REACTOR CONTAINMENT BUILDING

INTEGRATED LEAK RATE TEST

QUAD-CITIES NUCLEAR POWER STATION

UNIT TWO

JUNE 12-13, 1988

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INTRODUCTION

This report presents the test method and results of the Integrated Primary Containment Leak Rate Test (IPCLRT) successfully performed on June 12-13, 1988 at Quad-Cities Nuclear Power Station, Unit One. The test was performed in accordance with 10 CFR 50, Appendix J, and the Quad-Cities Unit One Technical Specifications.

For the fourth time at Quad-Cities a short duration test (less than 24 hours) was conducted using the general test method outlined in BN-TOP-1, Revision 1 (Bechtel Corporation Topical Report) dated November 1, 1972. The first short duration test was conducted on Unit One in December, 1982.

Using the above test method, the total primary containment integrated leak rate was calculated to be 0.4155 wt %/day at a test pressure greater than 48 PSIG. The calculated leak rate was within the 0.750 wt %/day acceptance criteria (75% of L_A). The associated upper 95% confidence limit was 0.4621 wt %/day.

The supplemental induced leakage test result was calculated to be 1.3542 wt %/day. This value should compare with the sum of the measured leak rate phase result (0.4155 wt %/day) and the inducted leak of 8.82 SCFM (1.0814 wt %/day). The calculated leak rate of 1.3542 wt %/day lies within the allowable tolerance band of 1.4969 wt %/day ± 0.250 wt %/day.

SECTION A - TEST PREPARATIONS

A.1 Type A Test Procedure

The IPCLRT was performed in accordance with Quad-Cities Procedure QTS 150-1, Rev. 15, including checklist QTS 150-S2, S3, S5, S6, S7, S8, S10, S11, S12, S13, S17, S18, S19, and subsections T2, T6, T8, T10, T11, T12, T13, T14, T15. Approved Temporary Procedures 5537, 5540, 5541, 5542, 5543, and 5547 were written in conjunction with the test. Procedure 5537 was written to cover the various manual isolation valves not included in the IPCLRT valve checklist QTS 150-S7. Procedure 5540 was written to allow resetting of the scram after original jumper installation. Procedure 5541 was written to cover exceptions to the manual isolation valve checklist. Procedure 5542, 5543, and 5547 were written to cover exceptions to the valve checklist of QTS 150-S7.

These procedures were written to comply with 10 CFR 50 Appendix J, ANS/ANSI N45.4-1972, and Quad-Cities Unit One Technical Specifications, and to reflect the Commission's approval of a short duration test using the BN-TOP-1, Rev. 1 Topical Report as a general test method.

A.2 Type A Test Instrumentation

Table One shows the specifications for the instrumentation utilized in the IPCLRT. Table Two lists the physical locations of the temperature and humidity sensors within the primary containment. Figure 1 is an idealized view of the drywell and suppression chamber used to calculate the primary containment free air subvolumes. Plant personnel performed all test instrumentation calibrations using NBS traceable standards. Quad Cities procedure QTS 150-9 was used to perform the calibration.

TABLE ONE
INSTRUMENT SPECIFICATIONS

INSTRUMENT	MANUFACTURER	MODEL NO.	SERIAL NO.	RANGE	ACCURACY	REPEATABILITY
Precision Pressure Gages (2)	Volumetrics		846,847	0-100 PSIA	±.015 PSI	±.001 PSI
RTD's (30)	Burns Engineering	SP1A1-5 :/2-3A	44210 - 44222 44224 - 44232 44234 - 44238 inclusive 191501, 191509, 191522	50-150°F	±.5°F	±.1°F
Dewcells (10)	Volumetrics (Foxboro)	Lithium Chloride	5835-1, 5835-2 5835-3, 6084-4 6084-9, 5835-6, 6084-7, 5835-9 5835-10, 6084-8	-20-104°F	±1.0°F	±.5°F
Thermocouple	Pall Trinity Micro	14-T-2H		0-600°F	±2.0°F	±.1°F
Flowmeter	Fischer & Porter	10A3555S	8405A0348A1	0.927-11.23scfm	±1.0% of max flow	
Level Indicator LI 263-101 LT 263-61	GE	Model 180 Type VSI Model 50-553122CAAU2		0-400" H_2O		
Torus Level Indicator	Rosemount	1151GP3B12MB	106958	10.85"H_2O=10mA 15.84"H_2O=30mA 20.84"H_2O=50mA		

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TABLE TWO
SENSOR PHYSICAL LOCATIONS

RTD NUMBER	SERIAL NUMBER	SUBVOLUME	ELEVATION	AZIMUTH*
1	191522	1	670'0"	180°
2	44210	1	670'0"	0°
3	44211	2	657'0"	20°
4	44212	2	657'0"	197°
5	44213	3	639'0"	70°
6	44214	3	639'0"	255°
7	44215	4(Annular Ring)	643'0"	55°
8	44216	4	615'0"	225°
9	44217	5	620'0"	5°
10	44218	5	620'0"	100°
11	44219	5	620'0"	220°
12	44220	6	608'0"	40°
13	44221	6	608'0"	130°
14	44222	6	608'0"	220°
15	191509	6	608'0"	310°
16	44224	7	598'0"	70°
17	44225	7	598'0"	160°
18	44226	7	598'0"	250°
19	44227	7	598'0"	340°
20	44228	8	587'0"	10°
21	44230	8	587'0"	100°
22	44232	8	587'0"	190°
23	191501	8	587'0"	280°
24	44234	9(CRD Space)	595'0"	170°
25	44235	9(CRD Space))	580'0"	170°
26	44236	10(Torus)	578'0"	70°
27	44237	10(Torus)	578'0"	140°
28	44238	10(Torus)	578'0"	210°
29	44229	10(Torus)	578'0"	280°
30	44231	10(Torus)	578'0"	350°
Thermocouple	(inlet to clean-up HX)	11(Rx Vessel)		

DEWCELL NO.	SERIAL NUMBER	SUBVOLUME	ELEVATION	AZIMUTH
1	5835-1	1	670'0"	180°
2	5835-2	2,3,4	653'0"	90°
3	5835-3	2,3,4	653'0"	270°
4	6084-4	5	620'0"	0°
5	6084-9	6	605'0"	45°
6	5835-6	7	600'0"	220°
7	6084-7	8,9	591'0"	0°
8	6084-8	8,9	591'0"	202°
9	5835-9	10	578'0"	90°
10	5835-10	10	578'0"	270°
Thermocouple (Saturated)		11	---	---

Idealized View of Drywell and Torus
Used to Calculate Free Volumes

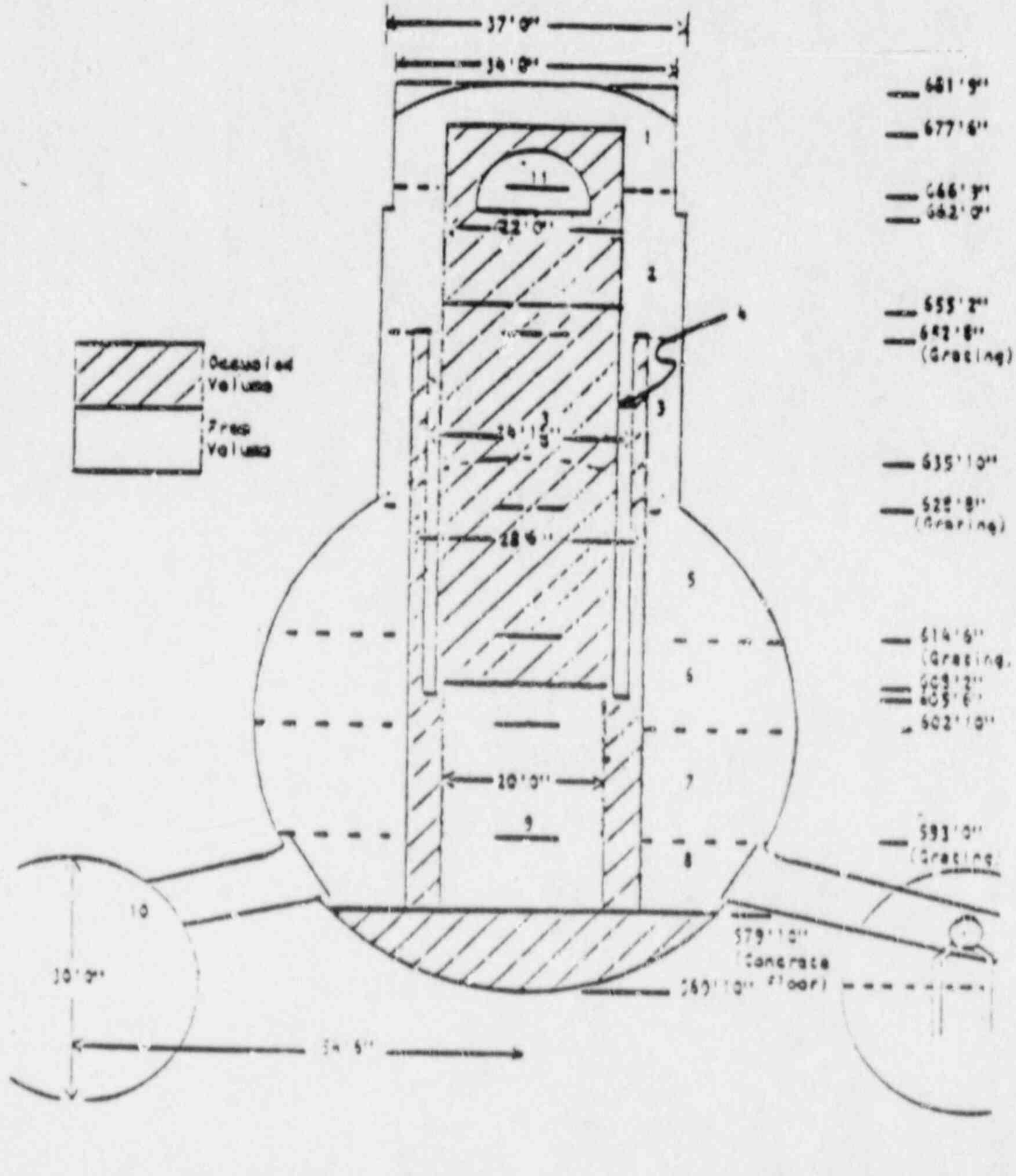

FIGURE 1

A.2.a. Temperature

The location of the 30 platinum RTD's was chosen to avoid conflict with local temperature variations and thermal influence from metal structures. A temperature survey of the containment was previously performed to verify that the sensor locations were representative of average subvolume conditions.

The RTD's were manufactured by Burns Engineering Inc. and are Model SP 1A1-5 1/2-3A. Each RTD and its associated bridge network was calibrated to yield an output of approximately 0-100 mV over a temperature range of 50-120°F. Each RTD was calibrated by comparing the bridge output to the true temperature as indicated by the temperature standard. Four temperatures were used for the calibration. Two calibration constants (a slope and intercept of the regression line) were computed for each RTD by performing a least squares fit of the RTD bridge output to the reference standard's indicated true temperature.

The temperature standard used for all calibrations was a Volumetrics RTD Model VMC 701-B used with a Dewcell/RTD Calibrator Model 07782. The standard was calibrated by Volumetrics on January 20, 1988 to standards traceable to the NBS.

The plant process computer scanned the output of each RTD-bridge network and converted the output to engineering units using the calibration constants.

A.2.b. Pressure

Two precision quartz bourdon tube, absolute pressure gauges were utilized to measure total containment pressure. Each gauge had a local digital readout and a Binary Coded Decimal (BCD) output to the process computer. Primary containment pressure was sensed by the pressure gauges in parallel through a 3/8" tygon tube connection to a special one inch pipe penetration to the containment.

Each precision pressure gauge was calibrated from 62.8-65.8 PSIA in approximately 0.5 PSI increments using a third precision pressure gauge (Volumetrics Model 07726) that had been sent to Volumetrics for calibration. The pressure standard was calibrated on February 19, 1988 using NBS traceable reference standards.

The digital readout of the instruments were in "counts" or arbitrary units. Calibration constants (a slope and intercept of a regression line) were entered into the computer program to convert "counts" into true atmospheric pressure as read by the third, reference gauge. No mechanical calibration of the gauges was performed to bring their digital displays into agreement with true pressure.

A.2.c. Vapor Pressure

Ten lithium chloride dewcells were used to determine the partial pressure due to water vapor in the containment. The dewcells were calibrated using the Volumetrics calibrator described in section A.2.a. above and a chilled mirror dewcell standard (Volumetrics S/N 1263) calibrated on January 20, 1988 by

Volumetrics. The calibration constants for each dewcell (the slope and intercept of a regression line) were computed relating the 0-100 mV output of the signal conditioning cards to the actual dewpoint indicated by the reference standard.

A.2.d. Flow

A rotameter flowmeter, Fischer-Porter serial number 8405A0348A1, was used for the flow measurement during the induced leakage phase of the IPCLRT. The flowmeter was calibrated by Fischer-Porter on February 19, 1988, to within ±1% of full scale (0.927-11.23 SCFM) using NBS traceable standards.

Plant personnel continuously monitored the flow during the induced leakage phase and corrected any minor deviations from the induced flow rate of 8.82 SCFM by adjusting a 3/8" needle valve on the flowmeter inlet. The flow meter outlet was unrestricted and vented to the atmosphere. The flowmeter was calibrated to standard atmospheric conditions.

A.3 Type A Test Measurement

The IPCLRT was performed utilizing a direct interface with the station process computer. This system consists of a hard-wired installation of temperature, dewpoint, and pressure inputs for the IPCLRT to the process computer. The interface allows the process computer to scan the inputs and send the data, still as a millivolt signal or BCD (binary coded decimal) in the case of pressure, to the PRIME computer with minimal manual inputs and without the disadvantages of multiplexers or positioning sensitive electronic hardware inside the containment during the test.

The PRIME computer was used to compute and print the leak rate data using either the ANSI/ANS mass plot method (ANSI/ANS 56.8), a total time method based on ANSI/ANS N45.4, or the BN-TOP-1 method. Key parameters, such as total time measured leak rate, volume weighted dry air pressure and temperature, and absolute pressure were monitored using a Tektronix 4208 terminal and a Tektronix plotter. Plant personnel also plotted a large number of other parameters, including reactor water level and temperature, torus water level, dry air mass, volume weighted partial pressures and temperature, total time leak rate, statistically averaged leak rate and UCL, and all sensor outputs in engineering units. In all cases, data was plotted hourly and computer summaries were obtained at 10 minute time intervals. The plotting of data and the computer printed summaries of data allowed rapid identification of any problems as they might develop. Figure 2 shows a schematic of the data acquisition system.

A.4 Type A Test Pressurization

A 3000 SCFM, 600 hp, 4kV electric oil-free air compressor was used to pressurize the primary containment. An identical compressor was available in standby during the IPCLRT. The compressors were physically located on a single enclosed truck trailer located outside the Reactor Building. The compressed air was piped using flexible metal hose to the Reactor Building, through an existing four inch fire header penetration, and piped to a temporary spool piece that, when installed, allowed the pressurization of the drywell through the "A" containment spray header. The inboard, containment spray isolation valve, MO-1-1001-26A was open during pressurization. Once the containment was pressurized, the MO-1-1001-26A valve was closed and the spool piece was removed and replaced with a blind flange. The outboard containment spray value MO-1001-23A was closed and out-of-service for the test.

Measurement System Schematic Arrangement

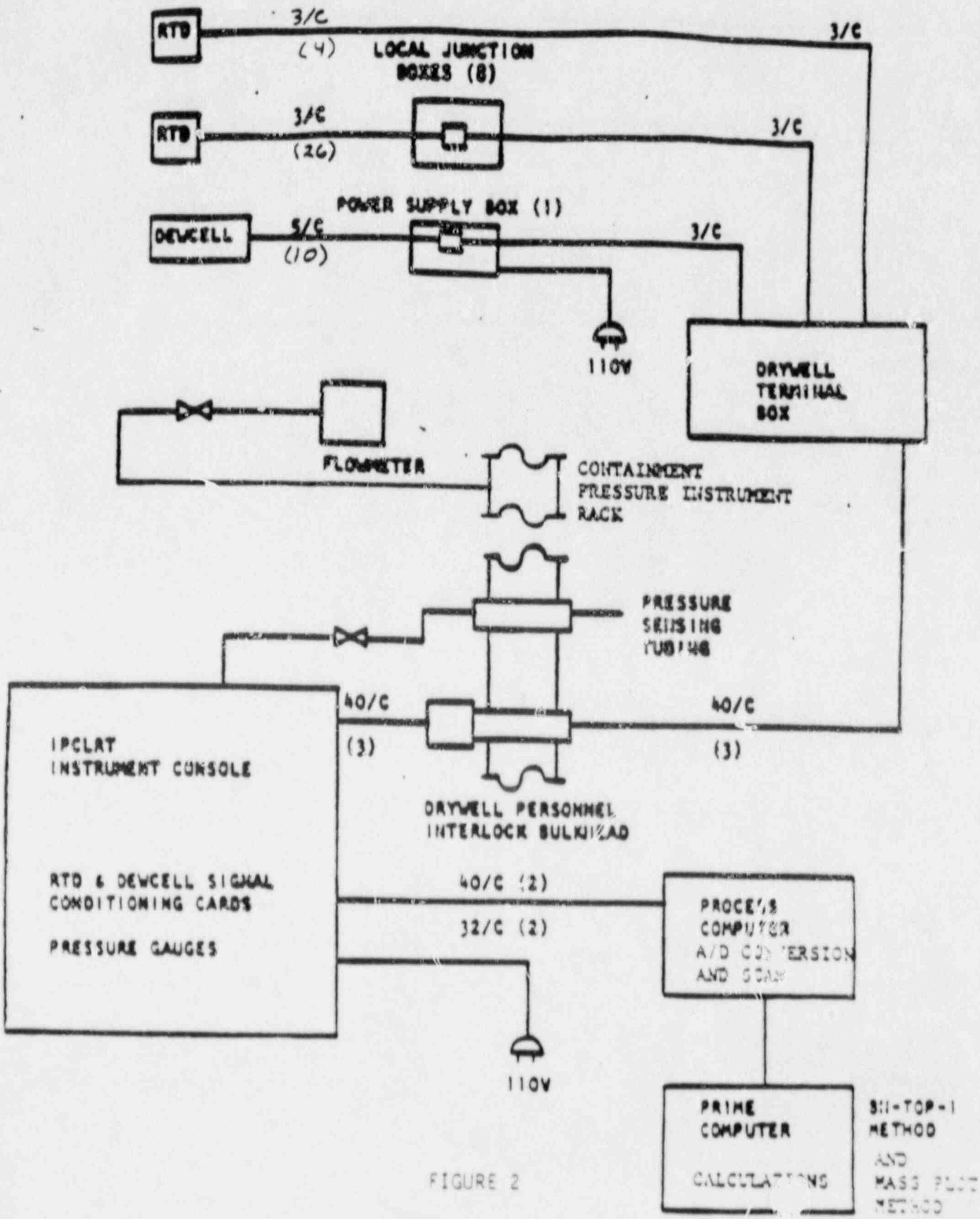

FIGURE 2

SECTION B - TEST METHOD

B.1 Basic Technique

The absolute method of leak rate determination was used. The absolute method uses the ideal gas laws to calculate the measured leak rate, as defined in ANSI N45.4-1972. The inputs to the measured leak rate calculation include subvolume weighted containment temperature, subvolume weighted vapor pressure, and total absolute air pressure.

As required by the Commission in order to perform a short duration test (measured leak rate phase of less then 24 hours), the measured leak rate was statistically analyzed using the principles outlined in BN-TOP-1, Rev. 1. A least squares regression line for the measured total time leak rate versus time since the start of the test is calculated after each new data set is scanned. The calculated leak rate at a point in time, t_i, is the leak rate on the regression line at the time t_i.

The use of a regression line in the BN-TOP-1, Rev. 1 report is different from the way it is used in the ANSI/ANS 56.8 standard. The latter standard uses the slope of the regression line for dry air mass as a function of time to derive a statistically averaged leak rate. In contrast, BN-TOP-1, Rev. 1 calculates a regression line for the measured leak late, which is a function of the change in dry air mass. For the ANSI/ANS calculations one would expect to always see a negative slope for the regression line, because the dry air mass is decreasing over time due to leakage from the containment. For the regression line computed in the BN-TOP-1, Rev.1 method the ideal slope is zero, since you presume that the leakage from the containment is constant over time. Since it is impossible to instantaneously and perfectly measure the containment leakage, the slope of the regression line will be positive or negative depending on the scatter in the measured leak rate values obtained early in the test. Since the measured leak rate is a total time calculation, the values computed early in the test will scatter much more than the values computed after a few hours of testing.

