RLB-91-160

June 21, 1991

Mr. Thomas E. Murley
Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, D.C. 20555

SUBJECT: Quad-Cities Nuclear Power Station
Reactor Containment Building Integrated Leak Rate Test
NRC 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 One, February 28 - March 2, 1991" 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 1992; 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/DFS/vmw

Attachment

cc: A.B. Davis, Regional Administrator
T. Taylor, Senior Resident Inspector

0483H

A017

REACTOR CONTAINMENT BUILDING

INTEGRATED LEAK RATE TEST

QUAD-CITIES NUCLEAR POWER STATION

UNIT ONE

FEBRUARY 28 - MARCH 2, 1991

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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 February 28 - March 2, 1991 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.

A full duration 24 hour test was conducted using the Mass Plot Method. Using the above test method, the total primary containment integrated leak rate was calculated to be 0.6035 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 0.6069 wt %/day.

The supplemental induced leakage test result was calculated to be 1.50 wt %/day. This value should compare with the sum of the measured leak rate phase result (0.6035 wt %/day) and the induced leak of 8.34 SCFM (1.0224 wt %/day). The calculated leak rate of 1.50 wt %/day lies within the allowable tolerance band of 1.6259 wt %/day $\pm$ 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. 18, including checklists QTS 150-S2, S4, S5, S6, S10, S12, S13, S17, S18, S19, S22 through S29, and subsections T2, T6, T8, T10, T11, T13, T14, T15, and T16. Approved temporary procedures 6642 was written to allow the use of alternate compressors to pressurize the primary containment.

These procedures were written to comply with 10 CFR 50 Appendix J, ANS/ANSI N45.4-1972, and Quad-Cities Unit One Technical Specifications.

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. Instrumentation calibrations were performed 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	PPM-1000	10141-2 10255-1	0.4 - 100 PSIA	±0.015% Rdg ±0.005% F.S.	±0.001% F.S.
Thermistors (30)	Volumetrics	418905000	SEE TABLE TWO	50° - 135°F	0.25°F	0.01°F
Dewcells (10)	Volumetrics	Lithium Chloride	SEE TABLE TWO	93-212°F	0.25°F	0.01°F
Thermocouple	Pall Trinity Micro	14-T-2H		0-600°F	±2.0°F	±.1°F
Flowmeter	Fischer & Porter	10A3555S	8405A0348A1	1.15-11.10 scfm	±.111 scfm	
Level Indicator LT 1-646B	GEMAC	555111BCAA 3AAA		0-60" H_2O		

TABLE TWO
SENSOR PHYSICAL LOCATIONS

THERMISTER NO.	SERIAL NUMBER	SUBVOLUME	ELEVATION	AZIMUTH*
1	10533-23	1	670'0"	180°
2	11340-12	1	670'0"	0°
3	10602-17	2	657'0"	20°
4	10533-8	2	657'0"	197°
5	10602-5	3	639'0"	70°
6	10602-29	3	639'0"	255°
7	10533-9	4(Annular Ring)	643'0"	55°
8	10602-8	4	615'0"	225°
9	10533-27	5	620'0"	5°
10	11340-1	5	620'0"	100°
11	11340-11	5	620'0"	220°
12	10533-3	6	608'0"	40°
13	11340-4	6	608'0"	130°
14	10533-29	6	608'0"	220°
15	10602-14	6	608'0"	310°
16	10602-9	7	598'0"	70°
17	11778-18	7	598'0"	160°
18	11778-6	7	598'0"	250°
19	11778-7	7	598'0"	340°
20	11778-15	8	587'0"	10°
21	11778-9	8	587'0"	100°
22	11778-17	8	587'0"	190°
23	11778-2	8	587'0"	280°
24	10533-15	9(CRD Space)	595'0"	170°
25	11778-5	9(CRD Space))	580'0"	170°
26	11778-11	10(Torus)	578'0"	70°
27	11778-1	10(Torus)	578'0"	140°
28	10602-11	10(Torus)	578'0"	210°
29	11778-4	10(Torus)	578'0"	280°
30	11778-8	10(Torus)	578'0"	350°
Thermocouple	(inlet to clean-up HX)	11(Rx Vessel)		

DEWCELL NO.	SERIAL NUMBER	SUBVOLUME	ELEVATION	AZIMUTH
1	11778-30	1	670'0"	180°
2	11778-12	2,3,4	653'0"	90°
3	10533-7	2,3,4	653'0"	270°
4	11778-13	5	620'0"	0°
5	11778-27	6	605'0"	45°
6	10602-22	7	600'0"	220°
7	11778-25	8,9	591'0"	0°
8	11778-10	8,9	591'0"	202°
9	11778-14	10	578'0"	90°
10	11778-26	10	578'0"	270°
Thermocouple (Saturated)		11	---	---

Idealized View of Drywell and Torus
Used to Calculate Free Volumes

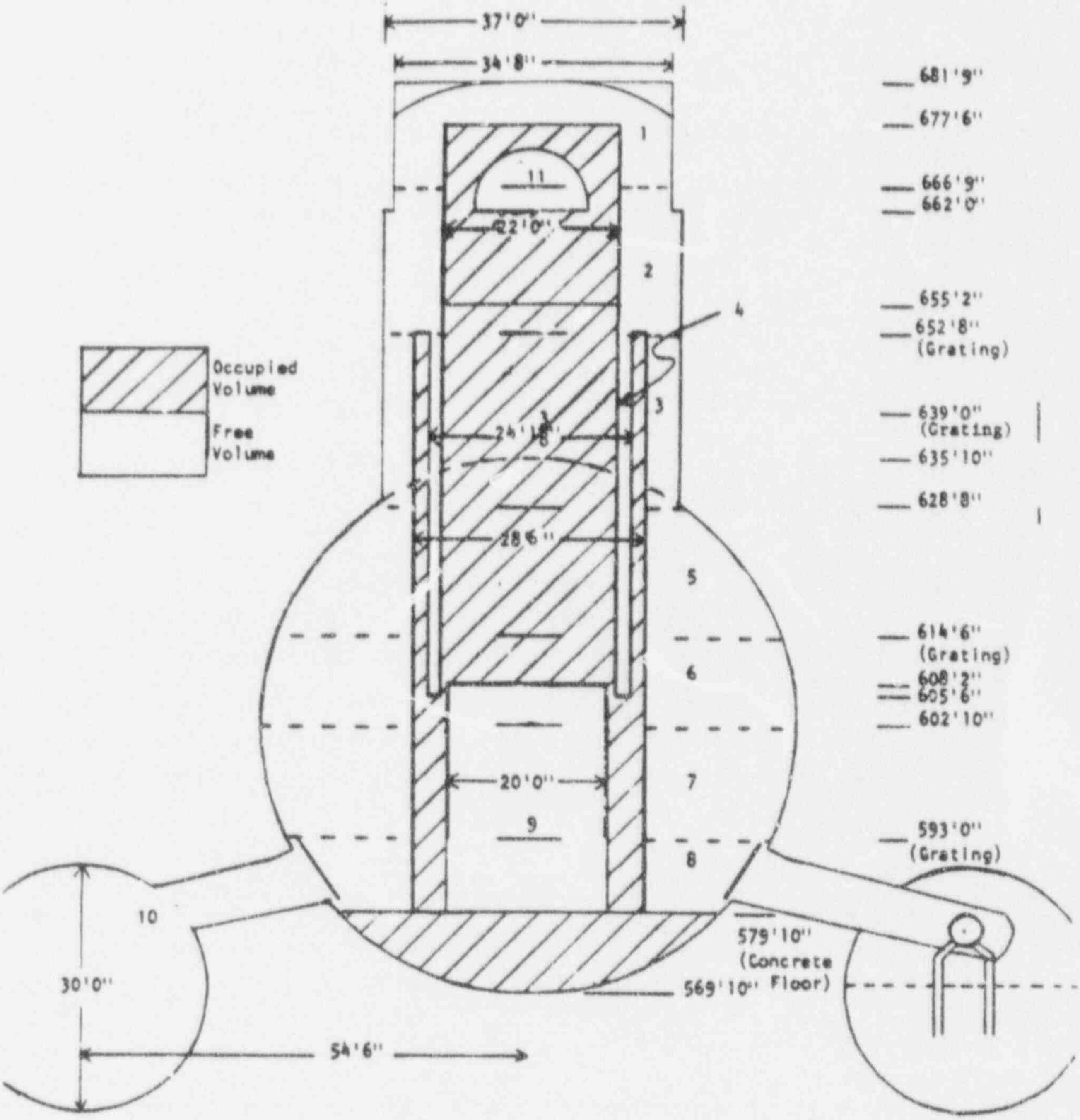

FIGURE 1

A.2.a. Temperature

The location of the 30 thermistor'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 Thermistors are hermetically sealed, glass encapsulated units manufactured by YSI Inc. These sensors have a recommended operating range between -110 and 390 degrees F. A stability of better than 0.018 degrees F per ten months can be expected when the units are stored at or below 212 degrees F. Interchangeable Thermistors, model 46043 were chosen. YSI certifies each sensor to follow the same Resistance verses Temperature curve within 0.1 degrees F over the range of 50 to 135 degrees F.

Each sensor is connected to a signal conditioning card. The Thermistor resistance is converted by this card to a known voltage. The voltage output from the cards is a function of the resistance in. The Thermistor's change in resistance with temperature is very nonlinear.

Therefore, the variation of output voltage with temperature is nonlinear. In order to allow direct reading of temperature values from the DAS, two sixth order polynominal curve fits are programmed into the DAS's EPROMs. As recommended in ANS 56.8, the DAS output and display has a resolution of 0.01 degrees F.

A.2.b. Pressure

Two volumetrics PPM-1000 Precision Pressure Monitors were utilized to measure total containment pressure. Each precision pressure gauge was calibrated from 0.4-100.0 PSIA. Primary containment pressure was sensed by the pressure gauges in parallel through a 3/8" tygon tube connected in parallel with a drywell pressure sensing instrument.

Each instrument contains a pressure-sensing element that delivers an electrical frequency (in relation to the applied pressure) to a microprocessor circuit. The microprocessor corrects the signal for nonlinearity, offset, scaling, and temperature effects and displays the corrected pressure value on a 5-1/2 digit LED readout.

The sensor is the vibrating cylinder type. The cylinder is a vibrating mechanical system. A vacuum reference in maintained on the outside of the cylinder. The pressure differential across the wall creates stress on the wall varying the natural resonant frequency of vibration. The resonant frequency depends upon the physical properties of the element such as mass, stress, elasticity, dimensions and temperature. The cylinder is made from a special nickel iron alloy, and closely controlled manaufacturing techniques eliminate mass, dimension, and elasticity effects. Temperature is measured using a calibrated diode and corrected by the microprocessor.

The sensor's electronic circuit conditions the frequency wave and sends it to the pulse rate converter board which counts the period. The period is sent in a 16-bit word to the microprocessor controlled panel meter (MPM).

The sensor's temperature sensing diode voltage is converted to a 15-bit digital signal using the analog-to-digital converter in the MPM. The pressure is calculated by the MPM and displayed in appropriate units on the 5-1/2 digit seven-segment LED display.

Each PPM-1000 was calibrated from 0.40-100.0 PSIA by volumetrics on December 12, 1990.

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 by volumetrics on December 12, 1990.

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 September 21, 1990, to within ±1% of full scale (0.9 - 11.4 SCFM) using NBS traceable standards, to standard atmospheric conditions.

Plant personnel continuously monitored the flow during the induced leakage phase and corrected any minor deviations from the induced flow rate of 8.34 SCFM by adjusting a 3/8" needle valve on the flowmeter inlet. The flow meter outlet was unrestricted and vented to the atmosphere.

A.3 Type A Test Measurement

The IPCLRT was performed utilizing a direct interface with the station prime computer. This system consists of a Data Acquisition System (DAS) and a multiplexer in containment.

Upon initiation of data acquisition cycle, the DAS reads the selected OPERATE mode of single, continuous, or interval, and either block or sequential scan. Once the system has determined which channels to scan (user-defined), it addresses the analog scanner to select the first channel for sampling. This address information (three BCD digits from the Printer/Scanner Interface Card) is transmitted at RS-232C voltage levels.

The scanner selects the channel and routes the analog signal to the Analog to Digital Converter (ADC) housed in the DAS. After a relay stabilizing time of approximately ten milliseconds, the Central Processing Card (CPU) initiates the ADC. Although the ADC is capable of 20 conversions per second, the actual scan rate is 10 per second because the CPU has numerous other functions to perform.

Upon conversion request, the ADC resets and selects a 0.1V or 1.0V full scale conversion factor as designated by the CPU. The CPU is then interrupted by the ADC to read the converted data and the ADC status word. The status word indicates the polarity of the input voltage and if it was an overrange. The data is stored in a buffer in RAM. The CPU addresses the scanner for data from the next channel, and the acquisition process continues until all the data from the channels programmed to be scanned is stored in the buffer.

Numerical calculation of the raw data may now begin. The CPU selects the most recent data entry from the buffer and divides it by 65536, the full scale count value of the ADC, to obtain the voltage value. The CPU checks the channel's format byte to determine the channel's assigned engineering unit (0-15). That unit's associated slope and intercept values (m and b) are user-accessible in CMOS RAM). The slope (m) is multiplied by the voltage value (x), then added to the intercept (b) to obtain the final data value (y).

