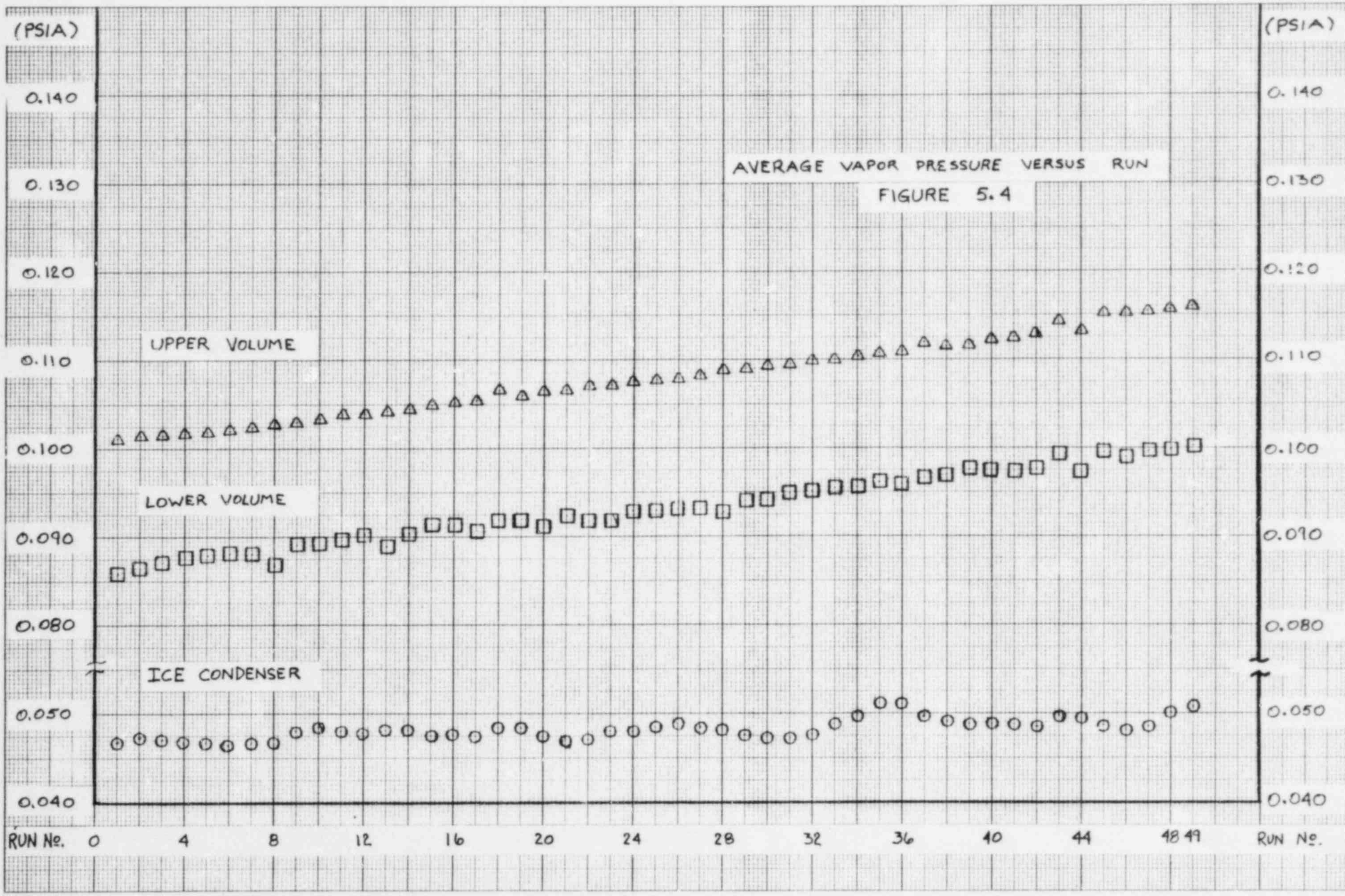
FIGURE 5.1



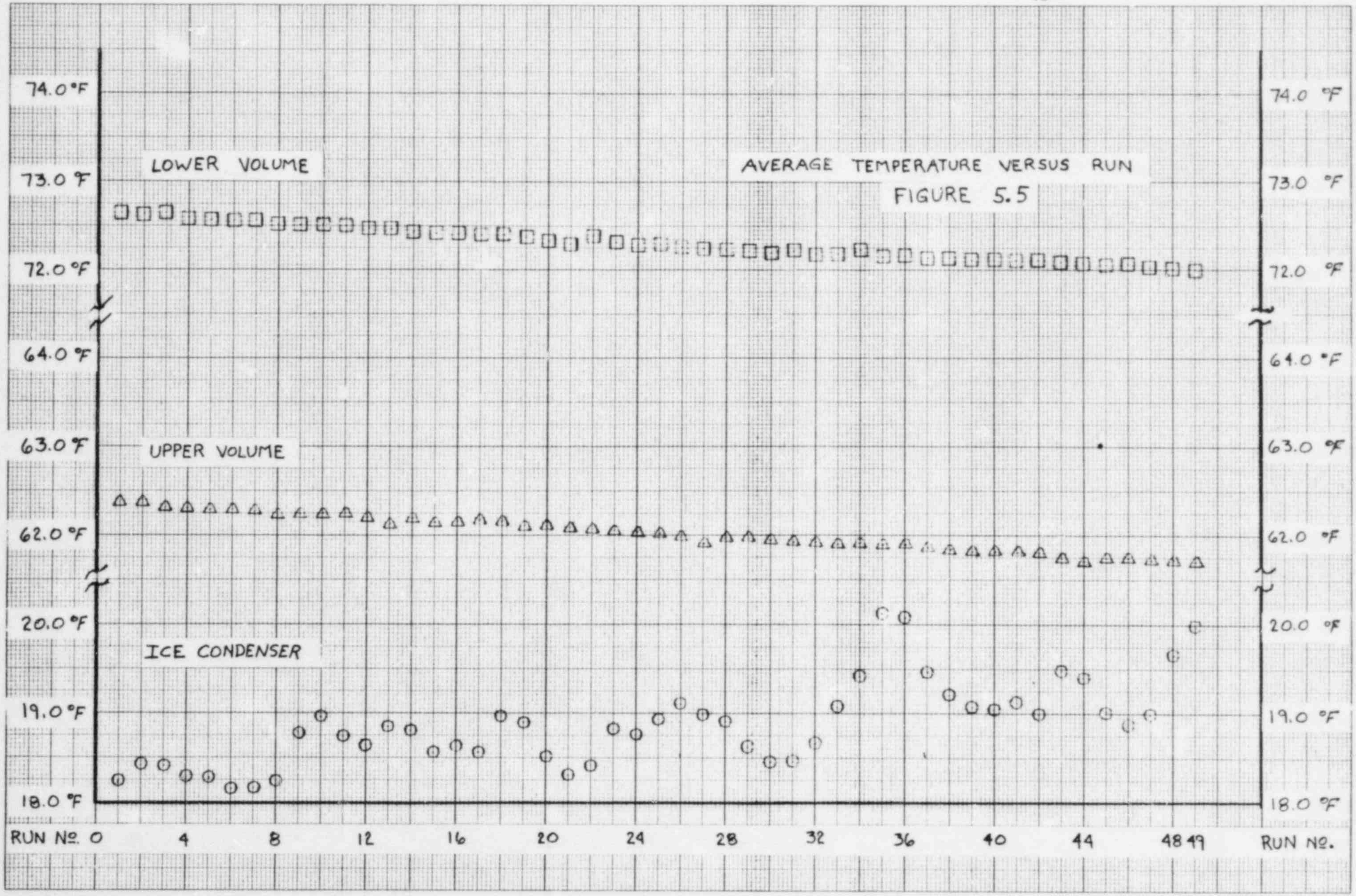
SUPPLEMENTAL TEST

FIGURE 5.2


(PSIA)
27.0150
27.0050
26.9950
26.9850
26.9750
26.9650
26.9550
26.9450
RUN №. 0
4
8
12
16
20
24
28
32
36
40
44
48 49
RUN №.
AVERAGE CONTAINMENT PRESSURE VERSUS RUN
FIGURE 5.3
UPPER VOLUME △
LOWER VOLUME □
ICE CONDENSER ○



AVERAGE VAPOR PRESSURE VERSUS RUN
FIGURE 5.4
(PSIA)
0.140
0.130
0.120
0.110
0.100
0.090
0.080
0.050
0.040
UPPER VOLUME
LOWER VOLUME
ICE CONDENSER
RUN No.
0
4
8
12
16
20
24
28
32
36
40
44
48 49


AVERAGE TEMPERATURE VERSUS RUN
FIGURE 5.5
LOWER VOLUME
UPPER VOLUME
ICE CONDENSER
74.0 °F
73.0 °F
72.0 °F
64.0 °F
63.0 °F
62.0 °F
20.0 °F
19.0 °F
18.0 °F
RUN №. 0 4 8 12 16 20 24 28 32 36 40 44 48 49

6.0 TABULATED RESULTS

The following pages are a tabulation of measured parameters and calculated values of the Integrated Leakage Rate Test and Supplemental Test.

RESULTS OF THE LINEAR REGRESSION ANALYSIS TEST
(VOLUMETRIC WEIGHTING)

RUN #	W EXPERIMENTAL	LEAKAGE RATE LOWER LIMIT	LEAKAGE RATE	LEAKAGE RATE UPPER LIMIT	W UPPER CONTAINMENT	W LOWER CONTAINMENT	W ICE CONDENSER
3	0.99980	-2.50771	-0.48023	1.54724	0.99989	0.99979	0.99946
4	0.99982	-0.65735	-0.28655	0.28424	0.99986	0.99982	0.99963
5	0.99977	-0.49482	-0.22963	0.03556	0.99981	0.99979	0.99961
6	0.99967	-0.40404	-0.24932	-0.09461	0.99972	0.99954	0.99978
7	0.99972	-0.32556	-0.20365	-0.08174	0.99973	0.99971	0.99973
8	0.99974	-0.26687	-0.16326	-0.05965	0.99976	0.99979	0.99953
9	0.99951	-0.30446	-0.20676	-0.10906	0.99971	0.99969	0.99836
10	0.99937	-0.35291	-0.25415	-0.15538	0.99962	0.99960	0.99789
11	0.99948	-0.32433	-0.24416	-0.16399	0.99965	0.99966	0.99844
12	0.99961	-0.28783	-0.20516	-0.12249	0.99980	0.99971	0.99865
13	0.99963	-0.25260	-0.17118	-0.08977	0.99991	0.99979	0.99820
14	0.99944	-0.24080	-0.17177	-0.10275	0.99959	0.99979	0.99810
15	0.99950	-0.22140	-0.16050	-0.09960	0.99975	0.99948	0.99853
16	0.99934	-0.21901	-0.16572	-0.11244	0.99952	0.99949	0.99836
17	0.99927	-0.22088	-0.17328	-0.12568	0.99939	0.99945	0.99843