The computer printouts titled "Leak Rate Based on Total Time Calculations" attached to the BN-TOP-1, Rev. 1 topical report are misleading in that the column titled "Calculated Leak Rate" actually has printed out the regression line values (based on all the measured leak rate data computed from the data sets received up until the last time listed on the printout). The calculated leak rate as a function of time (t_i) can only be calculated from data available up until that point in time, t_i. This is significant in that the calculated leak rate may be decreasing over time, despite a substantial positive slope in the last computed regression line. Extrapolation of the regression line is not required by the BN-TOP-1, Rev. 1 criteria to terminate a short duration test. What is required is that the calculated leak rate be decreasing over time or that an increasing calculated leak rate be extrapolated to 24 hours. The distinction between the regression line values and the calculated leak rate as a function of time is made in Section 6.4 of BN-TOP-1, Rev. 1. Calculated leak rates, as a function of time, are correctly printed out in the "Trends Based on Total Time Calculations" computer printouts in Appendix B of BN-TOP-1, Rev. 1.

Associated with each calculated leak rate is a statistically derived upper confidence limit. Just as the calculated leak rate in BN-TOP-1, Rev. 1 and the statistically averaged leak rate in the ANSI/ANS standards are not the same (and do not necessarily yield nearly equal values), the upper confidence limit calculations are greatly different. In the BN-TOP-1, Rev. 1 topical report the upper confidence limit is defined as the calculated leak rate plus the product of the two sided 97.5% T-distribution value (as opposed to the one-sided 95% T-distribution used in the ANS/ANSI standard) and the standard deviation of the measured leak rate data about the computed regression line (which has no relationship to the value computed in the ANSI/ANS standards).

There are two important conclusions that can be derived from data analyzed using the BN-TOP-1, Rev. 1 method: 1) the upper confidence limit for the same measured leak rate data can be substantially greater than the value calculated using the ANSI/ANS method, and 2) the upper confidence limit does not converge to the calculated leak rate nearly as quickly as usually observed in the latter method as the number of data sets becomes large. With this in mind, the upper confidence limit can become the critical parameter for concluding a short duration test, even when the measured leak rate seems to be well under the maximum allowable leak rate. A graphical comparison of the two methods can be made by referring to Figure 3 for the BN-TOP-1, Rev. 1 calculated leak rate and upper confidence limit and to Figure F-1 in Appendix F for the statistically averaged leak rate and upper confidence limit based on ANSI/ANS 56.8-1981. This data supports the contention of many that BN-TOP-1, while it may not give the best estimate of containment leakage, is a conservative method of testing. The ANSI/ANS 56.8 data contained in Appendix F is provided for information only. The reported test results are based on BN-TOP-1, only.

B.2 Supplemental Verification Test

The supplemental verification test superimposes a known leak of approximately the same magnitude as L_A (8.16 SCFM or 1.0 wt %/day as defined in Technical Specifications). The degree of detectability of the combined leak rate (containment calculated leak rate plus the superimposed, induced leak rate) provides a basis for resolving any uncertainty associated with measured leak rate phase of the test. The allowed error band is $\pm$ 25% of L_A.

There are no references to the use of upper confidence limits to evaluate the acceptability of the induced leakage phase of the IPCLRT in the ANS/ANSI standards or in BN-TOP-1, Rev. 1.

B.3 Instrument Error Analysis

An instrument error analysis was performed prior to the test in accordance with BN-TOP-1, Rev. 1 Section 4.5. The instrument system error was calculated in two parts. The first was to determine the system accuracy uncertainty. The second and more important calculation (since the leak rate is impacted most by changes in the containment parameters) was performed to determine the system repeatability uncertainty. The results were 0.1801 wt %/day and .0265 wt %/day for a 6-hour test, respectively. These values are inversely proportional to the test duration.

The instrumentation uncertainty is used only to illustrate the system's ability to measure the required parameters to calculate the primary containment leak rate. The mathematical derivation of the above values can be found in Appendix D. The method of calculating the equipment uncertainty is in conformance with the method outlined in BN-TOP-1.

It is extremely important during a short duration test to quickly identify a failed sensor and in real time back the spurious data out of the calculated volume weighted containment temperature and vapor pressure. Failure to do so can cause the upper confidence limit value to place a short duration test in jeopardy. It has been the stations experience that sensor failures should be removed from all data collected, not just subsequent to the apparent failure, in order to minimize the discontinuity in computed values that are related to the sensor failure (not any real change in containment conditions). For this test, however, no instrument failures after the start of the test were encountered. However, a single RTD failed in the drywell, RTD 8 in subvolume 4, prior to the start of the test for spiking high and then reading high. The effect of this failure is analyzed in section F.5 of this report. The instrument error analysis in Appendix D reflects the instrument failure and unused instrument.

SECTION C - SEQUENCE OF EVENTS

C.1 Test Preparation Chronology

The pretest preparation phase and containment inspection was completed on June 12, 1988 with no apparent structural deterioration being observed. Major preliminary steps included:

1) Blocking open three pairs of drywell to suppression chamber vacuum breakers.

2) Installation of all IPCLRT test equipment in the suppression chamber.

3) Completion of all repairs and installations in the drywell affecting primary containment.

4) Venting of the reactor vessel to the drywell by opening the manual head vent line to the drywell equipment drain sump.

5) Installation of the IPCLRT data acquisition system including computer programs, instrument console, locating instruments in the drywell, and associated wiring.

6) Completion of the pre-test valve line-up.

This test was conducted at the end of the refuel outage to test the containment in an "As Left" condition with repairs and adjustments. The Station has an exemption to 10CFR50, Appendix J requirements to allow performing the test at the end of the refuel outage.

C.2 Test Pressurization and Stabilization Chronology

DATE	TIME	EVENT
06-12-88	0300	Began pressurizing containment.
	0550	Drywell Head, X-1, and X-4 snooped. No leaks observed. Snooped all accessible penetrations in reactor building. No leaks observed.
	0613	2-1402-4B leaks excessively through packing.
	0807	Stopped pressurization due to reactor water and torus water level decreasing at an unacceptable rate. Increased reactor water level to approximately 87".
	0820	Closed the 2-1001-26A and 2-4799-127 valves, Unloaded the compressor and stopped pressurization. Raised reactor water level to approximately 100".
	0900	Tightened packing on the 2-1402-4B, 2-1001-28A, 34A valves. Closed the 2-2301-6 valve to fully seat.
	1052	Containment is pressurized to 65 PSIA. Beginning containment stabilization phase.
	1200	Attempts are being made to determine a leak of approximately 500 SCFH. All systems are being snooped.
	2050	Closed the 2-1001-25A valve on the outboard side of the 2-1001-26A valve. No effect on the leakage rate.
	2355	Leakrate has stabilized at 1.3L_A still searching for the leakage.
6-13-88	0225	Locked out RTD #8 in subvolume #42-2499-20A was found blowing air inside the hydrogen monitoring panel. Heater sample box was disconnected and removed.
	0230	2-2499-20A valve was closed. The leakage path was found.
	0405	All stabilization criteria have been satisfied.

C.3 Measured Leak Rate Phase Chronology

DATE	TIME	EVENT
06-13-88	0405	Containment temperature stable below 0.1°F/hour. Reactor vessel level drop of approximately 0.5 inches/hour. Reactor water temperature stable below 1°F/hour.
	0405	Started meausred leak rate phase. Base data set #181.
	1006	Terminated measured leak rate phase at 6 hour point, base data set #218. Calculated leak rate was 0.4155 wt %/day and decreasing over time. The average measured leak rate over the last five hours was 0.4194 wt %/day. The upper confidence limit was 0.4621 wt%/day. All other BN-TOP-1, Rev. 1 criteria for terminating the test were satisfied.

C.4 Induced Leakage Phase Chronology

DATE	TIME	EVENT
06-13-88	1040	Valved in the flowmeter at 8.82 SCFM (80% scale reading). Radiation Protection is collecting a sample of containment air.
	1106	Stabilization began for induced phase. Data set #224.
	1206	Began induced phase of the test. Base Data set #230. The one hour stabilization required by BN-TOP-1 was complted.
	1517	Terminated induced phase. Last data set was #249. Calculated leak rate was 1.3542 wt%/day. With an upper confidence limit of 1.4626. Data indicates a successful test.

C.5 Depressurization Phase Chronology

DATE	TIME	EVENT
06-13-88	1650	Began containment depressurization using procedure for venting through the Standby Gas Treatment System (SBGT). Flowmeter isolated.
	1810	Depressurized down to 52.24 PSIA to perform special test 2-81.

DATE	TIME	EVENT
06-13-88	2010	Completed special test 2-81 preparing to depressurization again.
	2210	Depressurized to 27 PSIA. Opened 2-1601-63 wide open for final depressurization.
06-14-88	0315	Technical Staff personnel entered drywell. No apparent structural damage. Verified all instruments remained in place. Removed all instrumentation in the drywell.
	0604	Made initial entry to suppression chamber. Verified all instrument remained in place and removed all remaining instruments. Sump levels in drywell checked and recorded.

SECTION D - TYPE A TEST DATA

D.1 Measured Leak Rate Phase Data

A summary of the computed data using the BN-TOP-1, Rev. 1 test method for a short duration test can be found in Table 3. Graphic results of the test are found in Figures 3-7. For comparison purposes only, the statistically averaged leak rate and upper confidence limit using the ANS/ANSI 56.8-1981 standard are graphed in Figure F-1. A summary of the computed data using the ANS/ANSI standard is found in Appendix F.

D.2 Induced Leakage Phase Data

A summary of the computed data for the Induced Leakage Phase of the IPCLRT is found in Table 4. The calculated leak rate and upper confidence limit using the BN-TOP-1, Rev. 1 method are shown in Figure 8. The measured leak rate and last computed regression line are shown in Figure 9. Containment conditions during the Induced Leakage Phase are presented graphically in Figures 10-12.

Measured Leak Rate Test Results
TABLE 3

DATA SET #	TIME	TEST DURATION	AVE. TEMP.	DRY AIR PRESSURE (PSIA)	REACTOR LEVEL (INCHES)	MEAS. LEAK RATE	CALC. LEAK RATE	UPPER CONF. LIMIT
181	04:05:31	0.000	93.1	63.6012	91.9940			
182	04:15:33	0.167	93.1	63.5971	91.8900	0.4937		
183	04:25_33	0.334	93.1	63.5935	91.7510	0.4135		
184	04:35:35	0.501	93.1	63.5907	91.7510	0.3569	0.3529	0.4471
185	04:45:35	0.668	93.1	63.5850	91.6120	0.4342	0.3893	0.6826
186	04:55:36	0.835	93.1	63.5825	91.5080	0.3940	0.3828	0.5716
187	05:05:39	1.002	93.1	63.5781	91.5080	0.4414	0.4050	0.5728
188	05:15:39	1.169	93.0	63.5752	91.3690	0.3843	0.3916	0.5297
189	05:16:01	1.175	93.0	63.5752	91.3690	0.3823	0.3885	0.5031
190	05:26:04	1.343	93.0	63.5714	91.3690	0.4185	0.3923	0.5006
191	05:36:05	1.509	93.0	63.5675	91.3690	0.4552	0.4087	0.5208
192	05:46:06	1.677	93.0	63.5636	91.2650	0.4381	0.4164	0.5223
193	05:56:09	1.844	93.0	63.5608	91.1260	0.4244	0.4184	0.5169
194	06:06:09	2.011	93.0	63.5576	91.1260	0.4328	0.4223	0.5150
195	06:16:10	2.178	93.0	63.5547	90.8830	0.4024	0.4171	0.5053
196	06:26:10	2.344	93.0	63.5505	90.8830	0.4323	0.4207	0.5047
197	06:36:14	2.512	93.0	63.5473	90.7440	0.4247	0.4217	0.5017
198	06:46:15	2.679	93.0	63.5434	90.7440	0.4387	0.4257	0.5026
199	06:56:15	2.846	93.0	63.5419	90.6400	0.4265	0.4250	0.4988
200	07:06:15	3.012	93.0	63.5389	90.5010	0.4115	0.4226	0.4938
201	07:16:16	3.180	92.9	63.5352	90.3620	0.4219	0.4226	0.4913
202	07:26:20	3.347	92.9	63.5324	90.3620	0.4302	0.4241	0.4906
203	07:36:21	3.514	92.9	63.5300	90.2580	0.4246	0.4244	0.4887
204	07:46:25	3.682	92.9	63.5282	90.2580	0.4147	0.4230	0.4855
205	07:56:25	3.849	92.9	63.5249	90.2580	0.4190	0.4225	0.4833
206	08:06:26	4.015	92.9	63.5206	90.0840	0.4151	0.4214	0.4806
207	08:16:28	4.183	92.9	63.5198	90.0840	0.4129	0.4202	0.4780
208	08:26:30	4.350	92.9	63.5168	89.9450	0.4224	0.4205	0.4768
209	08:36:33	4.517	92.9	63.5147	89.8070	0.4176	0.4200	0.4751
210	08:46:33	4.684	92.9	63.5131	89.8070	0.4176	0.4197	0.4735
211	08:56:35	4.851	92.9	63.5091	89.7020	0.4249	0.4203	0.4730
212	09:06:35	4.018	92.9	63.5084	89.7020	0.4162	0.4197	0.4714
213	09:16:36	5.185	92.9	63.5070	89.5630	0.4082	0.4183	0.4691
214	09:26:36	5.352	92.9	63.5033	89.5630	0.4212	0.4185	0.4684
215	09:36:37	5.519	92.9	63.5020	89.5280	0.4158	0.4181	0.4670
216	09:46:39	5.686	92.9	63.5003	89.3900	0.4086	0.4169	0.4651
217	09:56:41	5.853	92.9	63.4975	89.2510	0.4151	0.4166	0.4639
218	10:06:43	6.020	92.9	63.4971	89.2510	0.4072	0.4155	0.4621

Induced Leakage Phase Test Results

TABLE 4

DATA SET #	TIME	TEST DURATION	AVE. TEMP.	DRY AIR PRESSURE (PSIA)	REACTOR LEVEL (INCHES)	MEAS. LEAK RATE	CALC. LEAK RATE	UPPER CONF. LIMIT
230	12:06:56	0.000	93.0	63.4372	88.4520			
231	12:16:57	0.167	93.0	63.4308	88.3130	1.3986		
232	12:27:00	0.335	93.0	63.4242	88.3130	1.5294		
233	12:37:04	0.502	93.0	63.4189	88.1750	1.4124	1.4537	2.4337
234	12:47:05	0.669	93.0	63.4132	88.1750	1.4618	1.4615	1.8206
235	12:57:05	0.836	93.0	63.4075	88.1750	1.4628	1.4652	1.6916
236	13:07:06	1.003	93.0	63.4023	88.0010	1.3386	1.4018	1.6317
237	13:17:06	1.170	93.0	63.3975	88.0010	1.3192	1.3566	1.5575
238	13:27:08	1.337	93.0	63.3905	87.8620	1.3553	1.3442	1.5174
239	13:37:10	1.504	93.0	63.3857	87.8620	1.3568	1.3373	1.4926
240	13:47:14	1.672	93.0	63.3806	87.7580	1.3598	1.3341	1.4774
241	13:57:15	1.839	93.1	63.3743	87.6190	1.3649	1.3340	1.4692
242	14:07:16	2.006	93.1	63.3695	87.6190	1.3661	1.3347	1.4635
243	14:17:16	2.173	93.1	63.3651	87.6190	1.3635	1.3348	1.4578
244	14:27:20	2.340	93.1	63.3589	87.4450	1.3623	1.3349	1.4528
245	14:37:25	2.508	93.1	63.3532	87.4450	1.3645	1.3356	1.4495
246	14:47:28	2.676	93.1	63.3476	87.3070	1.3663	1.3369	1.4473
247	14:57:29	2.843	93.1	63.3411	87.3070	1.3991	1.3451	1.4569
248	15:07:31	3.010	93.1	63.3369	87.2020	1.3821	1.3485	1.4579
249	15:17:33	3.177	93.1	63.3307	87.2020	1.3962	1.3542	1.4626

