ID/TS-4C,4D

REACTOR CONTAINMENT BUILDING

INTEGRATED LEAK RATE TEST

QUAD-CITIES NUCLEAR POWER STATION

UNIT ONE

JULY 24-27, 1984

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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 July 24-27, 1984 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.

This test was conducted using the ANS/ANSI N45.4-1972, 24 hour Mass Plot method. The calculated leak rate, statistically averaged leak rate, and the statistical upper confidence limit were computed in a manner consistent with the ANSI/ANS 56.8-1981 standard.

Simultaneously with the above method, calculations were performed using the Total Time Leak Rate method of BN-TOP-1, Rev. 1, a Bechtel Corporation Topical report approved by the Commission for short duration testing. The test duration criteria of BN-TOP-1 were easily satisfied for terminating the test in 10 hours or less. Because of the present regulatory uncertainty due to the ongoing revision to Appendix J and technical uncertainty due to ANSI/ANS standard changes, a full 24 hour test was performed and is the basis of this report.

SECTION A - TEST PREPARATIONS

A.1 Type A Test Procedure

The IPCLRT was performed in accordance with Quad-Cities Procedure QTS 150-1, Rev. 11, including checklists QTS 150-S1, S2, S3, S4, S5, S6, S9, S10, S11, S12, S13, S17, and subsections T1, T2, T3, and T8. Approved Temporary Procedure 2195 was written to exclude valves AO-1-203-2B and 2C (outboard MSIV's) from the pre-test valve line-up (QTS 150-S5), isolate the hydrogen/oxygen monitor system (QTS 150-S2), delete moisture trap installation requirements (QTS 150-S3), delete graphing the hourly measured leak rate readings and add a plot of the reactor water temperature (QTS 150-S4), add valves 1-1001-151A and B (pressure test tap isolation off the RHR system) to the pre-test valve checklist (QTS 150-S5), and to change test instrument positions (QTS 150-S17). Approved Temporary Procedure 2197 was written to change service air isolation allowing air to the reactor building but excluding the primary containment (a "tell tale" drain valve was open verifying proper isolation).

These procedures were written to comply with 10 CFR 50 Appendix J, ANS/ANSI N45.4-1972, and Quad-Cities Unit One Technical Specifications. The methods for calculating the containment leakage and upper confidence limit are in compliance with the ANSI/ANS 56.8-1981 standard. Compliance with all features of the ANSI/ANS 56.8-1981 standard was not possible, because the Commission has not approved the standard for use due to a pending change to 10 CFR 50, Appendix J.

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 volumes used for weighting the sensor readings. Plant personnel performed all test instrumentation calibrations using NBS traceable standards.

TABLE ONE
INSTRUMENT SPECIFICATIONS

INSTRUMENT	MANUFACTURER	MODEL NO.	RANGE	ACCURACY	REPEATABILITY
Precision Pressure Gages (2)	Volumetrics		0-100 PSIA	±.015PSI	±.001 PSI
RTD's (30)	Burns Engineering	SP1A1-5½-3A	50-200°F	±.5°F	±.1°F
Dewcells (10)	Volumetrics (Foxboro)	Lithium Chloride	-50-+140°F	±1.0°F	±.5°F
Thermocouple	Pall Trinity Micro	14-T-2H	0-600°F	±2.0°F	±.1°F
Flowmeter	Fischer & Porter	83	1.1-11.1 scfm	±.111 scfm	
Level Indicator LT 1-646B	GEMAC		0-+60" H_2O		

TABLE TWO
SENSOR PHYSICAL LOCATIONS

RTD NUMBER	SUBVOLUME	ELEVATION	AZIMUTH*
1	1	670'0"	180°
2	1	670'0"	0°
3	2	657'0"	20°
4	2	657'0"	200°
5	3	634'0"	70°
6	3	634'0"	265°
7	4(Annular Ring)	643'0"	45°
8	4	615'0"	225°
9	5	620'0"	5°
10	5	620'0"	100°
11	5	620'0"	220°
12	6	608'0"	40°
13	6	608'0"	130°
14	6	608'0"	220°
15	6	608'0"	310°
16	7	598'0"	70°
17	7	598'0"	160°
18	7	598'0"	250°
19	7	598'0"	340°
20	8	587'0"	10°
21	8	587'0"	100°
22	8	587'0"	190°
23	8	587'0"	250°
24	9(CRD Space)	586'0"	0°
25	10(Torus)	578'0"	10°
26	10(Torus)	578'0"	100°
27	10(Torus)	578'0"	160°
28	10(Torus)	578'0"	220°
29	10(Torus)	578'0"	280°
30	10(Torus)	578'0"	340°
Thermocouple	11(Rx Vessel)	(Inlet to CU Hx)	

DEWCELL NO.	SUBVOLUME	ELEVATION	AZIMUTH
1	1	670'	180°
2	2,3,4	653'	90°
3	2,3,4	653'	270°
4	5	620'	0°
5	6,7	600'	45°
6	6,7	600'	225°
7	8,9	586'	0°
8	8,9	586'	180°
9	10	578'	130°
10	10	578'	310°
Thermocouple (Saturated)	11	---	---

*WEST = 0° AZIMUTH

Idealized View of Drywell and Torus
Used to Calculate Free Volumes

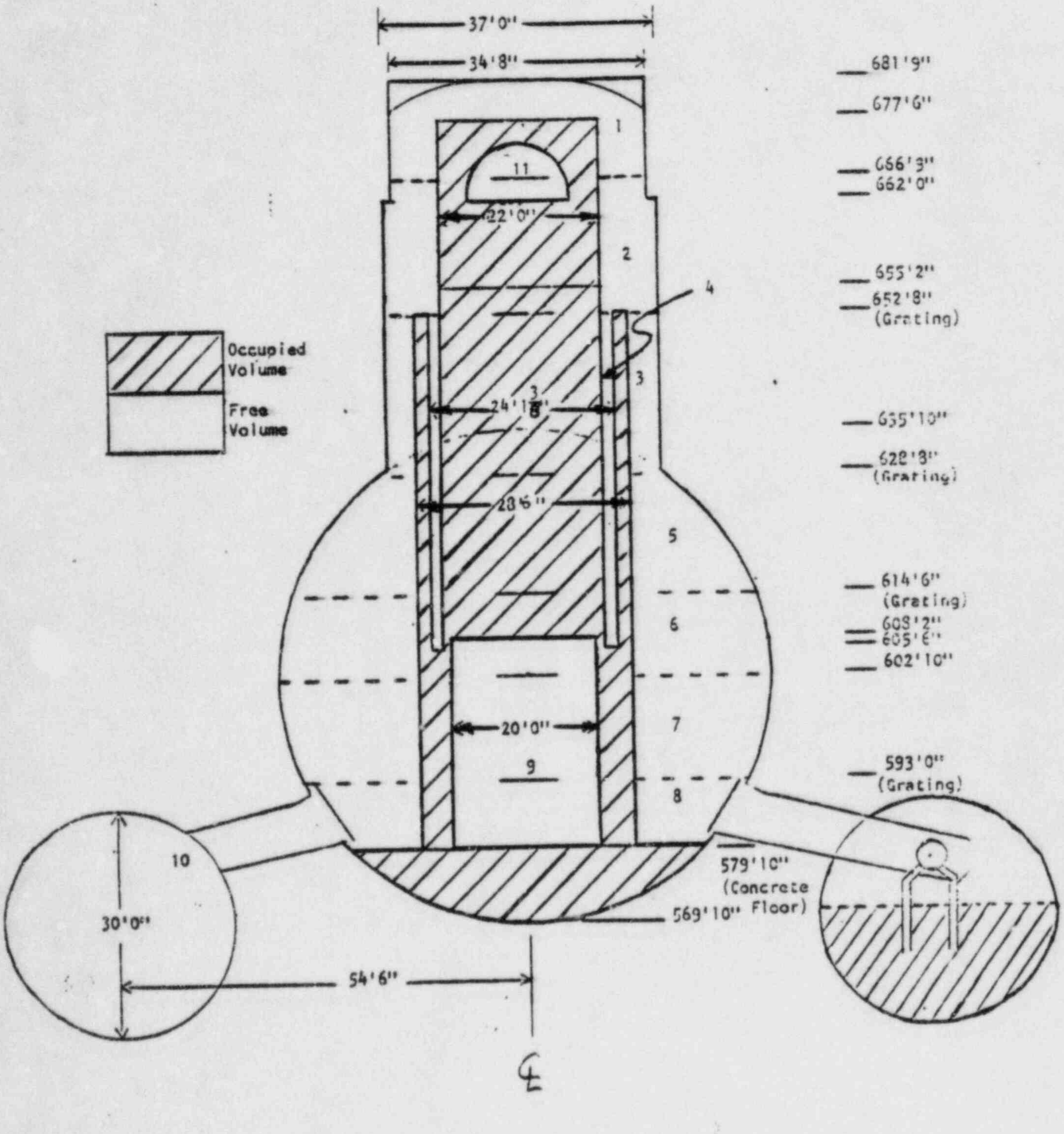

FIGURE 1

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.

The RTD's were manufactured by Burns Engineering Inc. and are Model SP 1A1-5½-3A. Each RTD and its associated bridge network was calibrated to yield an output of approximately 0-100 mV over a temperature range of 50-150°F. Each RTD was calibrated by comparing the bridge output to the true temperature as indicated by the temperature standard. Three 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 June 4, 1984 to standards traceable to the NBS. The sensors used during the test were calibrated within 6 months of the calibration date for the standard.

The plant process computer was used to scan the output of each RTD-bridge network. These digital inputs were then transferred to the PRIME computer and converted to engineering units for use in the leak rate calculations.

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 50-70 PSIA in 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 June 18, 1984 using NBS traceable reference standards. The pressure instruments used during the test were calibrated within 6 months of the standard's calibration.

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

Nine lithium chloride dewcells were used to determine the partial pressure due to water vapor in the containment. The dewcells were calibrated using the Volumetrics standard described in section A.2.a. and a chilled mirror dewcell standard calibrated on March 27, 1984 by Volumetrics.

The calibration constants (the slope and intercept of a regression line) for each dewcell 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 on June 14, 1984 by Fischer-Porter to within ±1% of full scale (1.1-11.1 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 6.65 SCFM by adjusting a 3/8" needle valve on the flowmeter inlet.

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 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 the ANSI/ANS mass plot method and 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 plotted on a Ramtek color terminal. Plant personnel also plotted a large number of other parameters, including temperature and partial pressure of water vapor for each subvolume, reactor water temperature and level, absolute pressure, etc. in real time. In all cases data was plotted within approximately 30 minutes of the time it was taken. The plotting of data and the computer printed summaries of data allowed rapid identificatin of any problems as they might develop. Figure 2 shows a schematic of the data acquisition system.

With the exception of a few problems with the process computer, all of the equipment performed perfectly. One instrument failed prior to the start of the test and no instrumentation inside the drywell failed once the test started.

A.4 Type A Test Pressurization

A 3000 SCFM, 600 hp, 4 kV 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.