18	0.99908	-0.23847	-0.19109	-0.14370	0.99928	0.99949	0.99747
19	0.99905	-0.24820	-0.20342	-0.15864	0.99929	0.99931	0.99757
20	0.99916	-0.24194	-0.20177	-0.16160	0.99924	0.99939	0.99839
21	0.99924	-0.23080	-0.19313	-0.15546	0.99930	0.99934	0.99879
22	0.99930	-0.21802	-0.18081	-0.14359	0.99941	0.99939	0.99865
23	0.99916	-0.21105	-0.17684	-0.14264	0.99939	0.99941	0.99773
24	0.99921	-0.20200	-0.16954	-0.13708	0.99942	0.99946	0.99786
25	0.99907	-0.19830	-0.16849	-0.13868	0.99936	0.99934	0.99737
26	0.99894	-0.19932	-0.17162	-0.14392	0.99928	0.99928	0.99691
27	0.99906	-0.19417	-0.16826	-0.14235	0.99942	0.99929	0.99714
28	0.99893	-0.19271	-0.16870	-0.14469	0.99920	0.99925	0.99723
29	0.99892	-0.19065	-0.16834	-0.14602	0.99910	0.99913	0.99777
30	0.99902	-0.18530	-0.16384	-0.14239	0.99915	0.99919	0.99815
31	0.99906	-0.17915	-0.15793	-0.13670	0.99923	0.99917	0.99819
32	0.99900	-0.17427	-0.15382	-0.13337	0.99920	0.99922	0.99776
33	0.99885	-0.17257	-0.15337	-0.13418	0.99922	0.99915	0.99681
34	0.99870	-0.17413	-0.15585	-0.13757	0.99918	0.99909	0.99666
35	0.99855	-0.17883	-0.16069	-0.14256	0.99921	0.99923	0.99456
36	0.99853	-0.18215	-0.16447	-0.14680	0.99918	0.99918	0.99464
37	0.99865	-0.18127	-0.16457	-0.14786	0.99912	0.99911	0.99586
38	0.99867	-0.17934	-0.16348	-0.14762	0.99908	0.99902	0.99636
39	0.99871	-0.17649	-0.16124	-0.14599	0.99910	0.99898	0.99662
40	0.99869	-0.17375	-0.15906	-0.14436	0.99900	0.99913	0.99658
41	0.99855	-0.17293	-0.15897	-0.14500	0.99894	0.99888	0.99635
42	0.99853	-0.17194	-0.15865	-0.14536	0.99889	0.99881	0.99658
43	0.99832	-0.17419	-0.16119	-0.14818	0.99885	0.99872	0.99539
44	0.99835	-0.17495	-0.16245	-0.14995	0.99887	0.99872	0.99553
45	0.99834	-0.17522	-0.16325	-0.15128	0.99869	0.99863	0.99633
46	0.99838	-0.17436	-0.16290	-0.15145	0.99870	0.99862	0.99665
47	0.99851	-0.17178	-0.16046	-0.14913	0.99886	0.99883	0.99651
48	0.99839	-0.17034	-0.15943	-0.14852	0.99893	0.99894	0.99514
49	0.99819	-0.17097	-0.16044	-0.14991	0.99886	0.99880	0.99433