MEASURED LEAK RATE PHASE
GRAPH OF CALCULATED LEAK RATE
AND UPPER CONFIDENCE LIMIT

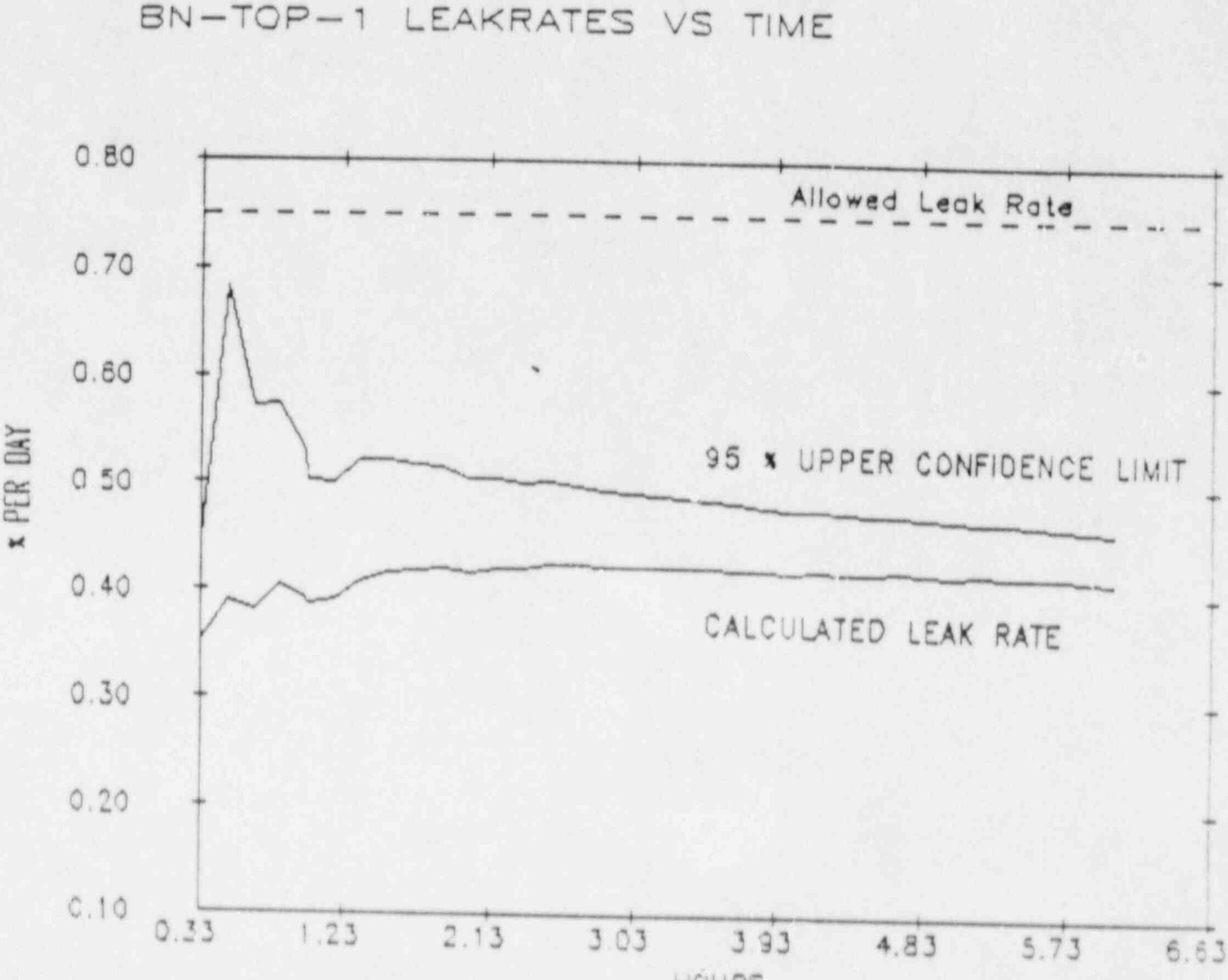

FIGURE 3

MEASURED LEAK RATE PHASE
GRAPH OF TOTAL TIME MEASURED
LEAK RATE AND REGRESSION LINE

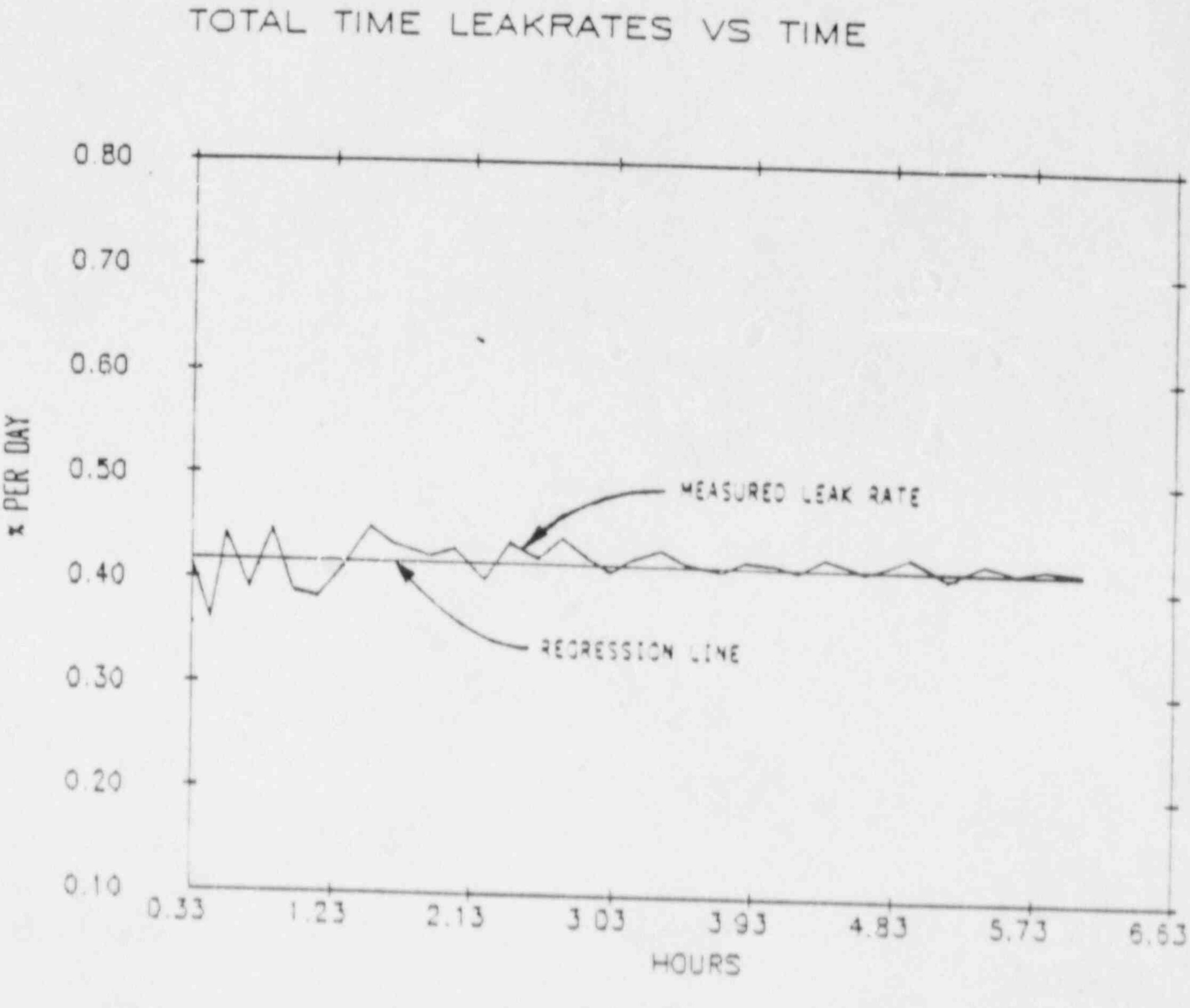

FIGURE 4

MEASURED LEAK RATE PHASE
GRAPH OF DRY AIR PRESSURE

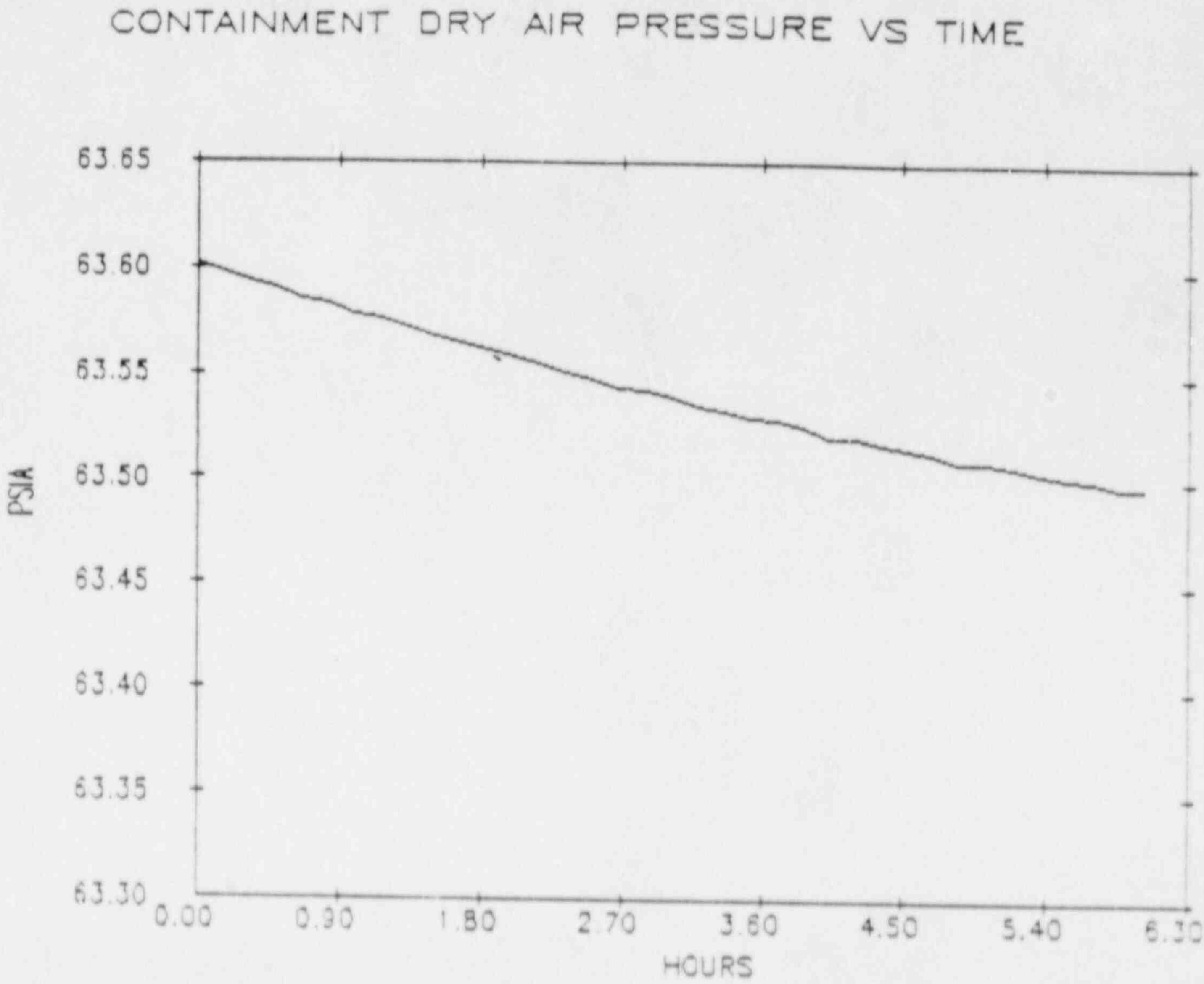

FIGURE 5

MEASURED LEAK RATE PHASE
GRAPH OF VOLUME WEIGHTED
AVERAGE CONTAINMENT VAPOR PRESSURE

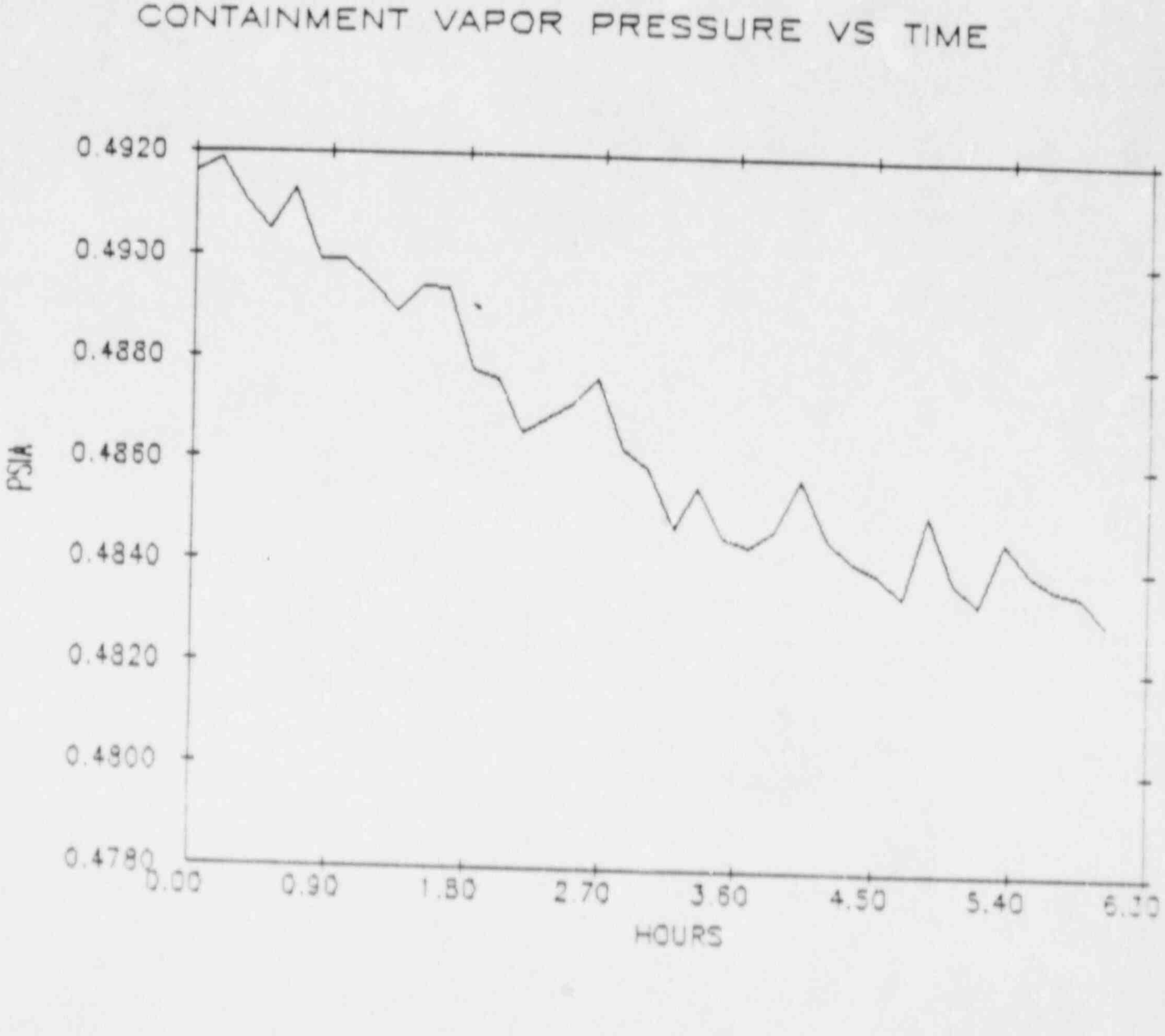

FIGURE 6

MEASURED LEAK RATE PHASE
GRAPH OF VOLUME
WEIGHTED AVERAGE CONTAINMENT TEMPERATURE

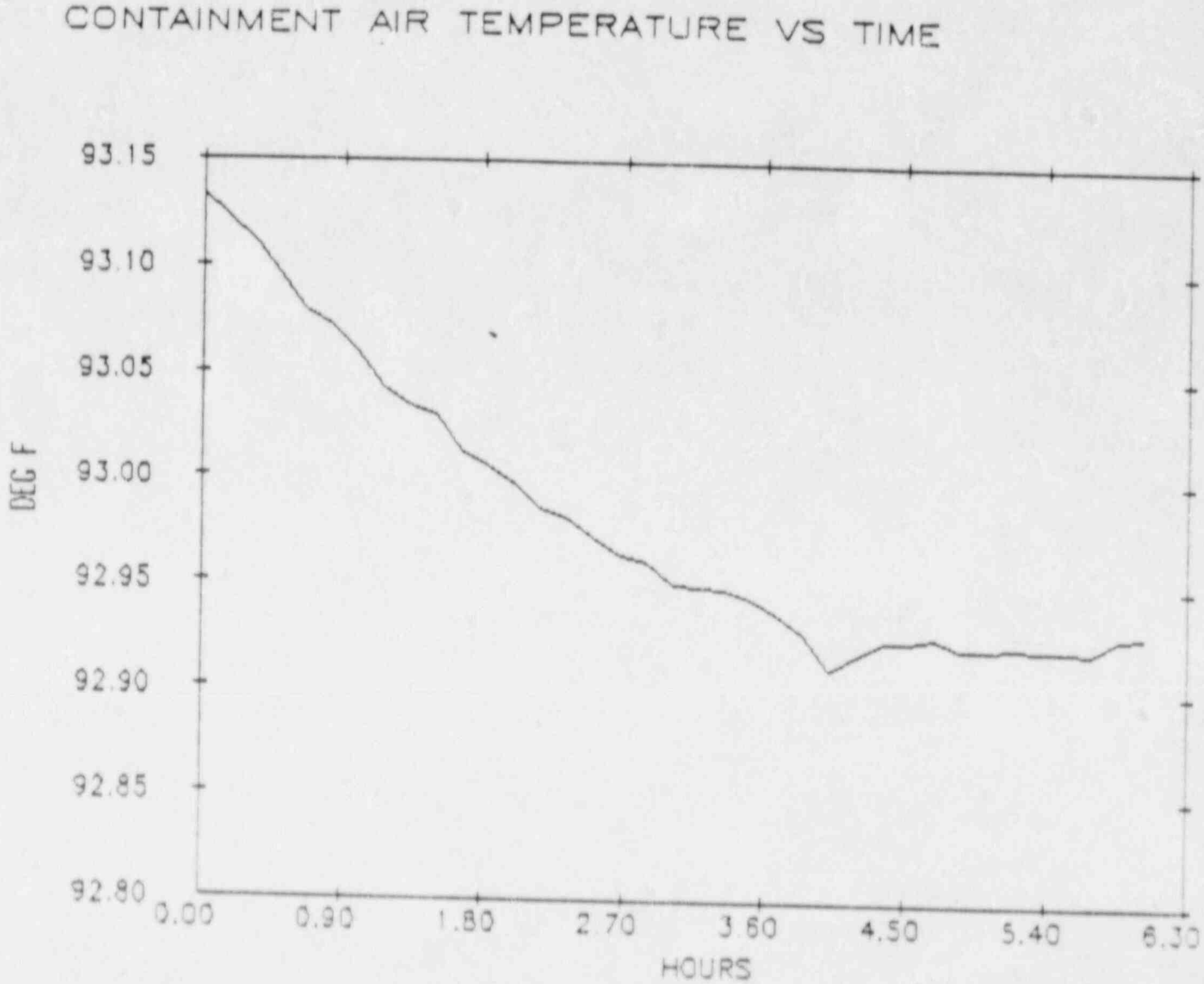

TABLE 7

INDUCED LEAKAGE PHASE
GRAPH OF CALCULATED
LEAK RATE

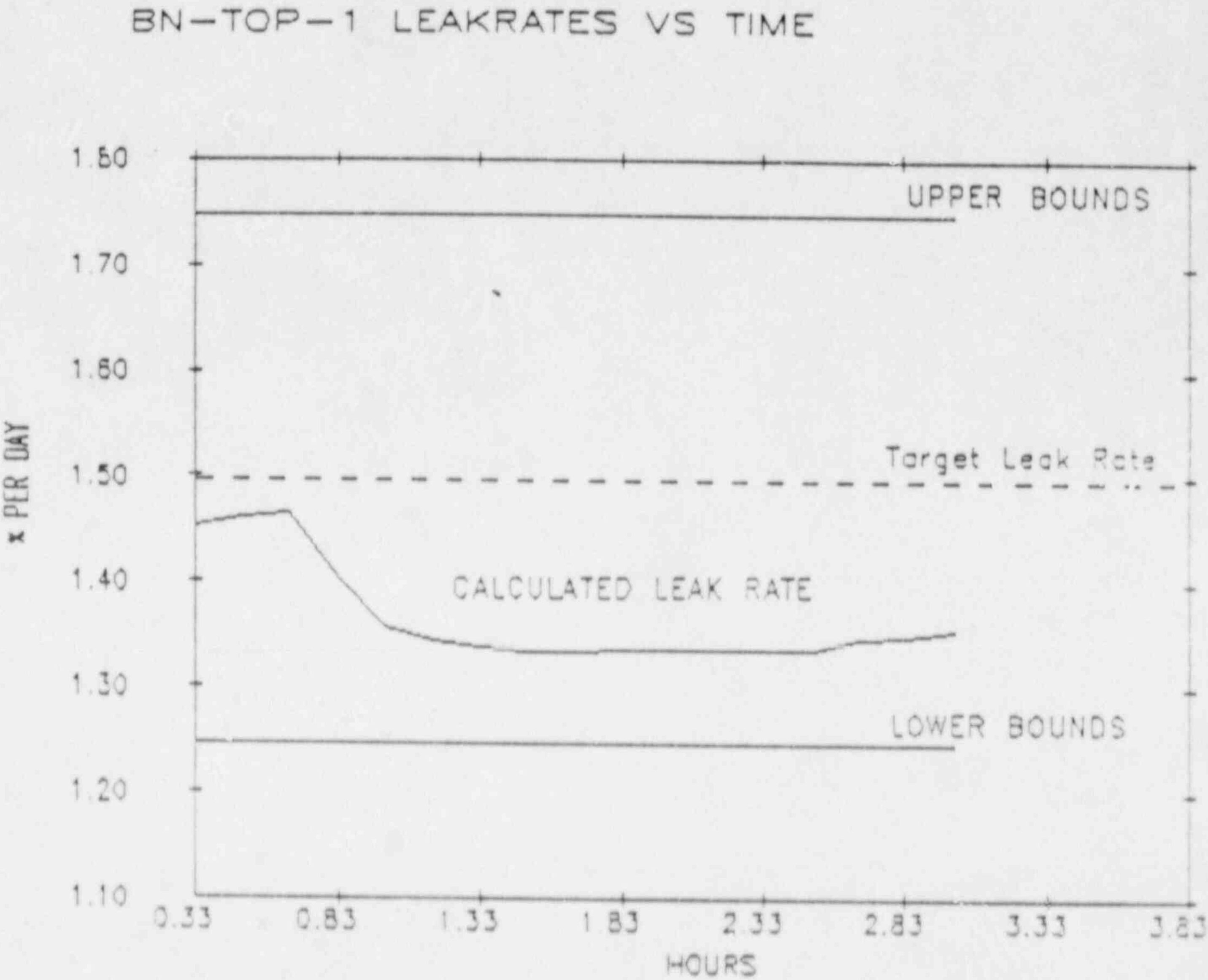

FIGURE 8

INDUCED LEAKAGE PHASE
GRAPH OF TOTAL TIME
MEASURED LEAK RATE AND REGRESSION LINE

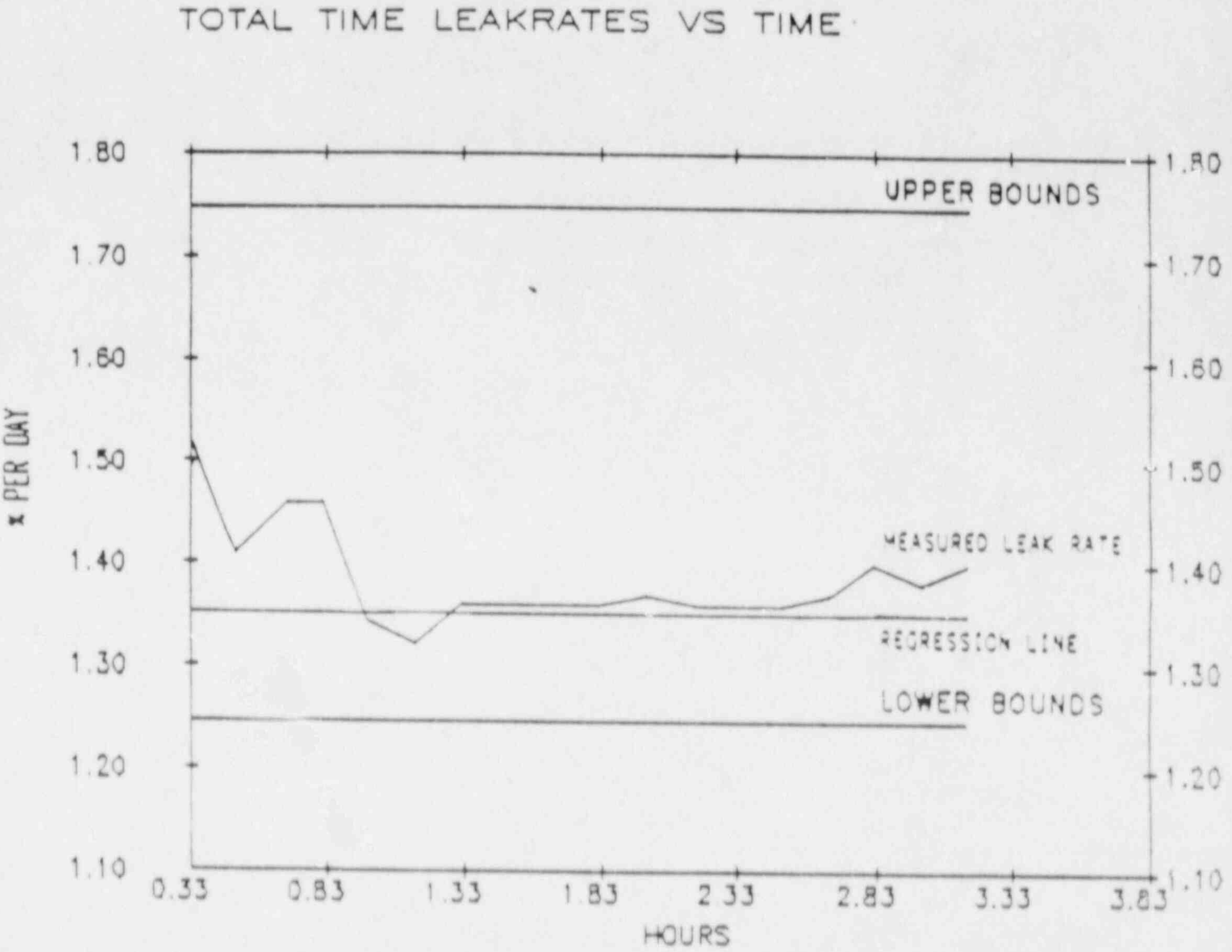

FIGURE 9

INDUCED LEAKAGE PHASE
GRAPH OF VOLUME
WEIGHTED AVERAGE CONTAINMENT TEMPERATURE

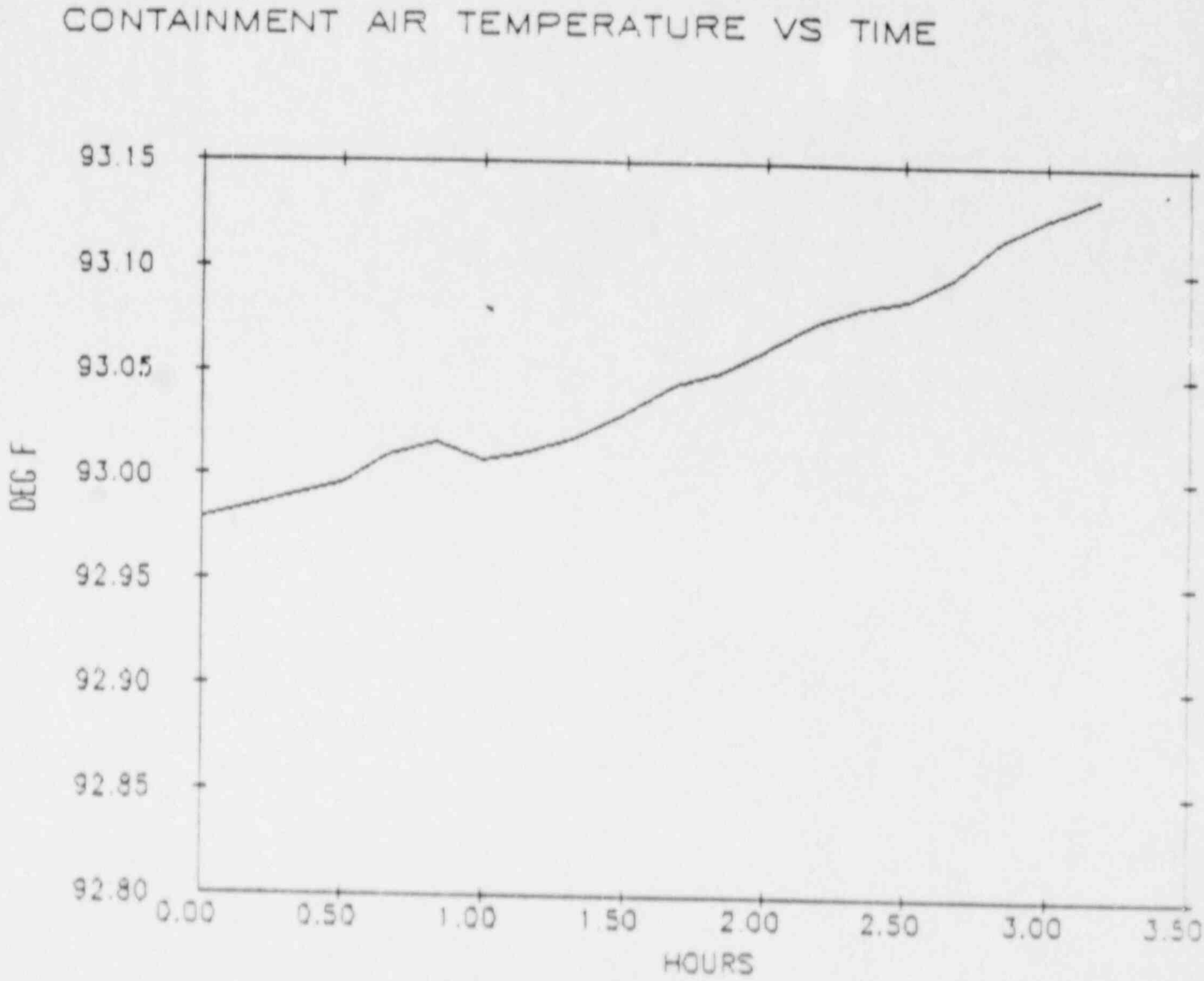

FIGURE 10

INDUCED LEAKAGE PHASE
GRAPH OF VOLUME
WEIGHTED AVERAGE CONTAINMENT VAPOR PRESSURE

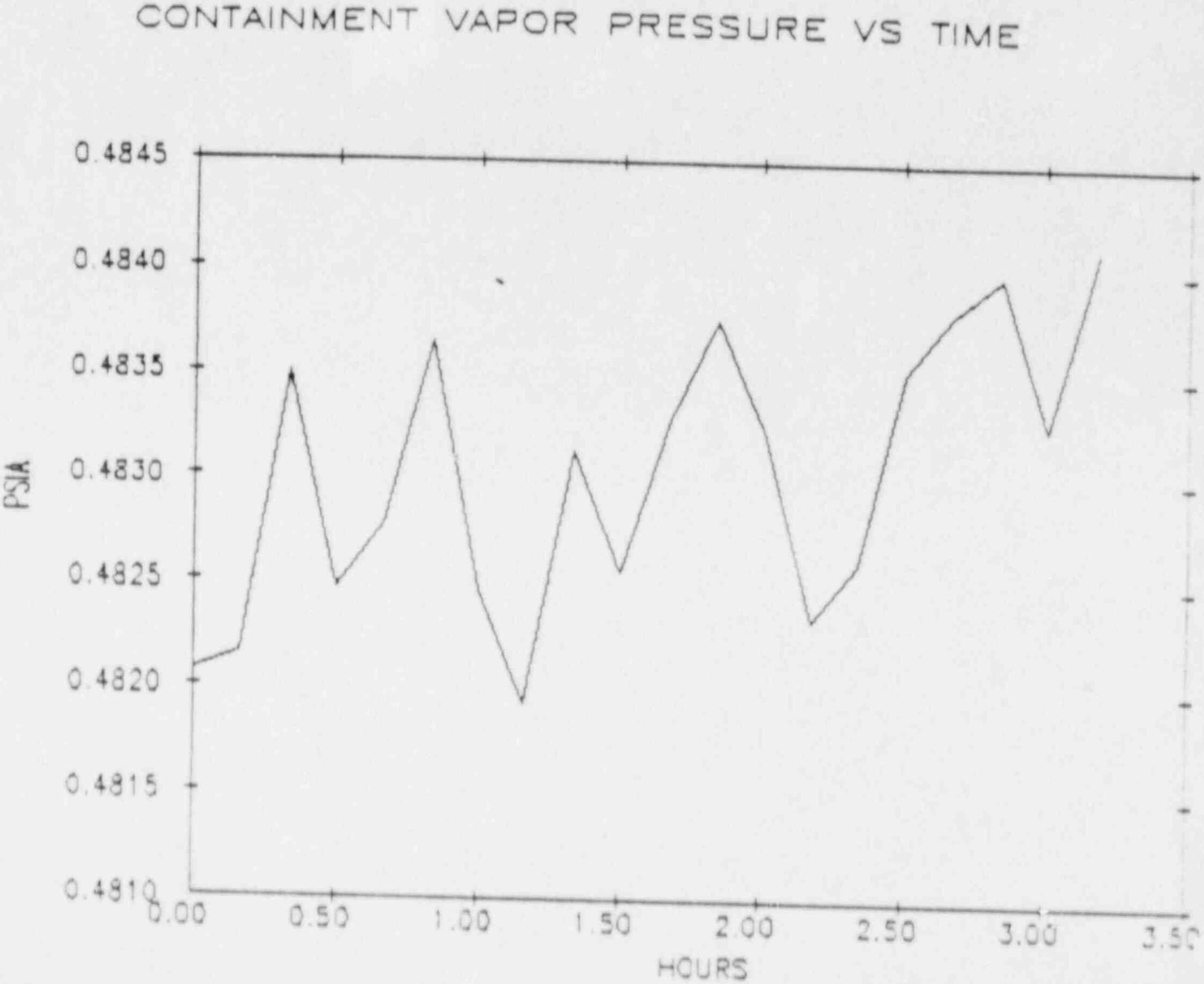

FIGURE 11

INDUCED LEAKAGE PHASE
GRAPH OF DRY AIR PRESSURE

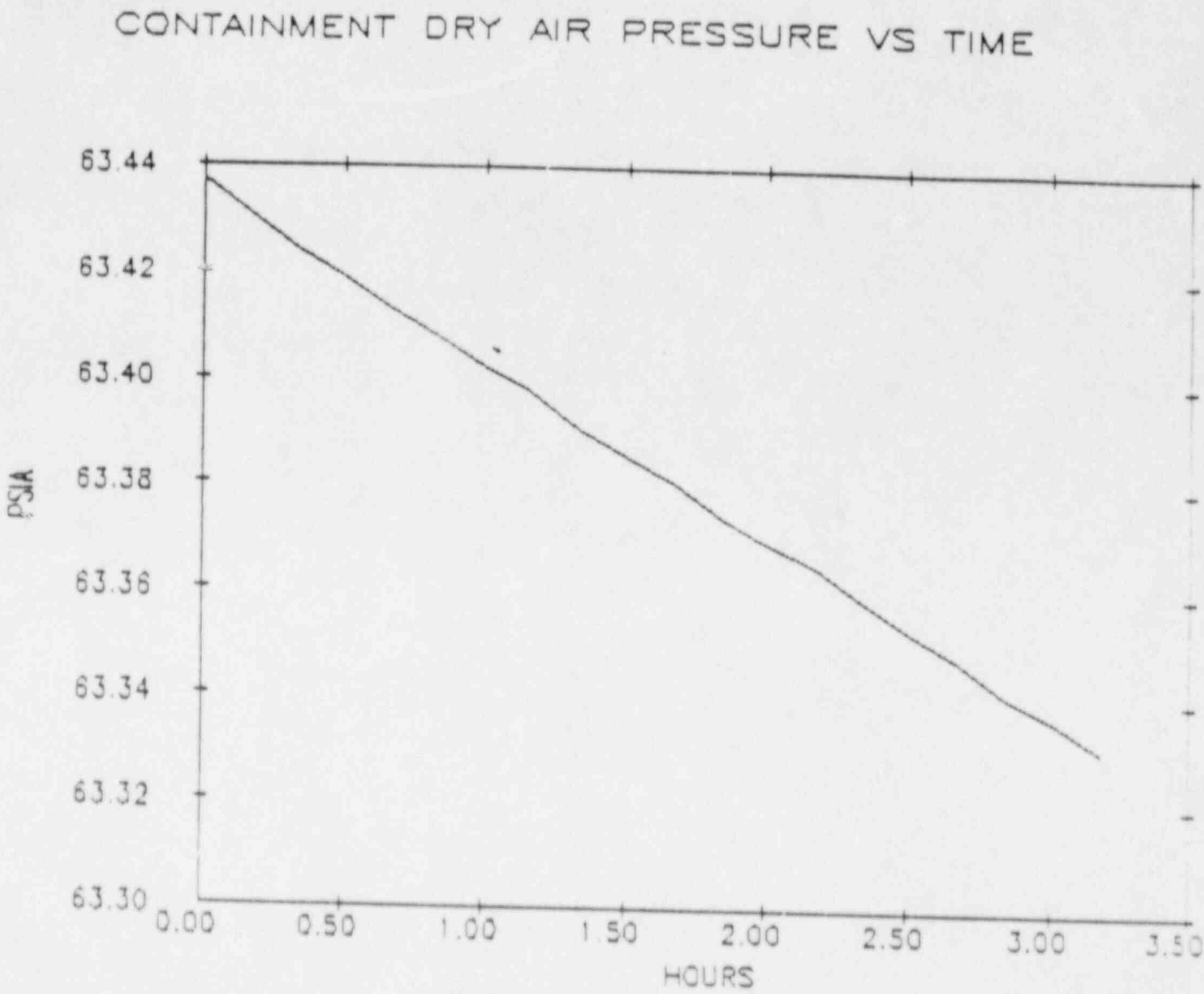

FIGURE 12

GRAPH OF REACTOR WATER LEVEL
THROUGH TESTING PERIOD

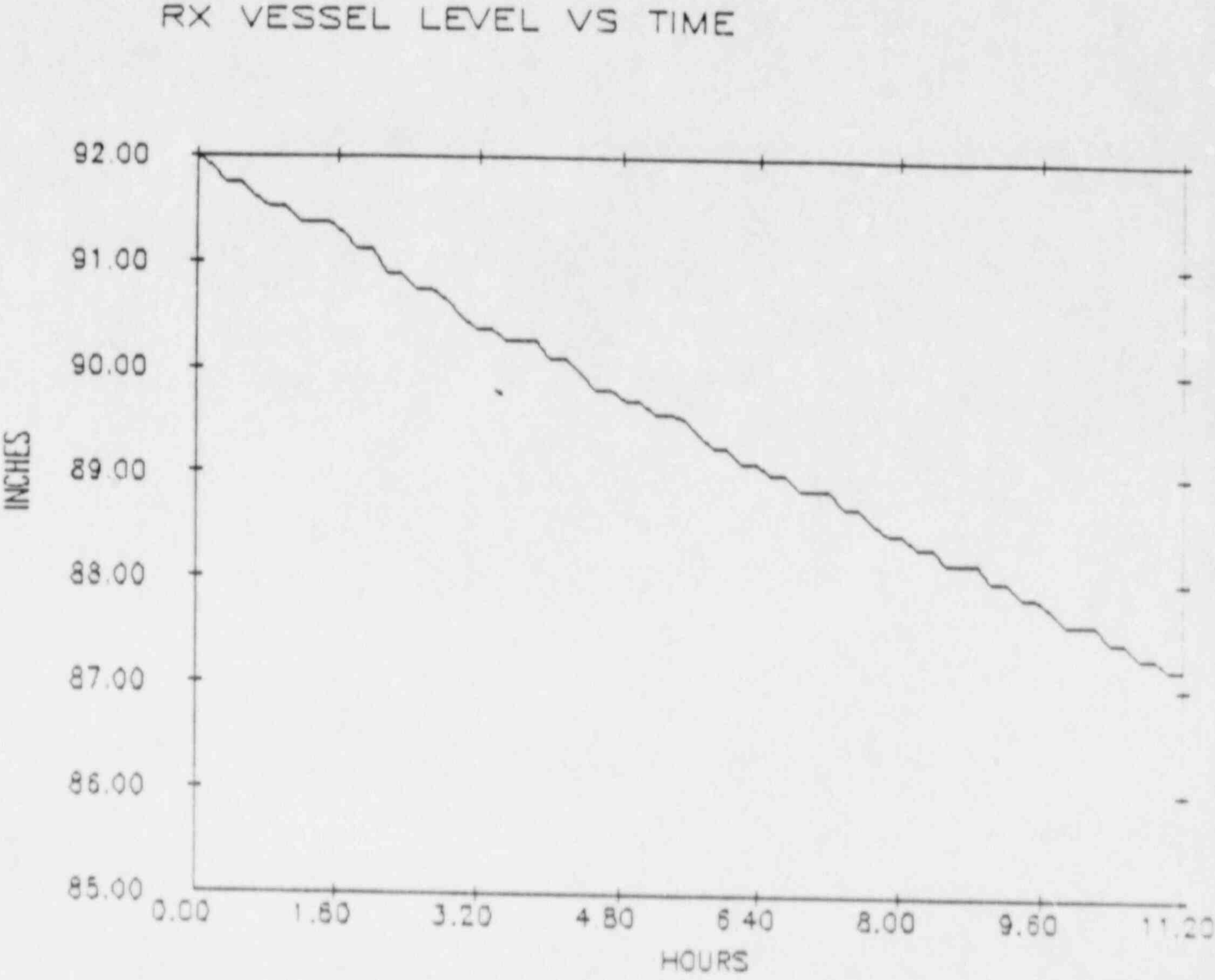

FIGURE 13

GRAPH OF TORUS WATER LEVEL
THROUGH TESTING PERIOD

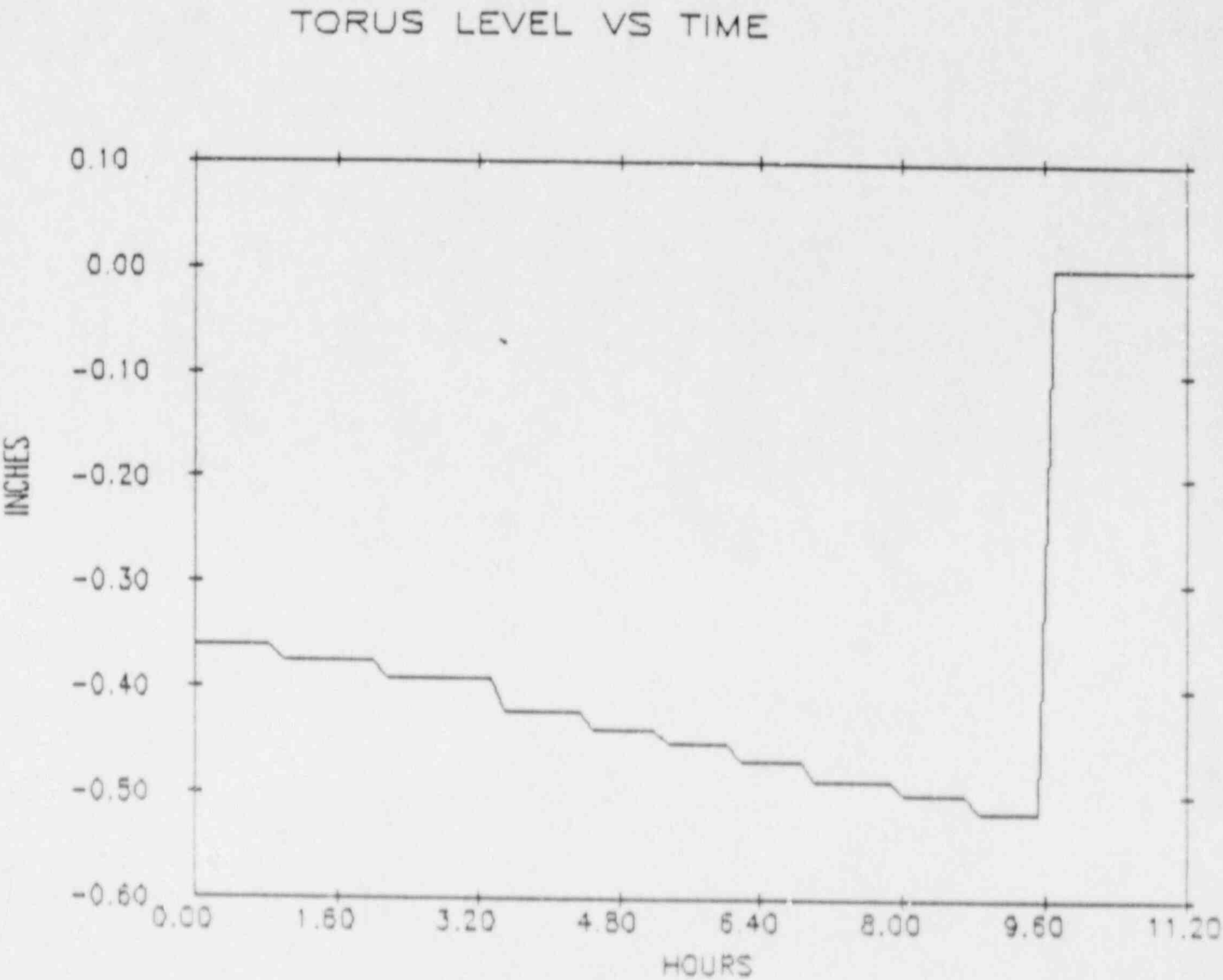

FIGURE 14

SECTION E - TEST CALCULATIONS