The final data value is printed out on all enabled outputs. The printout includes the channel number, the final data, the assigned engineering unit, and the channel header. Digital input data, headers, date, and time are also printed out.

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 measure 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, 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

Two Atlas Copco 1500 SCFM, Diesel powered oil-free air compressors were used to pressurize the primary containment. The compressors were physically 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-2-1001-26A was open during pressurization. Once the containment was pressurized, the MO-2-1001-26A valve was closed and the spool piece was removed and replaced with a blind flange.

Measurement System Schematic Arrangement

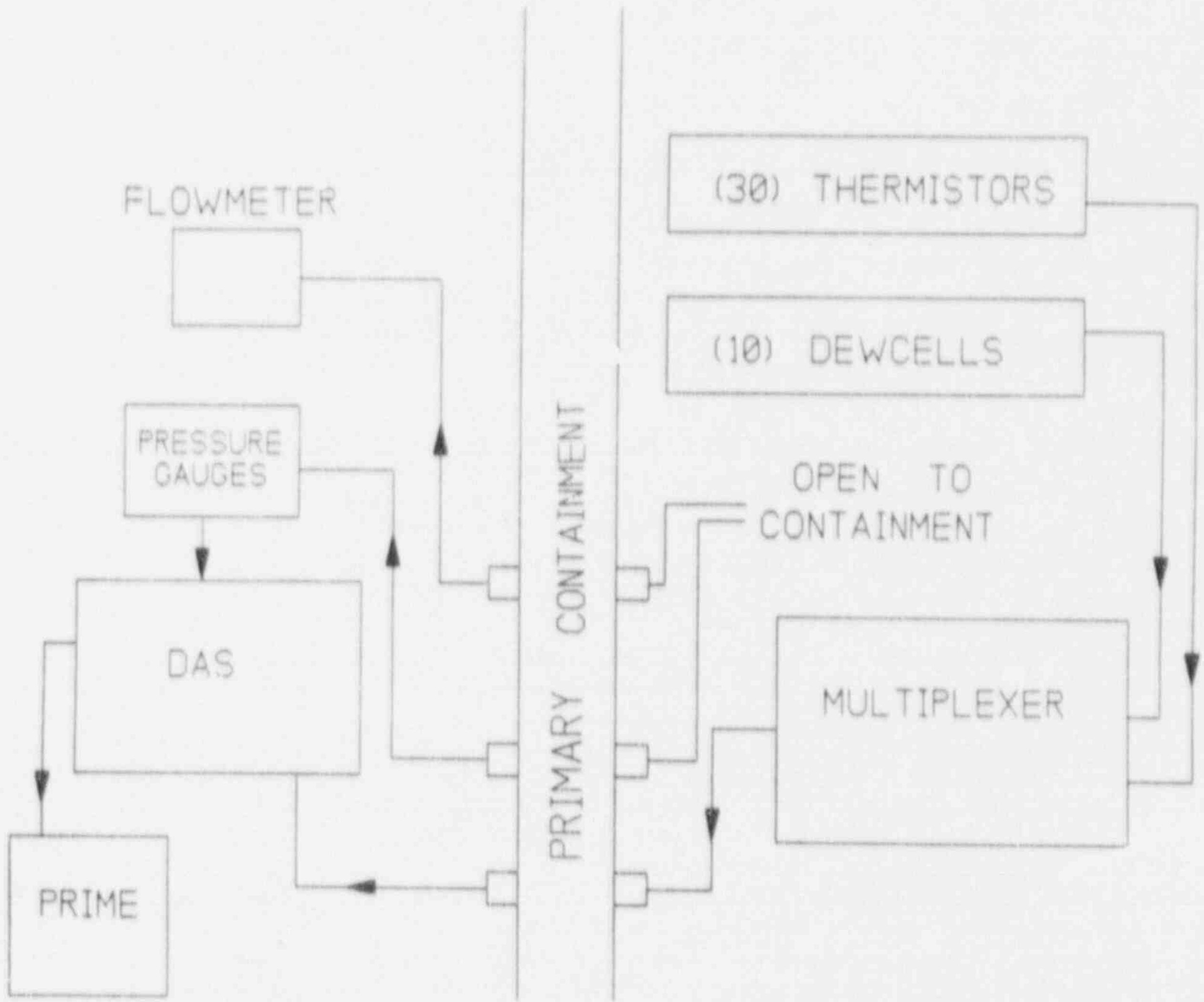

FIGURE 2

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 total containment dry air mass calculation include subvolume weighted containment temperature, subvolume weighted vapor pressure, and total absolute air pressure. Each time a data set is collected (approximately every 10 min.) during the Type A test, the time of collection and the total containment dry air mass are calculated and recorded. The Mass Plot method calls for performing a least squares fit of the mass points. This fit determines the slope and Y-Intercept of the line that minimizes the total amount of scatter of the points along it. The slope divided by the Y-Intercept of the line yields the statistically averaged leak rate. The upper confidence limit is defined as the statistically averaged leak rate plus the product of the one-sided 95% T-distribution and the standard deviation of the regression line slope. The mathematical expressions for these calculations are found in Appendix B.

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.

B.3 Instrument Error Analysis

An instrument error analysis was performed prior to the test. 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 0.032 wt %/day and 0.0048 wt %/day for a 24-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 C.

There were no instrument failures during the performance of this test.

SECTION C - SEQUENCE OF EVENTS

C.1 Test Preparation Chronology

The pretest preparation phase and containment inspection was completed on February 27, 1991 with no apparent structural deterioration being observed. Major preliminary steps included:

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

2) Installaticn 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 exemtpion 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
2-28-91	0908	Began Pressurizing Containment.
	1015	MSIV room snooped. No leaks observed.
	1045	Leak discovered at X-25 bellows.
	1110	Test director inspected leak to access magnitude. Considered to be serious.
	1115	Station Management and Operating notified of leak. Continue pressurization while evaluating.
	1130	Radiation Protection foreman to have frequent samples in X-25 area.
		Corner rooms, torus area, and top of torus snooped. No leaks observed.
	1145	Remainder of accesible penetrations in the reactor building were snooped. No leaks observed.
2-28-91	1300	Inspection of leak with F. Maura (NRC).
		Decision to complete pressurization.
	1435	Pressurization completed.

C.3 Measured Leak Rate Phase Chronology

2-28-91	1930	Containment temperature stable below 0.5 degrees F/hr for the last 4.0 hr. Rx water level stable below 1.25 in/hr. for the last 1.0 hr. Rx water temperature stable below 2 degrees F/hr. for the last hr.
	1930	Began measured phase base data set #318 of buffile.
3-1-91	1932	Terminated measured leak rate phase at 24 hours 2 min., basedata set #463 of buffile. Calculated leakrate was 0.6035 wt%/day and decreasing over time. The mass plot 95% upper confidence limit was 0.6069 wt%/day.

C.4 Induced Leakage Phase Chronology

3-1-91	2032	Valved in flowmeter at 8.34 SCFM (equivalent to 1.0224 wt%/day). Began induced leakage phase at data set #469 of buffile.
3-2-91	0032	Terminated induced phase. Base data set #493 of buffile calculated leak rate of 1.500 wt%/day.

C.5 Depressurization Phase Chronology

3-2-91	0115	Began depressurization using procedure for venting through the standby gas treatment system.
3-2-91	0500	Depressurization complete.
	0730	Technical Staff personnel entered drywell. No apparent structural damage and instruments still in place.
	1200	Instruments removed from the drywell and torus.

SECTION D - TYPE A TEST DATA

D.1 Measured Leak Rate Phase Data

Graphic results of the test are found in Figures 3-7. The statistically averaged leak rate and upper confidence limit using the ANS/ANSI 56.8-1981 standard are graphed in Figure 3. A summary of the computed data using the ANS/ANSI standard is found in Tables 3 and 4.

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 Mass Plot method are shown in Figure 7. Containment conditions during the Induced Leakage Phase are presented graphically in Figures 8-10.

MEASURED LEAK RATE TEST RESULTS

TABLE 3

DATA SET	TIME	TEST DURATION	AVE. TEMP.	DRY AIR PRESSURE	CALC. LEAK RATE	UPPER CONFIDENCE LIMIT
318	19:30:04	0.000	87.0	62.7629	---	---
319	19:32:04	0.033	87.0	62.7620	---	---
320	19:42:04	0.200	87.0	62.7562	0.5184	0.1091
321	19:52:04	0.366	87.0	62.7495	0.6548	0.8412
322	20:02:04	0.533	86.9	62.7437	0.6937	0.7847
323	20:12:04	0.700	86.9	62.7383	0.6737	0.7298
324	20:22:04	0.866	86.9	62.7314	0.6799	0.7170
325	20:32:04	1.033	86.9	62.7259	0.6849	0.7116
326	20:42:04	1.200	86.9	62.7201	0.6746	0.6972
327	20:52:04	1.366	86.8	62.7145	0.6678	0.6867
328	21:02:04	1.533	.86.8	62.7091	0.6664	0.6816
329	21:12:04	1.700	86.8	62.7042	0.6574	0.6728
330	21:22:04	1.866	86.8	62.6989	0.6448	0.6630
331	21:32:04	2.033	86.8	62.6928	0.6473	0.6629
332	21:42:04	2.200	86.7	62.6870	0.6506	0.6644
333	21:52:04	2.366	86.7	62.6806	0.6501	0.6621
334	22:02:04	2.533	86.7	62.6746	0.6511	0.6616
335	22:12:04	2.700	86.7	62.6685	0.6519	0.6612
336	22:22:04	2.866	86.6	62.6629	0.6521	0.6604
337	22:32:04	3.033	86.6	62.6574	0.6512	0.6587
338	22:42:04	3.200	86.6	62.6515	0.6508	0.6576
339	22:52:04	3.366	86.6	62.6460	0.6478	0.6547
340	23:02:04	3.533	86.6	62.6407	0.6459	0.6524
341	23:12:04	3.700	86.5	62.6347	0.6465	0.6524
342	23:22:04	3.866	86.5	62.6295	0.6460	0.6514
343	23:32:04	4.033	86.5	62.6245	0.6454	0.6505
344	23:42:04	4.200	86.5	62.6194	0.6432	0.6483
345	23:52:04	?.366	86.5	62.6141	0.6412	0.6464
346	00:02:04	2.533	86.5	62.6092	0.6391	0.6444
347	00:12:04	2.700	86.4	62.6039	0.6376	0.6427
348	00:22:04	2.866	86.4	62.5995	0.6353	0.6405
349	00:32:04	5.033	86.4	62.5942	0.6343	0.6393
350	00:42:04	5.200	86.4	62.5890	0.6345	0.6392
351	00:52:04	5.366	86.4	62.5848	0.6322	0.6371
352	01:02:04	5.533	86.4	62.5794	0.6316	0.6363
353	01:12:04	5.700	86.4	62.5739	0.6317	0.6361
354	01:22:04	5.866	86.3	62.5702	0.6304	0.6348
355	01:32:04	6.033	86.3	62.5652	0.6291	0.6335
356	01:42:04	6.200	86.3	62.5604	0.6291	0.6332
357	01:52:04	6.366	86.3	62.5560	0.6285	0.6324
358	02:02:04	6.533	86.3	62.5511	0.6278	0.6316
359	02:12:04	6.700	86.3	62.5473	0.6270	0.6307
360	02:22:04	6.886	86.3	62.5423	0.6268	0.6304
361	02:32:04	7.033	86.3	62.5396	0.6265	0.6299
362	02:42:04	6.800	86.3	62.5353	0.6266	0.6299
363	02:52:04	7.366	96.3	62.5317	0.6269	0.6300