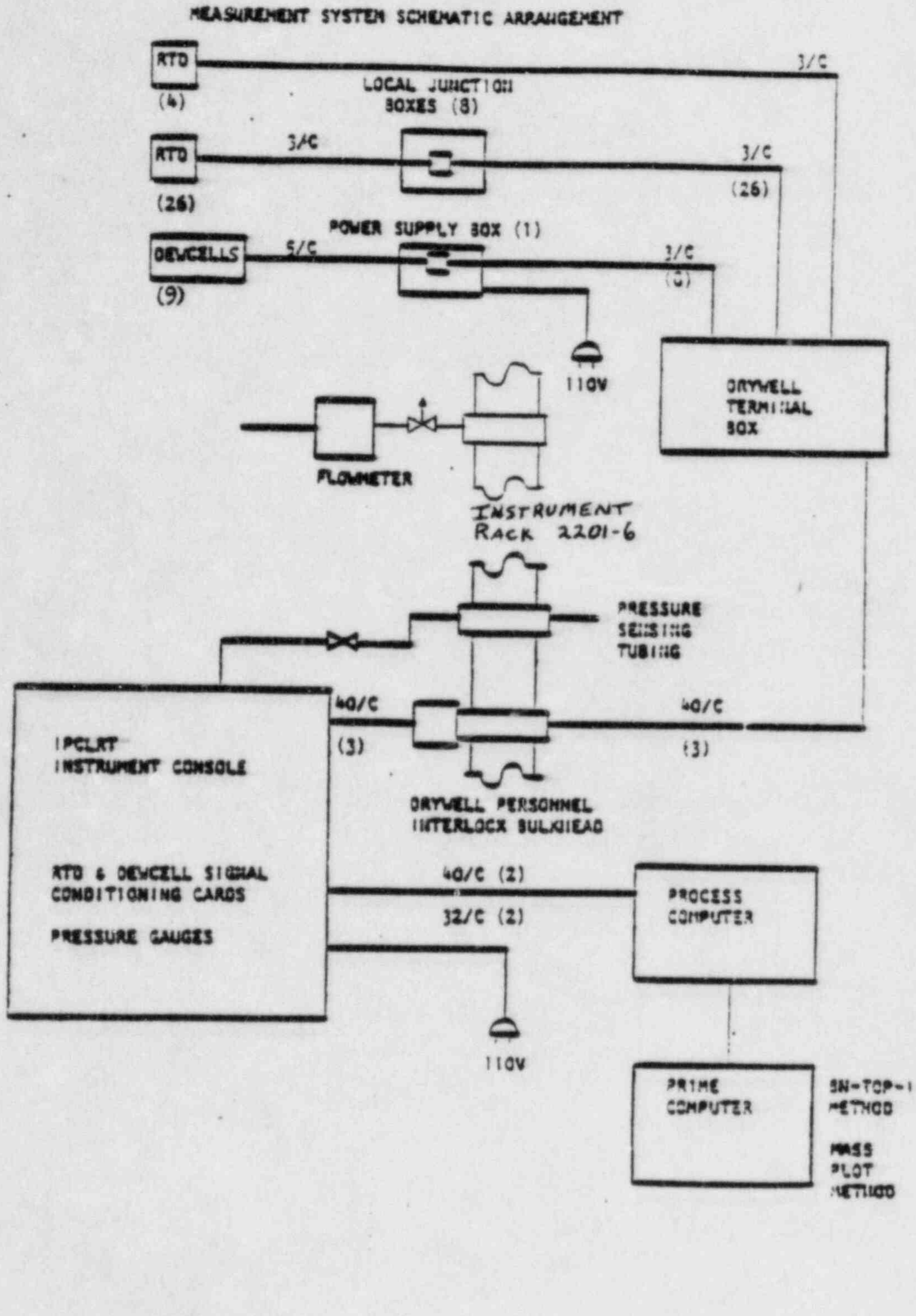
MEASUREMENT SYSTEM SCHEMATIC ARRANGEMENT
RTD
(4)
3/C
LOCAL JUNCTION
BOXES (8)
RTD
3/C
3/C
(26)
(26)
POWER SUPPLY BOX (1)
DEWCELLS
5/C
3/C
(9)
110V
DRYWELL
TERMINAL
BOX
FLOWMETER
INSTRUMENT
RACK 2201-6
PRESSURE
SENSING
TUBING
40/C
40/C
(3)
(3)
IPCLRT
INSTRUMENT CONSOLE
DRYWELL PERSONNEL
INTERLOCK BULKHEAD
RTD & DEWCELL SIGNAL
CONDITIONING CARDS
PRESSURE GAUGES
40/C (2)
32/C (2)
PROCESS
COMPUTER
110V
PRIME
COMPUTER
BN-TOP-1
METHOD
MASS
PLOT
METHOD

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 ANS/ANSI N45.4-1972. The inputs to the total containment dry air mass calculation include subvolume weighted containment temperature, subvolume weighted vapor pressure, total absolute air pressure, and a total containment volume correction for reactor water level. As the data sets are collected over time a regression line is computed for the measured dry air mass as a function of time. The slope divided by the "y-intercept" of the regression line gives 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 C.

There has been some criticism of this technique on a technical basis (Gogol and Reytblatt) in that the use of a volume weighted temperature and vapor pressure is not mathematically equivalent to computing a dry air mass for each subvolume and totalling the results to obtain a containment dry air mass. While the criticism has some merit in terms of mathematical exactness, using the two different methods give nearly the same results. The correction for a change in sump levels inside the containment is shown in Appendix B and uses the G-R method for computing the leak rate.

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 wt %/day as defined in the 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 the measured leak rate phase of the test. The allowed error band is ± 25% of L_A.

There are no references to the use of upper confidence limits to evaluate the acceptablility of the induced leakage phase of the IPCLRT in the ANS/ANSI standards or in BN-TOP-1, Rev. 1. The induced leak used for this test was 6.65 SCFM or 0.815 wt %/day.

B.3 Instrument Error Analysis

An instrument error analysis was performed prior to the test to demonstrate the adequacy of the data acquisition system. 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 0.0833 wt %/day and 0.0169 wt %/day for a 24-hour test, respectively. These results are inversely proportional to the test duration. When a dewcell failed prior to the start of the test, the values were re-calculated giving 0.0835 wt %/day and 0.0171 wt %/day for a 24-hour test.

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 instrumentation uncertainty is always present in the data and is incorporated in the 95% upper confidence limit.

SECTION C - SEQUENCE OF EVENTS

C.1 Test Preparation Chronology

The pretest preparation phase and containment inspection was completed on July 24, 1984 with no apparent structural deterioration being observed. Major preliminary steps included:

1) Completion of all Type B and C tests, component repairs and modifications where appropriate, and retests as required, except for two outboard MSIV's.

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

3) Installation of all IPCLRT test equipment including the sensors, associated wiring, and data acquisition system.

4) In situ test of data acquisition system and computer programs for data processing.

5) Dewcell number 2 failed.

6) Completion of all repairs and installations in the containment.

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

C.2 Test Pressurization and Stabilization Chronology

DATE	TIME	EVENT
07-24-84	0424	Began pressurizing the Unit One containment.
		Process Computer problem due to fast containment pressure changes.
	0500	Containment piping and valves inspected for apparent leaks.
	0600	30 psia in drywell.
	0855	Compressor tripped due to third stage hi temperature.
	0910	Restarted compressor.
	1005	Compressor tripped again - would not run over 20 percent loaded.
	1045	Switched over to spare compressor.
	1230	Pressurization complete at 65 psia.
	1238	Stabilization phase beginning.
	1904	Stabilization phase ending ($\Delta T \simeq 0.1°F/hr$)

C.3 Measured Leak Rate Phase Chronology

DATE	TIME	EVENT
07-24-84	1914	24 hour leakage rate phase begun.
		Reactor water level is 53.74 inches and decreasing steadily at 0.75 inch/hour. This will be no problem for the test.
		Reactor water temperature is 125°F and decreasing steadily at 1.75 degrees F per hour.
	2105	Adjusted RHR heat exchanger valve 17A to slow down the reactor water temperature drop.
	2226	Adjusted RHR system 17A valve again.
07-25-84	0240	Adjusted RHR system 17A valve again.
	0246	Adjusted RHR system 17A valve again.
	0318	Bad data set because RTD's 1 and 2 dropped out of scan.
	1150	Computer problem.
	1151	Computer up. Did not effect next data point.
	1415	Computer problem.
	1430	Computer working. Found that the first six RTD's were not being scanned correctly.*
	1750	Decided to restart 24 hour leak rate phase at 1430. This was the first point when all RTD's were scanned properly.
		Reactor water level is 47.83 inches and decreasing at about 0.1 inch per hour. This will be no problem for the test.
		Reactor water temperature is 115.8 degrees F and increasing at 0.5 degree F per hour. This will be no problem for the test.

C.3 Measured Leak Rate Phase Chronology (Continued

DATE	TIME	EVENT
07-26-84	0315	Computer problem.
	0320	Computer working. Missed one data transfer.
	0650	Computer problem.
	0723	Computer working. Missed data transfers for about 45 minutes.
	1430	End of 24 hour leak rate phase. Total containment pressure is 63.6 psia.

C.4 Induced Leakage Phase Chronology

DATE	TIME	EVENT
07-26-84	1442	Leakage induced at 6.65 scfm or 0.815 weight percent per day. Radiation Protection taking sample for release to reactor building.
	1544	Stabilization complete. Computer program set for first scan on this part of the test.
	1944	Induced leakage phase terminated successfully. Total containment pressure is 63.48 psia.

C.5 Depressurization Phase Chronology

DATE	TIME	EVENT
07-26-84	2015	Started depressurization phase.
	2330	Depressurization complete.
07-27-84	0015	Drywell entry made to verify undisturbed instrumentation and begin post-test checklist.

* At 1430 on July 25 after re-initializing the process computer it was noticed that the first six RTD points only got scanned one time after re-initializing the process computer. The computer was then processing a constant value for these 6 sensors. Once this was noticed Computer Systems people were able to correct the problem in a couple of minutes. At 1750, the same day, the Station decided to restart the 24 hour leak rate phase beginning at the time the scanning process was repaired.

SECTION D - TYPE A TEST DATA

D.1 Measured Leak Rate Phase Data

A summary of the computed data using the ANSI N45.4 test method can be found in Table 3. Shown in the table are data set number, time since the start of the test (after pressurization and stabilization complete), volume weighted containment temperature in degrees R, dry air pressure in PSIA, reactor water level in inches, total time measured leak rate, point-to-point leak rate, statistically averaged leak rate, and the ANSI calculation of the upper confidence limit.

Graphic results for the test are found in Figures 3-6.

D.2 Induced Leakage Phase Data

A summary of the computed data using the ANSI N45.4 test method can be found in Table 4. Graphic results for the test are found in Figures 7-10.