Calculations for the IPCLRT are based on the BN-TOP-1, Rev. 1 test method and are found in the functional requirements specification CECo Generic ILRT computer code document ID# SSS-88-002 Dated April 1, 1988. A reproduction of the BN-TOP-1, Rev. 1 test method can be found in Appendix C. In preparing for the first Quad Cities short duration test using BN-TOP-1, Rev. 1 a number of editorial errors and ambiguous statements in the topical report were identified. These errors are presented in Appendix E and are editorial in nature only. The Station has made no attempt to improve or deviate from the methodology outlined in the topical report.

Section 2.3 of BN-TOP-1, Rev. 1 gives the test duration criteria for a short duration test. By station procedure some of these duration criteria have been made more conservative and in some cases these changes may be required by regulations.

A. "Containment Atmosphere Stabilization"

Once the containment is at test pressure the containment atmosphere shall be allowed to stabilize for about four hours (4 hours required by Quad Cities procedure and actual stabilization: 17 hrs, 57 min) The atmosphere is considered stabilized when:

1. The rate of change of average temperature is less than 1.0°F/hour averaged over the last two hours.

DATA SET*	AVE. CONTAINMENT TEMP.		ΔT
180	93.153		
174	93.237		0.084
168	93.294		0.057
		average:	0.0705°F/hour

* Approximate time interval between data sets is 10 minutes.

or

2. "The rate of change of temperature changes less than 0.5°F/hour/hour averaged over the last two hours."