364	03:02:04	7.533	86.3	62.5279	0.6272	0.6302
365	03:12:04	7.700	86.3	62.5241	0.6282	0.6312
366	03:22:04	7.866	86.3	62.5208	0.6288	0.6318
367	03:32:04	8.033	86.3	62.5178	0.6293	0.6322
368	03:42:04	8.200	86.3	62.5148	0.6298	0.6326
369	03:52:04	8.366	86.2	62.5114	0.6302	0.6392
370	04:02:04	8.533	86.3	62.5074	0.6312	0.6339
371	04:12:04	8.700	86.3	62.5041	0.6320	0.6348
372	04:22:04	8.866	86.3	62.5008	0.6329	0.6357
373	04:32:04	9.033	86.3	62.4979	0.6336	0.6365
374	04:42:04	9.200	86.3	62.4948	0.6344	0.6372
375	04:52:04	9.366	86.3	62.4924	0.6350	0.6378
376	05:02:04	9.533	86.3	62.4894	0.6354	0.6382
377	05:12:04	9.700	86.3	62.4862	0.6361	0.6388
378	05:22:04	9.866	86.3	62.4836	0.6363	0.6389
379	05:32:04	10.033	86.3	62.4804	0.6368	0.6393
380	05:42:04	10.200	86.3	62.4778	0.6371	0.6396
381	05:52:04	10.366	86.3	62.4753	0.6375	0.6399
382	06:02:04	10.533	86.3	62.4723	0.6376	0.6400
383	06:12:04	10.700	86.3	62.4693	0.6379	0.6403
384	06:22:04	10.866	86.3	62.4663	0.6380	0.6403
385	06:32:04	11.033	86.3	62.4635	0.6382	0.6404
386	06:42:04	11.200	86.3	62.4607	0.6382	0.6404
387	06:52:04	11.366	86.3	62.4573	0.6384	0.6405
388	07:02:04	11.533	86.3	62.4548	0.6387	0.6407
389	07:12:04	11.700	86.3	62.4525	0.6386	0.6406
390	07:22:04	11.866	86.3	62.4497	0.6386	0.6405
391	07:32:04	12.033	86.3	62.4468	0.6387	0.6406
392	07:42:04	12.200	86.3	62.4440	0.6388	0.6407
393	07:52:04	12.366	86.3	62.4417	0.6388	0.6406
394	08:02:04	12.533	86.3	62.4395	0.6386	0.6404
395	08:12:04	12.700	86.3	62.4371	0.6387	0.6404
396	08:22:04	12.866	86.3	62.4351	0.6383	0.6400
397	08:32:04	13.033	86.3	62.4324	0.6379	0.6396
398	08:42:04	13.200	86.3	62.4295	0.6378	0.6394
399	08:52:04	13.366	86.3	62.4265	0.6376	0.6393
400	09:02:04	13.533	86.3	62.4241	0.6376	0.6392
401	09:12:04	13.700	86.3	62.4217	0.6373	0.6389
402	09:22:04	13.866	86.4	62.4194	0.6370	0.6386
403	09:32:04	14.033	86.4	62.4166	0.6367	0.6383
404	09:42:04	14.200	86.4	62.4137	0.6365	0.6380
405	09:52:04	14.366	86.4	62.4114	0.6362	0.6377
406	10:02:04	14.533	86.4	62.4087	0.6360	0.6375
407	10:12:04	14.700	86.4	62.4082	0.6354	0.6370
408	10:22:04	14.866	86.4	62.4037	0.6352	0.6367
409	10:32:04	15.033	86.4	62.4015	0.6348	0.6364
410	10:42:04	15.200	86.4	62.3993	0.6345	0.6360
411	10:52:04	15.366	86.4	62.3971	0.6340	0.6356
412	11:02:04	15.533	86.4	62.3947	0.6337	0.6353
413	11:12:04	15.700	86.4	62.3924	0.6332	0.6348
414	11:22:04	15.866	86.4	62.3915	0.6326	0.6343
415	11:32:04	16.033	86.4	62.3878	0.6322	0.6335
416	11:42:04	16.200	86.4	62.3851	0.6318	0.6335
417	11:52:04	16.366	86.4	62.3826	0.6314	0.6331
418	12:02:04	16.533	86.4	62.3805	0.6309	0.6327

419	12:12:04	16.700	86.4	62.3782	0.6304	0.6322
420	12:22:04	16.866	86.4	62.3776	0.6297	0.6316
421	12:32:04	17.033	86.4	62.3734	0.6293	0.6311
422	12:42:04	17.200	86.4	62.3711	0.6288	0.6307
423	12:52:04	17.366	86.5	62.3684	0.6284	0.6303
424	13:02:04	17.533	86.5	62.3661	0.6279	0.6298
425	13:12:04	17.700	86.5	62.3638	0.6274	0.6293
426	13:22:04	17.866	86.5	62.3637	0.6266	0.6287
427	13:32:04	18.033	86.5	62.3588	0.6262	0.6282
428	13:42:04	18.200	86.5	62.3572	0.6256	0.6277
429	13:52:04	18.366	86.5	62.3551	0.6251	0.6272
430	14:02:04	18.533	86.5	62.3526	0.6246	0.6267
431	14:12:04	18.700	86.5	62.3510	0.6239	0.6261
432	14:22:04	18.866	86.5	62.3483	0.6233	0.6256
433	14:32:04	19.033	86.5	62.3474	0.6227	0.6249
434	14:42:04	19.200	86.5	62.3453	0.6224	0.6246
435	14:52:04	19.366	86.5	62.3456	0.6223	0.6245
436	15:02:04	19.533	86.5	62.3465	0.6222	0.6243
437	15:12:04	19.700	86.5	62.3493	0.6221	0.6242
438	15:22:04	19.866	86.5	62.3513	0.6220	0.6241
439	15:32:04	20.033	86.5	62.3589	0.6214	0.6236
440	15:42:04	20.200	86.5	62.3587	0.6210	0.6231
441	15:52:04	20.366	86.5	62.3583	0.6204	0.6226
442	16:02:04	20.533	86.5	62.3572	0.6197	0.6220
443	16:12:04	20.700	86.5	62.3556	0.6189	0.6212
444	16:22:04	20.866	86.5	62.3537	0.6180	0.6205
445	16:32:04	21.033	86.5	62.3530	0.6171	0.6197
446	16:42:04	21.200	86.6	62.3486	0.6163	0.6190
447	16:52:04	21.366	86.6	62.3461	0.6156	0.6183
448	17:02:04	21.533	86.6	62.3438	0.6148	0.6175
449	17:12:04	21.700	86.6	62.3415	0.6140	0.6169
450	17:22:04	21.866	86.6	62.3411	0.6131	0.6160
451	17:32:04	22.033	86.6	62.3362	0.6124	0.6153
452	17:42:04	22.200	86.6	62.3342	0.6116	0.6146
453	17:52:04	22.366	86.6	62.3323	0.6108	0.6138
454	18:02:04	22.533	86.6	62.3291	0.6100	0.6131
455	18:12:04	22.700	86.6	62.3272	0.6093	0.6124
456	18:22:04	22.866	86.6	62.3263	0.6084	0.6116
457	18:32:04	23.033	86.6	62.3216	0.6077	0.6110
458	18:42:04	23.200	86.6	62.3196	0.6070	0.6103
459	18:52:04	23.366	86.6	62.3167	0.6064	0.6097
460	19:02:04	23.533	86.6	62.3147	0.6057	0.6090
461	19:12:04	23.700	86.6	62.3122	0.6049	0.6082
462	19:22:04	23.866	86.6	62.3111	0.6041	0.6075
463	19:32:04	24.033	86.6	62.3060	0.6035	0.6069

INDUCED LEAKAGE PHASE TEST RESULTS

TABLE 4

DATA SET	TIME	TEST DURATION	AVE. TEMP.	DRY AIR PRESSURE	CALC. LEAK RATE	UPPER CONFIDENCE LIMIT
469	20:32:04	0.000	86.6	62.2739	---	---
470	20:42:04	0.167	86.6	62.2671	---	---
471	20:52:04	0.333	86.6	62.2595	1.512	2.463
472	21:02:04	0.500	86.6	62.2526	1.505	1.651
473	21:12:04	0.667	86.6	62.2473	1.453	1.550
474	21:22:04	0.833	86.6	62.2385	1.486	1.556
475	21:32:04	0.000	86.6	62.2322	1.484	1.531
476	21:42:04	1.67	86.6	62.2237	1.533	1.597
477	21:52:04	0.333	86.6	62.2155	1.556	1.611
478	22:02:04	0.500	86.6	62.2098	1.541	1.587
479	22:12:04	0.667	86.6	62.2008	1.554	1.593
480	22:22:04	0.833	86.6	62.1953	1.548	1.581
481	22:32:04	2.000	86.6	62.1888	1.538	1.568
482	22:42:04	2.167	86.6	62.1822	1.530	1.556
483	22:52:04	2.333	86.6	62.1756	1.526	1.549
484	23:02:04	2.500	86.6	62.1701	1.513	1.537
485	23:12:04	2.667	86.6	62.1617	1.511	1.533
486	23:22:04	2.833	86.6	62.1549	1.514	1.533
487	23:32:04	2.000	86.6	62.1488	1.509	1.527
488	23:42:04	2.167	86.6	62.1418	1.506	1.522
489	23:52:04	2.333	86.6	62.1359	1.502	1.517
490	00:02:04	2.500	86.6	62.1274	1.503	1.516
491	00:12:04	2.667	86.6	62.1205	1.504	1.517
492	00:22:04	2.833	86.6	62.1143	1.502	1.514
493	00:32:04	4.000	86.6	62.1071	1.500	1.511