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**** SUMMARY OF DATA SETS 1 THRU 139 ****

DATA SET	TAPE TIME	TEST DURATION (HRS)	TEMP (R)	DRY AIR PRESSURE (PSIA)	RX WATER LEVEL (IN)	MEASURED MASS	CALCULATED MASS T = 0	MEAS LEAK RATE TOTAL % / DAY	MEAS LEAK RATE POINT % / DAY	CALC LEAK RATE % / DAY	95% UPPER CONFIDENCE LIMIT
1	001 14:29:53	0.000000	558.56409	63.85355	47.83400	8.90064E+04	0.00000E-01	0.0000	0.0000	0.0000	0.0000
2	001 14:56:43	0.447220	558.53113	63.84776	47.56899	8.90056E+04	0.00000E-01	0.0480	0.0480	0.0000	0.0000
3	001 15:06:43	0.613892	558.52820	63.84450	47.55299	8.90017E+04	8.90069E+04	0.2093	0.6421	0.1759	0.7913
4	001 15:16:44	0.780830	558.51404	63.84190	47.45900	8.90010E+04	8.90070E+04	0.1867	0.1035	0.1954	0.3963
5	001 15:26:44	0.947495	558.49707	63.83960	47.47500	8.90004E+04	8.90069E+04	0.1716	0.1011	0.1906	0.2996
6	001 15:36:45	1.114449	558.49084	63.83786	47.49599	8.89980E+04	8.90070E+04	0.1845	0.2574	0.1953	0.2660
7	001 15:46:46	1.281387	558.48718	63.83584	47.55299	8.89961E+04	8.90073E+04	0.2163	0.4291	0.2161	0.2737
8	001 15:56:48	1.448608	558.51416	63.83372	47.53200	8.89890E+04	8.90087E+04	0.3237	1.1465	0.2879	0.3888
9	001 16:06:49	1.615562	558.51489	63.83194	47.53200	8.89865E+04	8.90096E+04	0.3333	0.4165	0.3327	0.4280
10	001 16:16:49	1.782227	558.50403	63.83094	47.49599	8.89871E+04	8.90098E+04	0.2929	-0.0986	0.3376	0.4140
11	001 16:26:50	1.949165	558.50781	63.82874	47.49599	8.89834E+04	8.90102E+04	0.3186	0.5932	0.3506	0.4148
12	001 16:36:50	2.115837	558.50940	63.82587	47.45900	8.89794E+04	8.90107E+04	0.3443	0.6448	0.3686	0.4257
13	001 16:46:51	2.282776	558.50623	63.82655	47.43800	8.89810E+04	8.90104E+04	0.2999	-0.2626	0.3611	0.4100
14	001 16:56:53	2.449997	558.50513	63.82336	47.43800	8.89768E+04	8.90105E+04	0.3266	0.6905	0.3648	0.4069
15	001 17:06:54	2.616951	558.50781	63.82148	47.43800	8.89737E+04	8.90107E+04	0.3370	0.4897	0.3702	0.4072
16	001 17:16:54	2.783615	558.49963	63.82040	47.41800	8.89737E+04	8.90105E+04	0.3172	0.0076	0.3664	0.3990
17	001 17:26:56	2.950829	558.49634	63.81832	47.40199	8.89714E+04	8.90104E+04	0.3198	0.3630	0.3637	0.3925
18	001 17:36:59	3.118340	558.49561	63.81786	47.38100	8.89710E+04	8.90101E+04	0.3059	0.0604	0.3567	0.3833
19	001 17:47:00	3.285286	558.48584	63.81612	47.38100	8.89702E+04	8.90099E+04	0.2975	0.1414	0.3484	0.3736
20	001 17:57:02	3.452499	558.49231	63.81440	47.34499	8.89670E+04	8.90096E+04	0.3076	0.5067	0.3444	0.3675
21	001 18:07:04	3.619729	558.49292	63.81126	47.30900	8.89628E+04	8.90097E+04	0.3246	0.6755	0.3456	0.3665
22	001 18:17:07	3.787224	558.48816	63.81115	47.27200	8.89637E+04	8.90095E+04	0.3041	-0.1384	0.3409	0.3605
23	001 18:27:08	3.954170	558.48633	63.80975	47.27200	8.89621E+04	8.90092E+04	0.3025	0.2651	0.3366	0.3549
24	001 18:37:09	4.121109	558.49011	63.80921	47.27200	8.89607E+04	8.90089E+04	0.2989	0.2146	0.3320	0.3494
25	001 18:47:10	4.288063	558.48682	63.80775	47.21500	8.89596E+04	8.90086E+04	0.2942	0.1767	0.3270	0.3438
26	001 18:57:11	4.455002	558.48999	63.80754	47.23000	8.89587E+04	8.90083E+04	0.2887	0.1490	0.3216	0.3380
27	001 19:07:13	4.622223	558.47751	63.80470	47.21500	8.89568E+04	8.90079E+04	0.2894	0.3075	0.3172	0.3330
28	001 19:17:13	4.788895	558.46997	63.80365	47.19399	8.89568E+04	8.90075E+04	0.2795	0.0051	0.3114	0.3271
29	001 19:27:13	4.955559	558.48010	63.80282	47.15700	8.89543E+04	8.90073E+04	0.2838	0.4072	0.3073	0.3225
30	001 19:37:14	5.122498	558.48645	63.80133	47.12099	8.89515E+04	8.90071E+04	0.2894	0.4545	0.3049	0.3193
31	001 19:47:17	5.290001	558.48669	63.80151	47.12099	8.89517E+04	8.90067E+04	0.2790	-0.0378	0.3009	0.3150
32	001 19:57:18	5.456947	558.48877	63.80045	47.08400	8.89502E+04	8.90064E+04	0.2780	0.2475	0.2973	0.3109
33	001 20:07:18	5.623611	558.48914	63.79910	47.06300	8.89484E+04	8.90062E+04	0.2783	0.2884	0.2943	0.3074
34	001 20:17:19	5.790558	558.49097	63.79713	47.04300	8.89455E+04	8.90060E+04	0.2836	0.4621	0.2926	0.3051
35	001 20:27:19	5.957222	558.49402	63.79593	47.02699	8.89435E+04	8.90060E+04	0.2850	0.3339	0.2914	0.3032
36	001 20:37:20	6.124168	558.48645	63.79456	47.00600	8.89429E+04	8.90059E+04	0.2797	0.0884	0.2894	0.3007
37	001 20:47:23	6.291672	558.47791	63.79439	46.94900	8.89445E+04	8.90055E+04	0.2654	-0.2567	0.2855	0.2968
38	001 20:57:23	6.458336	558.48987	63.79198	46.93400	8.89393E+04	8.90054E+04	0.2801	0.8373	0.2843	0.2951
39	001 21:07:24	6.625275	558.47632	63.78951	46.91299	8.89382E+04	8.90052E+04	0.2776	0.1818	0.2829	0.2933
40	001 21:17:24	6.791946	558.48352	63.78982	46.89700	8.89376E+04	8.90050E+04	0.2732	0.0961	0.2810	0.2910
41	001 21:27:25	6.958893	558.48462	63.78725	46.87600	8.89340E+04	8.90050E+04	0.2806	0.5834	0.2805	0.2900
42	001 21:37:25	7.125557	558.47009	63.78603	46.84000	8.89349E+04	8.90048E+04	0.2707	-0.1442	0.2786	0.2878
43	001 21:47:27	7.292786	558.47046	63.78421	46.81099	8.89325E+04	8.90048E+04	0.2734	0.3883	0.2773	0.2862
44	001 21:57:28	7.459724	558.48450	63.78285	46.80299	8.89285E+04	8.90047E+04	0.2817	0.6466	0.2773	0.2858
45	001 22:07:29	7.626663	558.47937	63.78228	46.78200	8.89287E+04	8.90046E+04	0.2749	-0.0278	0.2764	0.2845
46	001 22:17:29	7.793335	558.48022	63.78181	46.74599	8.89281E+04	8.90045E+04	0.2708	0.0835	0.2751	0.2830
47	001 22:27:30	7.960281	558.48694	63.77924	46.74599	8.89235E+04	8.90045E+04	0.2810	0.7578	0.2752	0.2828
48	001 22:37:32	8.127502	558.48096	63.77867	46.68800	8.89241E+04	8.90044E+04	0.2732	-0.0904	0.2743	0.2817
49	001 22:47:33	8.294449	558.48572	63.77737	46.65199	8.89218E+04	8.90043E+04	0.2751	0.3663	0.2738	0.2808
50	001 22:57:36	8.461945	558.48242	63.77596	46.63100	8.89205E+04	8.90042E+04	0.2737	0.2065	0.2732	0.2800
51	001 23:07:39	8.629440	558.48096	63.77404	46.59499	8.89183E+04	8.90042E+04	0.2752	0.3500	0.2728	0.2793
52	001 23:17:39	8.796112	558.50488	63.77198	46.59499	8.89117E+04	8.90043E+04	0.2905	1.0830	0.2742	0.2806
53	001 23:27:40	8.963058	558.46777	63.77103	46.57400	8.89164E+04	8.90041E+04	0.2700	0.7655	0.2733	0.2796
54	001 23:37:40	9.129723	558.45959	63.76961	46.53799	8.89160E+04	8.90040E+04	0.2671	0.0633	0.2721	0.2702