(Not required if A.1 satisfied)

B. Data Recording and Analysis

1. "The Trend Report based on Total Time calculations shall indicate that the magnitude of the calculated leak rate is tending to stabilize at a value less than the maximum allowable leak rate (L_A)..."

By Quad Cities procedure the calc[illegible]d leak rate must be less than 0.75 L_A. The actual value [illegible].155 L_A, stable, and decreasing (no extrapolation requi[illegible]

and

2. "The end of the test upper 95% confidence limit for the calculated leak rate based on total time calculations shall be less than the maximum allowable leak rate."

   By Quad Cities procedure the upper confidence limit must be less than 0.75 L_A. The actual value was 0.4621 L_A.

and

3. "The mean of the measured leak rates based on Total Time calculations over the last five hours of the test or last 20 data points, whichever provides the most data, shall be less than the maximum allowable leak rate."

   By Quad Cities procedure this average must be less than 0.75 L_A. The actual value was 0.4194 L_A for the last 5 hours.

and

4. "Data shall be recorded at approximately equal intervals and in no case at intervals greater than one hour."

   At Quad Cities data scans are automatically performed on 10 minute intervals. No data sets were missed or lost during the 6 hour test period. No computer failures were encountered.

and

5. "At least twenty (20) data point shall be provided for proper statistical analysis."

   There were 38 data sets taken for this test.

and

6. "In no case shall the minimum test duration be less than six (6) hours."

   Quad Cities' procedure limits a short duration test to a minimum of six (6) hours. The data taken during this test would support the argument that a shorter duration test can be conducted. All of the above termination criteria were satisfied in six (6) hours.

SECTION F - TYPE A TEST RESULTS

F.1 Measured Leak Rate Test Results

Based upon the data obtained during the short duration test, the following results were determined: (L_A = 1.0 wt %/day)

1) Calculated leak rate at 6 hours equals 0.4155 wt %/day and declining steadily over time (<0.7500 wt %/day).

2) Upper confidence limit equals 0.4621 wt %/day and declining (<0.750 wt %/day).

3) Mean of the measured leak rates for the last 5 hours (32 data sets) equals 0.4194 wt %/day (<0.750 wt %/day).

4) Data sets were accumulated at approximately 10 minute time intervals and no intervals exceeded 1 hours.

5) There were 38 data sets accumulated in 6 hours measured phase.

6) The minimum test duration (by procedure) of 6 hours was successfully accomplished ($\geq$ 6 hours).

F.2 Induced Leakage Test Results

A leak rate of 8.82 scfm (1.0814 wt %/day) was induced on the primary containment for this phase of the test. The leak rates during this phase of the test were as follows.

BN-TOP-1 Calculated Leak Rate (Measured Leak Rate Phase)	0.4155	0.4155
Induced Leak (8.79 scfm)	1.0814	1.0814
Allowed Error Band	+0.2500	-0.2500
	1.7469	1.2469
BN-TOP-1 Calculated Leak Rate (Induced Leak Rate Phase)	1.4626 wt %/day	

The induced phase of the test has a duration criteria given in Section 2.3.C of BN-TOP-1. The test duration requirements are listed below and were satisfied by the test procedure and the data analysis:

1. Containment atmospheric conditions shall be allowed to stabilize for about one hour after superimposing the known leak. (actual: 1 hour).

2. The verification test duration shall be approximately equal to half the integrated leak rate test duration. (actual: 3 hours for 6 hour test)

3. Results of this verification test shall be acceptable provided the correlation between the verification test data and the integrated leak rate test data demonstrate an agreement within plus or minus 25 percent. (actual: see results above)

F.3 Pre-Operational Results vs Test Results

Past IPCLRT reports have compared the results of each test with the pre-operational IPCLRT, performed April 20-21, 1971. Over the last 16 years, different test equipment, sensor locations and number of sensors, test methods, and test duration have been used. This test yielded results that compare favorably with recent tests and demonstrate that there has been no substantial deterioration in containment integrity.

TEST DATA	TEST DURATION (HOURS)	CALCULATED LEAK RATE (BN-TOP-1)	STATISTICALLY AVE. LEAK RATE (A[illegible]./ANS)
August, 1971	24	Not Available	0.1112
1976	24	Not Available	0.327
1980	24	Not Available	0.449
1983	24	Not Available	0.464
February, 1984	24	Not Available	0.385
May, 1985	24	.3670	0.4071
October, 1986	8	.3225	0.3294
June, 1987	6	.4155	0.4141

F.4 TYPE A TEST PENALTIES

During the type A test, there were a number of systems that were not drained and vented outside the containment. The isolation valves for these systems or penetrations were not "challenged" by the type A test. Even though these systems would not be drained and vented during a DBA event, historically, penalties for these systems have been added to the type A test results.

	AS LEFT MINIMUM PATHWAY LEAKAGE SCFH	WT%/DAY
Primary Sample Valves	0.00	0.00
ACAD	3.30	0.00674
RHR A	2.45	0.00500
RHR B	1.65	0.00337
Feedwater		
DWFDS	0.75	0.00153
DWEDS	0.40	0.00082
RCIC steam exhaust	3.88	0.00792
RCIC drain	1.65	0.00337
HPCI steam exhaust	3.22	0.00658
HPCI Drain	2.10	0.00429
All electrical penetrations	0.20	0.00041
Oxygen analyzer	16.0	0.03268
Tip purge check valves	3.0	0.00613
CAM-Isolation Valves & Panels	0.00	0.00
MSIV drain valves	0.00	0.00
SRM/IRM Purge	0.00	0.00
Total	38.60 SCFH	0.0788 wt%/day

F.5 EVALUATION OF INSTRUMENT FAILURES

Prior to the start of the test, RTD No. 8, located behind the biological shield, failed. The instrument spiked high, then read high. The failure was noted and locked out approximately one hour forty minutes prior to the measure phase.

The effect of this instrument failure on the instrument error reported in section B.3 of this report is minimal.

The system accuracy uncertainty becomes 0.1801 wt %/day and the system repeatability uncertainty becomes 0.0265 wt %/day for a 6 hour test.

F.6 AS FOUND TYPE A TEST RESULTS

The following table summarizes the results of all type B and C testing, as well as the IPCLRT results to arrive at an "As Found" type A test result. Since the total is more than the 0.750 wt %/day, the present schedule of performing a type A test every refuel outage must be maintained.

SUMMARY OF ALL CONTAINMENT
LEAK RATE TESTING DURING
UNIT TWO REFUEL OUTAGE
SPRING, 1988

	AS FOUND (SCFH) MINIMUM PATHWAY LEAKAGE	AS LEFT (SCFH) MINIMUM PATHWAY LEAKAGE
(1) MSIV's @ 25 PSIG	17.28	17.28
(2) MSIV's converted to 48 PSIG*	27.30	27.30
(3) All Type C Tests (Except MSIV's)	1511.84	64.94
(4) All Type B Tests	12.5	12.2
TOTAL (2 + 3 + 4)	1568.92	121.72

(1) Type A Test Integrated Leak Rate Test)	= 0.4155 wt %/day	
(2) Upper Confidence Limit of Type A Test Result	= 0.4621 wt %/day	
(3) Correction for Unvented Volumes During Type A Test	= 0.0788 wt %/day	
(4) Correction for Repairs Prior to Type A Test (As Found - As Left)	= 2.956 wt %/day	(1568.92 - 121.72) / 489.59
(5) Correction for Change Sump Levels	= 0.000 wt %/day	in
TOTAL (2 + 3 + 4 + 5)	3.497 wt %/day (As Found ILRT Result)	

* Leak Rate at 25 PSIG converts to Leak Rate at 48 PSIG using conversion ratio of 1.58. REFERENCE ORNL - NISC - 5, Oak Ridge National Laboratory, Aug. 1965, page 10.55.

APPENDIX A
TYPE B AND C TESTS

Presented herin are the results of local leak rate tests conducted on all penetrations, double-gasketed seals, and isolation valves since the previous IPCLRT in October 1986. Total leakage for double gasketed seals and total leakage for all penetrations and isolation valves following repairs satisfied the Technical Specification limits.

REFUEL OUTAGE LOCAL
LEAK RATE TEST SUMMARY

QTS 100-S1
Revision 7
May 1987

APPROVED
SEP 09 1987
O.C.O.S.R.

UNIT Two
TEST DIRECTOR [illegible signature]
OPERATING ENG. [illegible signature]
TECH STAFF SUPV. [illegible signature] for

DESCRIPTION	VALVE(S)/ PENETRATION	AS FOUND (SCFH) DATE	TOTAL	MINIMUM PATHWAY	MAXIMUM PATHWAY	AS LEFT (SCFH) DATE	TOTAL	MINIMUM PATHWAY	MAXIMUM PATHWAY
'A' MSIV	AO 203-1A,2A	4-10-88	3.46	1.73	3.46	4-10-88	3.46	1.73	3.46
'B' MSIV	AO 203-1B,2B	4-10-88	4.61	2.31	4.61	4-10-88	4.61	2.31	4.61
'C' MSIV	AO 203-1C,2C	4-10-88	6.91	3.46	6.91	4-10-88	6.91	3.46	6.90
'D' MSIV	AO 203-1D,2D	4-10-88	2.30	1.15	2.30	4-10-88	2.30	1.15	2.30
		TOTAL		17.28		TOTAL		17.28	
		TOTAL CORRECTED *		27.30		TOTAL CORRECTED *		27.30	

DESCRIPTION	VALVE(S)/ PENETRATION	AS FOUND DATE	TOTAL	MINIMUM PATHWAY	MAXIMUM PATHWAY	AS LEFT DATE	TOTAL	MINIMUM PATHWAY	MAXIMUM PATHWAY
MSL DRAIN	MO 220-1,2	4-11-88	65.45	32.73	65.45	6-21-88	0.0	0.0	0.0
PRIMARY SAMPLE	AO 220-44,45	5-2-88	0.0	0.0	0.0	5-2-88	0.0	0.0	0.0
'A' FEEDWATER	CV 220-58A,62A	4-27-88	508.2	508.2	508.2	6-6-88	3.26	1.85 58A	[illegible] 62A
'B' FEEDWATER	CV 220-58B,62B	4-13-88	890.1	890.1	890.1	6-6-88	2.06	.68 58B	2.06 58B
RHR TO RADWASTE	MO 1001-20,21	4-13-88	0.0	0.0	0.0	4-13-88	0.0	0.0	0.0
'A' DW SPRAY	MO 1001-23A,26A	4-17-88	0.28	0.14	0.28	4-17-88	0.28	0.14	0.28
'A' RHR RETURN	MO 1001-29A	4-19-88	4.5	2.25	4.5	4-19-88	4.5	2.25	4.5
'A' TORUS COOLING SPRAY	MO 1001-34,36,37A	4-19-88	1.22	0.41	1.22	6-14-88	1.02	0.20	1.02
'B' DW SPRAY	MO 1001-23B,26B	5-27-88	6.43	3.22	6.43	5-27-88	6.43	3.22	6.43
'B' RHR RETURN	MO 1001-29B	5-27-88	2.07	1.04	2.07	5-27-88	2.07	1.04	2.07
'B' TORUS COOLING/SPRAY	MO 1001-34,36,37B	5-27-88	1.82	0.61	1.82	5-27-88	1.82	0.61	1.82
	PAGE TOTAL (EXCEPT MSIV'S)	NA	1480.07	1438.70	1480.07	NA	50.78	9.69	50.78

10/0168s

-1-

UNIT Two

REFUEL OUTAGE LOCAL LEAK RATE TEST SUMMARY

QTS 100-S1
Revision 7

DESCRIPTION	VALVE(S)/ PENETRATION	AS FOUND (SCFH) DATE	TOTAL	MINIMUM PATHWAY	MAXIMUM PATHWAY	AS LEFT (SCFH) DATE	TOTAL	MINIMUM PATHWAY	MAXIMUM PATHWAY
SHUTDOWN COOLING	MO 1001-47,50	4-27-88	0.0	0.0	0.0	6-1-88	3.52	1.76	3.52
HEAD SPRAY	MO 1001-60,63	4-22-88	0.57	0.28	0.57	4-22-88	0.57	0.28	0.57
CLEAN UP SUCTION	MO 1201-2,5	5-4-88	13.1	6.55	13.1	6-7-88	1.88	0.94	1.88
RCIC STEAM SUPPLY	MO 1301-16,17	4-11-88	0.07	0.04	0.07	6-11-88	1.64	0.82	1.64
RCIC STEAM EXHAUST	CV 1301-41	4-10-88	7.75	3.88	[illegible]	4-10-88	7.75	3.88	7.75
RCIC VAC. PUMP EX	CV 1301-40	4-10-88	3.3	1.65	3.3	4-10-88	3.3	1.65	3.3
DW/TORUS PURGE SUPPLY	AO 1601-21,22,55,56	4-11-88	14.45	7.23	14.45	4-11-88	14.45	7.23	14.45
DW/TORUS PURGE EX	AO 1601-23,24,60, 61,62,63	5-15-88	0.0	0.0	0.0	5-15-88	0.0	0.0	0.0
'A' TORUS VENT	AO 1601-20A, CV 1601-31A	4-11-88	3.56	1.78	3.56	4-11-88	3.56	1.78	3.56
'B' TORUS VENT	AO 1601-20B, CV 1601-31B	4-11-88	9.67	4.84	9.67	4-11-88	9.67	4.84	9.67
DW/TORUS PURGE	AO 1601-57,58,59	4-10-88	0.60	0.30	0.60	4-10-88	0.60	0.30	0.60
DW FLOOR DRAIN SUMP	AO 2001-3,4 *1	4-18-88	40	40	40	6-4-88	1.50	0.75	1.50
DW EQ. DR. SUMP	AO 2001-15, 16	4-18-88	0.8	0.4	0.8	4-18-88	0.8	0.4	0.8
HPCI STEAM SUPPLY	MO 2301-4,5	4-11-88	2.3	1.15	2.3	4-11-88	2.3	1.15	2.3
HPCI STEAM EX	CV 2301-45	4-10-88	6.43	3.22	6.43	4-10-88	6.43	3.22	6.43
HPCI DRAIN POT EX	CV 2301-34	4-10-88	4.2	2.1	4.2	4-10-88	4.2	2.1	4.2
DW PNEUMATIC	AO 4720, 4721	5-2-88	0.20	0.15	0.20	5-2-88	0.20	0.15	0.20
PAGE TOTAL		NA	71.00	37.57	71.00	NA	62.37	31.25	62.37

APPROVED
SEP 09 1987
OCOSR

*1 see field worksheet - leakage was quantified on the 2001-4 valve as 40 scfh

10/0168s

-2-

UNIT *TWO*

REFUEL OUTAGE LOCAL
LEAK RATE TEST SUMMARY

QTS 100-S1
Revision 7

DESCRIPTION	VALVE(S)/ PENETRATION	AS FOUND (SCFH) DATE	TOTAL	MINIMUM PATHWAY	MAXIMUM PATHWAY	AS LEFT (SCFH) DATE	TOTAL	MINIMUM PATHWAY	MAXIMUM PATHWAY
O_2 ANALYZER	AO 8801A, 8802A	5-3-88	2.0	0.0	2.0	5-3-88	2.0	0.0	2.0
O_2 ANALYZER	AO 8801B, 8802B	5-3-88	1.5	0.0	1.5	5-3-88	1.5	0.0	1.5
O_2 ANALYZER	AO 8801C, 8802C	5-3-88	10.6	0.6	10.0	6-11-88	12.0	12.0	12.0
O_2 ANALYZER	AO 8801D, 8802D	5-3-88	9.0	4.0	5.0	5-3-88	9.0	4.0	5.0
O_2 ANALYZER	AO 8803, 8804	4-11-88	0.12	0.12	0.12	6-11-88	1.6	0.0 8804	1.6 8803
TIP BALL VALVE	~~733-1~~ 737-1B	5-12-88	0.0	0.0	0.0	6-11-88	0.3	0.3	0.3
TIP BALL VALVE	~~733-2~~ 737-1C	5-12-88	0.0	0.0	0.0	6-11-88	0.0	0.0	0.0
TIP BALL VALVE	~~733-3~~ 737-1D	5-12-88	10.1	10.1	10.1	6-11-88	0.0	0.0	0.0
TIP BALL VALVE	~~733-4~~ 737-1E	5-12-88	1.0	1.0	1.0	6-11-88	1.2	1.2	1.2
TIP BALL VALVE	~~733-5~~ 737-1F	5-12-88	2.2	2.2	2.2	6-11-88	0.2	0.2	0.2
TIP PURGE CHECK	700-743	5-12-88	3.0	3.0	3.0	5-12-88	3.0	3.0	3.0
CAM	SO 2499-1A,2A	4-14-88	0.0	0.0	0.0	4-14-88	0.0	0.0	0.0
CAM	SO 2499-1B,2B	4-14-88	0.0	0.0	0.0	4-14-88	0.0	0.0	0.0
CAM	SO 2499-3A,4A	4-14-88	0.0	0.0	0.0	4-14-88	0.0	0.0	0.0
CAM	SO 2499-3B,4B	4-14-88	0.0	0.0	0.0	4-14-88	0.0	0.0	0.0
ACAD	AO 2599-2A,23A	4-14-88	2.4	0.0 23A	2.4 2A	4-14-88	2.4	0.0 23A	2.4 2A
ACAD	AO 2599-2B,23B	4-14-88	2.1	0.2 23B	1.9 2B	4-14-88	2.1	0.2 23B	1.9 2B
ACAD	AO 2599-3A,24A	4-14-88	6.1	2.4 3A	3.7 24A	4-14-88	6.1	2.4 3A	3.7 24A
ACAD	AO 2599-3B,24B	4-14-88	2.3	0.0 24B	2.3 3B	4-14-88	2.3	0.0 24B	2.3 3B
ACAD	AO 2599-4A,5A	5-5-88	0.9	0.7 4A	0.2 5A	5-5-88	0.9	0.7 4A	0.2 5A
ACAD	AO 2599-4B,5B	5-5-88	1.0	0.0 5B	1.0 4B	5-5-88	1.0	0.0 5B	1.0 4B
	PAGE TOTAL	NA	66.2	36.2	58.3	NA	45.60	24.0	38.3

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UNIT *Two*

REFUEL OUTAGE LOCAL
LEAK RATE TEST SUMMARY

QTS 100-S1
Revision 7

DESCRIPTION	VALVE(S)/ PENETRATION	AS FOUND (SCFH) DATE	TOTAL	MINIMUM PATHWAY	MAXIMUM PATHWAY	AS LEFT (SCFH) DATE	TOTAL	MINIMUM PATHWAY	MAXIMUM PATHWAY
EQUIPMENT HATCH	X-1	4-11-88	0.0	0.0	0.0	6-11-88	0.0	0.0	0.0
DW ACCESS HATCH	X-4	4-11-88	0.0	0.0	0.0	6-19-88	0.0	0.0	0.0
CRD HATCH	X-6	5-13-88	0.0	0.0	0.0	5-31-88	0.0	0.0	0.0
TIP PENETRATION	X-35A	5-14-88	0.6	0.6	0.6	5-14-88	0.6	0.6	0.6
TIP PENETRATION	X-35B	5-14-88	0.0	0.0	0.0	5-14-88	0.0	0.0	0.0
TIP PENETRATION	X-35C	5-14-88	0.0	0.0	0.0	5-14-88	0.0	0.0	0.0
TIP PENETRATION	X-35D	5-14-88	0.0	0.0	0.0	5-14-88	0.0	0.0	0.0
TIP PENETRATION	X-35E	5-14-88	0.0	0.0	0.0	5-14-88	0.0	0.0	0.0
TIP PENETRATION	X-35F	5-14-88	0.0	0.0	0.0	5-14-88	0.0	0.0	0.0
TIP PENETRATION	X-35G	5-14-88	0.0	0.0	0.0	5-14-88	0.0	0.0	0.0
TORUS HATCH	X-200A	4-10-88	0.0	0.0	0.0	6-11-88	0.0	0.0	0.0
TORUS HATCH	X-200B	4-10-88	0.0	0.0	0.0	6-11-88	0.0	0.0	0.0
DRYWELL HEAD	----	4-11-88	0.3	0.3	0.3	6-11-88	0.0	0.0	0.0
SHEAR LUG INSP. HATCH	SL-1	5-17-88	0.0	0.0	0.0	5-17-88	0.0	0.0	0.0
SHEER LUG INSP. HATCH	SL-2	5-17-88	0.0	0.0	0.0	5-17-88	0.0	0.0	0.0
SHEAR LUG INSP. HATCH	SL-3	5-17-88	0.0	0.0	0.0	5-17-88	0.0	0.0	0.0
SHEER LUG INSP. HATCH	SL-4	5-17-88	0.0	0.0	0.0	5-17-88	0.0	0.0	0.0
SHEAR LUG INSP. HATCH	SL-5	5-17-88	0.0	0.0	0.0	5-17-88	0.0	0.0	0.0
SHEER LUG INSP. HATCH	SL-6	5-17-88	0.0	0.0	0.0	5-17-88	0.0	0.0	0.0
SHEAR LUG INSP. HATCH	SL-7	5-17-88	0.3	0.3	0.3	5-17-88	0.3	0.3	0.3
SHEER LUG INSP. HATCH	SL-8	5-17-88	0.0	0.0	0.0	5-17-88	0.0	0.0	0.0
	PAGE TOTAL	NA	1.2	1.2	1.2	NA	0.9	0.9	0.9