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

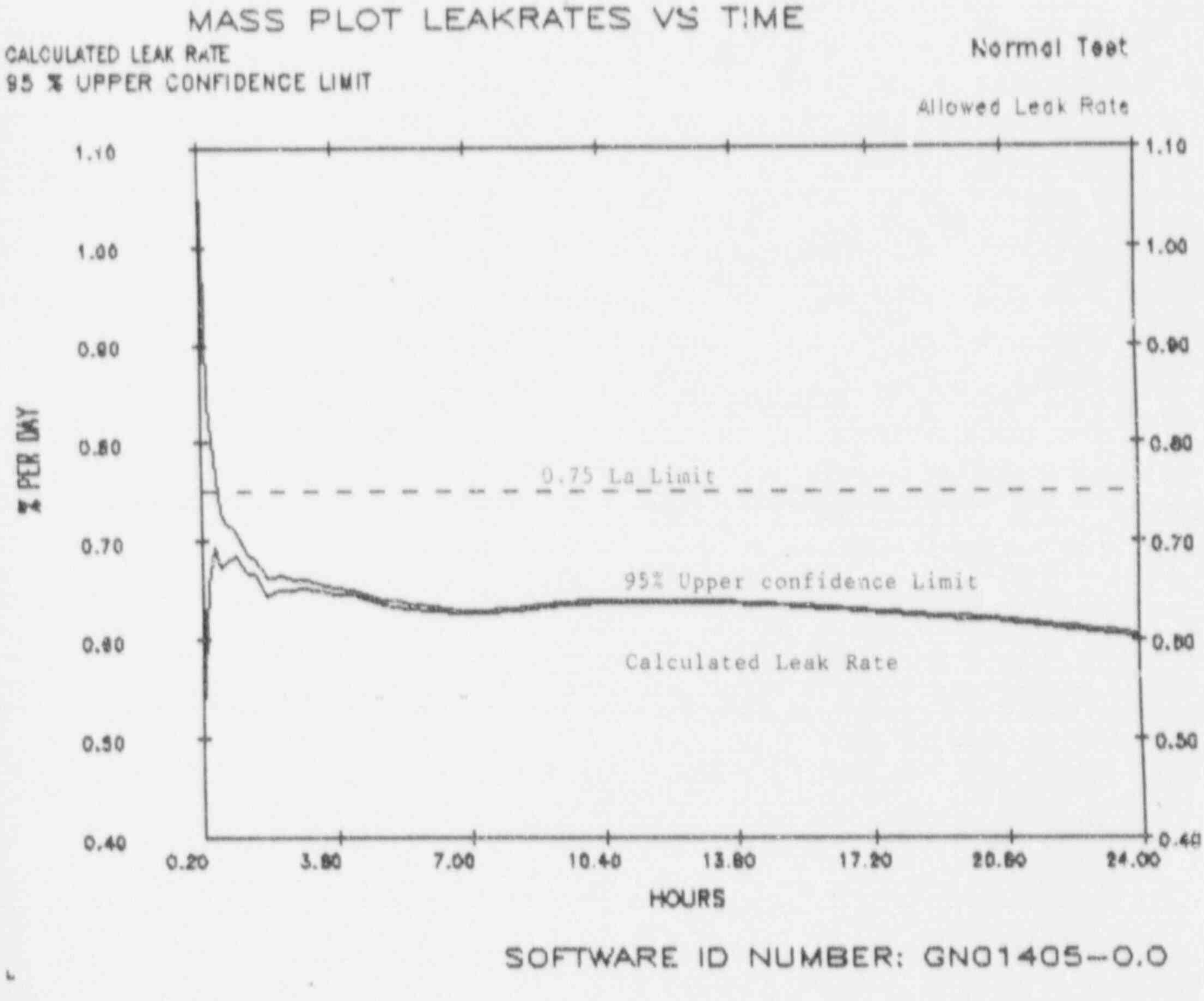

FIGURE 3

MEASURED LEAK RATE PHASE
GRAPH OF DRY AIR PRESSURE

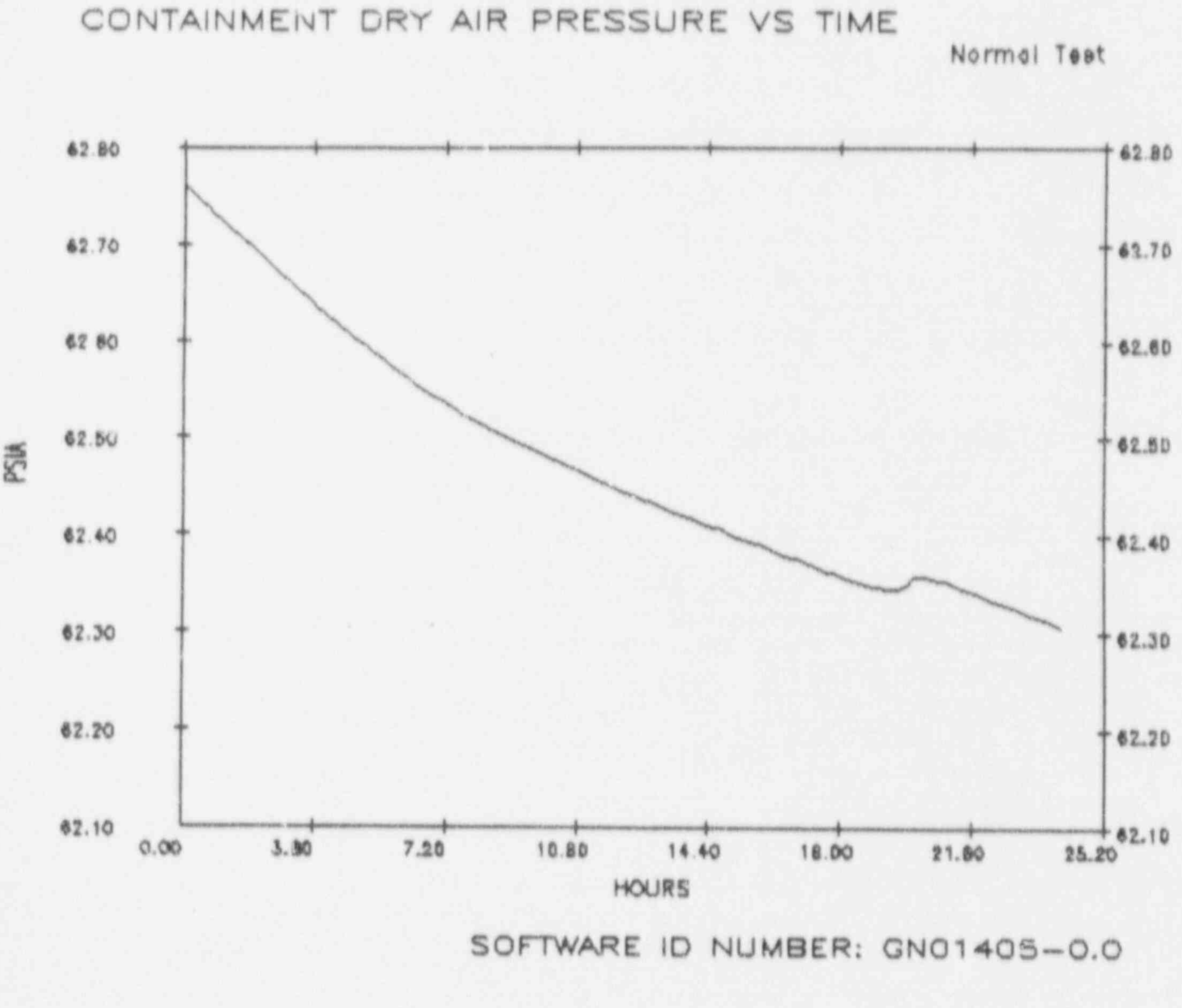

FIGURE 4

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

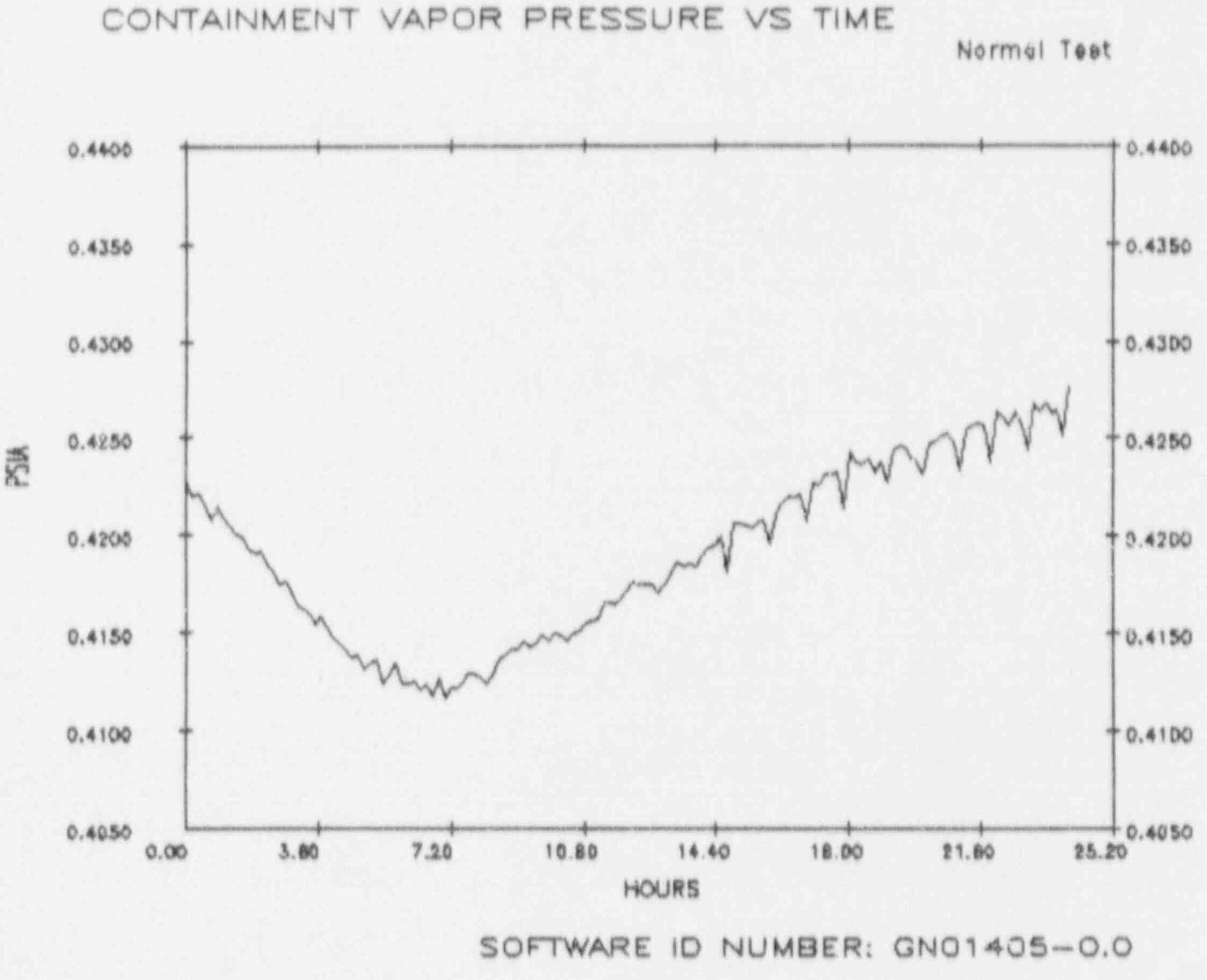

FIGURE 5

MEASURED LEAK RATE PHASE
GRAPH OF VOLUME
WEIGHTED AVERAGE CONTAINMENT TEMPERATURE

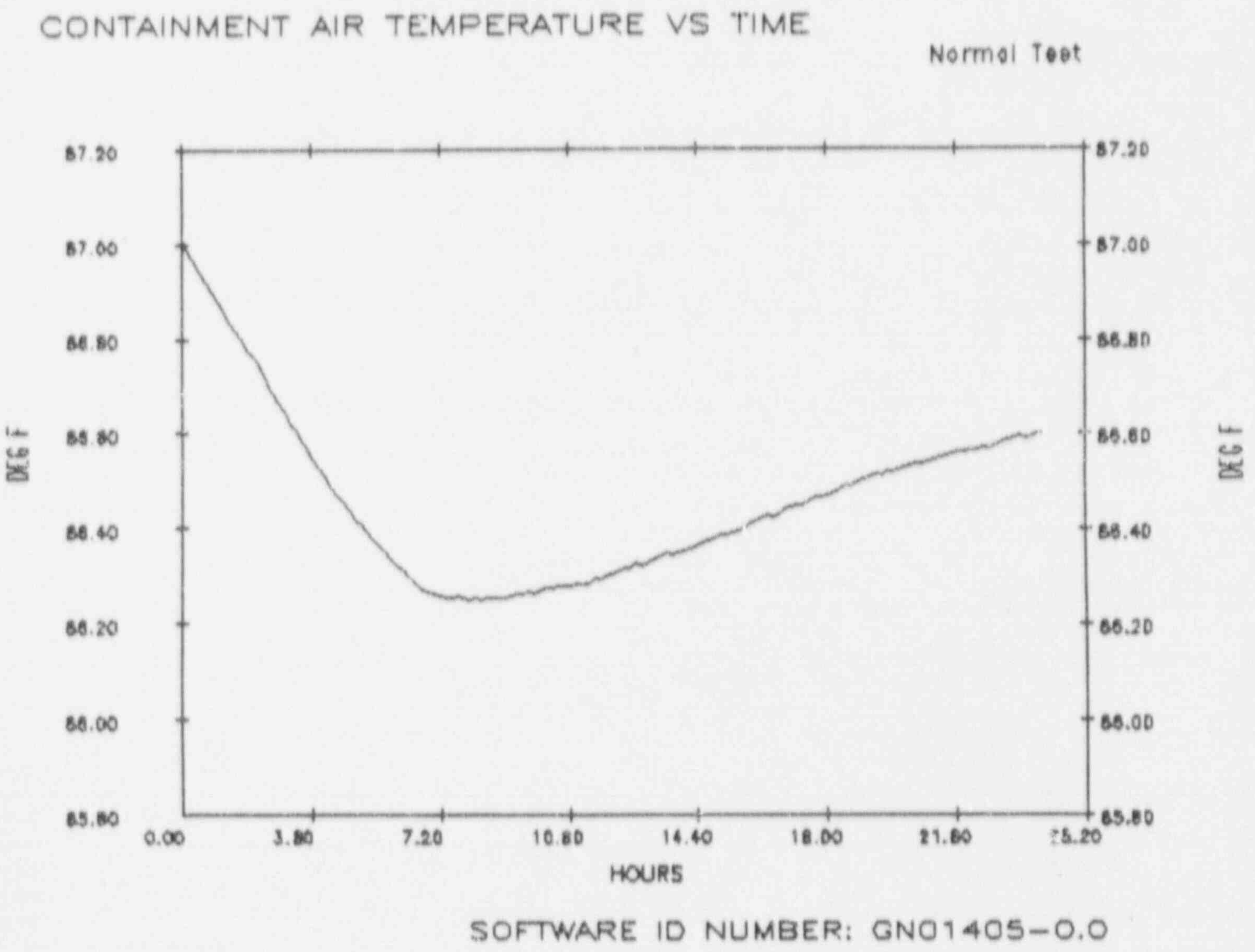

FIGURE 6

INDUCED LEAKAGE PHASE
GRAPH OF CALCULATED
LEAK RATE

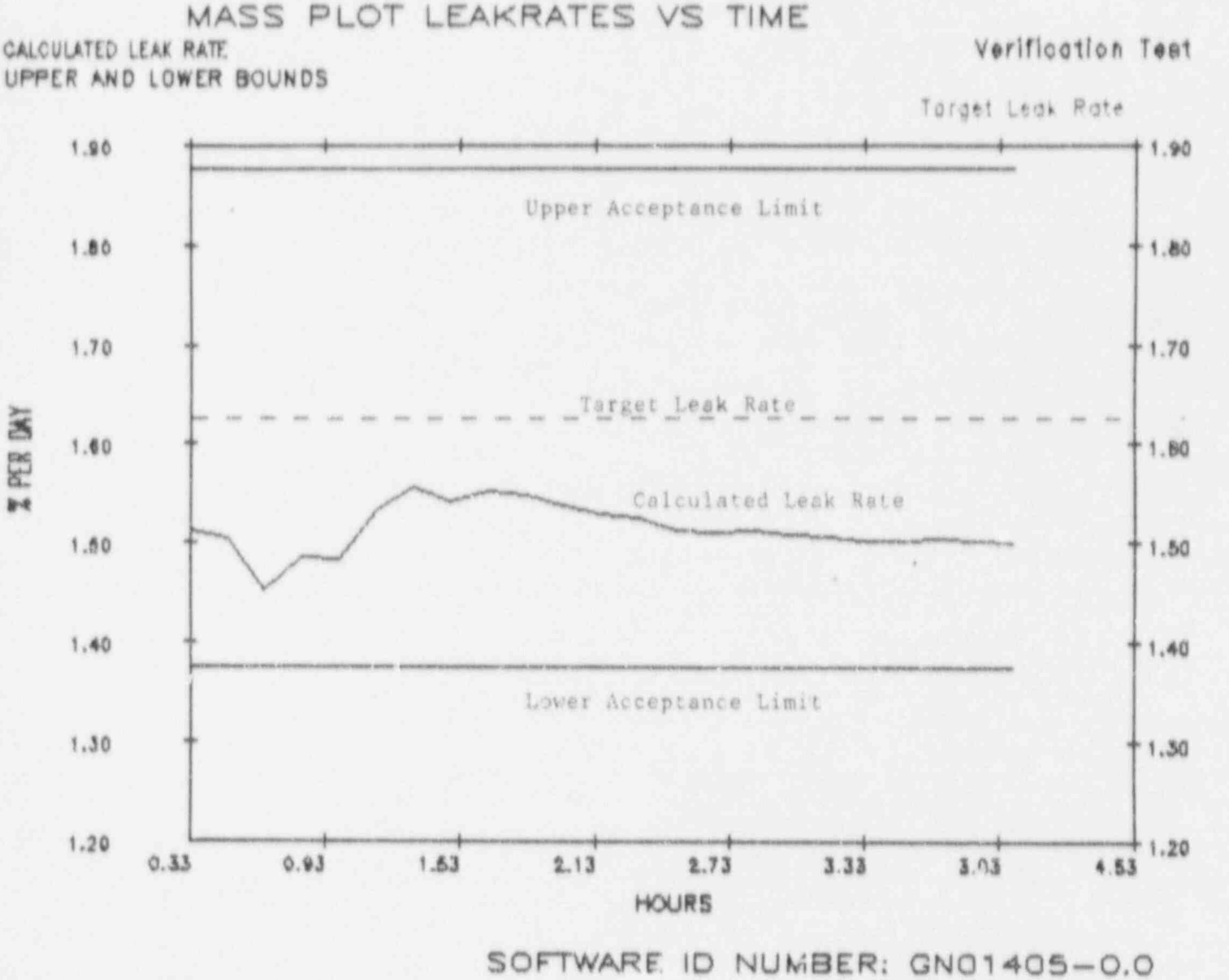

FIGURE 7

INDUCED LEAKAGE PHASE
GRAPH OF VOLUME
WEIGHTED AVERAGE CONTAINMENT TEMPERATURE

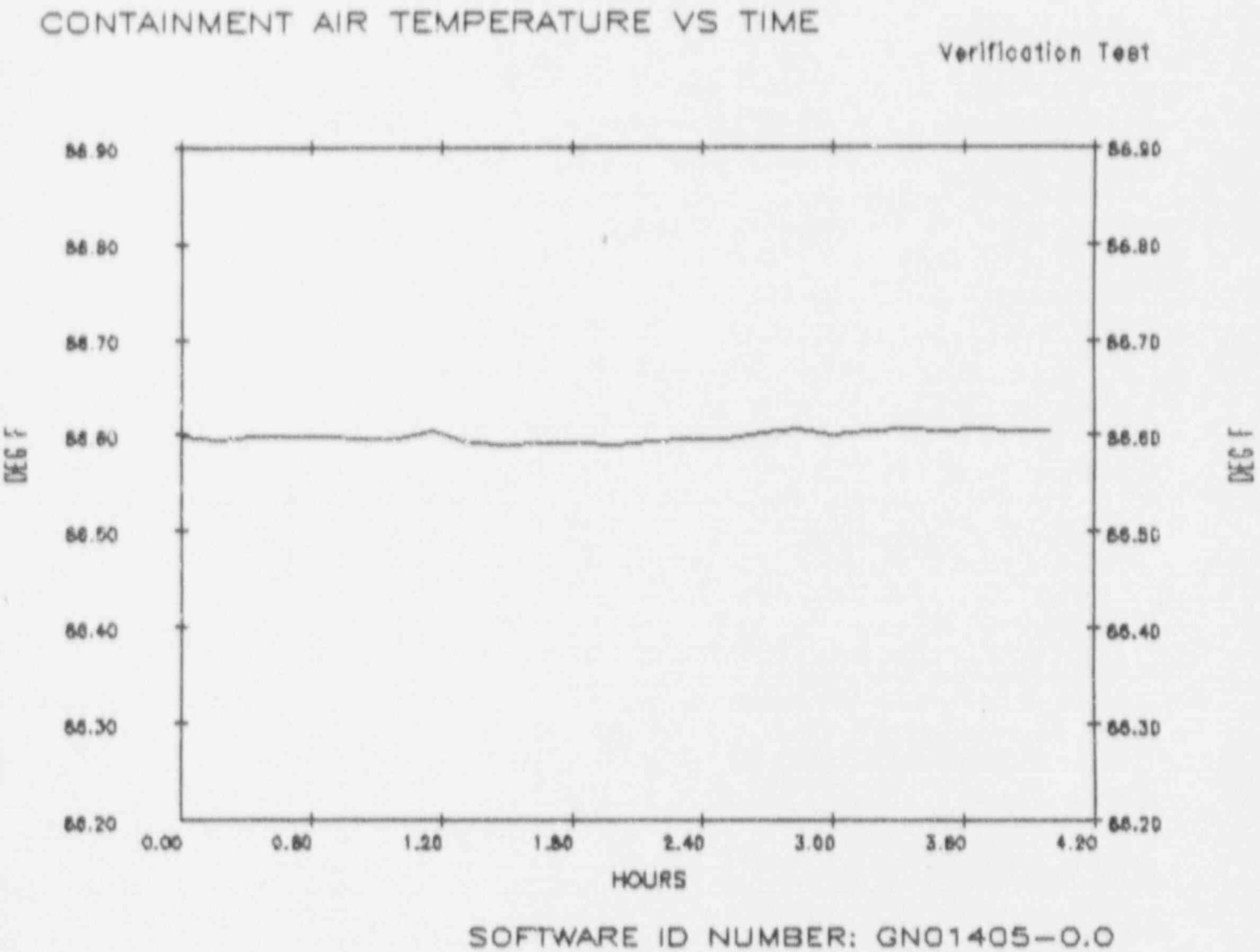

FIGURE 8

INDUCED LEAKAGE PHASE
GRAPH OF VOLUME
WEIGHTED AVERAGE CONTAINMENT VAPOR PRESSURE

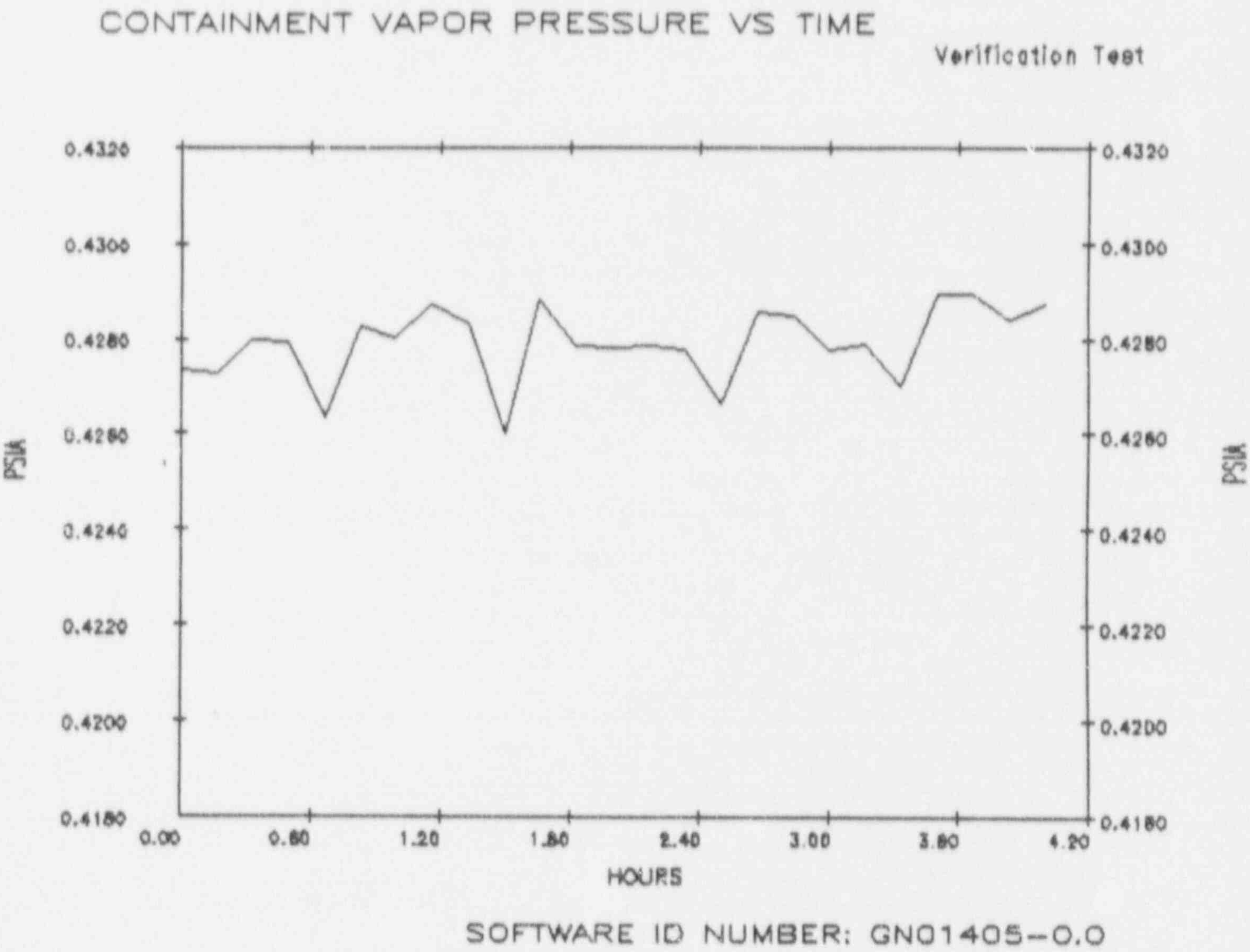

FIGURE 9

INDUCED LEAKAGE PHASE
GRAPH OF DRY AIR PRESSURE

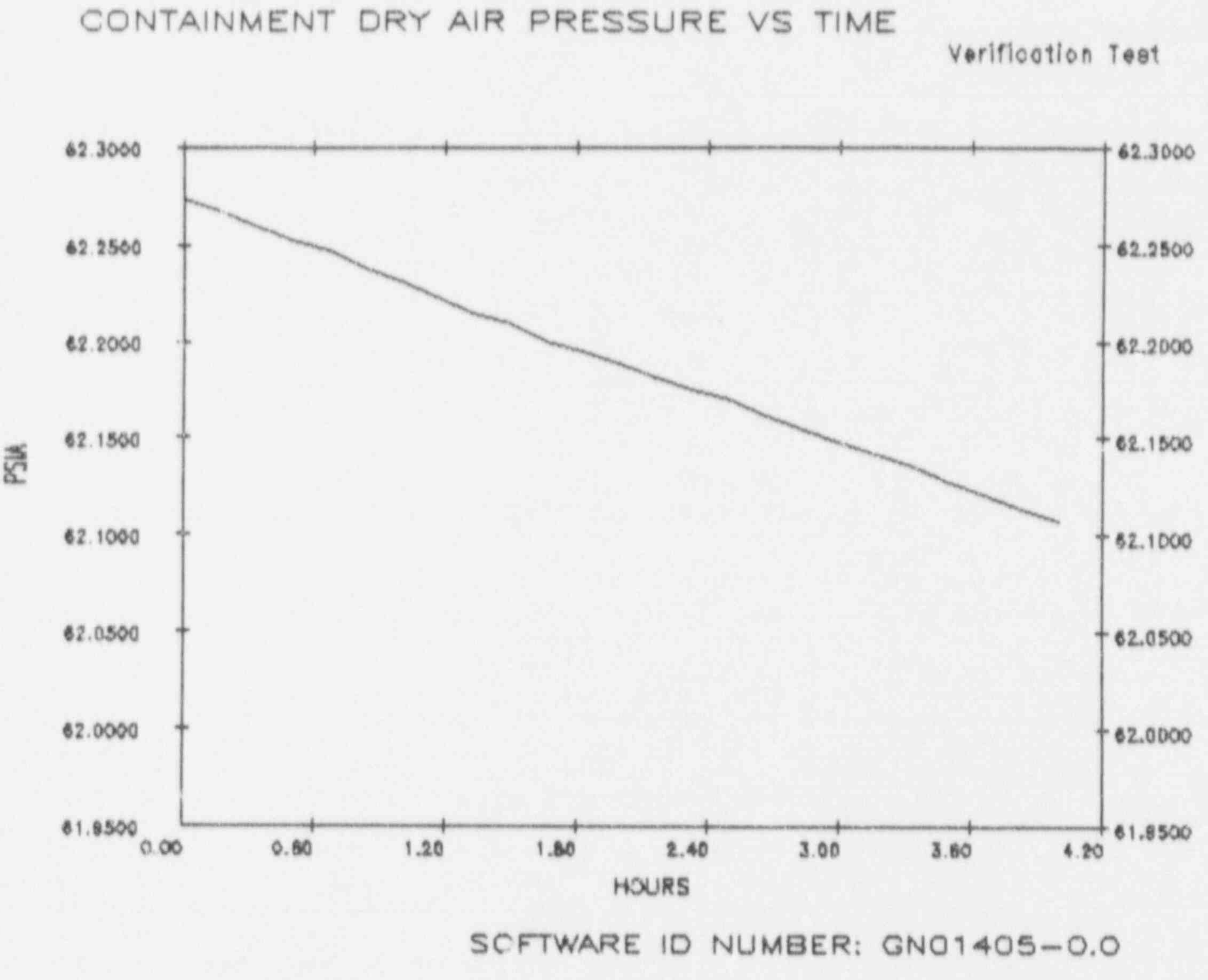

FIGURE 10

GRAPH OF REACTOR WATER LEVEL
THROUGH TESTING PERIOD

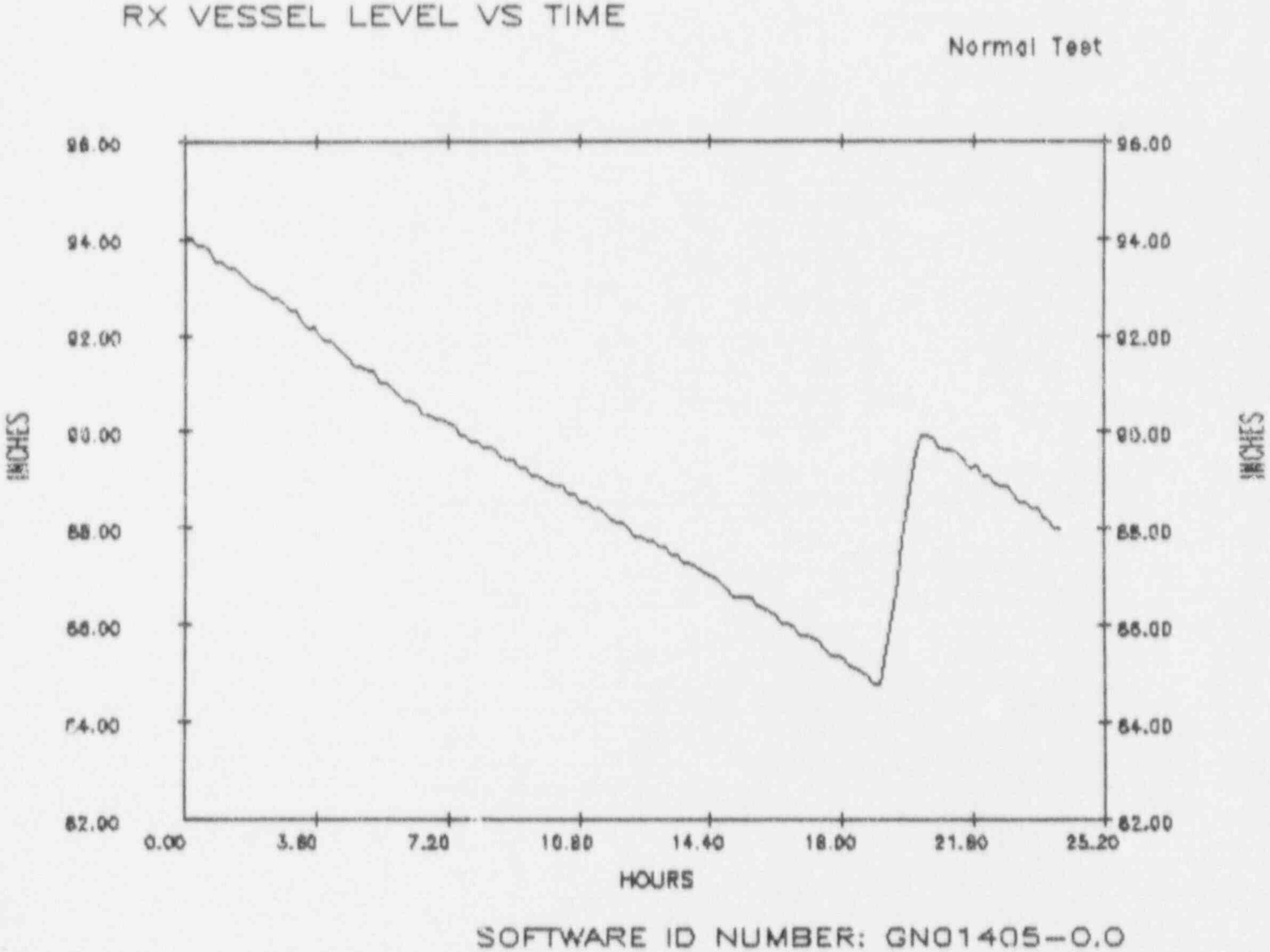

FIGURE 11

GRAPH OF TORUS WATER LEVEL
THROUGH TESTING PERIOD

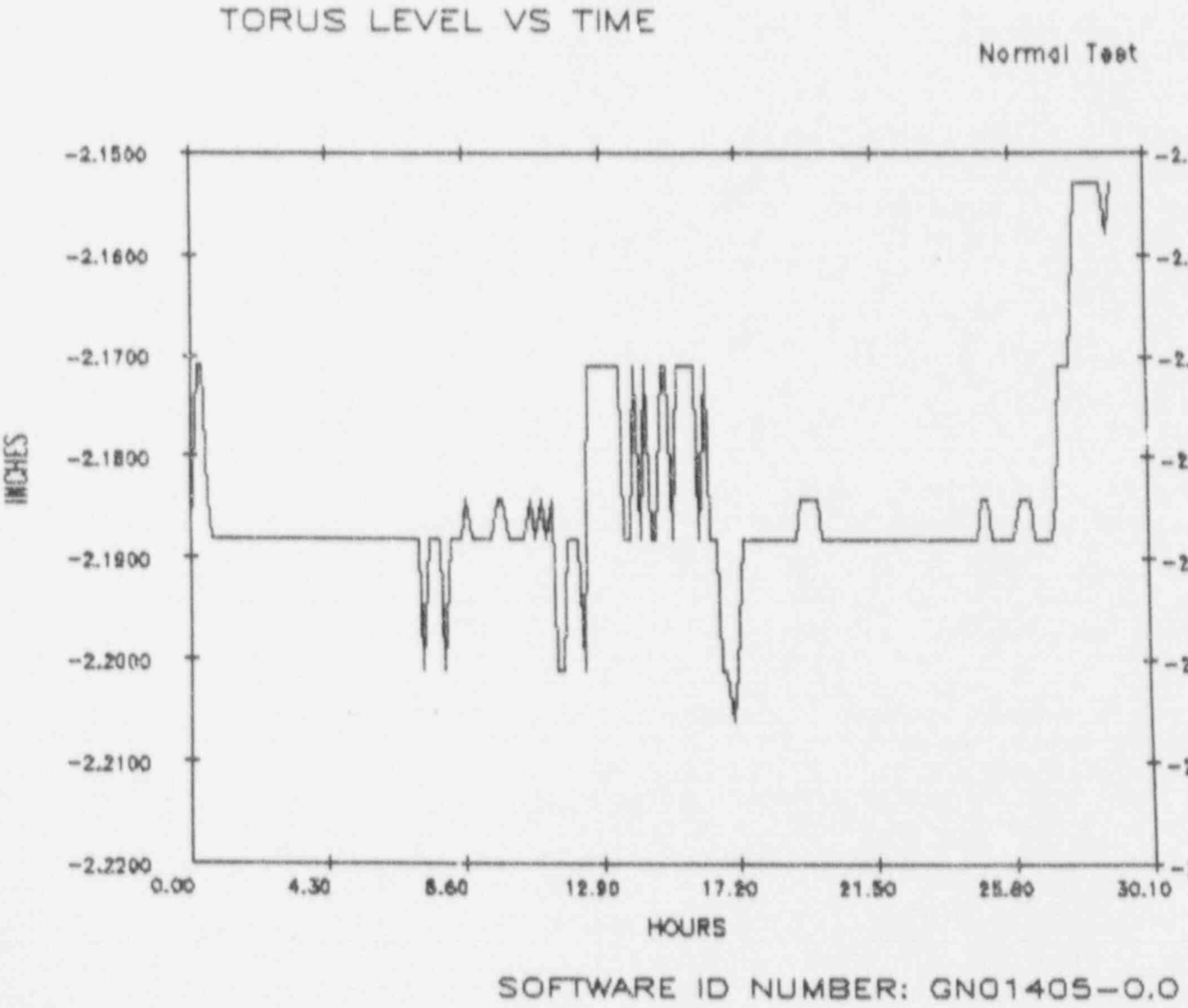

FIGURE 12

SECTION E - TEST CALCULATIONS

Calculations for the IPCLRT are based on the Mass Plot test method and are found in the functional requirements specification CECo Generic ILRT computer code software ID No. GN1405-0.0, Document ID No. ILRT-FRS-0.0. A reproduction of the Mass Plot method can be found in Appendix B.

SECTION F - TYPE A TEST RESULTS

F.1 Measured Leak Rate Test Results

Based on the data collected over 24 hours on approximately 10 minute intervals the statistically averaged leak rate was found to be 0.6035 wt%/day with a 95% upper confidence limit of 0.6069 wt%/day.

F.2 Induced Leakage Test Results

A leak rate of 8.34 scfm (1.0224 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.

Statistically Averaged Leak Rate (Measured Leak Rate Phase)	0.6035	0.6035
Induced Leak (8.34 scfm)	1.0224	1.0224
Allowed Error Band	+0.2500	-0.2500
	1.8759	1.3759
Statistically Averaged Leak Rate (Induced Leak Rate Phase)	1.500 wt %/day	