FINAL LEAKAGE RATE (% PER DAY) = -0.16044 INTERCEPT= 0.99988

FINAL CONFIDENCE LIMITS FOR THE RATE ARE -0.17097 TO -0.14991

SUMMARY OF AVERAGES
(VOLUMETRIC WEIGHTING)

RUN #	ELAPSED TIME	AVG TEMP UPPER	AVG PRESS UPPER	AVG V PRESS UPPER	AVG TEMP LOWER	AVG PRESS LOWER	AVG V PRESS LOWER	AVG TEMP ICE	AVG PRESS ICE	AVG V PRESS ICE
1	0.0	62.6819	27.0030	0.1012	72.9587	27.0045	0.0858	18.5255	27.0101	0.0468
2	0.50	62.6835	27.0005	0.1014	72.9488	27.0024	0.0864	18.7261	27.0077	0.0472
3	1.00	62.6333	26.9978	0.1015	72.9502	26.9999	0.0872	18.6939	27.0053	0.0471
4	1.50	62.6259	26.9968	0.1017	72.9021	26.9987	0.0876	18.5955	27.0041	0.0469
5	2.00	62.6011	26.9944	0.1019	72.8753	26.9968	0.0880	18.5690	27.0021	0.0469
6	2.50	62.6080	26.9923	0.1020	72.8627	26.9897	0.0882	18.4555	27.0001	0.0466
7	3.00	62.5858	26.9920	0.1024	72.8602	26.9941	0.0882	18.4712	26.9995	0.0467
8	3.50	62.5423	26.9909	0.1027	72.8192	26.9927	0.0868	18.5456	26.9985	0.0468
9	4.00	62.5531	26.9902	0.1030	72.8133	26.9920	0.0891	19.0716	26.9977	0.0480
10	4.50	62.5597	26.9888	0.1034	72.8217	26.9902	0.0893	19.2578	26.9960	0.0484
11	5.00	62.5519	26.9896	0.1039	72.8041	26.9913	0.0897	19.0203	26.9969	0.0479
12	5.50	62.5081	26.9913	0.1039	72.7962	26.9930	0.0902	18.9498	26.9985	0.0477
13	6.00	62.4360	26.9909	0.1042	72.7753	26.9927	0.0889	19.1504	26.9982	0.0482
14	6.50	62.5022	26.9860	0.1045	72.7495	26.9929	0.0904	19.1168	26.9935	0.0481
15	7.00	62.4524	26.9882	0.1049	72.7381	26.9850	0.0914	18.8678	26.9903	0.0475
16	7.50	62.4600	26.9826	0.1052	72.7247	26.9844	0.0914	18.9370	26.9899	0.0477
17	8.00	62.4755	26.9800	0.1054	72.7105	26.9818	0.0906	18.8621	26.9873	0.0475
18	8.50	62.4652	26.9778	0.1066	72.7159	26.9846	0.0919	19.2600	26.9848	0.0484
19	9.00	62.4374	26.9761	0.1060	72.6834	26.9781	0.0920	19.1958	26.9836	0.0483
20	9.50	62.4362	26.9752	0.1066	72.6477	26.9777	0.0912	18.8097	26.9832	0.0474
21	10.00	62.3935	26.9746	0.1066	72.6391	26.9770	0.0923	18.6155	26.9827	0.0470
22	10.50	62.3796	26.9776	0.1071	72.6490	26.9785	0.0918	18.7244	26.9853	0.0472
23	11.00	62.3609	26.9761	0.1072	72.6291	26.9780	0.0919	19.1280	26.9840	0.0481
24	11.50	62.3499	26.9768	0.1076	72.5951	26.9786	0.0929	19.0745	26.9845	0.0480
25	12.00	62.3155	26.9736	0.1078	72.5905	26.9753	0.0930	19.2481	26.9814	0.0484
26	12.50	62.2988	26.9705	0.1079	72.5651	26.9725	0.0931	19.4101	26.9785	0.0488
27	13.00	62.2034	26.9697	0.1083	72.5519	26.9721	0.0931	19.2984	26.9782	0.0485
28	13.50	62.2813	26.9684	0.1088	72.5403	26.9703	0.0928	19.2246	26.9764	0.0484
29	14.00	62.2760	26.9657	0.1090	72.5280	26.9677	0.0941	18.9334	26.9738	0.0477
30	14.50	62.2583	26.9664	0.1093	72.5095	26.9683	0.0941	18.7688	26.9745	0.0473
31	15.00	62.2299	26.9672	0.1095	72.5202	26.9692	0.0949	18.7681	26.9753	0.0473
32	15.50	62.2357	26.9673	0.1099	72.4900	26.9691	0.0951	18.9634	26.9753	0.0478
33	16.00	62.1966	26.9658	0.1100	72.4919	26.9678	0.0954	19.3770	26.9738	0.0487
34	16.50	62.2236	26.9665	0.1104	72.5315	26.9683	0.0957	19.7367	26.9746	0.0496
35	17.00	62.1996	26.9665	0.1107	72.4511	26.9684	0.0961	20.4266	26.9744	0.0512
36	17.50	62.1988	26.9658	0.1109	72.4667	26.9677	0.0959	20.3783	26.9739	0.0511
37	18.00	62.1656	26.9635	0.1120	72.4482	26.9655	0.0966	19.7779	26.9716	0.0497
38	18.50	62.1424	26.9610	0.1116	72.4401	26.9629	0.0969	19.5064	26.9693	0.0490
39	19.00	62.1223	26.9606	0.1118	72.4388	26.9626	0.0975	19.3810	26.9689	0.0487
40	19.50	62.1208	26.9583	0.1122	72.4185	26.9653	0.0973	19.3560	26.9664	0.0487
41	20.00	62.1138	26.9568	0 1125	72.4190	26.9588	0.0974	19.4361	26.9648	0.0488
42	20.50	62.1032	26.9550	0.1129	72.4196	26.9571	0.0977	19.2987	26.9630	0.0485
43	21.00	62.0438	26.9523	0.1143	72.3800	26.9543	0.0993	19.7997	26.9603	0.0497
44	21.50	62.0182	26.9504	0.1132	72.3798	26.9524	0.0973	19.7022	26.9584	0.0495
45	22.00	62.0481	26.9491	0.1151	72.3574	26.9510	0.0995	19.3130	26.9571	0.0486
46	22.50	62.0418	26.9489	0.1151	72.3707	26.9508	0.0990	19.1616	26.9568	0.0432
47	23.00	62.0267	26.9528	0.1154	72.3237	26.9549	0.0997	19.2963	26.9610	0.0485
48	23.50	62.0277	26.9549	0.1156	72.3039	26.9570	0.0999	19.9639	26.9631	0.0501
49	24.00	62.0037	26.9521	0.1160	72.3118	26.9540	0.1002	20.2865	26.9601	0.0509