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REFUEL OUTAGE LOCAL
LEAK RATE TEST SUMMARY

QTS 100-S1
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UNIT *Two*

DESCRIPTION	VALVE(S)/ PENETRATION	AS FOUND (SCFH) DATE	AS FOUND TOTAL	AS FOUND MINIMUM PATHWAY	AS FOUND MAXIMUM PATHWAY	AS LEFT (SCFH) DATE	AS LEFT TOTAL	AS LEFT MINIMUM PATHWAY	AS LEFT MAXIMUM PATHWAY
MECH. PENETRATION	X-7A	4-14-88	0.0	0.0	0.0	4-14-88	0.0	0.0	0.0
MECH. PENETRATION	X-7B	4-14-88	0.0	0.0	0.0	4-14-88	0.0	0.0	0.0
MECH. PENETRATION	X-7C	4-11-88	0.0	0.0	0.0	4-11-88	0.0	0.0	0.0
MECH. PENETRATION	X-7D	4-11-88	0.0	0.0	0.0	4-11-88	0.0	0.0	0.0
MECH. PENETRATION	X-8	4-14-88	0.0	0.0	0.0	4-14-88	0.0	0.0	0.0
MECH. PENETRATION	X-9A	4-14-88	0.0	0.0	0.0	4-14-88	0.0	0.0	0.0
MECH. PENETRATION	X-9B	4-11-88	0.8	0.8	0.8	4-11-88	0.8	0.8	0.8
MECH. PENETRATION	X-10	4-11-88	0.0	0.0	0.0	4-11-88	0.0	0.0	0.0
MECH. PENETRATION	X-11	4-11-88	0.3	0.3	0.3	4-11-88	0.3	0.3	0.3
MECH. PENETRATION	X-12	4-11-88	5.0	5.0	5.0	4-11-88	5.0	5.0	5.0
MECH. PENETRATION	X-13A	4-14-88	0.0	0.0	0.0	4-14-88	0.0	0.0	0.0
MECH. PENETRATION	X-13B	4-11-88	0.2	0.2	0.2	4-11-88	0.2	0.2	0.2
MECH. PENETRATION	X-14	4-14-88	1.4	1.4	1.4	4-14-88	1.4	1.4	1.4
MECH. PENETRATION	X-23	4-11-88	0.0	0.0	0.0	4-11-88	0.0	0.0	0.0
MECH. PENETRATION	X-24	4-11-88	0.0	0.0	0.0	4-11-88	0.0	0.0	0.0
MECH. PENETRATION	X-25	4-14-88	0.0	0.0	0.0	4-14-88	0.0	0.0	0.0
MECH. PENETRATION	X-26	4-14-88	0.0	0.0	0.0	4-14-88	0.0	0.0	0.0
MECH. PENETRATION	X-36	4-11-88	0.3	0.3	0.3	4-11-88	0.3	0.3	0.3
MECH. PENETRATION	X-47	4-11-88	0.0	0.0	0.0	4-11-88	0.0	0.0	0.0
MECH. PENETRATION	X-17	4-14-88	1.4	1.4	1.4	4-14-88	1.4	1.4	1.4
MECH. PENETRATION	X-16A	4-10-88	1.3	1.3	1.3	4-10-88	1.3	1.3	1.3
	PAGE TOTAL	NA	10.7	10.7	10.7	NA	10.7	10.7	10.7

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UNIT Two

REFUEL OUTAGE LOCAL
LEAK RATE TEST SUMMARY

QTS 100-S1
Revision 7

DESCRIPTION	VALVE(S)/ PENETRATION	AS FOUND (SCFH) DATE	TOTAL	MINIMUM PATHWAY	MAXIMUM PATHWAY	AS LEFT (SCFH) DATE	TOTAL	MINIMUM PATHWAY	MAXIMUM PATHWAY
MECH. PENETRATION	X-16B	4-13-88	0.4	0.4	0.4	4-13-88	0.4	0.4	0.4
ELECTRICAL PENETRATION	X-100A	N/A	N/A	N/A	N/A	N-A	N/A	N/A	N/A
ELECTRICAL PENETRATION	X-100B	4-13-88	0.0	0.0	0.0	4-13-88	0.0	0.0	0.0
ELECTRICAL PENETRATION	X-100C	4-11-88	0.0	0.0	0.0	4-11-88	0.0	0.0	0.0
ELECTRICAL PENETRATION (UNIT ONE ONLY)	X-100D	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
ELECTRICAL PENETRATION	X-100E	4-11-88	0.0	0.0	0.0	4-11-88	0.0	0.0	0.0
ELECTRICAL PENETRATION	X-100F	5-13-88	0.0	0.0	0.0	5-13-88	0.0	0.0	0.0
ELECTRICAL PENETRATION	X-100G	5-13-88	0.0	0.0	0.0	5-13-88	0.0	0.0	0.0
ELECTRICAL PENETRATION	X-101A	4-11-88	0.0	0.0	0.0	4-11-88	0.0	0.0	0.0
ELECTRICAL PENETRATION	X-101B	4-11-88	0.0	0.0	0.0	4-11-88	0.0	0.0	0.0
ELECTRICAL PENETRATION	X-101D	5-3-88	0.0	0.0	0.0	5-13-88	0.0	0.0	0.0
ELECTRICAL PENETRATION (UNIT ONE ONLY)	X-102A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
ELECTRICAL PENETRATION (UNIT TWO ONLY)	X-102B	4-11-88	0.2	0.2	0.2	4-11-88	0.2	0.2	0.2
ELECTRICAL PENETRATION	X-103	4-11-88	0.0	0.0	0.0	4-11-88	0.0	0.0	0.0
ELECTRICAL PENETRATION (UNIT TWO ONLY)	X-104A	4-13-88	0.0	0.0	0.0	4-13-88	0.0	0.0	0.0
ELECTRICAL PENETRATION	X-104B	4-13-88	0.0	0.0	0.0	4-13-88	0.0	0.0	0.0
ELECTRICAL PENETRATION	X-104C	4-11-88	0.0	0.0	0.0	4-11-88	0.0	0.0	0.0
APPROVED SEP 09 1987	PAGE TOTAL	NA	0.6	0.6	0.6	NA	0.6	0.6	0.6

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UNIT Two

REFUEL OUTAGE LOCAL
LEAK RATE TEST SUMMARY

QTS 100-S1
Revision 1

DESCRIPTION	VALVE(S)/ PENETRATION	AS FOUND (SCFH) DATE	TOTAL	MINIMUM PATHWAY	MAXIMUM PATHWAY	AS LEFT (SCFH) DATE	TOTAL	MINIMUM PATHWAY	MAXIMUM PATHWAY
ELECTRICAL PENETRATION (UNIT TWO ONLY)	X-104D	4-11-88	0.0	0.0	0.0	4-11-88	0.0	0.0	0.0
ELECTRICAL PENETRATION	X-104F	5-13-88	0.0	0.0	0.0	5-13-88	0.0	0.0	0.0
ELECTRICAL PENETRATION (UNIT ONE ONLY)	X-105A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
ELECTRICAL PENETRATION (UNIT ONE ONLY)	X-105B	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
ELECTRICAL PENETRATION	X-105C	4-11-88	0.0	0.0	0.0	4-11-88	0.0	0.0	0.0
ELECTRICAL PENETRATION (UNIT ONE ONLY)	X-105D	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
ELECTRICAL PENETRATION (UNIT TWO ONLY)	X-106A	4-11-88	0.0	0.0	0.0	4-11-88	0.0	0.0	0.0
ELECTRICAL PENETRATION (UNIT TWO ONLY)	X-106B	4-11-88	0.0	0.0	0.0	4-11-88	0.0	0.0	0.0
ELECTRICAL PENETRATION	X-107A	5-13-88	0.0	0.0	0.0	5-13-88	0.0	0.0	0.0
ELECTRICAL PENETRATION (UNIT TWO ONLY)	X-107B	4-12-88	0.0	0.0	0.0	4-12-88	0.0	0.0	0.0
TORUS PENETRATION	X-227A	4-15-88	0.0	0.0	0.0	4-15-88	0.0	0.0	0.0
TORUS PENETRATION	X-227B	4-14-88	0.0	0.0	0.0	4-14-88	0.0	0.0	0.0
'A' TORUS LEVEL FLANGES	----	4-26-88	0.0	0.0	0.0	4-26-88	0.0	0.0	0.0
PAGE TOTAL		NA	0.0	0.0	0.0	NA	0.0	0.0	0.0

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UNIT *Two*

REFUEL OUTAGE LOCAL
LEAK RATE TEST SUMMARY

QTS 100-S1
Revision 7

DESCRIPTION	VALVE(S)/ PENETRATION	AS FOUND (SCFH) DATE	TOTAL	MINIMUM PATHWAY	MAXIMUM PATHWAY	AS LEFT (SCFH) DATE	TOTAL	MINIMUM PATHWAY	MAXIMUM PATHWAY
'B' TORUS LEVEL FLANGES	----	4-26-88	0.0	0.0	0.0	4-26-88	0.0	0.0	0.0
SRM/IRM PURGE (UNIT TWO ONLY)	----	5-18-88	0.0	0.0	0.0	5-18-88	0.0	0.0	0.0
PERSONNEL INTERLOCK X-2	X-2	4-15-88	0.0	0.0	0.0	5-25-88	15.11	15.11	15.11
H_2/O_2 MONITORING SYSTEM (TOTAL)	---- A loop *1 B loop	5-26-88 5-27-88	0.0 0.0	0.0	0.0	5-26-88 5-27-88	0.0	0.0	0.0
PAGE TOTAL		NA	0.0	0.0	0.0	NA	0.0	0.0	0.0
TEST TOTAL +		NA	~~0.0~~ 1627.77	1524.97	1621.87 **	NA	~~[illegible]~~ [illegible]	92.25	178.76

*To determine the corrected leakage of the MSIV's (as if they had been tested at 48 PSIG), multiply by 1.58.

**When the maximum pathway leakage exceeds 0.6 La (293.75 SCFH), write an LER immediately.

+The test total is the sum of all page totals in the checklist (exclude MSIV's from all test totals).

Reference: QTS 150 8, "Determination of Total Containment Leak Rate."

*1 The "A" H_2/O_2 cabinet leak rate was quantified by Temporary procedure 5484 through the 2-2499-22A check valve. Leak rate = 0.0 scfh

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(final)

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APPENDIX B

TEST CORRECTION FOR SUMP LEVEL CHANGES

The total time measured leak rate, given by the functional requirements specification CECo Generic ILRT Computer Code Document ID # SSS-88-002 Dated April 1, 1988 (see Appendix C), assumes that the containment free air space is 280,327.5 ft^3 at a water level in the reactor of 35", torus water level is zero, and that any change in reactor water level is due to a water leakage from the containment changing the free air volume. If the water leakage is from the containment and due to the operation of the shutdown cooling mode of RHR to maintain reactor water temperature, this leakage would not be representative of accident conditions when shutdown cooling would be isolated.

During the stabilization phase of the test considerable effort went into reducing the rate of level decline to approximately 0.45 inches/hour (11.25 ft^3/hr or 1.40 GPM) that was experienced during the test. Since the leakage could not be reduced further and level indication for the suppression pool indicated that most of the water leaving the reactor was not entering the suppression pool, but leaving containment, the computer program option for including the vessel level in the leak rate calculation was selected.

The test verification during the induced phase of the test demonstrates the accuracy of this model and the change was completely explained to the NRC inspector witnessing the test.

A hand calculation, using a complete water balance, is included in this Appendix to show that the leak rate reported is not significantly affected by a more detailed analysis, including changing subvolume free air space due to water leaking from the reactor vessel to the drywell sumps and suppression pool.

To perform a leak rate calculation with a changing containment free air space, the dry air mass for each containment subvolume is calculated using the following equation:

$$W_i = \frac{2.6995 \times P_i \times V_i}{(T_i + 459.69)}$$

where P_i = dry air pressure in i^{th} subvolume,

V_i = free air space in the i^{th} subvolume, and

T = average temperature in the i^{th} subvolume.

The total containment dry air mass is given by the sum of the dry air masses for all of the subvolumes.

$$W^t = \sum_{i=1}^{11} W_i$$

The computed leak rate will be the total time leak rate and is given by:

$$L^t = -\frac{2400}{H} \times \frac{W^t - W^\circ}{W^\circ}$$

where W° = dry air mass of the containment at the start of the test,

W^t = dry air mass of the containment at time t,

H = duration of the test from start to time t in hours, and

L^t = total time leak rate at time t.

There are 3 subvolumes to consider in evaluating the effects of water leakage from the vessel: the vessel itself (subvolume 11), the suppression pool (subvolume 10), and the subvolume for the drywell equipment drain sump (DWEDS) and the drywell floor drain sump (DWFDS) (subvolume 9). Any water leaking from the vessel in excess of that added to the sumps and suppression pool will be assumed to have leaked from the containment through the shutdown cooling mode of RHR.

DATE	TIME	DWFDS*	DWEDS*
06/21/88	0300	10	8.0
06/14/88	0315	24.0	6.2
Rate of level change (in/hr)		0.290	0.0373
Rate of free air vol change (ft^3/hr):		-1.108	0.142

*The sumps are assumed to have filled at a constant rate during the period when the containment was fully pressurized. Each sump holds 1200 gallons and is 42" deep.

The following table gives the extrapolated values of the subvolume free air spaces using the above data:

SUBVOLUME NO. (i)	6 HOUR TEST V_i t=0	6 HOUR TEST V_i t=6	INDUCED TEST V_i t=0	INDUCED TEST V_i t=3
1	10,550	10,550	10,550	10,550
2	9,596	9,596	9,596	9,596
3	10,990	10,990	10,990	10,990
4	3,783	3,783	3,783	3,783
5	24,125	24,125	24,125	24,125
6	32,265	32,265	32,265	32,265
7	27,618	27,618	27,618	27,618
8	26,071	26,071	26,071	26,071
9*	8,808	8,802	8,800	8,797
10*	119,580	119,658	119,700	119,714
11*	5,146	5,215	5,235	5,266

* $V_9 = 8,901 - \left(\frac{DWFDS}{42} \times 1200 \times .13368\right) - \left(\frac{DWEDS}{42} \times 1200 \times .13368\right)$

$V_{10} = 119,268 - 863.75 \; (\frac{ft^3}{in}) \times \text{Torus level (in)}$

$V_{11} = 6571.0 - 25(\text{Level} - 35)$

Using the subvolume vapor pressure, subvolume temperature, and the subvolume free air space, the dry air mass for each subvolume can now be calculated. The following table gives the necessary data for the start of the test as 04:05:31 on 06/13/88(Data Set No. 181).

SUBVOLUME NO.	VAPOR PRESSURE (PSI)	DRY AIR PRESSURE (PSIA)	SUBVOLUME TEMPERATURE °F	DRY AIR MASS (lbs. mass)
1	.473	63.620	104.456	3211.72
2	.482	63.611	110.334	2890.76
3	.482	63.611	109.135	3317.68
4	.482	63.611	109.428	1141.43
5	.494	63.599	106.536	7314.94
6	.496	63.597	101.419	9871.98
7	.458	63.635	96.697	8526.97
8	.443	63.630	86.329	8204.11
9	.443	63.650	87.720	2764.68
10	.481	63.612	83.287	37,818.08
11	2.264	61.829	130.436	1455.46

$$W^{\circ} = \sum_{i=1}^{11} W_i = 86,517.81$$

The following table gives the necessary data for the end of the 6 hour test at 10:06:43 on 06/13/88 (Data Set No. 218).

SUBVOLUME NO.	VAPOR PRESSURE (PSI)	DRY AIR PRESSURE (PSIA)	SUBVOLUME TEMPERATURE °F	DRY AIR MASS (lbs. mass)
1	.458	63.522	102.829	3216.05
2	.467	63.513	109.441	2890.84
3	.467	63.513	109.030	3313.18
4	.467	63.513	109.397	1139.73
5	.481	63.499	106.680	7301.59
6	.481	63.499	101.512	9855.14
7	.446	63.534	96.630	8514.46
8	.444	63.536	86.203	8191.31
9	.444	63.536	87.616	2758.38
10	.475	63.536	83.043	37,796.08
11	2.218	61.762	129.686	1475.25

$W^6 =$ 86,452.01

The leak rate for the 6 hour test is:

$$L^{6th} = -\frac{2400}{6.020} \times \frac{86{,}452.01 - 86{,}517.81}{86{,}517.81}$$

L^{6hr} = .3032 wt % / day (compared to .4072 computed ignoring sump level changes)

The following table gives the necessary data for the start of the induced phase of the test at 12:06:56 on 06/13/88 (Data Set No. 230).

SUBVOLUME NO.	VAPOR PRESSURE (PSI)	DRY AIR PRESSURE (PSIA)	SUBVOLUME TEMPERATURE °F	DRY AIR MASS (lbs. mass)
1	.456	63.463	103.329	3210.21
2	.463	63.456	109.392	2888.49
3	.463	63.456	109.154	3309.48
4	.463	63.456	109.580	1138.34
5	.476	63.443	106.780	7293.86
6	.479	63.440	101.555	9845.23
7	.443	63.476	96.648	8506.41
8	.447	63.472	86.206	8183.01
9	.447	63.472	87.621	2754.95
10	.475	63.444	83.051	37,772.47
11	2.234	61.685	129.949	1478.40

$W^{start}_{induced}$ = 86,380.85

The following table gives the necessary data for the end of the induced phase of the test at 15:17:33 on 06/13/88 (Data Set No. 249).

SUBVOLUME NO.	VAPOR PRESSURE (PSI)	DRY AIR PRESSURE (PSIA)	SUBVOLUME TEMPERATURE °F	DRY AIR MASS (lbs. mass)
1	.456	63.359	104.369	3199.04
2	.463	63.352	109.674	2882.33
3	.463	63.352	109.394	3302.67
4	.463	63.352	109.883	1135.87
5	.477	63.338	106.971	7279.33
6	.478	63.337	101.668	9827.26
7	.442	63.373	96.703	8491.77
8	.455	63.361	86.166	8169.30
9	.455	63.361	87.740	2748.60
10	.476	63.339	83.148	37,707.63
11	2.273	61.542	130.586	1482.11

$W^{end}_{induced}$ = 86,225.91

The leak rate for the induced phase is

$$L\ (\text{induced}) = -\ \frac{2400}{3.177}\ \text{X}\ \frac{(86{,}225.91 - 86{,}380.85)}{86{,}380.85}$$

$$= 1.3550\ \text{wt \% / day}$$ (compared to 1.3962 computed ignoring sump level changes)

The above calculations show that the leakage from the reactor vessel did not significantly affect the reported leak rate and that the reported values are conservative values with respect to the actual leakage.

APPENDIX C

COMPUTATIONAL PROCEDURE

D. INPUT PROCESSING .

Calculations perfomed by the software are outlined below:

D.1 Average temperature of subvolume #i (T_i)
= The average of all RTD temps in subvolume #i

$$T_i = \frac{1}{N} \sum_{j=1}^{N} T_{i,j}$$

where N = The number of RTDs in subvolume #i

D.2 Average dew temperature of subvolume #i (D_i)
= The average of all dew cell dew temps in subvolume #i

$$D_i = \frac{1}{N} \sum_{j=1}^{N} D_{i,j}$$

where N = The number of RTDs in subvolume #i

D.3 Total corrected pressure #1, (P_1)

C_1 First correction factor for raw pressure #1, (from program initialization data set).

M_1 Second correction factor for raw pressure #1, (from program initialization data set).

Pr_1 Raw pressure #1, from BUFFILE.

$P_1 = C_1 + M_1\, Pr_1/1000$, for 5 digit pressure transmittors

$P_1 = C_1 + M_1\, Pr_1/10000$, for 6 digit pressure transmitters

D.4 Total corrected pressure #2, (P_2)

C_2 First correction factor for raw pressure #2, (from program initialization data set.

M_2 Second correction factor for raw pressure #2, (from program initialization data set.

Pr_2 Raw pressure #2, from BUFFILE.

$P_2 = C_2 + M_2\, Pr_2/1000$, for 5 digit pressure transmitters

$P_2 = C_2 + M_2\, Pr_2/10000$, for 6 digit pressure transmitters

D.5 Whole Containment Volume Weighted Average Temperature, (T_c)

Approximate Method

$$T_c = \sum_{i=1}^{N} f_i T_i$$

Exact Method

$$T_c = \frac{1}{\sum_{i=1}^{N} \frac{f_i}{T_i}}$$

where: f_i = The volume fraction of the i^{th} subvolume
N = The total # of subvolumes in containment

D.6 Average Vapor Pressure of Subvolume i, (Curve fit of ASME steam tables.) (Pv_i)

$$Pv_i = 0.01529125 + 0.001653476\ D_i - 1.44734 \times 10^{-6}\ (D_i)^2 + 7.081828 \times 10^{-7}\ (D_i)^3 - 2.28128 \times 10^{-9}\ (D_i)^4 + 3.03544 \times 10^{-11}\ (D_i)^5$$

D.7 Whole Containment Average Vapor Pressure, (Pv_c)

Approximate Method

$$Pv_c = \sum_{i=1}^{N} f_i Pv_i$$

Exact Method

$$Pv_c = T_c \sum_{i=1}^{N} \frac{f_i Pv_i}{T_i}$$

N = The total of subvolumes in containment
f_i = Volume fraction of the i^{th} subvolume

D.8 Whole Containment Average Dew Temperature, (D_c)

Approximate Method

$$D_c = \sum_{i=1}^{N} f_i D_i$$

Exact Method: The whole containment average vapor pressure, (Pv_c) calculated with the exact method is used to find D_c. An initial value of D_c is guessed and used with the equation in D.6 to calculate Pv_c. This value is then compared to the known value from D.7. A new value of D_c is guessed and the process is repeated until a value of D_c is found that results in a calculated value of Pv_c that is within .0001 psia of the value from D.7.