TABLE 3

55	001	23:47:42	9.296951	558.44658	63.76779	46.52200	8.89127E+04	8.90039E+04	0.2720	0.5397	0.2715	0.2774
56	001	23:57:43	9.463890	558.45923	63.76627	46.52200	8.89115E+04	8.90030E+04	0.2703	0.1794	0.2708	0.2766
57	002	00:07:44	9.630829	558.44836	63.76453	46.48000	8.89112E+04	8.90036E+04	0.2667	0.0632	0.2698	0.2754
58	002	00:17:45	9.797783	558.44006	63.76318	46.44399	8.89109E+04	8.90033E+04	0.2630	0.0480	0.2685	0.2741
59	002	00:27:47	9.965004	558.43787	63.76032	46.44399	8.89073E+04	8.90037E+04	0.2683	0.5026	0.2679	0.2733
60	002	00:37:48	10.131943	558.43066	63.75392	46.42799	8.89080E+04	8.90031E+04	0.2621	-0.1127	0.2667	0.2721
61	002	00:47:49	10.298897	558.42419	63.75723	46.40700	8.89054E+04	8.90030E+04	0.2645	0.4118	0.2659	0.2711
62	002	00:57:49	10.465561	558.41235	63.75658	46.40700	8.89064E+04	8.90027E+04	0.2578	-0.1569	0.2644	0.2697
63	002	01:07:50	10.632500	558.41431	63.75533	46.33400	8.89049E+04	8.90025E+04	0.2574	0.2375	0.2631	0.2684
64	002	01:17:51	10.799446	558.41772	63.75260	46.31300	8.89007E+04	8.90023E+04	0.2640	0.6822	0.2625	0.2676
65	002	01:27:53	10.966667	558.41528	63.75225	46.27699	8.89007E+04	8.90022E+04	0.2595	-0.0303	0.2616	0.2666
66	002	01:37:54	11.133614	558.41321	63.75048	46.25600	8.88989E+04	8.90021E+04	0.2604	0.3209	0.2608	0.2657
67	002	01:47:55	11.300560	558.40649	63.74826	46.19900	8.88973E+04	8.90018E+04	0.2603	0.2527	0.2600	0.2649
68	002	01:57:57	11.467781	558.40369	63.74797	46.19900	8.88973E+04	8.90018E+04	0.2565	0.0025	0.2590	0.2638
69	002	02:07:58	11.634720	558.39136	63.74663	46.18400	8.88976E+04	8.90016E+04	0.2523	-0.0354	0.2577	0.2626
70	002	02:17:58	11.801392	558.38818	63.74409	46.14700	8.88948E+04	8.90014E+04	0.2550	0.4454	0.2568	0.2615
71	002	02:27:59	11.968338	558.39746	63.74326	46.16800	8.88920E+04	8.90014E+04	0.2578	0.4540	0.2561	0.2608
72	002	02:38:00	12.135284	558.39905	63.74103	46.10999	8.88891E+04	8.90014E+04	0.2607	0.4700	0.2558	0.2603
73	002	02:48:04	12.303055	558.39771	63.73984	46.09000	8.88978E+04	8.90013E+04	0.2600	0.2087	0.2554	0.2598
74	002	02:58:05	12.470001	558.38745	63.73863	46.06899	8.88879E+04	8.90011E+04	0.2563	-0.0177	0.2547	0.2591
75	002	03:20:48	12.848610	558.40015	63.73449	45.99599	8.88807E+04	8.90011E+04	0.2639	0.5170	0.2548	0.2590
76	002	03:30:48	13.015282	558.39209	63.73366	45.99599	8.88808E+04	8.90010E+04	0.2602	-0.0253	0.2545	0.2587
77	002	03:40:49	13.182228	558.39331	63.73279	45.95900	8.88797E+04	8.90010E+04	0.2592	0.1020	0.2542	0.2582
78	002	03:50:50	13.349167	558.39270	63.73090	45.93800	8.88773E+04	8.90009E+04	0.2608	0.3816	0.2540	0.2580
79	002	04:00:50	13.515839	558.38977	63.72858	45.91800	8.88747E+04	8.90009E+04	0.2628	0.4270	0.2540	0.2579
80	002	04:10:53	13.683334	558.37952	63.72738	45.88100	8.88752E+04	8.90007E+04	0.2586	-0.0831	0.2537	0.2575
81	002	04:20:53	13.849998	558.38403	63.72592	45.88100	8.88722E+04	8.90008E+04	0.2613	0.4886	0.2537	0.2573
82	002	04:30:54	14.016953	558.37769	63.72376	45.84499	8.88705E+04	8.90008E+04	0.2615	0.2780	0.2536	0.2572
83	002	04:40:55	14.183891	558.37939	63.72260	45.84499	8.88687E+04	8.90007E+04	0.2619	0.2907	0.2536	0.2571
84	002	04:50:55	14.350555	558.38220	63.72079	45.82400	8.88658E+04	8.90007E+04	0.2643	0.4709	0.2538	0.2572
85	002	05:00:58	14.518059	558.36951	63.71969	45.78799	8.88665E+04	8.90006E+04	0.2598	-0.1234	0.2536	0.2570
86	002	05:10:58	14.684723	558.37390	63.71815	45.71500	8.88643E+04	8.90006E+04	0.2611	0.3697	0.2536	0.2568
87	002	05:20:59	14.851669	558.37366	63.71670	45.69399	8.88624E+04	8.90007E+04	0.2615	0.2903	0.2536	0.2567
88	002	05:30:59	15.018341	558.37292	63.71687	45.65700	8.88630E+04	8.90006E+04	0.2574	-0.1013	0.2533	0.2564
89	002	05:41:02	15.185829	558.36462	63.71378	45.60000	8.88605E+04	8.90006E+04	0.2591	0.4082	0.2532	0.2562
90	002	05:51:05	15.353340	558.36100	63.71360	45.62099	8.88606E+04	8.90005E+04	0.2560	-0.0227	0.2528	0.2558
91	002	06:01:07	15.520554	558.35132	63.71102	45.60000	8.88588E+04	8.90004E+04	0.2565	0.3029	0.2526	0.2555
92	002	06:11:08	15.687500	558.36597	63.70857	45.56300	8.88533E+04	8.90004E+04	0.2632	0.8822	0.2527	0.2556
93	002	06:21:09	15.854446	558.34253	63.70911	45.54300	8.88580E+04	8.90004E+04	0.2525	-0.7500	0.2522	0.2551
94	002	06:31:10	16.021393	558.34436	63.70905	45.54300	8.88575E+04	8.90002E+04	0.2506	0.0657	0.2516	0.2544
95	002	06:41:10	16.188057	558.35669	63.70575	45.50600	8.88513E+04	8.90001E+04	0.2584	1.0154	0.2515	0.2543
96	002	07:22:26	16.892502	558.34583	63.69817	45.39700	8.88433E+04	8.90001E+04	0.2604	0.3062	0.2516	0.2543
97	002	07:33:29	17.059723	558.34314	63.69336	45.37600	8.88455E+04	8.90000E+04	0.2543	-0.3610	0.2513	0.2540
98	002	07:43:28	17.226387	558.33472	63.69765	45.34000	8.88448E+04	8.89999E+04	0.2531	0.1266	0.2509	0.2535
99	002	07:53:29	17.393333	558.32849	63.69687	45.30299	8.88450E+04	8.89998E+04	0.2503	-0.0329	0.2504	0.2530
100	002	08:03:29	17.559998	558.32239	63.69476	45.30299	8.88430E+04	8.89997E+04	0.2510	0.3191	0.2499	0.2525
101	002	08:13:30	17.726944	558.31152	63.69335	45.24599	8.88432E+04	8.89995E+04	0.2483	-0.0354	0.2493	0.2519
102	002	08:23:30	17.893616	558.29932	63.69227	45.20900	8.88439E+04	8.89994E+04	0.2449	-0.1114	0.2485	0.2512
103	002	08:33:33	18.061111	558.29651	63.68967	45.20900	8.88407E+04	8.89992E+04	0.2474	0.5116	0.2480	0.2506
104	002	08:43:33	18.227776	558.28760	63.68733	45.16000	8.88392E+04	8.89991E+04	0.2474	0.2457	0.2474	0.2501
105	002	08:53:34	18.394722	558.28931	63.68573	45.15199	8.88368E+04	8.89989E+04	0.2486	0.3843	0.2470	0.2496
106	002	09:03:34	18.561386	558.27783	63.68464	45.13100	8.88373E+04	8.89988E+04	0.2457	-0.0735	0.2464	0.2490
107	002	09:13:35	18.728333	558.27344	63.68319	45.05900	8.88365E+04	8.89987E+04	0.2447	0.1290	0.2458	0.2484
108	002	09:23:35	18.895004	558.27319	63.68240	45.02200	8.88357E+04	8.89985E+04	0.2436	0.1241	0.2452	0.2478
109	002	09:33:36	19.061943	558.26978	63.68075	45.03799	8.88341E+04	8.89983E+04	0.2437	0.2554	0.2446	0.2473
110	002	09:43:38	19.229164	558.26245	63.67825	45.00100	8.88318E+04	8.89981E+04	0.2448	0.3761	0.2441	0.2468
111	002	09:53:38	19.395836	558.25427	63.67807	44.90000	8.88330E+04	8.89979E+04	0.2410	-0.1976	0.2435	0.2461
112	002	10:03:39	19.562775	558.24756	63.67617	44.90700	8.88320E+04	8.89978E+04	0.2404	0.1618	0.2428	0.2455
113	002	10:13:39	19.729439	558.25281	63.67270	44.88699	8.88265E+04	8.89977E+04	0.2459	0.8992	0.2425	0.2451
114	002	10:23:40	19.896393	558.24768	63.67266	44.87099	8.88274E+04	8.89975E+04	0.2427	0.1441	0.2420	0.2446
115	002	10:33:40	20.063057	558.23877	63.66976	44.81300	8.88252E+04	8.89974E+04	0.2436	0.3546	0.2416	0.2442
116	002	10:43:42	20.230278	558.23010	63.66803	44.81300	8.88242E+04	8.89973E+04	0.2429	0.1666	0.2411	0.2437
117	002	10:53:44	20.397499	558.21875	63.66669	44.79300	8.88242E+04	8.89971E+04	0.2408	0.012[illegible]	0.2406	0.2432
118	002	11:03:44	20.564163	558.21220	63.66505	44.77699	8.88[illegible]1E+04	8.89970E+04	0.2[illegible]	0.1824	0.2401	0.2427
119	002	11:13:45	20.731110	558.21155	63.66460	44.69900	8.88219E+04	8.89968E+04	0.2401	0.2993	0.2396	0.1422

TABLE 3

121	002	11:33:47	21.065002	558.20007	63.66013	44.59000	8.88182E+04	8.89966E+04	0.2403	0.3464	0.2397	0.2412
122	002	11:43:47	21.231667	558.18481	63.65929	44.53200	8.88213E+04	8.89963E+04	0.2351	-0.5016	0.2380	0.2406
123	002	11:53:48	21.398613	558.17871	63.65661	44.49599	8.88186E+04	8.89962E+04	0.2364	0.3796	0.2375	0.2401
124	002	12:03:48	21.565277	558.16980	63.65491	44.47500	8.88180E+04	8.89961E+04	0.2355	0.1292	0.2369	0.2395
125	002	12:13:49	21.732224	558.15918	63.65295	44.43000	8.88173E+04	8.89958E+04	0.2347	0.1239	0.2363	0.2389
126	002	12:23:50	21.899170	558.15002	63.65221	44.38100	8.88101E+04	8.89957E+04	0.2318	-0.1391	0.2356	0.2383
127	002	12:33:52	22.066391	558.14893	63.64917	44.38100	8.88141E+04	8.89956E+04	0.2350	0.6539	0.2350	0.2378
128	002	12:43:53	22.233330	558.14007	63.64893	44.34499	8.88141E+04	8.89954E+04	0.2332	-0.0076	0.2345	0.2372
129	002	12:53:53	22.400002	558.14026	63.64674	44.30900	8.88126E+04	8.89953E+04	0.2333	0.2432	0.2339	0.2366
130	002	13:03:53	22.566666	558.14502	63.64632	44.30900	8.88113E+04	8.89951E+04	0.2332	0.2204	0.2334	0.2361
131	002	13:13:54	22.733612	558.14172	63.64304	44.21500	8.88079E+04	8.89950E+04	0.2354	0.5413	0.2330	0.2357
132	002	13:23:55	22.900558	558.13379	63.64150	44.19399	8.88072E+04	8.89948E+04	0.2346	0.1163	0.2326	0.2353
133	002	13:33:55	23.067223	558.12415	63.63995	44.15700	8.88069E+04	8.89946E+04	0.2332	0.0507	0.2321	0.2348
134	002	13:43:58	23.234718	558.12122	63.63881	44.12099	8.88060E+04	8.89946E+04	0.2326	0.1437	0.2316	0.2343
135	002	13:53:58	23.401390	558.12005	63.63643	44.10000	8.88029E+04	8.89945E+04	0.2345	0.5016	0.2313	0.2339
136	002	14:03:59	23.568336	558.12207	63.63559	44.08400	8.88017E+04	8.89944E+04	0.2342	0.1998	0.2309 -	0.2336
137	002	14:14:00	23.735283	558.11487	63.63365	44.04300	8.88004E+04	8.89942E+04	0.2340	0.2024	0.2305	0.2332
138	002	14:24:03	23.902779	558.10730	63.63214	43.99100	8.87999E+04	8.89941E+04	0.2329	0.0807	0.2302	0.2328
139	002	14:34:05	24.070007	558.09888	63.63290	43.96999	8.87997E+04	8.89939E+04	0.2316	0.0354	0.2297	0.2324