Therefore, the required test accuracy was satisfied. The verification test was 7.7% different than the predicted result (0.6035 + 1.0224). The magnitude of this difference is within the allowed error band and demonstrates that the instrumentation and modeling of the containment is adequate to measure a leakage with a magnitude of the allowable limit.

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 20 years, different test equipment, sensor locations and number of sensors, test methods, and test duration have been used. This test yielded results which were substantially larger than in previous years. The source of the increase has been identified as resulting from the leak discovered in the X-25 bellows. This leakage was later measured to be 137 SCFH (0.2798 wt%/day). When this leakage is removed from the measured leak rate the result, 0.3270 wt%/day, compares favorably with recent tests, and indicates that no significant deterioration in containment integrity has occured. The X-25 bellows were replaced prior to the Unit One startup.

TEST DATA	TEST DURATION (HOURS)	CALCULATED LEAK RATE (BN-TOP-1)	STATISTICALLY AVE. LEAK RATE (ANSI/ANS)
April, 1971	24	Not Available	0.111
February, 1976	24	Not Available	0.3175
December, 1982	12	0.4532	0.3796
July, 1984	24	0.4281	0.2297
March, 1986	12	0.2286	0.2286
December, 1987	6	.3194	0.3162
November, 1989	6	.3786	0.3714
March, 1991	24		0.6069

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.

	AS LEFT MINIMUM PATHWAY LEAKAGE	
	SCFH	WT%/DAY
Primary Sample Valves	0.0	0.00000
ACAD	0.31	0.00063
RHR A	0.5	0.00102
Feedwater A	0.4	0.00082
Feedwater B	0.5	0.00102
Oxygen Analyzer	0.4	0.00082
TIP Purge Check Valves	0.0	0.00000
CAM A, B	0.0	0.00000
RBCCW Return	16.0	0.03268
RBCCW Supply	1.8	0.00368
Core Spray A	2.6	0.00531
Core Spray B	0.4	0.00082
SBLC	6.0	0.01226
RWCU	0.65	0.00133
Shutdown Cooling	1.32	0.00270
Clean Demin To Drywell	0.5	0.00102
Totals	38.38	0.0784

This penalty increases the type A test result to 0.6819 wt%/day with an upper confidence limit of 0.6853 wt%/day.

F.5 EVALUATION OF INSTRUMENT FAILURES

There were no instrument failures during the 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, 1990

	AS FOUND (SCFH) MINIMUM PATHWAY LEAKAGE	AS LEFT (SCFH) MINIMUM PATHWAY LEAKAGE
(1) MSIV's @ 25 PSIG	13.8	13.8
(2) MSIV's converted to 48 PSIG*	23.9	23.9