D.9 Average total containment pressure, (P)

$$P = (P_1 + P_2) / 2$$

Average total containment dry air pressure, (P_d)

$$P_d = P - Pv_c$$

D.10 Total Containment dry air mass, (M)

Type 1:
$$M = \frac{P_d V_c}{R \ T_c}$$

where: R = Perfect gas constant, V_c = Total containment free volume.

Type 2: Type 2 dry air mass accounts for changes in Reactor Vessel level.

For uncorrected dry air mass, (Type 1) the below definitions apply.

$$V_c = \sum_{i=1}^{N} V_i \quad \text{and} \quad f_i = V_i/V_c$$

where V_i is the user entered free volume in subvolume i.

For corrected dry air mass, (Type 2) the same definitions for V_c and f_i apply, except that one of the V_is is corrected for changes in vessel level. If k is the subvolume number of the corrected subvolume then:

$$V_k = V_{ko} - a(C - b)$$

a is the number of cubic feet of free volume per inch of vessel level.

b is the base level of the reactor vessel, in inches.

C is the actual water level in the reactor vessel, in inches.

V_{ko} is the volume of the subvolume k when C equals b.

The volume fractions (f_i) are then calculated with the corrected volume, and all other calculations are subsequently performed as previously specified for Type 1 dry air mass.

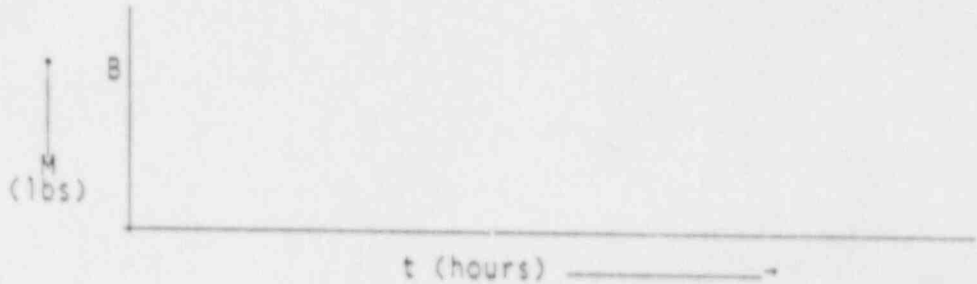
D.11 Leakrate Calculations using Mass-Plot Method:

This method assumes that the leakage rate is constant during the testing period, a plot of the measured contained dry air mass versus time would ideally yield a straight line with a negative slope.

Based on the least squares fit to the data obtained, the calculated containment leakage rate is obtained from the equation:

$$M = At + B$$

Where	M = containment dry air mass at time t	(lbs.)
	B = calculated dry air mass at time t=0	(lbs.)
	A = calculated leakage rate	(lbs/hr)
	t = time interval since start of test	(hours)



The values of the constants A and B such that the line is linear least squares best fitted to the leak rate data are:

$$A = \frac{N\Sigma(t_i)(M_i) - (\Sigma t_i)(\Sigma M_i)}{N\Sigma(t_i)^2 - (\Sigma t_i)^2}$$

$$B = \frac{\Sigma M_i - A\Sigma t_i}{N}$$

By definition, leakage out of the containment is considered positive leakage. Therefore, the statistically averaged least squares containment leakage rate in weight percent per day is given by:

$$L = (-A)\ (2400)/B \qquad \text{(weight \%/day)}$$

In order to calculate the 95% confidence limit of the least squares averaged leak rate, the standard deviation of the least squares slope and the student's T-Distribution function are used as follows:

$$\sigma = \left[\frac{1}{(N-2)} \quad \frac{N\Sigma(M_i)^2 - (\Sigma M_i)^2}{N\Sigma(t_i)^2 - (\Sigma t_i)^2} - A^2 \right]^{1/2} \frac{(2400)}{B} \quad \text{(weight \% per day)}$$

$$UCL = L + \sigma\ (T)$$

where
$$T = \frac{1.6449(N-2) + 3.5283 + 0.85602/(N-2)}{(N-2) + 1.2209 - 1.5162/(N-2)}$$

N	=	Number of data sets	
t_i	=	test duration at the i^{th} data set	(hours)
σ	=	standard deviation of least squares slope	(weight%/day)
T	=	Value of the single-sided T-Distribution function with 2 degrees of freedom	
L	=	calculated leak rate in weight %/day	
UCL	=	95% upper confidence limit	(%/day)
B	=	calculated containment dry air mass at time t=0	(lbs.)

D.12 Point to Point Calculations

This method calculates the rate of change with respect to time of dry air mass using the Point to Point Method.

For every data set, the rate of change of dry air mass between the most recent, (t_i) and the previous time (t_{i-1}) is calculated using the two point method shown below:

$$\dot{M}_i = \frac{2400}{(t_i - t_{i-1})} (1 - M_i/M_{i-1})$$

Then the least square fit of the point to point leakrates is calculated as described for dry air masses in section D.11

D.13 Total Time Calculations

This method calculates the rate of change with respect to time of dry air mass using the Total Time Method

Initially, a reference time (t_r) is chosen. For every data set the rate of change of dry air mass between t_r and the most recent time, t_i is calculated using the two point method shown below.

$$\dot{M}_i = \frac{2400}{(t_i - t_r)} \quad (1 - M_i/M_r)$$

Then the least squares fit and 95% UCL of the Total Time leakrates are calculated as shown below:

$$B = \frac{\Sigma \dot{M}_i \, \Sigma (t_i)^2 - \Sigma t_i \, \Sigma \dot{M}_i \, t_i}{N \, \Sigma (t_i)^2 - (\Sigma t_i)^2}$$

$$A = \frac{(N \, \Sigma t_i \dot{M}_i - \Sigma t_i \, \Sigma \dot{M}_i)}{N \, \Sigma (t_i)^2 - (\Sigma t_i)^2}$$

$$L = B + At$$

$$T = \frac{1.6449(N-2) + 1.5283 + 0.85602/(N-2)}{(N-2) + 1.2209 - 1.5162/(N-2)}$$

Note: N is the number of data sets minus one.

$$F = \frac{1}{N} + \frac{(t_p - \Sigma (t_i) / N)^2}{\Sigma (t_i)^2 - (\Sigma t_i)^2 / N}$$

$$\sigma = \sqrt{\frac{F}{N}} \sqrt{\Sigma (\dot{M}_i)^2 - B \Sigma \dot{M} - A \Sigma \dot{M}_i t_i}$$

$$UCL = L + T\sigma$$

Note: This equation is calculated for information only from the start of the test up to 24 hours, then it becomes the official leakrates for future times.

D.14 BN-TOP-1

This method calculates the rate of change with respect to the time of dry air mass using the Total Time Method.

Initially, a reference time (t_r) is chosen. For every data set the rate of change of the data item between t_r and the most recent time, (t_i) is calculated using the two point method shown below:

$$\dot{M}_i = \frac{2400}{(t_i - t_r)} (1 - M_i/M_r)$$

Then the least squares fit of the Total Time leakrates and the BN-TOP-1 95% UCLs are calculated as shown below.

$$B = \frac{(\Sigma \dot{M}_i \Sigma (t_i)^2 - \Sigma t_i \Sigma \dot{M}_i t_i)}{N \Sigma (t_i)^2 - (\Sigma t_i)^2}$$

Note: N is the number of data sets minus one.

$$A = \frac{(N \Sigma t_i \dot{M}_i - \Sigma t_i \Sigma \dot{M}_i)}{N \Sigma (t_i)^2 - (\Sigma t_i)^2}$$

$$L = B + At$$

$$T = 1.95996 + \frac{2.37226}{(N - 2)} + \frac{2.8225}{(N - 2)^2}$$

$$F = 1 + \frac{1}{N} + \frac{(t_p - \Sigma (t_i) / N)^2}{\Sigma (t_i)^2 - (\Sigma t_i)^2 / N}$$

$$\sigma = \sqrt{\frac{F}{N}} \sqrt{\Sigma (\dot{M}_i)^2 - B \Sigma \dot{M}_i - A \Sigma \dot{M}_i t_i}$$

$$UCL = L + T\sigma$$

Note: This equation is calculated for information only from the start of the test up to 24 hours, then it becomes the official leakrates for future times.

D.15 Temperature stabilization checking per ANSI 56.8-1981

T_i Weighted average containment air temperature at hour i.

$T_{i,n}$ Rate of change of weighted average containment air temperature over an n hour period at hour i, using a two point backwards difference method,

$$T_{i,n} = \frac{T_i - T_{i-n}}{n}$$

Z_i is the ANSI 56.8-1981 Temperature stabilization criteria at hour i,

$$Z_i = | T_{i,4} - T_{i,1} | \quad i \text{ must be} \geq 4.$$

Per ANSI 56.8-1981, Z must be less than or equal to 0.5 °F/hr

NOTE: If the data sampling interval is less than one hour, then:

Option #1 Use data collected at hourly intervals

Option #2 Use average of data collected in previous hour for that hour's data.

D.16 Calculation of Instrument Selection Guide, (ISG)

$$ISG = \frac{2400}{t} \sqrt{\frac{2}{N_p}(e_p/p)^2 + \frac{2}{N_r}(e_r/T)^2 + \frac{2}{N_d}(e_d/p)^2}$$

where: t is the test time, in hours
p is test pressure, psia
T is the volume weighed average containment temperature, °R
N_p is the number of pressure transmitters
N_r is the number of RTDs
N_d is the number of dew cells
e_p is the combined pressure transmitters' error, psia
e_r is the combined RTDs' error, °R
e_d is the combined dew cells' error, °R

$$e_p = \sqrt{(S_p)^2 + (RP_p + RS_p)^2}$$

where: S_p is the sensitivity of a pressure transmitter
RP_p is the repeatability of a pressure transmitter
RS_p is the resolution of pressure transmitter

$$e_r = \sqrt{(S_r)^2 + (RP_r + RS_r)^2}$$

where: S_r is the sensitivity of an RTD
RP_r is the repeatability of an RTD
RS_p is the resolution of an RTD

$$e_d = \frac{\Delta P_v}{\Delta T_d}\bigg|_{T_d} \sqrt{(S_d)^2 + (RP_d + RS_d)^2}$$

where: S_d is the sensitivity of a dew cell
RP_d is the repeatability of a dew cell
RS_d is the resolution of a dew cell

$$\frac{\Delta P_v}{\Delta T_d}\bigg|_{T_d} = \frac{\text{change in vapor pressure}}{\text{change in saturation temperature}}$$

The above ratio is from ASME steam tables and evaluated at the containment's saturation temperature at that time.

D.17 BN-TOP-1 Temperature Stabilization Criteria Calculation

A. The rate of change of temperature is less than 1 °F/Hr averaged over the last two hours.

$K_1 = |T_i - T_{i-1}|$ $K_2 = |T_{i-1} - T_{i-2}|$
K_1 and K_2 must both be less than 1 to meet the criteria listed in A.

B. The rate of change of temperature changes less than 0.5 °F/hour/hour averaged over the last two hours.

$$K_1 = (T_i - T_{i-1})/(t_i - t_{i-1})$$
$$K_2 = (T_{i-1} - T_{i-2})/(t_{i-1} - t_{i-2})$$
$$Z = |(K_1 - K_2)/(t_i - t_{i-1})|$$

Z must be less than 0.5 to meet the criteria listed in B.

D.18 Reactor Vessel Free Volume Mass Calculation

As shown in section D.10, the free volume of the Reactor Vessel subvolume κ is given by the below equation.

$$V_\kappa = V_{\kappa o} - a\ (c-b)$$

The dry air mass in subvolume κ can then be written as:

$$M_\kappa = 144\ (\bar{P}-\bar{P}_{v\kappa})\ V_\kappa/R\bar{T}_\kappa$$

Where: M_κ is the dry air mass in subvolume κ, (lbm)

R is the gas constant of air

$\overline{T_\kappa}$ is the average temperature of subvolume κ, (°R)

$\overline{P_{v\kappa}}$ is the average vapor pressure of subvolume κ, (pisa)

$\bar{P}$ is the average containment pressure, (psia)

V_κ is the free air volume in subvolume κ, (ft^3)

D.19 Torus Free Volume Calculation

Free volume calculations of the Torus rely upon narrow range Torus water level inputs. These values range between plus and minus five inches. It is assumed that the Torus subvolume free air volume is that subvolume's volume when the Torus level equals zero. The user may enter three constants to model the variation of Torus air volume with water level.

The equations for Torus free volume in subvolume t are given:

$$V_t = V_{to} - (aL + bL + cL^3) \text{ when } L \geq 0$$
$$V_t = V_{to} + (-aL + bL^2 - cL^3) \text{ when } L \leq 0$$

The dry air mass in subvolume t can then be written as:

$$M_t = 144\ (\bar{P} - \bar{P}_{vt})\ V_t / R\bar{T}_t$$

Where: Mt is the dry air mass in subvolume τ, (lbm)

$\bar{P}$ is the average containment pressure, (psia)

$\overline{P_{vt}}$ is the average vapor pressure of subvolume t (pisa)

V_t is the free volume in subvolume t, (ft^3)

R is the gas constant of air

T_t is the average temperature in subvolume t (^oR)

L is the Torus level, (inches)

a,b,c are Torus level constants

V_{to} is the free volume in subvolume T when L equals zero, taken from standard free volume inputs, (ft^3)

E. OUTPUTS

E.1 OUTPUT DEVICE TYPES: The below output devices shall be supported. There are no special constraints on output device locations.

PRINTERS:	PRIME High Speed Line Printer		
	OKIDATA 2410		
	OKIDATA 93		
	LA120		
PLOTTERS:	Hewlet Packard	7475A	8.5" X 11"
	Hewlet Packard	7585A	8.5" X 11"
	Hewlet Packard	7585A	11" X 17"
CRTs:	Wyse	Wy75	
	View Point 60		
	Ampex Dialogue 80 & 81		
	PRIME	PT200	
GRAPHICS TERMINALS:	RamTech	6200	
	RamTech	6211	
	Tektronix	4107	
	Tektronix	4208	
	Tektronix	4014	

APPENDIX D

INSTRUMENT ERROR ANALYSIS

IPCLRT SAMPLE ERROR ANALYSIS
FOR SHORT DURATION TEST

A. ACCURACY ERROR ANALYSIS

Per Topical Report BN-TOP-1 the measured total time leak rate (M) in weight percent per day is computed using the Absolute Method by the formula:

$$M\ (\%\ /\ DAY) = \frac{2400}{H} \cdot \left(1 - \frac{T_1 \overline{P}_N}{T_N \overline{P}_1}\right) \qquad (1)$$

where: $\overline{P}_1$ = total (volum~ weighted) containment dry air pressure (PSIA) a. :e start of the test;

$\overline{P}_N$ = total (volume weighted) containment dry air pressure (PSIA) at data point N after the start of the test;

H = test duration from the start of the test to data point N in hours;

T_1 = containment volume weighted temperature in °R at the start of the test;

T_N = containment volume weighted temperature in °R at the data point N.

The following assumptions are made:

$\overline{P}_1 = \overline{P}_N = \hat{P}$ where $\hat{P}$ is the average dry air pressure of the containment (PSIA) during the test;

$T_1 = T_N = \hat{T}$ where $\hat{T}$ is the average volume weighted primary containment air temperature (°R) during the test;

$P_1 = P_N$ where P is the total containment atmospheric pressure (PSIA);

$P_{V1} = P_{VN}$ Where P_V is the partial pressure of water vapor in the primary containment.

Taking the partial derivative in terms of pressure and temperature of (1) equation and substituting in the above assumptions yields the following equation found in Section 4.5 of BN-TOP-1 Rev. 1:

$$e_M = \pm \frac{2400}{H} \cdot \left[2 \left(\frac{e_p}{\hat{P}} \right)^2 + 2 \left(\frac{e_t}{\hat{T}} \right)^2 \right]^{1/2}$$

where e_p = the error in the total pressure measurement system,

$e_p = \pm [(e_{pT})^2 + (e_{pV})^2]^{1/2}$;

e_{pT} = (instrument accuracy error) / $\sqrt{\text{no. of inst.}}$ in measuring total containment pressure;

e_{pV} = (instrument accuracy error) / $\sqrt{\text{no. of inst.}}$ in measuring vapor partial pressure;

e_t = (instrument accuracy error) / $\sqrt{\text{no. of inst.}}$ in measuring containment temperature;

e_M = the error in the measured leak rate;

H = duration of the test.

NOTE

Subvolume #11, the free air space above the water in the reactor vessel, is treated separately from the rest of the containment volume. The reason for the separate treatment is that neither the air temperature or the partial pressure of water vapor is measured directly. The temperature of the air space is assumed to be the temperature of the reactor water, as measured in the shutdown cooling or clean-up demineralizer piping before the heat exchangers. The partial pressure of water vapor is computed assuming saturation conditions at the temperature of the water. Volume weighting the errors for the two volumes (Subvolume #11 and Subvolumes #1-10) is the method used.

B. EQUIPMENT SPECIFICATIONS

INSTRUMENT	RTD (°F)	PPG (PSIA)	DEWCELL (°F)	FLOWMETER (SCFM)	THERMOCOUPLE (°F)
Range	50-150	0-100	20 - 104	0.927-11.23	0 - 600
Accuracy	±.50	±.015	±1	±.111	±2.0
Repeat-ability	±.10	±.001	±.50	±.02	±.10

C. COMPUTATION OF INSTRUMENT ACCURACY UNCERTAINTY

1. Computing " e_T "

Volume Fraction for Volume #11 = .02344
Volume Fraction for Volumes #1-10 = .97656

$$e_T = \pm\left(.97656 * \frac{.50}{\sqrt{29}} + .02344 * \frac{2}{\sqrt{1}}\right)$$

$e_T = \pm$ .1375°R

2. Computing " e_{p_T} "

$$e_{p_T} = \pm \frac{.015}{\sqrt{2}}$$

$e_{p_T} = \pm$ .0106 PSIA

3. Computing " e_{p_V} "

At a dewpoint of 65°F (assumed), an accuracy of ± 1°F corresponds to ± .011 PSIA. For subvolume #11 at an average temperature of 140°F, an accuracy of ± 2°F corresponds to ± .150 PSI.

$$e_{p_V} = \pm\left(.97656 * \frac{.011}{\sqrt{10}} + .02344 * \frac{.150}{\sqrt{1}}\right)$$

$e_{p_V} = \pm$ .0069 PSIA

4. Computing " e_p "

$$e_p = \pm\left[(.0106)^2 + (.0069)^2\right]^{1/2}$$

$e_p = \pm$ .0126 PSIA

5. Computing total instrument accuracy uncertainty " e_M^A "

$$e_M^A = \pm \frac{2400}{H} * \left[2 * \left(\frac{.0126}{63.5}\right)^2 + 2 * \left(\frac{0.1376}{552.6}\right)^2 \right]^{1/2}$$

assuming $\hat{P} = 63.5$ PSIA

$\hat{T} = 552.6°R$

Therefore, for a 6 hour test (H),

$e_M^A = \pm .1801$ wt % / DAY

D. COMPUTATION OF INSTRUMENT REPEATABILITY UNCERTAINTY

1. Computing " e_T "

$$e_T = \pm \frac{.10}{\sqrt{30}}$$

$e_T = \pm .0183°R$

2. Computing " e_{p_T} "

$$e_{p_T} = \pm \frac{.001}{\sqrt{2}}$$

$e_{p_T} = \pm .0007$ PSIA

3. Computing " e_{p_V} "

$$e_{p_V} = \pm \left(.97656 * \frac{.006}{\sqrt{10}} + .02344 * \frac{.008}{\sqrt{1}}\right)$$

$e_{p_V} = \pm .0020$ PSIA

4. Computing " e_p "

$$e_p = [(.0007)^2 + (.0020)^2]^{1/2}$$

$e_p = \pm .0021$ PSIA

5. Computing the total instrument repeatability uncertainty " e_M^R"

$$e_M^R = \frac{2400}{H} * \left[2 \left(\frac{.0021}{63.5} \right)^2 + 2 \left(\frac{0.0183}{552.6} \right)^2 \right]^{1/2}$$

Therefore, for a 6 hour test,

$e_M^R = \pm .0265$ wt % / DAY

E. COMPUTING TOTAL INSTRUMENT UNCERTAINTY

$$e_M = \pm 2 * [(e_M^A)^2 + (e_M^R)^2]^{1/2}$$

$$e_M = \pm 2 * [(.1801)^2 + (.0265)^2]^{1/2}$$

$e_M = \pm .3641$ weight % / DAY for a 6 hour test.