SUMMARY OF AVERAGES
(VOLUMETRIC WEIGHTING)

RUN #	ELAPSED TIME	AVG TEMP UPPER	AVG PRESS UPPER	AVG V PRESS UPPER	AVG TEMP LOWER	AVG PRESS LOWER	AVG V PRESS LOWER	AVG TEMP ICE	AVG PRESS ICE	AVG V PRESS ICE
1	0.0	62.6819	27.0030	0.1012	72.9587	27.0045	0.0858	18.5255	27.0101	0.0468
2	0.50	62.6835	27.0005	0.1014	72.9488	27.0024	0.0864	18.7261	27.0077	0.0472
3	1.00	62.6333	26.9978	0.1015	72.9502	26.9999	0.0872	18.6939	27.0053	0.0471
4	1.50	62.6259	26.9968	0.1017	72.9021	26.9987	0.0876	18.5955	27.0041	0.0469
5	2.00	62.6011	26.9944	0.1019	72.8753	26.9968	0.0880	18.5690	27.0021	0.0469
6	2.50	62.6080	26.9923	0.1020	72.8627	26.9897	0.0882	18.4555	27.0001	0.0466
7	3.00	62.5858	26.9920	0.1024	72.8602	26.9941	0.0882	18.4712	26.9995	0.0467
8	3.50	62.5423	26.9909	0.1027	72.8192	26.9927	0.0868	18.5456	26.9985	0.0468
9	4.00	62.5531	26.9902	0.1030	72.8133	26.9920	0.0891	19.0716	26.9977	0.0480
10	4.50	62.5597	26.9888	0.1034	72.8217	26.9902	0.0893	19.2578	26.9960	0.0484
11	5.00	62.5519	26.9896	0.1039	72.8041	26.9913	0.0897	19.0203	26.9969	0.0479
12	5.50	62.5081	26.9913	0.1039	72.7962	26.9930	0.0902	18.9498	26.9985	0.0477
13	6.00	62.4360	26.9909	0.1042	72.7753	26.9927	0.0889	19.1504	26.9982	0.0482
14	6.50	62.5022	26.9860	0.1045	72.7495	26.9929	0.0904	19.1168	26.9935	0.0481
15	7.00	62.4524	26.9882	0.1049	72.7381	26.9850	0.0914	18.8678	26.9903	0.0475
16	7.50	62.4600	26.9826	0.1052	72.7247	26.9844	0.0914	18.9370	26.9899	0.0477
17	8.00	62.4755	26.9800	0.1054	72.7105	26.9818	0.0906	18.8621	26.9873	0.0475
18	8.50	62.4652	26.9778	0.1066	72.7159	26.9846	0.0919	19.2600	26.9848	0.0484
19	9.00	62.4376	26.9761	0.1060	72.6834	26.9781	0.0920	19.1958	26.9836	0.0483
20	9.50	62.4362	26.9752	0.1066	72.6477	26.9777	0.0912	18.8097	26.9832	0.0474
21	10.00	62.3935	26.9746	0.1066	72.6391	26.9770	0.0923	18.6155	26.9827	0.0470
22	10.50	62.3796	26.9776	0.1071	72.6490	26.9785	0.0918	18.7244	26.9853	0.0472
23	11.00	62.3609	26.9761	0.1072	72.6291	26.9780	0.0919	19.1280	26.9840	0.0481
24	11.50	62.3499	26.9768	0.1076	72.5951	26.9786	0.0929	19.0745	26.9845	0.0480
25	12.00	62.3155	26.9736	0.1078	72.5905	26.9753	0.0930	19.2481	26.9814	0.0484
26	12.50	62.2988	26.9705	0.1079	72.5651	26.9725	0.0931	19.4101	26.9785	0.0488
27	13.00	62.2034	26.9697	0.1083	72.5519	26.9721	0.0931	19.2984	26.9782	0.0485
28	13.50	62.2813	26.9684	0.1088	72.5403	26.9703	0.0928	19.2246	26.9764	0.0484
29	14.00	62.2760	26.9657	0.1090	72.5280	26.9677	0.0941	18.9334	26.9738	0.0477
30	14.50	62.2583	26.9664	0.1093	72.5095	26.9683	0.0941	18.7688	26.9745	0.0473
31	15.00	62.2299	26.9672	0.1095	72.5202	26.9692	0.0949	18.7681	26.9753	0.0473
32	15.50	62.2357	26.9673	0.1099	72.4900	26.9691	0.0951	18.9634	26.9753	0.0478
33	16.00	62.1966	26.9658	0.1100	72.4919	26.9678	0.0954	19.3770	26.9738	0.0487
34	16.50	62.2236	26.9665	0.1104	72.5315	26.9683	0.0957	19.7367	26.9746	0.0496
35	17.00	62.1996	26.9665	0.1107	72.4511	26.9684	0.0961	20.4266	26.9744	0.0512
36	17.50	62.1988	26.9658	0.1109	72.4667	26.9677	0.0959	20.3783	26.9739	0.0511
37	18.00	62.1656	26.9635	0.1120	72.4482	26.9655	0.0966	19.7779	26.9716	0.0497
38	18.50	62.1424	26.9610	0.1116	72.4401	26.9629	0.0969	19.5064	26.9693	0.0490
39	19.00	62.1223	26.9606	0.1118	72.4388	26.9626	0.0975	19.3810	26.9689	0.0487
40	19.50	62.1208	26.9583	0.1122	72.4185	26.9653	0.0973	19.3560	26.9664	0.0487
41	20.00	62.1138	26.9568	0.1125	72.4190	26.9588	0.0974	19.4361	26.9648	0.0488
42	20.50	62.1032	26.9550	0.1129	72.4196	26.9571	0.0977	19.2987	26.9630	0.0485
43	21.00	62.0438	26.9523	0.1143	72.3800	26.9543	0.0993	19.7997	26.9603	0.0497
44	21.50	62.0182	26.9504	0.1132	72.3798	26.9524	0.0973	19.7022	26.9584	0.0495
45	22.00	62.0481	26.9491	0.1151	72.3574	26.9510	0.0995	19.3130	26.9571	0.0486
46	22.50	62.0418	26.9489	0.1151	72.3707	26.9508	0.0990	19.1616	26.9568	0.0482
47	23.00	62.0267	26.9528	0.1154	72.3237	26.9549	0.0997	19.2963	26.9610	0.0485
48	23.50	62.0277	26.9549	0.1156	72.3039	26.9570	0.0999	19.9639	26.9631	0.0501
49	24.00	62.0037	26.9521	0.1160	72.3118	26.9540	0.1002	20.2865	26.9601	0.0509