(3) All Type C Tests (Except MSIV's)	161.0	58.5
(4) All Type B Tests	170.1	21.4
TOTAL (2 + 3 + 4)	355.0	103.8

(1) Type A Test Integrated Leak Rate Test)	= 0.6035 wt %/day
(2) Upper Confidence Limit of Type A Test Result	= 0.6069 wt %/day
(3) Correction for Unvented Volumes During Type A Test	= 0.0784 wt %/day
(4) Correction for Repairs Prior to Type A Test (As Found - As Left)**	0.2332 wt%/day

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

** The As Found does not include the X-25 bellows leakage (137 SCFH).

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 November, 1989. lotal leakage for double gasketed seals and total leakage for all penetrations and isolation valves following repairs satisfied the Technical Specification limits.

QTS 100-S1
Revision 8
December 1989

REFUEL OUTAGE LOCAL LEAK RATE TEST SUMMARY

UNIT ONE Cycle 11
TEST DIRECTOR Jay Rehr
OPERATING ENG. [illegible]
TECH STAFF SUPV. [illegible] 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	11-12-90	10.0	5.0	10.0	11-12-90	10.0	5.0	10.0
B MSIV	AO 203-1B,2B	11-12-90	3.8	1.9	5.0	11-12-90	3.8	1.9	3.8
C MSIV	AO 203-1C,2C	11-12-90	10.0	5.0	10.0	11-12-90	10.0	5.0	10.0
D MSIV	AO 203-1D,2D	11-12-90	3.8	1.9	3.8	11-12-90	3.8	1.9	3.8
			TOTAL	13.8			TOTAL	13.8	
			TOTAL CORRECTED *	23.9			TOTAL CORRECTED *	23.9	
MSL DRAIN	MO 220-1,2	11-12-90	2.3	1.2	2.3	3-23-91	3.1	* 1.2	3.1
PRIMARY SAMPLE	AO 220-44,45	11-15-90	0.0	0.0	0.0	2-21-91	0.0	0.0	0.0
A FEEDWATER	CV 220-58A,62A	12-3-90	278.0	[illegible]	[illegible]	1-23-91	2.9	0.4	2.5
B FEEDWATER	CV 220-58B,62B	11-15-90	UD	8.[illegible]	[illegible]	2-12-91	1.0	0.5	0.5
A DW SPRAY	MO 1001-23A,26A	11-14-90	16.0	8.0	16	11-[illegible]	16.0	8.0	16.0
A RHR RETURN	MO 1001-29A	11-14-90	1.1	1.1	1.1	2-11-91	0.5	0.5	0.5
A TORUS COOLING SPRAY	MO 1001-34,36,37A	11-14-90	2.5	1.3	2.5	3-4-91	15.0	* 1.3	15.0
B DW SPRAY	MO 1001-23B,26B	12-20-90	1.4	0.7	1.4	12-20-90	1.4	0.7	1.4
B RHR RETURN	MO 1001-29B	12-20-90	0.4	0.4	0.4	1-14-91	7.0	* 0.4	7.0
B TORUS COOLING/SPRAY	MO 1001-34,36,37B	12-20-90	3.4	1.7	3.4	12-20-90	3.4	1.7	3.4
SHUTDOWN COOLING	MO 1001-47,50	12-5-90	2.6	1.3	2.6	3-13-91	1.4	0.7	1.4
	PAGE TOTAL (EXCEPT MSIVs)	NA	UD	64.0	UD	NA	51.7	39.3	50.8

APPROVED
APR 1 2 1991
O.C.O.S.R.