APPENDIX E

BN-TOP-1, REV 1 ERRATA

APPENDIX E

BN-TOP-1, REV. 1 ERRATA

The Commission has approved short duration testing for the IPCLRT provided the Station uses the general test method outlined in the BN-TOP-1, Rev. 1 topical report. The primary difference between that method and the ones previously used is in the statistical analysis of the measured leak rate data.

Without making any judgments concerning the validity of this test method, certain errors in the editing of the mathematical expressions were discovered. The intent here is not to change the test method, but rather to clarify the method in a mathematically precise manner that allows its implementation. The errors are listed below.

EQUATION 3A, SECTION 6.2

Reads: $L_i = A + B\ t_i$

Should Read: $L_i = A_i + B_i\ t_i$

Reason: The calculated leak rate (L_i) at time t_i is computed using the regression line constants A_i, B_i (computed using equations 6 and 7). The summation signs in equation 6 are defined as $\Sigma = \sum_{i=1}^{n}$, where n is the number of data sets up until time t_i. The regression line constants change each time a new data set is received. The calculated leak rate is not a linear function of time.

PARAGRAPH FOLLOWING EQ. 3A, SECTION 6.2

Reads: The deviation of the measured leak rate (M) from the calculated leak rate (L) is shown graphically on Figure A.1 in Appendix A and is expressed as:

Deviation = $M_i - L_i$

Should Read: The deviation of the measured leak rate (M_i) from the regression line (N_i) is shown graphically on Figure A.1 in Appendix A and is expressed as:

Deviation = $M_i - N_i$

where $N_i = A_p + B_p * t_i$,

A_p, B_p = Regression line constants computed from all data sets available from the start of the test to the last data set at time t_p,

t_i = time from the start of the test to the ith data set

Reason: The calculated leak rate as a function of time during the test is based on a regression line. The regression line constants, A_i and B_i, are changing as each additional data set is received. Equation 3A is used later in the test to compute the upper confidence limit as a function of time. For the purpose of this calculation, it is the deviation from the last computed regression line at time t_p that is important.

EQUATION 4, SECTION 6.2

Reads: $SSQ = \Sigma (M_i - L_i)^2$

Should Read: $SSQ = \Sigma (M_i - N_i)^2$

Reason: Same As Above

EQUATION 5, SECTION 6.2

Reads: $SSQ = \Sigma [M_i - (A + Bt_i)]^2$

Should Read: $SSQ = \Sigma [M_i - (A_p + B_p * t_i)]^2$

Reason: Same As Above

EQUATION ABOVE EQUATION 6, SECTION 6.2

Reads: $B = \frac{(t_i - \bar{t})(M_i - \bar{M})}{\Sigma(t_i - t)^2}$

Should Read: $B_i = \frac{\Sigma[(t_i - \bar{t})(M_i - \bar{M})]}{\Sigma(t_i - \bar{t})^2}$

Reason: Regression line constant B_i changes over time (as a function of t_p) as each additional data set is received. Bar of "t" left out of denominator. Summation signs omitted.

EQUATION 6, SECTION 6.2

Reads: $B = \frac{n \Sigma t_i M_i - (\Sigma t_i)(\Sigma M_i)}{n \Sigma t_i^2 - (\Sigma t_i)^2}$

Should Read: $B_i = \frac{n \Sigma t_i M_i - (\Sigma t_i)(\Sigma M_i)}{n \Sigma t_i^2 - (\Sigma t_i)^2}$

Reason: Same As Above

EQUATION 7, SECTION 6.2

Reads: $A = \bar{M} - B\,\bar{t}$

Should Read: $A_i = \bar{M} - B_i\,\bar{t}$

Reason: Same As Above

EQUATION 10, SECTION 6.2

Reads:

$$A = \frac{(\Sigma M_i)(\Sigma t_i^2) - (\Sigma t_i)(\Sigma t_i M_i)}{n \Sigma t_i^2 - (\Sigma t_i)^2}$$

Should Read:

$$A_i = \frac{(\Sigma M_i)(\Sigma t_i^2) - (\Sigma t_i)(\Sigma t_i M_i)}{n \Sigma t_i^2 - (\Sigma t_i)^2}$$

Reason: Same As Above

EQUATION 13, SECTION 6.3

Reads:

$$\sigma^2 = s^2 \left[1 + \frac{1}{n} + \frac{(t_p - t)^2}{(t_i - t)^2}\right]$$

Should Read:

$$\sigma^2 = s^2 \left[1 + \frac{1}{n} + \frac{(t_p - \bar{t})^2}{\Sigma (t_i - \bar{t})^2}\right]$$

where t_p = time from the start of the test of the last data set for which the standard deviation of the measured leak rates (M_i) from the regression line (M_i) is being computed;

t_i = time from the start of the test of the i^{th} data set;

n = number of data sets to time t_p;

$\Sigma = \sum_{i=1}^{n}$; and

$\bar{t} = \frac{1}{n} \Sigma t_i$.

Reason: Appears to be error in editing of the report. Report does a poor job of defining variables.

EQUATION 14, SECTION 6.3

Reads: $\sigma = s\left[1 + \frac{1}{n} + \frac{(t_p - t)^2}{(t_i - t)^2}\right]$

Should Read: $\sigma = s\left[1 + \frac{1}{n} + \frac{(t_p - \bar{t})^2}{\Sigma (t_i - \bar{t})^2}\right]$

Reason: Same As Above

EQUATION 15, SECTION 6.3

Readr: Confidence Limit = L ± T

Should Read: Confidence Limits = L ± T x σ

where L = calculated leak rate at time t_p,

T = T distribution value based on n, the number of data sets received up until time t_p;

σ = standard deviation of measured leak rate values (M_i) about the regression line based on data from the start of the test until time t_p.

Reason: Same As Above

EQUATION 16, SECTION 6.3

Reads: UCL = L + T

Should Read: UCL = L + T * σ

Reason: Same As Above

EQUATION 17, SECTION 6.3

Reads: LCL = L - T

Should Read: LCL = L - T * σ

Reason: Same As Above

APPENDIX F

TYPE A TEST RESULTS
USING MASS - PLOT METHOD
MEASURED LEAK RATE PHASE

TYPE A TEST RESULTS
USING MASS - PLOT METHOD
MEASURED LEAK RATE PHASE

DATA SET #	DATA SET TIME DAY HH MM SS	TEST TIME, (HR)	DRY AIR MASS, (LBM)	LEAK RATE, (%/D)	95% UP CONF LIMIT, (%/D)
181	165 04:05:31	0.000	0.86622156E+05		
182	165 04:15:33	0.167	0.86619172E+05		
183	165 04:25:33	0.334	0.86617172E+05	0.4136E+00	0.8110E+00
184	165 04:35:35	0.501	0.86615703E+05	0.3545E+00	0.4720E+00
185	165 04:45:35	0.668	0.86611687E+05	0.4051E+00	0.4926E+00
186	165 04:55:36	0.835	0.86610281E+05	0.3950E+00	0.4483E+00
187	165 05:05:39	1.002	0.86606187E+05	0.4217E+00	0.4690E+00
188	165 05:15:39	1.169	0.86605937E+05	0.4012E+00	0.4422E+00
189	165 05:16:01	1.175	0.86605937E+05	0.3918E+00	0.4273E+00
190	165 05:26:04	1.343	0.86601875E+05	0.4011E+00	0.4318F+00
191	165 05:36:05	1.509	0.86597359E+05	0.4237E+00	0.4594E+00
192	165 05:46:06	1.677	0.86595640E+05	0.4316E+00	0.4623E+00
193	165 05:56:09	1.844	0.86593906E+05	0.4312E+00	0.4569E+00
194	165 06:06:09	2.011	0.86590750E+05	0.4340E+00	0.4559E+00
195	165 06:16:10	2.178	0.86590531E+05	0.4245E+00	0.4455E+00
196	165 06:26:10	2.344	0.86585578E+05	0.4282E+00	0.4467E+00
197	165 06:36:14	2.512	0.86583656E+05	0.4282E+00	0.4444E+00
198	165 06:46:15	2.679	0.86579734E+05	0.4326E+00	0.4474E+00
199	165 06:56:15	2.846	0.86578969E+05	0.4303E+00	0.4437E+00
200	165 07:06:15	3.012	0.86577422E+05	0.4260E+00	0.4386E+00
201	165 07:16:16	3.180	0.86573734E+05	0.4255E+00	0.4368E+00
202	165 07:26:20	3.347	0.86570187E+05	0.4272E+00	0.4375E+00
203	165 07:36:21	3.514	0.86568312E+05	0.4271E+00	0.4365E+00
204	165 07:46:25	3.682	0.86567047E+05	0.4246E+00	0.4335E+00
205	165 07:56:25	3.849	0.86563953E+05	0.4236E+00	0.4318E+00
206	165 08:06:26	4.015	0.86562000E+05	0.4220E+00	0.4296E+00
207	165 08:16:28	4.183	0.86559828E+05	0.4201E+00	0.4274E+00
208	165 08:26:30	4.350	0.86555844E+05	0.4205E+00	0.4273E+00
209	165 08:36:33	4.517	0.86554078E+05	0.4199E+00	0.4262E+00
210	165 08:46:33	4.684	0.86551562E+05	0.4194E+00	0.4253E+00
211	165 08:56:35	4.851	0.86547765E+05	0.4204E+00	0.4259E+00
212	165 09:06:35	5.018	0.85646781E+05	0.4196E+00	0.4249E+00
213	165 09:16:36	5.185	0.86545765E+05	0.4176E+00	0.4229E+00
214	165 09:26:36	5.352	0.86540797E+05	0.4180E+00	0.4230E+00
215	165 09:36:37	5.519	0.86539344E+05	0.4175E+00	0.4222E+00
216	165 09:46:39	5.686	0.86538297E+05	0.4160E+00	0.4207E+00
217	165 09:56:41	5.853	0.86534469E+05	0.4156E+00	0.1201E+00
218	165 10:06:43	6.020	0.86533672E+05	0.4141E+00	0.4186E+00

TYPE A TEST RESULTS
USING MASS - PLOT METHOD
INDUCED LEAK PHASE

DATA SET #	DATA SET TIME DAY HH MM SS	TEST TIME, (HR)	DRY AIR MASS, (LBM)	LEAK RATE, (%/D)	95% UP CONF LIMIT, (%/D)
230	165 12:06:56	0.000	0.86450312E+05		
231	165 12:16:57	0.167	0.86441875E+05		
232	165 12:27:00	0.335	0.86431859E+05	0.1529E+01	0.2176E+01
233	165 12:37:04	0.502	0.86424750E+05	0.1437E+01	0.1623E+01
234	165 12:47:05	0.669	0.86415062E+05	0.1453E+01	0.1542E+01
235	165 12:57:05	0.836	0.86406265E+05	0.1640E+01	0.1513E+01
236	165 13:07:06	1.003	0.86401953E+05	0.1383E+01	0.1479E+01
237	165 13:17:06	1.170	0.86394719E+05	0.1336E+01	0.1423E+01
238	165 13:27:08	1.337	0.86385047E+05	0.1332E+01	0.1398E+01
239	165 13:37:10	1.504	0.86376812E+05	0.1332E+01	0.1383E+01
240	165 13:47:14	1.672	0.86368422E+05	0.1334E+01	0.1376E+01
241	165 13:57:15	1.839	0.86359906E+05	0.1339E+01	0.1374E+01
242	165 14:07:16	2.006	0.86351609E+05	0.1343E+01	0.1372E+01
243	165 14:17:16	2.173	0.86343593E+05	0.1345E+01	0.1370E+01
244	165 14:27:20	2.340	0.86335469E+05	0.1347E+01	0.1368E+01
245	165 24:37:25	2.508	0.86327031E+05	0.1349E+01	0.1368E+01
246	165 14:47:28	2.676	0.86318625E+05	0.1351E+01	0.1368E+01
247	165 14:57:29	2.843	0.86307047E+05	0.1363E+01	0.1382E+01
248	165 15:07:31	3.010	0.86300469E+05	0.1367E+01	0.1384E+01
249	165 15:17:33	3.177	0.86290515E+05	0.1374E+01	0.1391E+01

MEASURED LEAK RATE PHASE
GRAPH OF CALUCLATED LEAK RATE
AND UPPER CONFIDENCE LIMIT

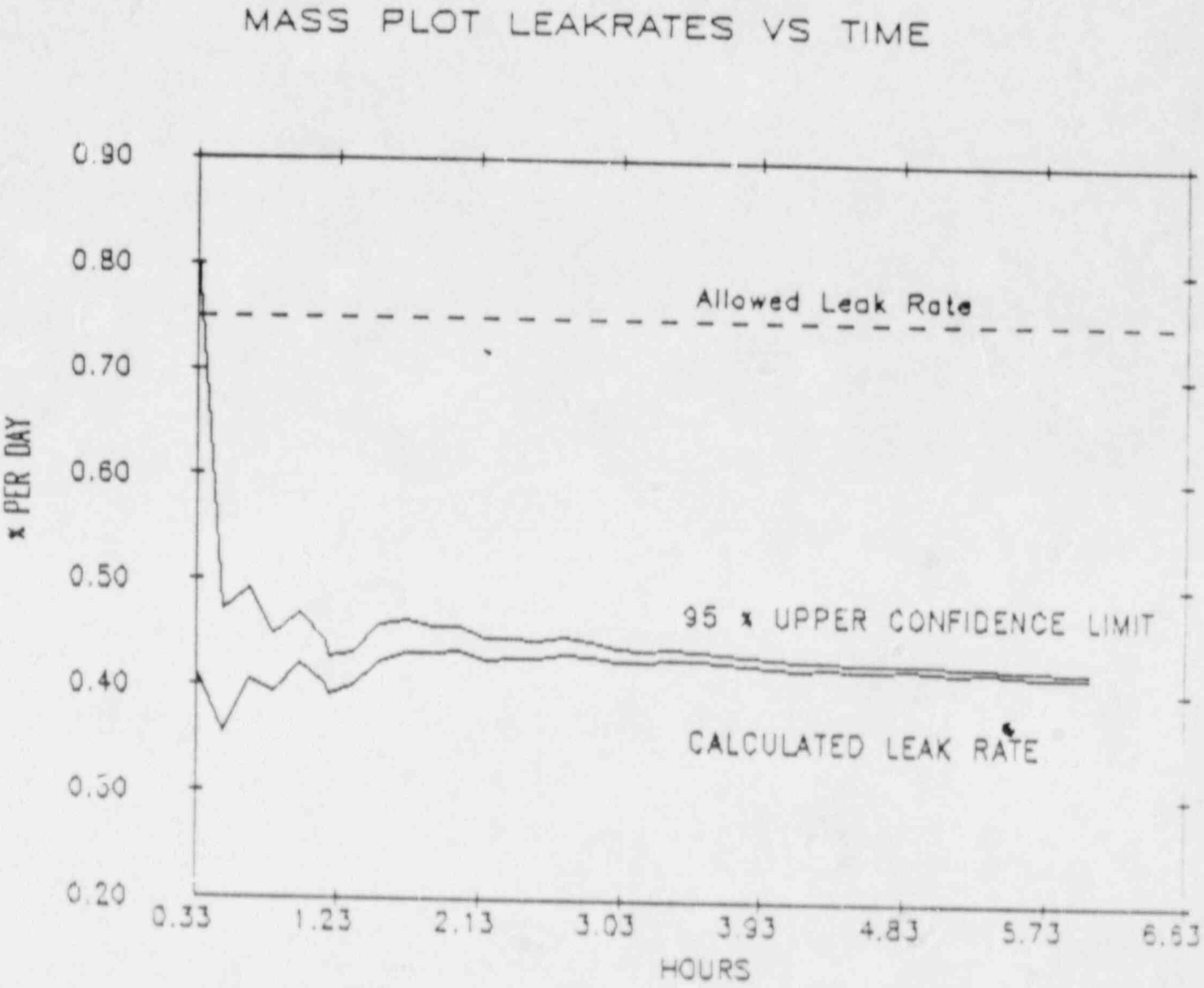


FIGURE F-1

INDUCED LEAKAGE PHASE
GRAPH OF CALUCLATED
LEAK RATE

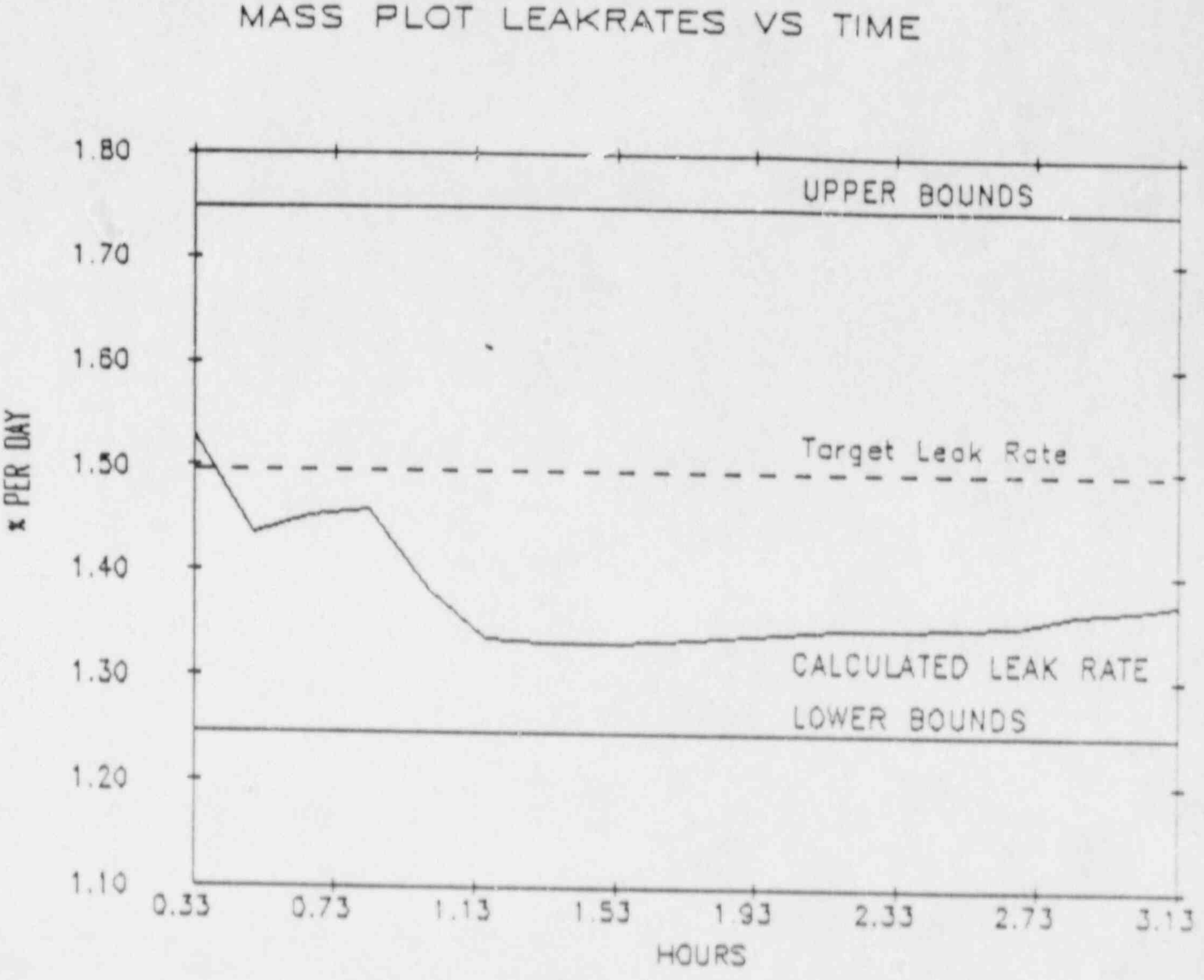


FIGURE F-2

Commonwealth Edison
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22710 206 Avenue North
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Telephone 309/654-2241

RLB-88-267

August 15, 1988

Mr. Thomas E. Murley
Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission
Washington, D.C. 20555

SUBJECT: Reactor Containment Building Integrated Leak Rate Test
Quad-Cities Nuclear Power Station
Docket No. 50-254, DPR-29, Unit One

Enclosed please find the report "Reactor Containment Building Integrated Leak Rate Test, Quad-Cities Nuclear Power Station, Unit Two, June 12-13, 1988" and the related appendices describing the Type A test. The performance of this test was witnessed and inspected by representatives of the NRC Region III Office.

This report is submitted to you in accordance with the requirements of 10 CFR 50, Appendix J, Section V.B.1. The information contained in Appendix A of this report is intended to comply with requirements of 10 CFR 50, Appendix J, Section V.B.3. According to 10 CFR 50, Appendix J, Section III.A.6, the test schedule for the next Type A test is to be reviewed and approved by the Commission. The next Type A test for Quad-Cities Unit One is scheduled for the fall of 1989; the Commission's review and approval of this schedule is hereby requested.

Very truly yours,

COMMONWEALTH EDISON COMPANY
Quad-Cities Nuclear Power Station

R. L. Bax
Station Manager

RLB/KRS/klm

Attachment

1490H/

A017
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