RESULTS OF THE LINEAR REGRESSION ANALYSIS TEST
(VOLUMETRIC WEIGHTING)

RUN #	W EXPERIMENTAL	LEAKAGE RATE LOWER LIMIT	LEAKAGE RATE	LEAKAGE RATE UPPER LIMIT	W UPPER CONTAINMENT	W LOWER CONTAINMENT	W ICE CONDENSER
3	0.99995	-3.14352	-0.12105	2.90142	0.99990	0.99990	1.00026
4	1.00001	-0.54017	-0.04407	0.45203	0.99995	0.99992	1.00039
5	0.99977	-0.67146	-0.24534	0.18078	0.99990	0.99933	1.00017
6	0.99972	-0.56896	-0.30655	-0.04415	0.99976	0.99988	0.99919
7	0.99955	-0.58502	-0.38084	-0.17666	0.99974	0.99985	0.99818
8	0.99952	-0.53572	-0.39026	-0.24481	0.99959	0.99974	0.99882
9	0.99956	-0.47480	-0.35662	-0.23843	0.99944	0.99966	0.99984
10	0.99954	-0.42627	-0.32535	-0.22444	0.99935	0.99958	1.00022
11	0.99951	-0.38721	-0.29974	-0.2122[illegible]	0.99925	0.99956	1.00045
12	0.99950	-0.35381	-0.27577	-0.19774	0.99932	0.99958	1.00006
13	0.99935	-0.34176	-0.27660	-0.21143	0.99925	0.99963	0.99915
14	0.99917	-0.35332	-0.29393	-0.23454	0.99927	0.99966	0.99772
15	0.99902	-0.37273	-0.31524	-0.25774	0.99921	0.99962	0.99705
16	0.99902	-0.37390	-0.32305	-0.27219	0.99912	0.99935	0.99793
17	0.99902	-0.36622	-0.32163	-0.27704	0.99889	0.99940	0.99876
18	0.99902	-0.35525	-0.31501	-0.27477	0.99891	0.99925	0.99898

FINAL LEAKAGE RATE (% PER DAY) = -0.31501   INTERCEPT= 1.00007

FINAL CONFIDENCE LIMITS FOR THE RATE ARE -0.35525 TO -0.27477

SUMMARY OF AVERAGES
(VOLUMETRIC WEIGHTING)

RUN #	ELAPSED TIME	AVG TEMP UPPER	AVG PRESS UPPER	AVG V PRESS UPPER	AVG TEMP LOWER	AVG PRESS LOWER	AVG V PRESS LOWER	AVG TEMP ICE	AVG PRESS ICE	AVG V PRESS ICE
1	0.0	61.9519	26.9284	0.1085	72.1661	26.9301	0.1000	19.8240	26.9366	0.0498
2	0.50	61.9297	26.9266	0.1086	72.1550	26.9292	0.1003	19.4363	26.9346	0.0490
3	1.00	61.9480	26.9256	0.1086	72.1578	26.9272	0.1003	19.6546	26.9336	0.0494
4	1.50	61.9179	26.9256	0.1088	72.1442	26.9272	0.1002	19.5939	26.9336	0.0492
5	2.00	61.9698	26.9239	0.1088	72.4336	26.9256	0.1000	19.6656	26.9319	0.0494
6	2.50	61.9630	26.9231	0.1090	72.1194	26.9249	0.1004	20.1016	26.9310	0.0504
7	3.00	61.9514	26.9222	0.1092	72.1206	26.9242	0.1005	20.5515	26.9299	0.0515
8	3.50	61.9620	26.9186	0.1092	72.1075	26.9207	0.1006	20.1957	26.9265	0.0506
9	4.00	61.9583	26.9144	0.1092	72.0907	26.9166	0.0995	19.6545	26.9224	0.0494
10	4.50	61.9624	26.9123	0.1093	72.0798	26.9145	0.1001	19.4490	26.9205	0.0489
11	5.00	61.9775	26.9104	0.1093	72.0643	26.9126	0.0995	19.3063	26.9183	0.0486
12	5.50	61.9571	26.9114	0.1095	72.0653	26.9136	0.1000	19.5060	26.9194	0.0490
13	6.00	62.0176	26.9123	0.1093	72.0475	26.9146	0.1003	19.9378	26.9202	0.0500
14	6.50	62.0032	26.9127	0.1097	72.0322	26.9150	0.1007	20.5957	26.9203	0.0516
15	7.00	62.0029	26.9110	0.1097	72.0254	26.9134	0.1007	20.8810	26.9188	0.0523
16	7.50	62.0013	26.9084	0.1097	72.0067	26.9058	0.1012	20.4297	26.9162	0.0512
17	8.00	62.0294	26.9039	0.1099	71.9878	26.9061	0.1011	19.9720	26.9118	0.0501
18	8.50	61.9414	26.9001	0.1099	71.9879	26.9022	0.1013	19.8037	26.9079	0.0497

RESULTS OF THE LINEAR REGRESSION ANALYSIS TEST
(MASS WEIGHTING)