TABLE 3

QUAD CITIES UNIT 1

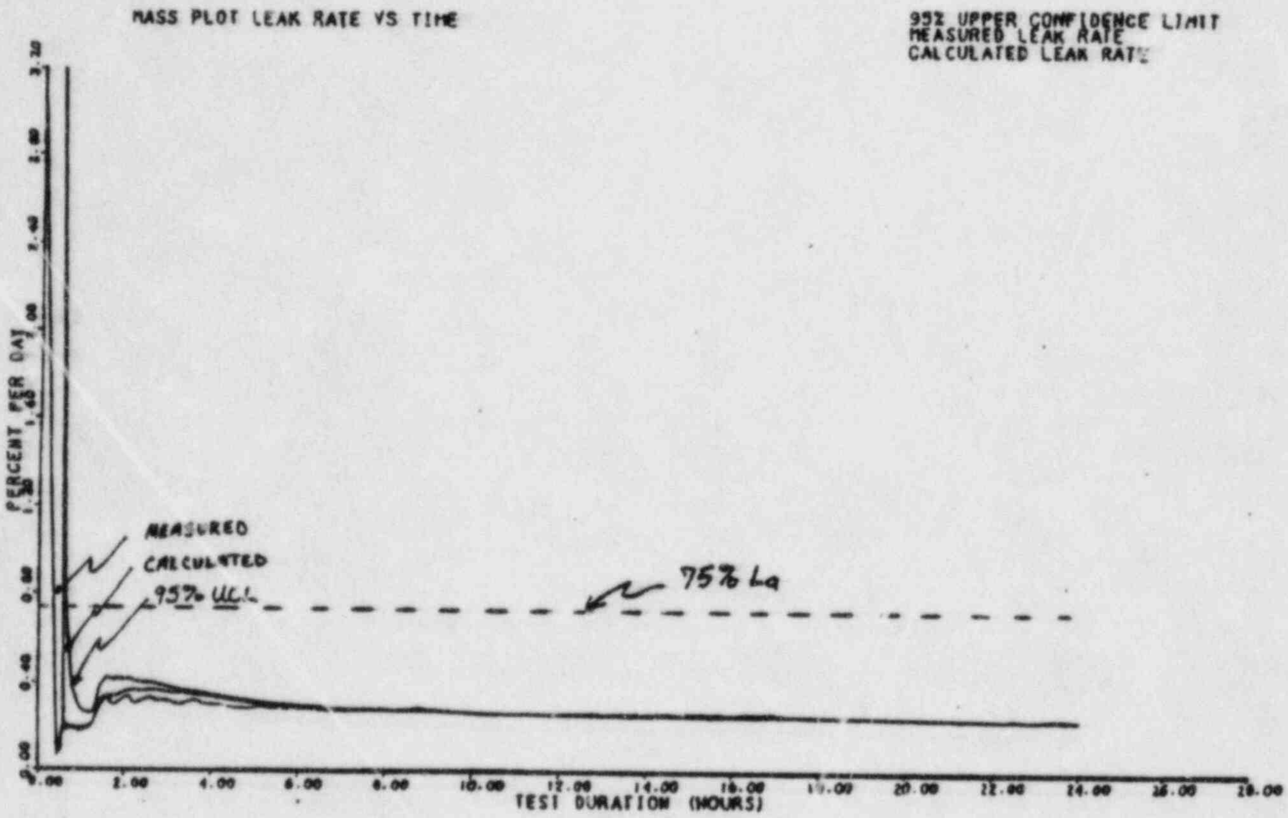


FIGURE 3

QUAD CITIES UNIT 1

CONTAINMENT DRY AIR PRESSURE VS TIME

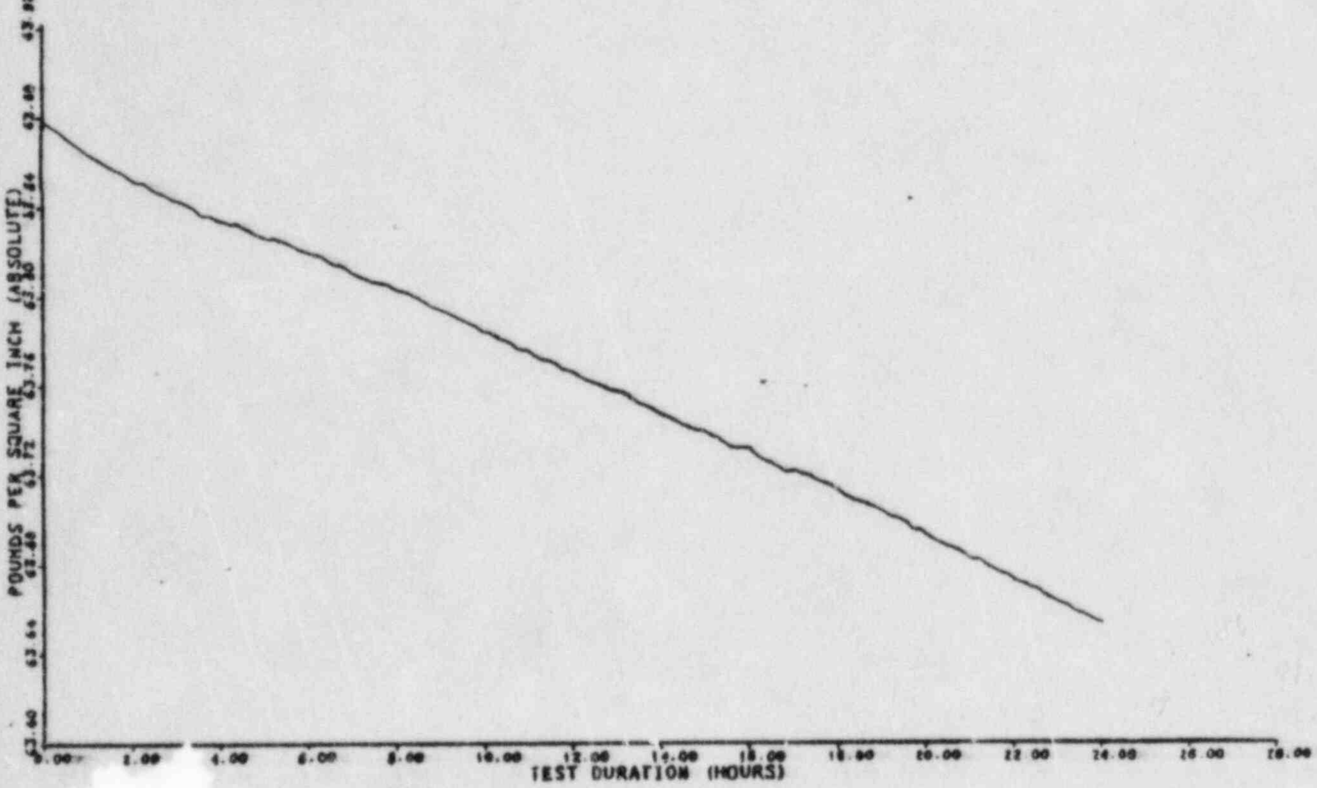


FIGURE 4

QUAD CITIES UNIT 1

TOTAL CONTAINMENT PRESSURE VS TIME

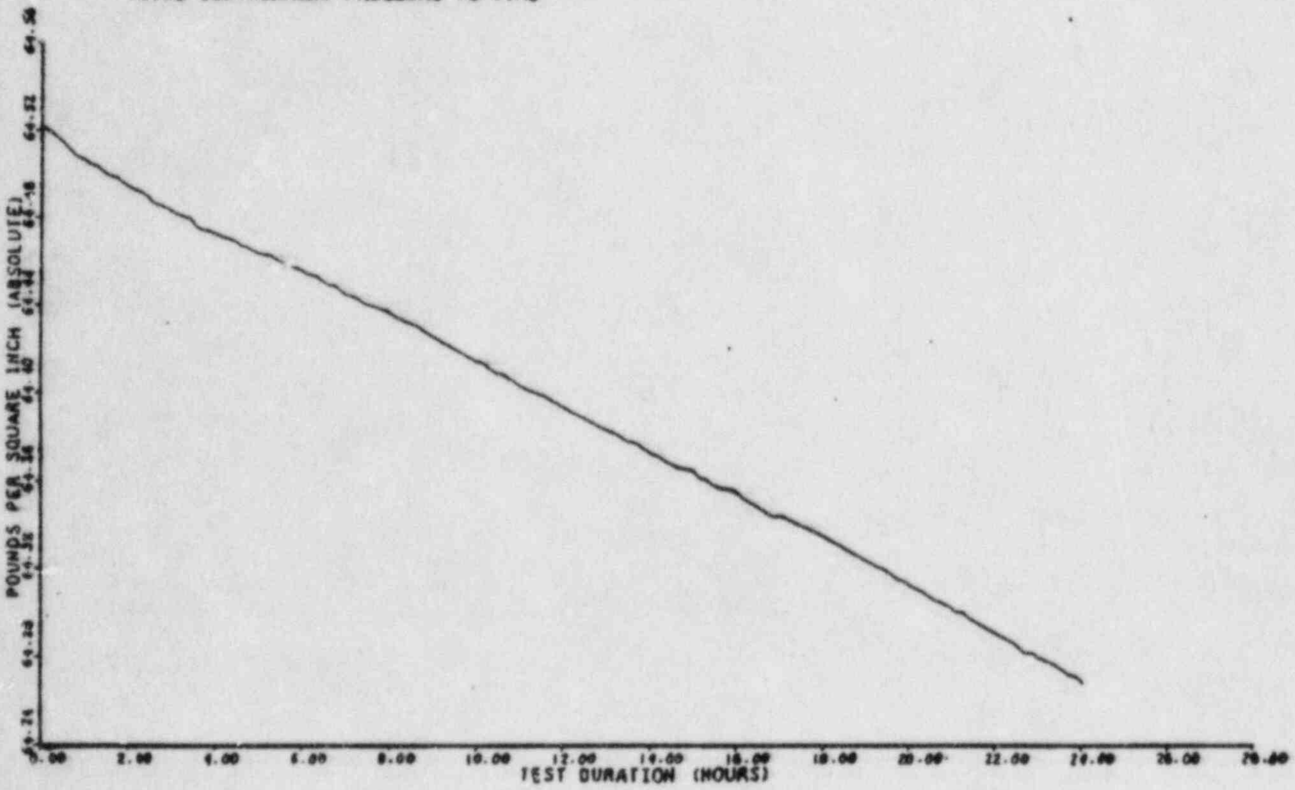


FIGURE 5

QUAD CITIES UNIT 1

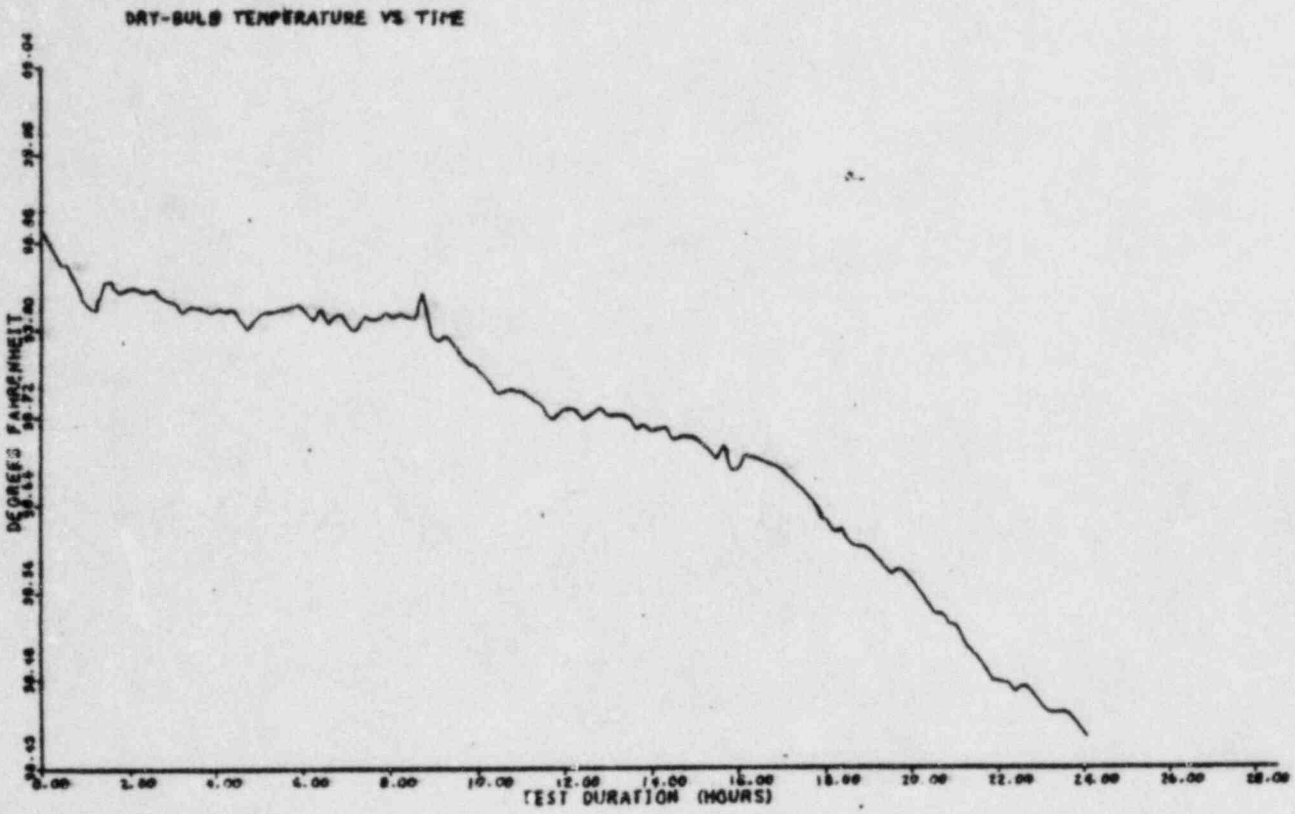


FIGURE 6

INDUCED LEAKAGE PHASE DATA

QUAD CITIES UNIT 1 19:46:59 THU, 26 JUL 1984

**** SUMMARY OF DATA SETS 146 THRU 170 ****

DATA SET	TAPE TIME	TEST DURATION (HRS)	TEMP (R)	DRY AIR PRESSURE (PSIA)	RX WATER LEVEL (IN)	MEASURED MASS	CALCULATED MASS T = 0	MEAS LEAK RATE TOTAL % / DAY	MEAS LEAK RATE POINT % / DAY	CALC LEAK RATE % / DAY	95% UPPER CONFIDENCE LIMIT
146	002 15:44:12	0.000000	558.08093	63.59060	43.68000	8.87570E+04	0.00000E-01	0.0000	0.0000	0.0000	0.0000
147	002 15:54:13	0.166946	558.08521	63.59289	43.66000	8.87512E+04	0.00000E-01	1.3893	1.3893	0.0000	0.0000
148	002 16:04:14	0.333085	558.08594	63.58785	43.63100	8.87443E+04	8.87594E+04	1.2508	1.1111	1.2508	1.6401
149	002 16:14:16	0.501106	558.10547	63.58301	43.57400	8.87390E+04	8.87597E+04	1.3431	1.5288	1.3199	1.4720
150	002 16:24:17	0.668053	558.09656	63.57815	43.55300	8.87276E+04	8.87592E+04	1.2199	0.8585	1.2400	1.3639
151	002 16:34:18	0.834999	558.10583	63.57358	43.53779	8.87219E+04	8.87590E+04	1.2260	1.2596	1.2186	1.3004
152	002 16:44:19	1.001930	558.11320	63.56691	43.48000	8.87119E+04	8.87594E+04	1.2920	1.6230	1.2542	1.3228
153	002 16:54:20	1.168092	558.11951	63.56464	43.38639	8.87005E+04	8.87588E+04	1.1866	0.5545	1.2167	1.2801
154	002 17:04:20	1.335364	558.12000	63.56010	43.40700	8.87029E+04	8.87584E+04	1.1692	1.0475	1.1795	1.2420
155	002 17:14:22	1.502769	558.12244	63.55553	43.40700	8.86951E+04	8.87581E+04	1.1631	1.1150	[illegible]	1.2133
156	002 17:24:23	1.669716	558.12946	63.55093	43.33400	8.86896E+04	8.87576E+04	1.1364	0.8965	1.1370	1.1865