10/0168s

* As left min path set equal to As Found to prevent negative Type A penalty.

UNIT ONE

REFUEL OUTAGE LOCAL
LEAK RATE TEST SUMMARY

QTS 100-S1
Revision 8

DESCRIPTION	VALVE(S)/ PENETRATION	AS FOUND (SCFH) DATE	TOTAL	MINIMUM PATHWAY	MAXIMUM PATHWAY	AS LEFT (SCFH) DATE	TOTAL	MINIMUM PATHWAY	MAXIMUM PATHWAY
SBLC	CV 1101-15, 16	12-14-90	15.0	6.0	9.0	12-14-90	15.0	6.0	9.0
CLEAN UP SUCTION	MO 1201-2,5	11-17-90	83.3	41.7	83.3	3-25-91	1.0	0.5	1.0
RCIC STEAM SUPPLY	MO 1301-16,17	11-13-90	4.3	2.2	4.3	2-12-91	0.4	0.2	0.4
RCIC STEAM EXHAUST	CV 1301-41	11-15-90	0.0	0.0	0.0	11-15-90	0.0	0.0	0.0
RCIC VAC. PUMP EX.	CV 1301-40	11-16-90	3.0	3.0	3.0	11-16-90	3.0	3.0	3.0
A CORE SPRAY	MO 1402-24A, 25A	11-14-90	5.3	2.6 25A	2.7 24A	11-14-90	5.3	2.6	2.7
B CORE SPRAY	MO 1402-24B, 25B	12-12-90	1.1	0.4 24B	0.7 25B	1-11-91	0.8	0.4	0.4
DW/TORUS PURGE SUPPLY	AO 1601-21,22,55,56	11-14-90	0.0	0.0	0.0	2-11-91	1.5	* 0.0	1.5
DW/TORUS PURGE EXHAUST	AO 1601-23,24,60, 61,62,63	11-12-90	35.0	17.5	35.0	2-11-91	3.1	1.6	3.1
A TORUS/RB VACUUM BREAKER	AO 1601-20A, CV 1601-31A	11-15-90	1.5	0.8	1.5	2-9-91	0.8	** 0.0	0.8
B TORUS RB VACUUM BREAKER	AO 1601-20B, CV 1601-31B	11-15-90	11.0	5.5	11.0	2-26-91	5.5	2.8	5.5
DW/TORUS PURGE	AO 1601-57,58,59	11-16-90	17.4	0.6	17.4	2-10-91	0.6	** 0.0	0.6
DWFDS	AO 2001-3,4	11-20-90	0.9	0.4	0.5	2-21-91	0.0	0.0	0.0
DWEDS	AO 2001-15, 16	11-24-90	1.9	1.0	1.9	11-24-90	1.9	1.0	1.9
HPCI STEAM SUPPLY	MO 2301-4,5	11-13-90	2.6	1.3	2.6	2-12-91	1.0	0.5	1.0
HPCI STEAM EXHAUST	CV 2301-45	11-14-90	0.0	0.0	0.0	11-14-90	0.0	0.0	0.0
HPCI DRAIN POT EXHAUST	CV 2301-34	11-15-90	0.5	0.5	0.5	2-13-91	0.4	0.4	0.4
RBCCW SUPPLY	MO 3702, CV 3799-31	12-24-90	27.0	8.0	19.0	1-22-91	9.8	1.8	8.0
RBCCW RETURN	MO 3703, 3706	12-30-90	33.5	16.0	17.5	12-30-90	33.5	16.0	17.5
	PAGE TOTAL	NA	243.3	107.5	209.9	NA	83.6	36.8	56.8

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* Only valve repaired

UNIT ONE

REFUEL OUTAGE LOCAL
LEAK RATE TEST SUMMARY

QTS 100-S1
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DESCRIPTION	VALVE(S)/ PENETRATION	AS FOUND (SCFH) DATE	TOTAL	MINIMUM PATHWAY	MAXIMUM PATHWAY	AS LEFT (SCFH) DATE	TOTAL	MINIMUM PATHWAY	MAXIMUM PATHWAY
CLEAN DEMIN	4399-45, CV 4399-46	12-19-90	2.0	0.5	1.5	12-19-90	2.0	0.5	1.5
SERVICE AIR	4699-46, CV 4699-47	1-9-91	4.1	1.9	3.2	1-9-91	4.1	1.9	3.2
DW PNEUMATIC	AO 4720, 4721	11-16-90	0.9	0.0	0.9	11-16-90	0.9	0.0	0.9
DW INSTRUMENT AIR	CV 4799-155, 156	1-9-91	5.3	2.0	3.3	1-9-91	5.3	2.0	3.3
TORUS INSTRUMENT AIR	CV 4799-158, 159	1-15-91	0.8	0.4	0.4	1-15-91	0.8	0.4	0.4
O_2 ANALYZER	AO 8801A, 8802A	11-21-90	0.0	0.0	0.0	11-21-90	0.0	0.0	0.0
O_2 ANALYZER	AO 8801B, 8802B	11-21-90	0.0	0.0	0.0	11-21-90	0.0	0.0	0.0
O_2 ANALYZER	AO 8801C, 8802C	11-21-90	0.0	0.0	0.0	11-21-90	0.0	0.0	0.0
O_2 ANALYZER	AO 8801D, 8802D	11-21-90	1.0	0.4	0.6	11-21-90	1.0	0.4	0.6
O_2 ANALYZER	AO 8803, 8804	11-21-90	0.6	0.0	0.6	11-21-90	0.6	0.0	0.6
DRYWELL PARTICULATE SAMPLE LINES	LINES 8803B-V-1/2"-H	11-26-90	0.8	0.4	0.4	11-26-90	0.8	0.4	0.4
TIP BALL VALVE	733-1	11-19-90	0.0	0.0	0.0	1-28-91	0.0	0.0	0.0
TIP BALL VALVE	733-2	11-19-90	0.0	0.0	0.0	1-28-91	0.0	0.0	0.0
TIP BALL VALVE	733-3	11-19-90	0.4	0.4	0.4	1-28-91	0.6	0.4	0.6
TIP BALL VALVE	733-4	11-19-90	0.0	0.0	0.0	1-28-91	0.0	0.0	0.0
TIP BALL VALVE	733-5	11-19-90	0.0	0.0	0.0	1-28-91	0.6	0.0	0.6
TIP PURGE CHECK	700-743	11-19-90	7.0	7.0	7.0	2-13-91	0.0	0.0	0.0
CAM	SO 2499-1A,2A	11-27-90	0.0	0.0	0.0	11-27-90	0.0	0.0	0.0
CAM	SO 2499-1B,2B	11-27-90	0.4	0.0	0.4	11-27-90	0.4	0.0	0.4
CAM	SO 2499-3A,4A	11-27-90	0.0	0.0	0.0	11-27-90	0.0	0.0	0.0
CAM	SO 2499-3B,4B	11-27-90	0.0	0.0	0.0	11-27-90	0.0	0.0	0.0
	PAGE TOTAL	NA	23.3	13.0	18.7	NA	17.1	6.0	12.5

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REFUEL OUTAGE LOCAL
LEAK RATE TEST SUMMARY

QTS 100-S1
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UNIT ONE

DESCRIPTION	VALVE(S)/ PENETRATION	AS FOUND (SCFH)				AS LEFT (SCFH)			
		DATE	TOTAL	MINIMUM PATHWAY	MAXIMUM PATHWAY	DATE	TOTAL	MINIMUM PATHWAY	MAXIMUM PATHWAY
ACAD	AO 2599-2A,23A	11-17-90	4.3	0.1	4.3	11-30-90	2.7	0.0	2.7
ACAD	AO 2599-2B,23B	11-17-90	1.6	0.0	1.6	11/30/90	1.7	0.0	1.7
ACAD	AO 2599-3A,24A	11-15-90	0.0	0.0	0.0	11-30-90	0.4	0.0	0.4
ACAD	AO 2599-3B,24B	11-15-90	0.0	0.0	0.0	11-30-90	0.6	0.0	0.6
ACAD	AO 2599-4A,5A	11-16-90	1.7	0.0	1.7	11-16-90	1.7	0.0	1.7
ACAD	AO 2599-4B,5B	11-16-90	1.9	0.3	1.6	11-16-90	1.9	0.3	1.6
EQUIPMENT HATCH	X-1	11-12-90	0.0	0.0	0.0	2-27-91	0.0	0.0	0.0
DW ACCESS HATCH	X-4	11-21-90	2.2	1.1	2.2	1-24-91	0.0	0.0	0.0
CRD HATCH	X-6	11-17-90	0.0	0.0	0.0	1-24-91	0.0	0.0	0.0
TIP PENETRATION	X-35A	11-19-90	0.0	0.0	0.0	11-19-90	0.0	0.0	0.0
TIP PENETRATION	X-35B	11-19-90	0.0	0.0	0.0	11-19-90	0.0	0.0	0.0
TIP PENETRATION	X-35C	11-19-90	0.0	0.0	0.0	11-19-90	0.0	0.0	0.0
TIP PENETRATION	X-35D	11-19-90	0.0	0.0	0.0	11-19-90	0.0	0.0	0.0
TIP PENETRATION	X-35E	11-19-90	0.0	0.0	0.0	11-19-90	0.0	0.0	0.0
TIP PENETRATION	X-35F	11-19-90	0.0	0.0	0.0	11-19-90	0.0	0.0	0.0
TIP PENETRATION	X-35G	11-19-90	0.0	0.0	0.0	11-19-90	0.0	0.0	0.0
TORUS HATCH	X-200A	11-12-90	0.0	0.0	0.0	3-2-91	0.0	0.0	0.0
TORUS HATCH	X-200B	11-12-90	0.0	0.0	0.0	3-30-91	0.0	0.0	0.0
DRYWELL HEAD	----	11-12-90	0.0	0.0	0.0	4-19-91	0.0	0.0	0.0
SHEAR LUG INSP. HATCH	SL-1	11-27-90	0.0	0.0	0.0	11-27-90	0.0	0.0	0.0
SHEER LUG INSP. HATCH	SL-2	11-27-90	0.0	0.0	0.0	11-27-90	0.0	0.0	0.0
SHEAR LUG INSP. HATCH	SL-3	11-27-90	0.0	0.0	0.0	11-27-90	0.0	0.0	0.0
	PAGE TOTAL	NA	11.7	1.5	11.4	NA	9.0	0.3	8.7

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UNIT ONE

REFUEL OUTAGE LOCAL
LEAK RATE TEST SUMMARY

QTS 100-S1
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DESCRIPTION	VALVE(S)/ PENETRATION	AS FOUND (SCFH) DATE	AS FOUND (SCFH) TOTAL	AS FOUND (SCFH) MINIMUM PATHWAY	AS FOUND (SCFH) MAXIMUM PATHWAY	AS LEFT (SCFH) DATE	AS LEFT (SCFH) TOTAL	AS LEFT (SCFH) MINIMUM PATHWAY	AS LEFT (SCFH) MAXIMUM PATHWAY
SHEER LUG INSP. HATCH	SL-4	11-27-90	0.0	0.0	0.0	11-27-90	0.0	0.0	0.0
SHEAR LUG INSP. HATCH	SL-5	11-27-90	0.0	0.0	0.0	11-27-90	0.0	0.0	0.0
SHEER LUG INSP. HATCH	SL-6	11-27-90	0.0	0.0	0.0	11-27-90	0.0	0.0	0.0
SHEAR LUG INSP. HATCH	SL-7	11-27-90	0.0	0.0	0.0	11-27-90	0.0	0.0	0.0
SHEER LUG INSP. HATCH	SL-8	11-27-90	0.0	0.0	0.0	11-27-90	0.0	0.0	0.0
MECH PENETRATION	X-7A	11-19-90	2.1	1.0	2.1	4-18-91	2.0	1.0	2.0
MECH. PENETRATION	X-7B	11-19-90	1.2	0.6	1.2	4-18-91	1.2	0.6	1.2
MECH. PENETRATION	X-7C	11-19-90	0.0	0.0	0.0	11-19-90	0.0	0.0	0.0
MECH. PENETRATION	X-7D	11-19-90	0.3	0.2	0.3	11-19-90	0.3	0.2	0.3
MECH. PENETRATION	X-8	11-19-90	0.7	0.4	0.7	4-18-91	0.5	0.4	0.5
MECH. PENETRATION	X-9A	11-19-90	0.0	0.0	0.0	11-19-90	0.0	0.0	0.0
MECH. PENETRATION	X-9B	11-19-90	0.0	0.0	0.0	11-19-90	0.0	0.0	0.0
MECH. PENETRATION	X-10	11-19-90	0.0	0.0	0.0	11-19-90	0.0	0.0	0.0
MECH. PENETRATION	X-11	11-19-90	0.0	0.0	0.0	11-19-90	0.0	0.0	0.0
MECH. PENETRATION	X-12	11-19-90	8.0	4.0	8.0	11-19-90	8.0	4.0	8.0
MECH. PENETRATION	X-13A	11-19-90	0.5	0.3	0.5	11-19-90	0.5	0.3	0.5
MECH. PENETRATION	X-13B	11-19-90	0.3	0.2	0.3	11-19-90	0.3	0.2	0.3
MECH. PENETRATION	X-14	11-19-90	0.0	0.0	0.0	11-19-90	0.0	0.0	0.0
MECH. PENETRATION	X-23	11-19-90	4.2	2.1	4.2	4-18-91	4.2	2.1	4.2
MECH. PENETRATION	X-24	11-19-90	0.0	0.0	0.0	11-19-90	0.0	0.0	0.0
MECH. PENETRATION	X-25	3-4-91	137.4	137.4	137.4	4-3-91/4-4-91	1.3	** 0.0	1.3
MECH. PENETRATION	X-26	11-19-90	0.0	0.0	0.0	11-19-90	0.0	0.0	0.0
APPROVED APR 1 2 1990	PAGE TOTAL	NA	154.7	146.2	154.7	NA	18.3	8.8	18.3