RUN #	W EXPERIMENTAL	LEAKAGE RATE LOWER LIMIT	LEAKAGE RATE	LEAKAGE RATE UPPER LIMIT	W UPPER CONTAINMENT	W LOWER CONTAINMENT	W ICE CONDENSER
3	0.99980	-2.45758	-0.47451	1.50856	0.99989	0.99979	0.99948
4	0.99982	-0.84459	-0.28396	0.27666	0.99986	0.99982	0.99964
5	0.99978	-0.48958	-0.22829	0.03200	0.99981	0.99979	0.99962
6	0.99968	-0.40110	-0.24884	-0.09658	0.99972	0.99954	0.99979
7	0.99973	-0.32383	-0.20367	-0.08351	0.99973	0.99971	0.99973
8	0.99974	-0.26591	-0.16352	-0.06113	0.99976	0.99979	0.99954
9	0.99951	-0.30381	-0.20692	-0.11003	0.99971	0.99969	0.99836
10	0.99937	-0.35219	-0.25409	-0.15599	0.99962	0.99960	0.99790
11	0.99948	-0.32370	-0.24405	-0.16439	0.99965	0.99966	0.99845
12	0.99961	-0.28737	-0.20500	-0.12263	0.99980	0.99971	0.99866
13	0.99963	-0.25217	-0.17087	-0.08957	0.99991	0.99979	0.99822
14	0.99944	-0.24040	-0.17146	-0.10253	0.99959	0.99979	0.99812
15	0.99950	-0.22104	-0.16023	-0.09941	0.99975	0.99948	0.99854
16	0.99934	-0.21866	-0.16546	-0.11225	0.99952	0.99949	0.99837
17	0.99927	-0.22059	-0.17305	-0.12550	0.99939	0.99945	0.99844
18	0.99908	-0.23822	-0.19087	-0.14352	0.99928	0.99949	0.99749
19	0.99905	-0.24803	-0.20326	-0.15849	0.99929	0.99931	0.99758
20	0.99916	-0.24185	-0.20169	-0.16154	0.99924	0.99939	0.99839
21	0.99924	-0.23076	-0.19313	-0.15549	0.99930	0.99934	0.99879
22	0.99930	-0.21809	-0.18083	-0.14367	0.99942	0.99939	0.99866
23	0.99916	-0.21097	-0.17679	-0.14261	0.99939	0.99941	0.99775
24	0.99921	-0.20189	-0.16943	-0.13698	0.99942	0.99946	0.99788
25	0.99907	-0.19816	-0.16835	-0.13854	0.99936	0.99934	0.99739
26	0.99894	-0.19917	-0.17148	-0.14378	0.99928	0.99928	0.99692
27	0.99906	-0.19406	-0.16816	-0.14227	0.99942	0.99929	0.99715
28	0.99893	-0.19264	-0.16863	-0.14463	0.99920	0.99925	0.99724
29	0.99892	-0.19060	-0.16830	-0.14599	0.99910	0.99913	0.99778
30	0.99902	-0.18527	-0.16384	-0.14240	0.99915	0.99919	0.99816
31	0.99906	-0.17914	-0.15794	-0.13674	0.99923	0.99917	0.99819
32	0.99900	-0.17424	-0.15392	-0.13339	0.99921	0.99922	0.99777
33	0.99886	-0.17253	-0.15336	-0.13418	0.99922	0.99915	0.99683
34	0.99871	-0.17407	-0.15531	-0.13755	0.99918	0.99909	0.99608
35	0.99856	-0.17867	-0.16058	-0.14249	0.99922	0.99923	0.99459
36	0.99854	-0.18194	-0.16432	-0.14669	0.99918	0.99918	0.99467
37	0.99865	-0.18105	-0.16440	-0.14774	0.99912	0.99911	0.99588
38	0.99860	-0.17912	-0.16331	-0.14750	0.99908	0.99902	0.99638
39	0.99871	-0.17628	-0.16107	-0.14586	0.99910	0.99898	0.99664
40	0.99870	-0.17353	-0.15888	-0.14422	0.99900	0.99913	0.99660
41	0.99856	-0.17271	-0.15878	-0.14485	0.99894	0.99888	0.99637
42	0.99854	-0.17172	-0.15847	-0.14521	0.99889	0.99881	0.99660
43	0.99832	-0.17397	-0.16100	-0.14802	0.99885	0.99872	0.99541
44	0.99835	-0.17474	-0.16227	-0.14980	0.99887	0.99872	0.99555
45	0.99834	-0.17503	-0.16309	-0.15114	0.99869	0.99863	0.99634
46	0.99838	-0.17418	-0.16275	-0.15133	0.99870	0.99862	0.99666
47	0.99852	-0.17160	-0.16031	-0.14901	0.99886	0.99883	0.99653
48	0.99839	-0.17015	-0.15925	-0.14836	0.99893	0.99894	0.99517
49	0.99820	-0.17075	-0.16024	-0.14974	0.99886	0.99880	0.99437

FINAL LEAKAGE RATE (% PER DAY) = -0.16024   INTERCEPT= 0.99988

FINAL CONFIDENCE LIMITS FOR THE RATE ARE -0.17075 TO -0.14974

SUMMARY OF AVERAGES (MASS WEIGHTING)

RUN #	ELAPSED TIME	AVG TEMP UPPER	AVG PRESS UPPER	AVG V PRESS UPPER	AVG TEMP LOWER	AVG PRESS LOWER	AVG V PRESS LOWER	AVG TEMP ICE	AVG PRESS ICE	AVG V PRESS ICE
1	0.0	62.6901	27.0030	0.1012	72.9516	27.0045	0.0958	18.5049	27.0101	0.0468
2	0.50	62.6815	27.0005	0.1014	72.9418	27.0024	0.0864	18.6978	27.0077	0.0472
3	1.00	62.6316	26.9978	0.1015	72.9435	26.9999	0.0872	18.6647	27.0053	0.0471
4	1.50	62.6240	26.9968	0.1017	72.8951	26.9987	0.0876	19.5690	27.0041	0.0469
5	2.00	62.5991	26.9944	0.1019	72.8679	26.9969	0.0880	18.5440	27.0021	0.0469
6	2.50	62.6062	26.9923	0.1020	72.8553	26.9897	0.0882	18.4313	27.0001	0.0466
7	3.00	62.5941	26.9920	0.1024	72.8531	26.9941	0.0882	18.4471	26.9995	0.0467
8	3.50	62.5406	26.9909	0.1027	72.8118	26.9927	0.0868	18.5224	26.9985	0.0468
9	4.00	62.5511	26.9902	0.1030	72.8061	26.9920	0.0891	19.0468	26.9977	0.0480
10	4.50	62.5577	26.9888	0.1034	72.8146	26.9902	0.0893	19.2309	26.9960	0.0484
11	5.00	62.5499	26.9896	0.1039	72.7971	26.9913	0.0897	18.9939	26.9969	0.0479
12	5.50	62.5062	26.9913	0.1039	72.7891	26.9930	0.0902	18.9229	26.9985	0.0477
13	6.00	62.4337	26.9909	0.1042	72.7684	26.9927	0.0889	19.1223	26.9982	0.0482
14	6.50	62.5003	26.9860	0.1045	72.7426	26.9929	0.0904	19.0895	26.9935	0.0481
15	7.00	62.4506	26.9882	0.1049	72.7311	26.9850	0.0914	18.8412	26.9903	0.0475
16	7.50	62.4582	26.9826	0.1052	72.7177	26.9844	0.0914	18.9095	26.9899	0.0477
17	8.00	62.4735	26.9800	0.1054	72.7034	26.9818	0.0966	18.8360	26.9873	0.0475
18	8.50	62.4632	26.9778	0.1066	72.7092	26.9846	0.0919	19.2333	26.9848	0.0484
19	9.00	62.4356	26.9761	0.1060	72.6763	26.9781	0.0920	19.1706	26.9836	0.0483
20	9.50	62.4342	26.9752	0.1066	72.6405	26.9777	0.0912	18.7874	26.9832	0.0474
21	10.00	62.3915	26.9746	0.1066	72.6321	26.9770	0.0923	18.5935	26.9827	0.0470
22	10.50	62.3775	26.9776	0.1071	72.6424	26.9785	0.0918	18.7606	26.9853	0.0472
23	11.00	62.3590	26.9761	0.1072	72.6224	26.9780	0.0919	19.0964	26.9840	0.0481
24	11.50	62.3481	26.9768	0.1076	72.5881	26.9786	0.0929	19.0446	26.9845	0.0490
25	12.00	62.3135	26.9736	0.1078	72.5836	26.9753	0.0930	19.2187	26.9814	0.0484
26	12.50	62.2968	26.9705	0.1079	72.5581	26.9725	0.0931	19.3828	26.9785	0.0488
27	13.00	62.1992	26.9697	0.1083	72.5448	26.9721	0.0931	19.2727	26.9782	0.0485
28	13.50	62.2795	26.9684	0.1088	72.5333	26.9703	0.0928	19.1997	26.9764	0.0484
29	14.00	62.2742	26.9657	0.1090	72.5209	26.9677	0.0941	19.9094	26.9738	0.0477
30	14.50	62.2567	26.9664	0.1093	72.5024	26.9683	0.0941	18.7451	26.9745	0.0473
31	15.00	62.2282	26.9672	0.1095	72.5134	26.9692	0.0949	19.7437	26.9753	0.0473
32	15.50	62.2337	26.9673	0.1099	72.4830	26.9691	0.0951	18.9258	26.9753	0.0478
33	16.00	62.1950	26.9658	0.1100	72.4852	26.9678	0.0954	19.3480	26.9738	0.0487
34	16.50	62.2216	26.9665	0.1104	72.5246	26.9683	0.0957	19.7068	26.9746	0.0496
35	17.00	62.1974	26.9665	0.1107	72.4439	26.9684	0.0961	20.2912	26.9744	0.0512
36	17.50	62.1969	26.9659	0.1109	72.4600	26.9677	0.0959	20.3432	26.9739	0.0511
37	18.00	62.1636	26.9635	0.1120	72.4411	26.9655	0.0966	19.7474	26.9716	0.0497
38	18.50	62.1404	26.9610	0.1116	72.4330	26.9629	0.0969	19.4775	26.9693	0.0490
39	19.00	62.1203	26.9606	0.1118	72.4319	26.9626	0.0975	19.3526	26.9689	0.0487
40	19.50	62.1188	26.9583	0.1122	72.4115	26.9653	0.0973	19.3254	26.9664	0.0487
41	20.00	62.1167	26.9568	0.1125	72.4121	26.9588	0.0974	19.4056	26.9648	0.0488
42	20.50	62.1012	26.9550	0.1129	72.4128	26.9571	0.0977	19.2700	26.9630	0.0485
43	21.00	62.0417	26.9523	0.1143	72.3728	26.9543	0.0993	19.7693	26.9603	0.0497
44	21.50	62.0162	26.9504	0.1132	72.3730	26.9524	0.0973	19.6745	26.9584	0.0495
45	22.00	62.0461	26.9491	0.1151	72.3503	26.9510	0.0955	19.2875	26.9571	0.0486
46	22.50	62.0397	26.9489	0.1151	72.3639	26.9508	0.0990	19.1348	26.9568	0.0482
47	23.00	62.0245	26.9528	0.1154	72.3167	26.9549	0.0997	19.2682	26.9510	0.0485
48	23.50	62.0258	26.9549	0.1156	72.2967	26.9570	0.0999	19.9280	26.9631	0.0501
49	24.00	62.0016	26.9521	0.1160	72.3049	26.9540	0.1002	20.2497	26.9601	0.0509