157	002 17:34:24	1.836662	558.13928	63.54719	43.29300	8.86817E+04	8.87575E+04	1.1495	1.2815	1.1299	1.1718
158	002 17:44:24	2.003319	558.12512	63.54310	43.21999	8.86790E+04	8.87568E+04	1.0929	0.4694	1.1036	1.1476
159	002 17:54:24	2.169991	558.13043	63.53723	43.24100	8.86683E+04	8.87570E+04	1.1390	1.6948	1.1039	1.1412
160	002 18:04:25	2.336958	558.14014	63.53238	43.18400	8.86616E+04	8.87569E+04	1.1259	1.0964	1.1039	1.1368
161	002 18:14:26	2.503863	558.13611	63.52728	43.12600	8.86527E+04	8.87568E+04	1.1239	0.9577	1.1006	1.1288
162	002 18:24:28	2.671104	558.14105	63.52327	43.14700	8.86490E+04	8.87567E+04	1.1210	1.0776	1.0979	1.1228
163	002 18:34:28	2.837776	558.13916	63.51836	43.05299	8.86436E+04	8.87565E+04	1.1071	0.8658	1.0923	1.1158
164	002 18:44:29	3.004707	558.14246	63.51266	43.01199	8.86351E+04	8.87566E+04	1.1215	1.3668	1.0926	1.1129
165	002 18:54:29	3.171379	558.14819	63.50780	42.97500	8.86277E+04	8.87565E+04	1.1258	1.2887	1.0943	1.1125
166	002 19:04:30	3.338341	558.14498	63.50402	42.93800	8.86233E+04	8.87565E+04	1.1055	0.7246	1.0908	1.1076
167	002 19:14:35	3.506306	558.14783	63.49770	42.93000	8.86140E+04	8.87563E+04	1.1241	1.4957	1.0929	1.1083
168	002 19:24:36	3.673332	558.15137	63.49349	42.90199	8.86078E+04	8.87566E+04	1.1183	0.9987	1.0935	1.1076
169	002 19:34:38	3.840553	558.15408	63.48956	42.86600	8.86022E+04	8.87563E+04	1.1093	0.9136	1.0922	1.1051
170	002 19:44:39	4.007404	558.15259	63.48442	42.82400	8.85956E+04	8.87564E+04	1.1078	1.0758	1.0909	1.1026

TABLE 4

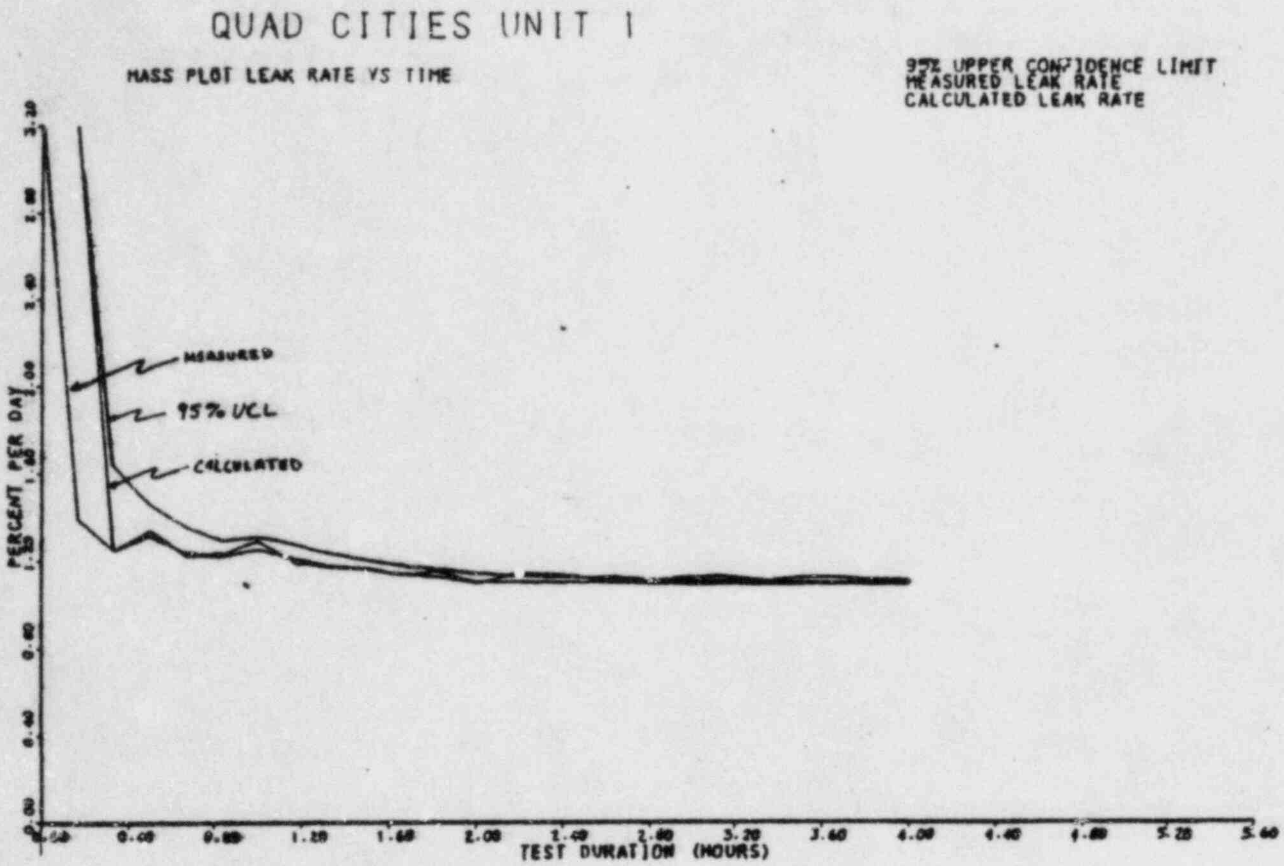

QUAD CITIES UNIT 1
MASS PLOT LEAK RATE VS TIME
95% UPPER CONFIDENCE LIMIT
MEASURED LEAK RATE
CALCULATED LEAK RATE
MEASURED
95% UCL
CALCULATED
PERCENT PER DAY
TEST DURATION (HOURS)

FIGURE 7

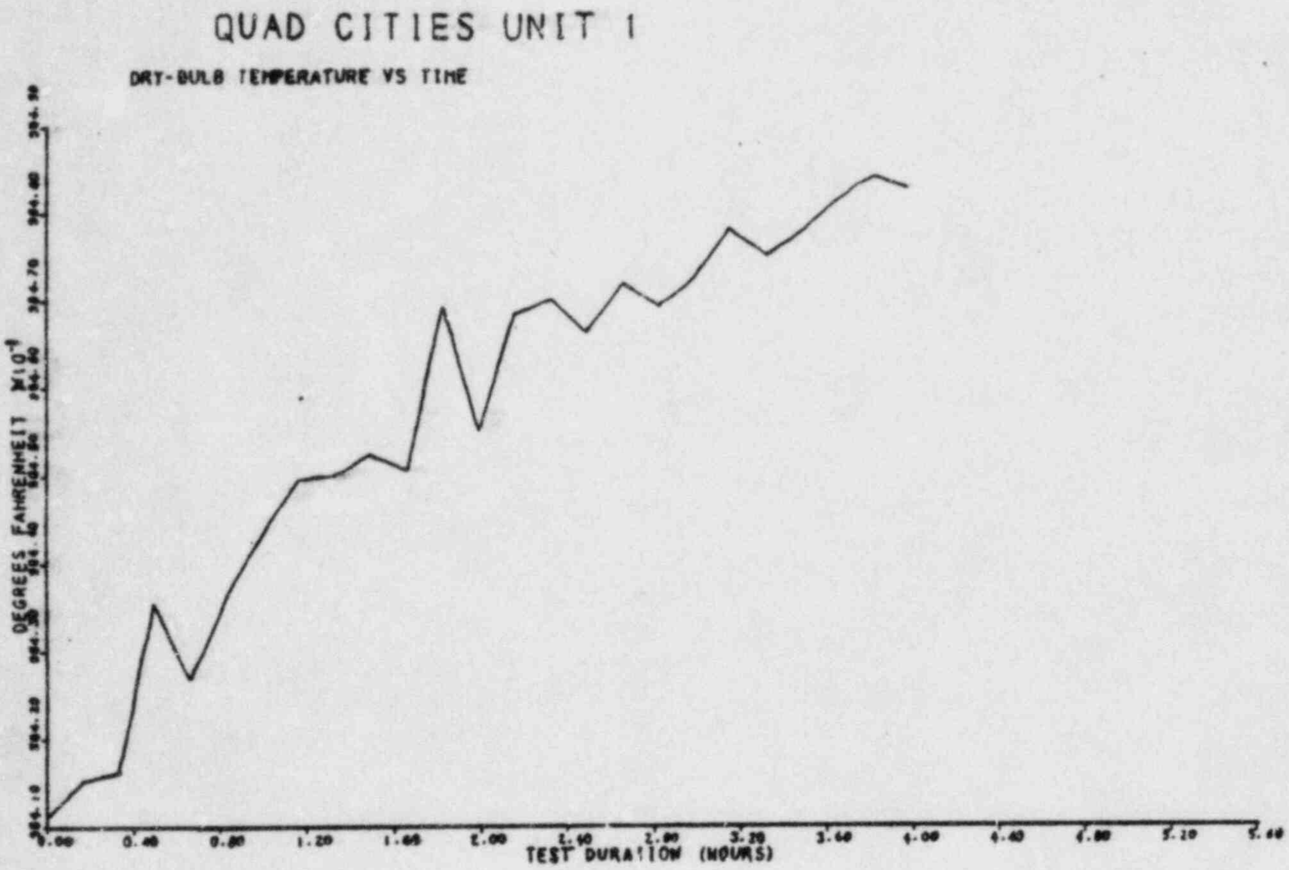

QUAD CITIES UNIT 1
DRY-BULB TEMPERATURE VS TIME
DEGREES FAHRENHEIT X10¹
TEST DURATION (HOURS)