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** As left min. path set at zero to yield maximum Type A Penalty

UNIT ONE

REFUEL OUTAGE LOCAL
LEAK RATE TEST SUMMARY

QTS 100-S1
Revision 8

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-36	11-19-90	0.4	0.2	0.4	11-19-90	0.4	0.2	0.4
MECH. PENETRATION	X-47	11-19-90	0.0	0.0	0.0	11-19-90	0.0	0.0	0.0
MECH. PENETRATION	X-17	11-19-90	0.4	0.2	0.4	11-19-90	0.4	0.2	0.4
MECH. PENETRATION	X-16A	11-19-90	0.0	0.0	0.0	11-19-90	0.0	0.0	0.0
MECH. PENETRATION	X-16B	1-23-91	0.0	0.0	0.0	1-23-91	0.0	0.0	0.0
ELECTRICAL PENETRATION	X-100A	11-23-90	0.4	0.2	0.4	11-23-90	0.4	0.2	0.4
ELECTRICAL PENETRATION	X-100B	11-23-90	0.4	0.2	0.4	11-23-90	0.4	0.2	0.4
ELECTRICAL PENETRATION	X-100C	11-23-90	0.0	0.0	0.0	11-23-90	0.0	0.0	0.0
ELECTRICAL PENETRATION (UNIT ONE ONLY)	X-100D	11-23-90	0.4	0.2	0.4	11-23-90	0.4	0.2	0.4
ELECTRICAL PENETRATION	X-100E	11-23-90	0.4	0.2	0.4	11-23-90	0.4	0.2	0.4
ELECTRICAL PENETRATION	X-100F	11-20-90	0.0	0.0	0.0	11-20-90	0.0	0.0	0.0
ELECTRICAL PENETRATION	X-100G	11-20-90	0.0	0.0	0.0	11-20-90	0.0	0.0	0.0
ELECTRICAL PENETRATION	X-101A	11-20-90	6.0	3.0	6.0	11-20-90	6.0	3.0	6.0
ELECTRICAL PENETRATION	X-101B	11-20-90	0.0	0.0	0.0	11-20-90	0.0	0.0	0.0
ELECTRICAL PENETRATION	X-101D	11-23-90	0.0	0.0	0.0	11-23-90	0.0	0.0	0.0
ELECTRICAL PENETRATION	X-102A	11-20-90	1.0	0.5	1.0	11-20-90	1.0	0.5	1.0
ELECTRICAL PENETRATION	X-102B	11-20-90	0.0	0.0	0.0	11-20-90	0.0	0.0	0.0
ELECTRICAL PENETRATION	X-103	11-20-90	0.0	0.0	0.0	11-20-90	0.0	0.0	0.0
ELECTRICAL PENETRATION (UNIT TWO ONLY)	X-104A	NA →							
PAGE TOTAL		NA	9.4	4.7	9.4	NA	9.4	4.7	9.4

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LEAK RATE TEST SUMMARY

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UNIT One

DESCRIPTION	VALVE(S)/ PENETRATION	AS FOUND (SCFH) DATE	TOTAL	MINIMUM PATHWAY	MAXIMUM PATHWAY	AS LEFT (SCFH) DATE	TOTAL	MINIMUM PATHWAY	MAXIMUM PATHWAY
ELECTRICAL PENETRATION	X-104B	11-23-90	0.4	0.2	0.4	11-23-90	0.4	0.2	0.4
ELECTRICAL PENETRATION	X-104C	11-20-90	0.0	0.0	0.0	11-20-90	0.0	0.0	0.0
ELECTRICAL PENETRATION (UNIT TWO ONLY)	X-104D	NA →							
ELECTRICAL PENETRATION	X-104F	11-20-90	0.0	0.0	0.0	11-20-90	0.0	0.0	0.0
ELECTRICAL PENETRATION	X-105A	11-23-90	0.4	0.2	0.4	11-23-90	0.4	0.2	0.4
ELECTRICAL PENETRATION (UNIT ONE ONLY)	X-105B	11-20-90	0.0	0.0	0.0	11-20-90	0.0	0.0	0.0
ELECTRICAL PENETRATION	X-105C	11-20-90	4.7	2.35	4.7	11-20-90	4.7	2.35	4.7
ELECTRICAL PENETRATION (UNIT ONE ONLY)	X-105D	11-23-90	0.0	0.0	0.0	11-23-90	0.0	0.0	0.0
ELECTRICAL PENETRATION (UNIT TWO ONLY)	X-106A	NA →							
ELECTRICAL PENETRATION (UNIT TWO ONLY)	X-106B	NA →							
ELECTRICAL PENETRATION	X-107A	11-23-90	0.8	0.4	0.8	11-23-90	0.8	0.4	0.8
ELECTRICAL PENETRATION (UNIT TWO ONLY)	X-107B	NA →							
TORUS PENETRATION	X-227A	11-21-90	0.0	0.0	0.0	11-21-90	0.0	0.0	0.0
TORUS PENETRATION	X-227B	11-21-90	0.0	0.0	0.0	11-21-90	0.0	0.0	0.0
'A TORUS LEVEL FLANGES	----	1-14-91	0.4	0.4	0.4	1-14-91	0.4	0.4	0.4
	PAGE TOTAL	NA	6.7	3.55	6.7	NA	6.7	3.6	6.7

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UNIT ONE

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	----	1-14-91	0.8	0.8	0.8	1-14-91	0.8	0.8	0.8
SRM/IRM PURGE (UNIT TWO ONLY)	----	NA →							
PERSONNEL INTERLOCK X-2	X-2	11-15-90	27.5	13.7	27.5	4-26-91	6.9	3.5	6.9
H_2/O_2 MONITORING SYSTEM (TOTAL)	----	12-7-90	4.9	0.0	4.9	1-24-91	1.2	0.0	1.2
	PAGE TOTAL	NA	33.2	14.5	33.2	NA	8.9	4.3	8.9
	TEST TOTAL +	NA	UD	355.0	UD **	NA	204.7 ~~UD~~ 4-26-91	103.8	172.1

*To determine the corrected leakage of the MSIVs (as if they had been tested at 48 PSIG), multiply by 1.73.

**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 MSIVs from all test totals).

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

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(final)

APPENDIX B

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 transmitters

$P_1 = C_1 + M_1\, Pr_1/10000$, 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.

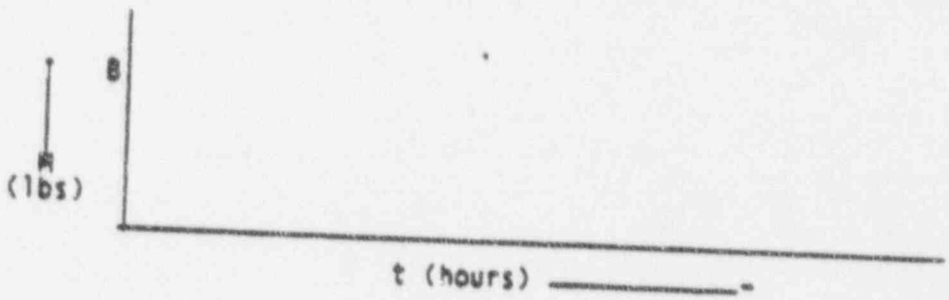
D.11 Leakrate Calculations using Mass-Plot Method:

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:

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

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

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

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

$$L = B + At$$

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

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.

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

$$L = B + At$$

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

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

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

$$UCL = L + T\sigma$$

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.

$Z_i = | T_{i-4} - T_{i-1} |$ i must be ≥ 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

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

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

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

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

$\bar{T}_\kappa$ is the average temperature of subvolume κ, (°R)

$\bar{P}_{v\kappa}$ 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 t, (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 C

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:

$$M\ (\%\ /\ DAY) = \frac{2400}{H} * \left[1 - \frac{T_1\ \bar{P}_N}{T_N\ \bar{P}_1}\right] \quad (1)$$

where: $\bar{P}_1$ = total (volume weighted) containment dry air pressure (PSIA) at the start of the test;

$\bar{P}_N$ = 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:

$\bar{P}_1 = \bar{P}_N = \hat{P}$ 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:

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

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	THERMISTER (°F)	PPG (PSIA)	DEWCELL (°F)	FLOWMETER (SCFM)	THERMOCOUPLE (°F)
Range	50-140	0.4-100	50 - 210	0.90-11.40	0 - 600
Accuracy	±0.25	±0.015%	±0.25	±1.0% Max Flow	±2.0
Repeat-ability	±0.01	±0.001%	±0.01	±0.02	±.10

C. COMPUTATION OF INSTRUMENT ACCURACY UNCERTAINTY

1. Computing " e_T "

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

$$e_T = \pm \left(0.97656 * \frac{0.25}{\sqrt{30}} + .02344 * \frac{2.0}{\sqrt{1}}\right)$$

$e_T = \pm$ 0.0914°R

2. Computing " e_{p_T} "

$$e_{p_T} = \pm \frac{0.015}{\sqrt{2}}(63.0)$$

$e_{p_T} = \pm$ 0.00668 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.

$$e_{p_V} = \pm \left(0.97656 * \frac{0.011}{\sqrt{10}} + 0.02344 * \frac{0.150}{\sqrt{1}}\right)$$

$e_{p_V} = \pm$ 0.0069 PSIA

4. Computing " e_p "

$$e_p = \pm \left[(0.00668)^2 + (0.0069)^2 \right]^{1/2}$$

$e_p = \pm$ 0.0096 PSIA

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

$$e_M^A = \pm \frac{2400}{H} * \left[2 * \left(\frac{0.0096}{63.0}\right)^2 + 2 * \left(\frac{0.0914}{544.7}\right)^2 \right]^{1/2}$$

assuming $\hat{P} = 63.0$ PSIA

$\hat{T} = 544.7°R$

Therefore, for a 6 hour test (H),

$$e_M^A = \pm 0.128 \text{ wt \% / DAY}$$

D. COMPUTATION OF INSTRUMENT REPEATABILITY UNCERTAINTY

1. Computing " e_T "

$$e_T = \pm \frac{0.01}{\sqrt{30}}$$

$$e_T = \pm 0.0018°R$$

2. Computing " e_{pT} "

$$e_{pT} = \pm \frac{0.001}{\sqrt{2}}$$

$$e_{pT} = \pm 7.071X10^{-4} \text{ PSIA}$$

3. Computing " e_{pV} "

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

$$e_{pV} = \pm 0.0020 \text{ PSIA}$$

4. Computing " e_p "

$$e_p = [(7.071X10^{-4})^2 + (0.0020)^2]^{1/2}$$

$$e_p = \pm 0.00212 \text{ PSIA}$$

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

$$e_M^R = \frac{2400}{H} * \left[2 \left(\frac{0.00212}{63.0} \right)^2 + 2 \left(\frac{0.0018}{544.7} \right)^2 \right]^{1/2}$$

Therefore, for a 6 hour test,

$$e_M^R = \pm\ 0.01912 \text{ wt \% / DAY}$$

E. COMPUTING TOTAL INSTRUMENT UNCERTAINTY

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

$$e_M = \pm\ 2 * [(0.128)^2 + (0.01912)^2]^{1/2}$$

$e_M = \pm$ 0.292 weight % / DAY for a 6 hour test.

$e_M = \pm$ 0.195 weight % / DAY for a 8 hour test.

$e_M = \pm$ 0.156 weight % / DAY for a 10 hour test.

$e_M = \pm$ 0.130 weight % / DAY for a 12 hour test.

$e_M = \pm$ 0.065 weight % / DAY for a 24 hour test.