7.0 LOCAL LEAK TEST PROGRAM

A local leak test program was conducted in accordance with guidelines specified in 10CFR50 Appendix J, FSAR, and Technical Specifications, under AEPSC written and I&M approved procedures, PO-033-330 "Containment Penetration and Personnel Lock Leakage Test", PO-033-331 "Sensitive Leakage Rate Test", and PO-033-332 "Containment Isolation System Pneumatic Leak Test". These tests were conducted as a prerequisite to the Integrated Leak Rate test to systematically verify acceptable leakage across each containment penetration and pressure containing boundry. The program consisted of type B tests, designed to determine leakage through the containment penetrations, air lock door seals, lock cover flange seal, ring body flange seal, overall air lock leakage, and weld channel leakage (internal to the containment), and type C tests designed to determine leakage across isolation valves.

Two test methods were employed in the conduct of these tests. Where test volumes were small enough to pressurized with our leak detection instrument, it was used to determine the leakage rate. This instrument (Volumetrics Leak Rate Monitor) is a self contained mass flow leak test system capable of measuring small gaseous leak rates. The monitor pressurized the test volume to a predetermined setpoint (12.0 PSIG). After test pressure is attained precise pressure regulators, internal to the instrument, maintain the pressure setpoint by adding air through a thermal flow sensor. Since the test volume pressure remains constant during the test the amount of air leakage is equal to the amount of air added. This leak rate is electronically converted and displayed on a digital rate meter.

7.0 LOCAL LEAK TEST PROGRAM (CONTD.)

Two such instruments were employed in our local leak test program each having calibration certification to NBS.

The following pressure boundaries were tested in this manner with results and acceptance criteria as listed.

	Measured Leakage	Acceptance Criteria
612' Personnel Access Hatch	.000294La	.001La
Door seals inner	.000037La	.0005La
outer	.000248La	.0005La
650' Personnel Access Hatch	.0000092La	.001La
Door seals inner	.0000184La	.0005La
outer	.0000737La	.0005La
650' Lock Cover Flange	34SCCM	N/A
650' Ring body flange	16SCCM	N/A
Isolation Valves (total Leakage)	16,835SCCM	54,516SCCM

For an individual accounting of containment isolation valve leakage rate, Table 7.1 is included. In this table each valve is identified by tag number, valve diameter, allowable leakage and actual leakage as measured during the pre-operation leak-test. The individual allowable leakage values were determined by allocating a portion of the total allowable leakage based on valve size (diameter). The allowable leakage values were determined as a guideline to enable the test engineer to decide which valves should be repaired, if necessary, to meet the total allowable leakage value of 54,516SCCM. Refering to Table 7.1, it can be seen that the actual leakage measured for isolation valves VCR-105 and VCR-205 exceeded their allowable leakage limit. The pre-operation test, however, was accepted because, as per 10 CFR 50; Appendix J, the combined leakage for all valves subject to Type 'C' tests must be less than the allowable limit. When the total actual leakage is compared to the total allowable leakage a value of 30.88 per cent of the allowable limit was attained.

The second test method used to measure leakage was the reference volume method. This method employs a reference volume, of known internal volume, fitted with precise pressure and temperature measuring equipment. A non-bleed type pressure regulator is attached to the discharge line of the volume. The discharge side of this regulator is attached to the test volume and the regulator is set to maintain test pressure (12.C PSIG) on the test volume. By timing the pressure decay in the reference volume, the leakage rate of the test volume can be calculated. The following pressure boundaries were tested in this manner with results and acceptance criteria as listed.