FIGURE 8

QUAD CITIES UNIT 1

TOTAL CONTAINMENT PRESSURE VS TIME

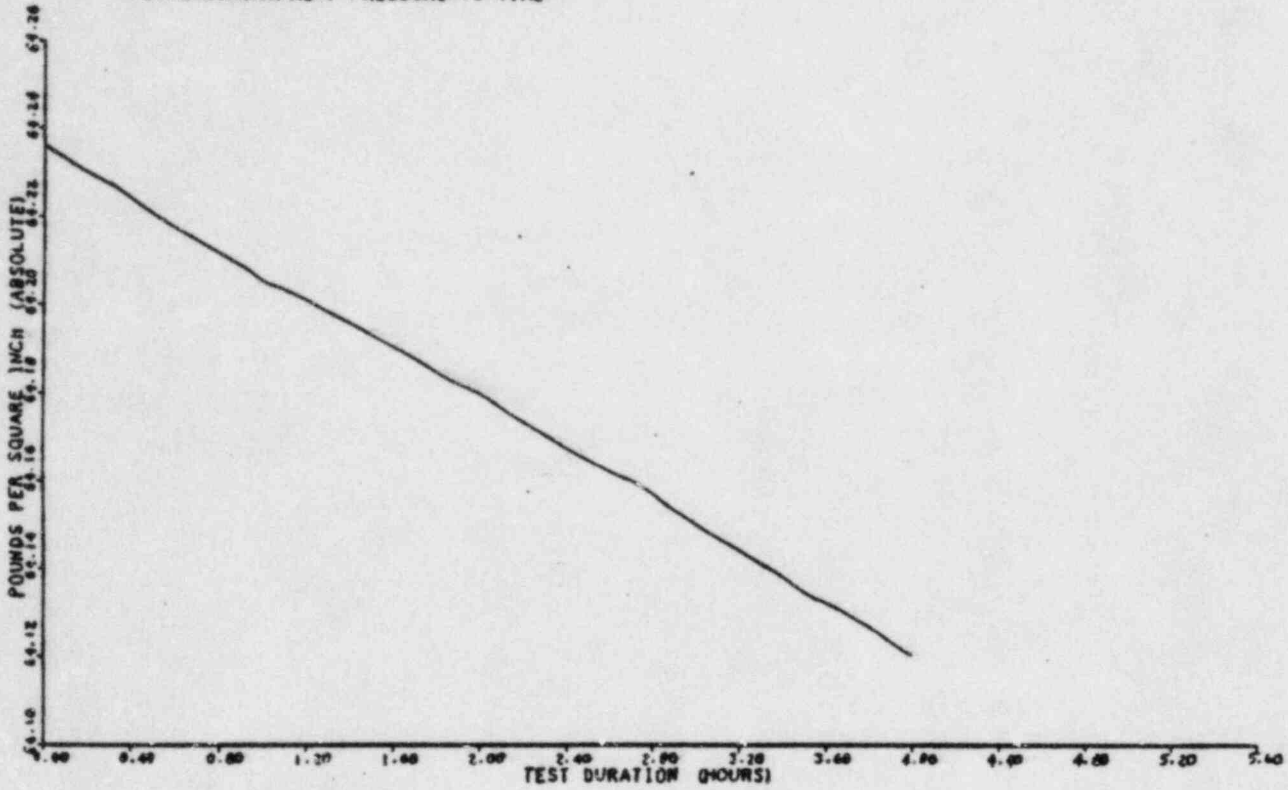


FIGURE 9

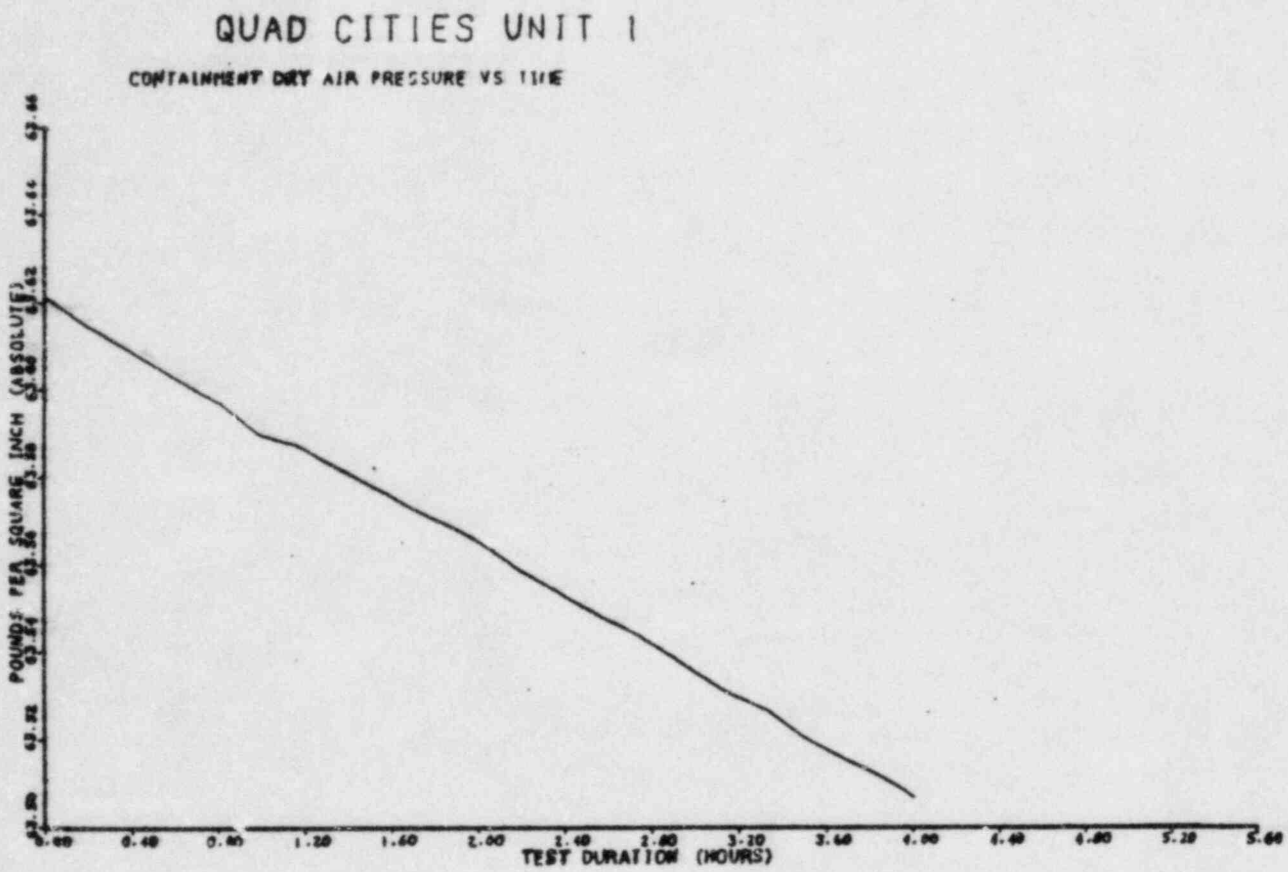

QUAD CITIES UNIT 1
CONTAINMENT DRY AIR PRESSURE VS TIME
POUNDS PER SQUARE INCH (ABSOLUTE)
TEST DURATION (HOURS)
1.20
1.60
2.00
3.20
3.60
5.20
5.60

FIGURE 10

SECTION E - TEST CALCULATIONS

Calculations for the IPCLRT using the ANSI method are found in Quad-Cities procedures QTS 150-T3. A reproduction of these procedures can be found in Appendix C. The origins of these calculations are the N274 draft for ANSI/ANS 56.8. These calculations are consistent with the standard as it was published in 1981.

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 time intervals the statistically averaged leak rate was found to be 0.230 wt %/day with an upper confidence limit of 0.232 wt %/day.

F.2 Induced Leakage Test Results

A leak rate of 6.65 SCFM (0.815 wt %/day) was induced from the containment for this phase of the test. The required accuracy for the test is computed below.

Statistically Averaged Leak Rate (Measured Leak Rate Phase)	0.230	0.230
Induced Leak (6.65 SCFM)	0.815	0.815
Allowed Error Band (25% L_a)	+ 0.250	- 0.250
	1.295	0.795
Statistically Averaged Leak Rate (Induced Leakage Phase)	1.1078 wt %/day	

Therefore, the required test accuracy was satisfied.

F.3 Leak Rate Compensation For Non-Vented Penetrations

The IPCLRT was performed with the following penetrations not drained and vented as required by 10 CFR 50, Appendix J. The "as left" leak rates for each of these penetrations, as determined by Type C testing, is also listed:

SYSTEM	STATUS	THROUGH LEAKAGE FROM TYPE B AND C TESTING SCFH	THROUGH LEAKAGE FROM TYPE B AND C TESTING WT %/DAY
'A' Rx Feedwater	Isolated, Filled	3.60	0.0074
'B' Rx Feedwater	Isolated, Filled	0.00	0.0000
RHR System	Operating for SDC	12.85	0.0267
Rx Water CU	Isolated, Filled	2.50	0.0051
ACAD/CAM	Isolated	1.75	0.0036
Primary Sample	Isolated	0.00	0.0000
Hydrogen Monitor Panel	Isolated	1.70	0.0035
HPCI Steam (Supp & Ex's)	Isolated	4.00	0.0082
RCIC Steam (Supp & Ex's)	Isolated	7.20	0.01470
All Electrical Penetrations	Test Bellows Pressurized with Dry N_2.	0.80	0.0033
		34.40	0.0725

This correction yields the following adjusted leak rates:

Statistically Averaged Leak Rate (ANSI) 0.303 wt %/day

Upper Confidence Limit (ANSI) 0.305 wt %/day

F.4 Pre-Operational Results vs. Test Results

The result of the pre-operational IPCLRT test done by General Electric between April 20 and April 21, 1971 was found to be 0.1112 weight %/day. Previous IPCLRT test reports for Unit One show that the uncertainty of the pre-operational test was large compared to more recent tests. The instrumentation and statistical analysis of the pre-operational test was relatively inexact by present standards. The leak rate of .230 wt %/day found in this test compares favorably with recent tests and shows that there is no significant deterioration of the containment.

F.5 As Found IPCLRT Result

The following table summarizes the results of all Type B and C as well as the IPCLRT results to arrive at an "as found" Type A test result. Since the total is more than 0.750 wt %/day (75 L_a), the present schedule of performing Type A tests every refuel outage must be maintained. Documentation for the values listed below can be found in RO 84-002, Rev. 1, Docket No. 50-254, DPR-29.