	Measured Leakage	Acceptance Criteria
Containment penetrations	3.735%La	15.7%La
Containment liner weld channels	8.105%La	10%La

7.0 LOCAL LEAK TEST PROGRAM

TABLE 7.1

VALVE I.D.	VALVE DIAMETER (INCHES)	ALLOWABLE LEAKAGE (SCCM)	ACTUAL LEAKAGE (SCCM)
CCR-455 & CCR-456	2.0	360	61
CCR-457 & CCW-135	2.0	360	45
CCR-462 & CCR-460	3.0	540	269
PW-275	3.0	270	23
DCR-201 & DCR-203	0.75	135	14
DCR-202 & DCR-204	0.75	135	20
DCR-207	1.0	90	12
DCR-600 & DCR-601	3.0	540	8
DCR-610 & DCR-611	2.5	450	137
DCR-620 & DCR-621	1.0	180	76
ECR-10 & ECR-20	0.5	90	32
ECR-11	0.5	45	28
ECR-21	0.5	45	31
ECR-12	0.5	45	2
ECR-22	0.5	45	0
ECR-13	0.5	45	17
ECR-23	0.5	45	4
ECR-14	0.5	45	3
ECR-24	0.5	45	7
ECR-15	0.5	45	0
ECR-25	0.5	45	10
ECR-16	0.5	45	1
ECR-26	0.5	45	1

7.0 LOCAL LEAK TEST PROGRAM

TABLE 7.1

VALVE I.D.	VALVE DIAMETER (INCHES)	ALLOWABLE LEAKAGE (SCCM)	ACTUAL LEAKAGE (SCCM)
ECR-17	0.5	45	10
ECR-27	0.5	45	15
ECR-18	0.5	45	0
ECR-28	0.5	45	6
ECR-19	0.5	45	0
ECR-29	0.5	45	2
GCR-301	0.75	67.5	14
GCR-314	1.0	90	38
ICR-5 & ICR-6	0.5	90	2
NCR-105 & NCR-106	0.5	90	6
NCR-107 & NCR-108	0.5	90	9
NCR-109 & NCR-110	0.5	90	2
NCR-252	3.0	270	11
QCM-250 & QCM-350	4.0	720	118
QCR-300	2.0	180	29
RCR-100 & RCR-101	0.375	67.5	1
VCR-10 & VCR-11	3.0	540	498
VCR-20 & VCR-21	3.0	540	9
XCR-100 & XCR-101	0.75	135	66
XCR-102 & XCR-103	0.75	135	63
CCM-458,-454 and - 452	3.0,4.0 8.0	1350	0
CCM-459,-453 and - 451	3.0,4.0 8.0	1350	0
ECR-31 & ECR-32	1.0	180	8

7.0 LOCAL LEAK TEST PROGRAM

TABLE 7.1

VALVE I.D.	VALVE DIAMETER (INCHES)	ALLOWABLE LEAKAGE (SCCM)	ACTUAL LEAKAGE (SCCM)
WCR-951 & WCR-955	3.0	540	88
WCR-952 & WCR-956	3.0	540	59
WCR-953 & WCR-957	3.0	540	31
WCR-954 & WCR-958	3.0	540	299
WCR-961 & WCR-963	2.0	360	103
WCR-965 & WCR-967	2.0	360	9
WCR-901 & WCR-903	6.0	1080	61
WCR-905 & WCR-907	6.0	1080	6
WCR-909 & WCR-911	6.0	1080	155
WCR-913 & WCR-915	6.0	1080	568
WCR-925 & WCR-927	3.0	540	167
WCR-933 & WCR-935	3.0	540	121
WCR-921	3.0	270	48
WCR-929	3.0	270	27
WCR-923	3.0	270	89
WCR-931	3.0	270	28
VCR-101 & VCR-201	14.0	2520	884
VCR-102 & VCR-202	14.0	2520	645
VCR-103 & VCR-203	30.0	4320	644
VCR-104 & VCR-204	30.0	5400	1211
VCR-105 & VCR-205	30.0	5400	8023
VCR-106 & VCR-206	24.0	4320	168
VCR-107 & VCR-207	14.0	2520	76
SI 189	4.0	360	303

7.0 LOCAL LEAK TEST PROGRAM

TABLE 7.1

VALVE I.D.	VALVE DIAMETER (INCHES)	ALLOWABLE LEAKAGE (SCCM)	ACTUAL LEAKAGE (SCCM)
CS 321	3.0	270	3
SI-171 & SI-172	0.75	135	15
N-102	1.0	90	26
DCR-206 & DCR-206	4.0	720	110
SF-159 & SF-160	3.0	540	4
DW-209 & DW-210	2.0	360	16
CS-442-1	2.0	180	116
CS 442-2	2.0	180	9
CS 442-3	2.0	180	111
CS 442-4	2.0	180	39
CA 181 N	0.5	45	23
CA 181 S	0.5	45	12
DA 145& Blind Flange	2.0	360	98
CPN-80 (2) Blind Flange	6.0	1080	51
CPN-57 (2) Blind Flange	4.0	720	14
SF-151	1.5	135	52
SF-153	1.5	135	0
ICM-250	4.0	360	18
ICM-251	4.0	360	38
ICM-260	4.0	360	184
ICM-265	4.0	360	198
ICM-305	18.0	168	46
ICM-306	18.0	168	96

7.0 LOCAL LEAK TEST PROGRAM

TABLE 7.1

INSTR. I. D.	DIAMETER (INCHES)	ALLOWABLE LEAKAGE (SCCM)	ACTUAL LEAKAGE (SCCM)
PPA-310 & PPA-311	0.5	90	22
PPA-312 & PPA-313	0.5	90	0
PPP-300	0.5	45	5
PPP-301	0.5	45	0
PPP-302	0.5	45	2
PPP-303	0.5	45	6

8.0 REFERENCES

8.1 D. C. Cook Nuclear Plant
Final Safety Analysis Report

8.1.1 Initial Leakage Rate Testing of Containment (Page 5.2-7).

8.1.2 Initial Containment (Pre-Operational) Leakage Rate Test (Page 5.7-4)

8.1.3 Containment Leakage Test Program
FSAR Question 5.93

8.2 D. C. Cook Nuclear Plant - Unit 1
Technical Specifications

8.2.1 Containment Systems - Containment Leakage (Page 3/4 6-2)

8.3 American National Standard - ANSI, N45.4-1972 Leakage-Rate Testing of Containment Structures for Nuclear Reactors.

8.4 10 CFR 50, Appendix J
Primary Reactor Containment Leakage Testing for Water-Cooled Power Reactors.

8.5 Basic Statistical Methods for Engineers and Scientists - A. M. Neville J. B. Kennedy

8.6 Hygrometric and Psychrometric Tables
Smithsonian Institution

8.7 D. C. Cook Nuclear Plant

Pre-Operational Test Procedure

8.7.1 Containment Penetration and Personnel Lock Leakage Test - PO-033-330

8.7.2 Sensitive Leakage Rate Test PO-033-331

8.7.3 Containment Isolation System Pneumatic Leak Test PO-033-332.

8.7.4 Cold Containment Integrated Leakage Rate Test - PO-033-334.