SUMMARY OF ALL CONTAINMENT
LEAK RATE TESTING DURING
UNIT TWO REFUEL OUTAGE
FALL, 1983

	AS FOUND (SCFH)		AS LEFT (SCFH)	
	LLRT (TOTAL MEASURED)	WORST CASE THROUGH LEAKAGE	LLRT (TOTAL MEASURED)	WORST CASE THROUGH LEAKAGE
(1) MSIV's @ 25 PSIG	1025.70	70.20	31.40	6.90
(2) MSIV's converted to 48 PSIG*	1620.61	110.92	49.61	10.90
(3) All Type C Tests (Except MSIV's)	1214.40**	193.15**	173.00	75.75
(4) All Type B Tests	284.20	142.10	30.70	15.35
TOTAL (2 + 3 + 4)	3119.21**	446.17**	253.31	102.00

(1) Type A Test Integrated Leak Rate Test) = 0.230 wt %/day

(2) Upper Confidence Limit of Type A Test Result = 0.232 wt %/day

(3) Correction for Unvented Volumes During Type A Test = 0.073 wt %/day

(4) Correction for Repairs Prior to Type A Test ** (As Found - As Left) = 0.703 wt %/day $\left(\frac{446.17 - 102.00}{489.59}\right)$

(5) Correction for Change in Sump Levels + = 0.065 wt %/day

TOTAL (2 + 3 + 4 + 5) 1.073 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.

** Total does not include four valves: three feedwater check valves and a HPCI steam exhaust check valve.

+ See Appendix B for calculations.

APPENDIX A
TYPE B AND C TESTS

Presented herein are the results of local leak rate tests conducted on all penetrations, double-gasketed seals, and isolation valves since the previous IPCLRT in December, 1982. All valves with leakage in excess of the individual valve leakage limit were restored to an acceptable leak tightness prior to the resumption of power operation. Total leakage for double gasketed seals and total leakage for all other penetrations and isolation valves following repairs satisfied the Technical Specification limits. These results are listed in Table A-1.

TABLE A-1
TYPE B AND C TEST RESULTS

VALVE(S) OR PENETRATION	TEST VOLUME	MEASURED LEAK RATE (SCFH) AS FOUND	DATE	AS LEFT	DATE
AO 203-1A	Main Steam Line Isolation Valves***	**** 4.60	03-06-84	4.60	03-06-84
AO 203-2A	MSIV	**** 4.60	03-06-84	4.60	03-06-84
AO 203-1B	MSIV	34.50	03-16-84	9.50	07-20-84
AO 203-2B	MSIV	70.30	03-16-84	2.30	08-04-84
AO 203-1C	MSIV	31.70	03-16-84	2.30	07-20-84
AO 203-2C	MSIV	416.70	03-16-84	11.50	08-05-84
AO 203-1D	MSIV	1.70	03-16-84	1.20	07-18-84
AO 203-2D	MSIV	466.20	03-16-84	0.00	07-07-84
MO 220-1 MO 220-2	Main Steam Line Drains	+7.53 118.40 338.20	03-12-83 09-17-83 03-07-84	+7.53 21.06 0.10	03-12-83 09-20-83 07-14-84
AO 220-44 AO 220-45	Primary Sample	0.00	05-16-84	0.00	05-16-84
CV 220-58A	Feedwater Inlet Loop "A" Inboard	UD*	04-24-84	3.60	05-21-84
CV 220-62A	Feedwater Inlet Loop "A" Outboard	**		33.40	05-22-84
CV 220-58B	Feedwater Inlet Loop "B" Inboard	UD*	03-26-84	0.00	06-21-84
CV 220-62B	Feedwater Inlet Loop "B" Outboard	563.80	03-26-84	0.00	05-24-84

* Unable to determine the leakage due to an inability to pressurize the volume with compressed air.

** Valve was disassembled before leak rate test was performed.

*** Test Pressure for MSIV's is 25 PSIG. Where the A and B valves in a steam line have identical leakages, the valves were tested as a single volume. The value is a maximum leak rate through the valve assuming that the other valve leaked 0.0 SCFH.

**** Values are the combined inboard and outboard leakage values.

+ 220-1 valve only following repairs.

TABLE A-1
TYPE B AND C TEST RESULTS

VALVE(S) OR PENETRATION	TEST VOLUME	MEASURED LEAK RATE (SCFH) AS FOUND	DATE	AS LEFT	DATE
MO 1001-20 MO 1001-21	RHRS to Radwaste	*5.20/5.20	03-07-84	5.20/5.20	03-07-84
MO 1001-23A MO 1001-26A	RHRS Containment Spray - System I	7.00	03-08-84	7.00	03-08-84
MO 1001-29A	RHRS Return Loop "A"	0.00	03-08-84	**6.00	08-16-84
MO 1001-34A MO 1001-36A MO 1001-37A	RHRS Suppression Chamber Spray - System I	3.00	03-08-84	3.00	03-08-84
MO 1001-23B MO 1001-26B	RHRS Containment Spray - System II	1.50	03-09-84	1.50	03-09-84
MO 1001-29B	RHRS Return Loop "B"	0.00	03-09-84	**4.60	08-11-84
MO 1001-34B MO 1001-36B MO 1001-37B	RHRS Suppression Chamber Spray System II	1.40	03-09-84	0.70	06-15-84
MO 1001-47 MO 1001-50	RHRS Shutdown Cooling Suction	3.10	05-15-84	3.10	05-15-84
MO 1001-60 MO 1001-63	RHRS Head Spray	0.00	03-09-84	0.40	07-13-84
MO 1201-2 MO 1201-5	Clean-Up System Suction	5.00	05-16-84	5.00	05-16-84
MO 1301-16 MO 1301-17	RCIC Steam Supply	0.10	03-06-84	0.40	07-20-84
CV 1301-40	RCIC Condensate Drain	3.00	03-08-84	3.00	03-08-84
CV 1301-	RCIC Turbine Exhaust	4.00	03-08-84	4.00	03-08-84
AO 1601-21 AO 1601-22 AO 1601-55 AO 1601-56	Drywell and Suppression Chamber Purge	2.10	03-23-84	2.10	03-23-84
AO 1601-20A CV 1601-31A	Suppression Chamber Vent Lines #1	0.00	03-13-84	0.00	03-13-84

* Valves tested separately. Individual valve leak rates shown.

** Performed following repairs after ILRT.

TABLE A-1
TYPE B AND C TEST RESULTS

VALVE(S) OR PENETRATION	TEST VOLUME	MEASURED LEAK RATE (SCFH) AS FOUND	DATE	AS LEFT	DATE
AO 1601-20B CV 1601-31B	Suppression Chamber Vent Lines #2	10.00	03-13-84	10.00	03-13-84
AO 1601-57 AO 1601-58 AO 1601-59	Drywell and Suppression Chamber Supply Air Purge	1.80	03-26-84	1.80	03-26-84
AO 1601-23 AO 1601-24 AO 1601-60 AO 1601-61 AO 1601-62 AO 1601-63	Drywell and Suppression Chamber Exhaust	81.00	03-23-84	27.00	03-27-84
AO 2001-3	Drywell Floor Drain	0.00	03-17-83	0.00	03-17-83
AO 2001-4	Sump Discharge	75.60	04-02-84	0.30	07-20-84
AO 2001-15 AO 2001-16	Drywell Equipment Drain Sump Discharge	16.20	04-10-84	3.20	07-21-84
MO 2301-4 MO 2301-5	HPCI Steam Supply	1.20	03-07-84	0.00	07-21-84
CV 2301-34	HPCI Condensate Drain	0.00	03-08-84	0.00	03-08-84
CV 2301-45	HPCI Steam Exhaust	UD*	03-12-84	4.00	07-13-84
AO 4720	Drywell Pneumatic Suction	1.90	03-16-84	1.90	03-16-84
AO 4721	Drywell Pneumatic Suction	1.70	03-16-84	1.70	03-16-84
AO 8801A	Oxygen Analyzer Suction	0.00	03-14-84	0.00	03-14-84
AO 8802A	Oxygen Analyzer Suction	0.00	03-14-84	0.00	03-14-84
AO 8801B	Oxygen Analyzer Suction	0.60	03-14-84	0.60	03-14-84
AO 8802B	Oxygen Analyzer Suction	0.70	03-14-84	0.70	03-14-84

* Unable to determine the leakage due to an inability to pressurize the volume with compressed air.

TABLE A-1
TYPE B AND C TEST RESULTS

VALVE(S) OR PENETRATION	TEST VOLUME	MEASURED LEAK RATE (SCFH) AS FOUND	DATE	AS LEFT	DATE
AO 8801C	Oxygen Analyzer Suction	2.50	03-14-84	2.50	03-14-84
AO 8802C	Oxygen Analyzer Suction	2.60	03-14-84	2.60	03-14-84
AO 8801D	Oxygen Analyzer Suction	1.50	03-14-84	1.50	03-14-84
AO 8802D	Oxygen Analyzer Suction	0.60	03-14-84	0.60	03-14-84
AO 8803	Oxygen Analyzer Return	15.00	03-15-84	4.00	06-27-84
AO 8804	Oxygen Analyzer Return	4.90	03-15-84	3.80	06-27-84
733-1	Automatic TIP Ball Valve			**4.50	03-14-83
				**0.40	12-23-83
				**0.50	01-04-84
		0.00	05-11-84	0.00	05-11-84
733-2	Automatic TIP Ball Valve	0.00	05-11-84	0.00	05-11-84
733-3	Automatic TIP Ball Valve	0.90	05-08-84	0.50	06-12-84
733-4	Automatic TIP Ball Valve	0.00	05-08-84	0.70	06-12-84
733-5	Automatic TIP Ball Valve	0.30	05-08-84	0.00	06-12-84
700-743	TIP Purge Check Valve	4.20	05-08-84	4.20	05-08-84
SO 2499-1A SO 2499-2A	CAM - Drywell	0.00	03-13-84	0.00	03-13-84
SO 2499-3A SO 2499-4A	CAM - Suppression Chamber	*0.00/17.00	03-13-84	0.00	07-17-84
SO 2499-1B SO 2499-2B	CAM - Drywell	0.00	03-13-84	0.00	03-13-84
SO 2499-3B SO 2499-4B	CAM - Suppression Chamber	*0.00/18.50	03-13-84	0.00	07-17-84

* Valves tested separately. Individual valve leak rates shown.
** Valves tested following repairs.

TABLE A-1
TYPE B AND C TEST RESULTS

VALVE(S) OR PENETRATION	TEST VOLUME	MEASURED LEAK RATE (SCFH) AS FOUND	DATE	AS LEFT	DATE
AO 2599-2A CV 2599-23A	ACAD to Drywell	0.30	03-13-84	0.30	03-13-84
AO 2599-3A CV 2599-24A	ACAD to Suppression Chamber	*1.30/0.00	03-15-84	1.30/0.00	03-15-84
AO 2599-2B CV 2599-23B	ACAD to Drywell	*2.20/0.10	03-13-84	2.20/0.10	03-13-84
AO 2599-3B CV 2599-24B	ACAD to Suppression Chamber	*5.00/0.00	03-15-84	5.00/0.00	03-15-84
AO 2599-4A FCV 2599-5A	ACAD Drywell Bleed to SBGTS	*0.60/0.00	03-16-84	0.60/0.00	03-16-84
AO 2599-4B FCV 2599-5B	ACAD Drywell Bleed to SBGTS	*2.10/1.50	03-16-84	2.10/1.50	03-16-84
X-1	Drywell Equipment Hatch	0.00 0.00	03-14-83 03-06-84	0.00 0.00	03-14-83 08-07-84
X-2	Drywell Personnel Airlock	**3.43	04-02-84	3.43	04-02-84
X-4	Drywell Head Access Hatch	105.00	06-11-84	0.00	06-18-84
X-6	CRD Removal Hatch	0.00	04-23-84	0.00	08-07-84
X-35A	TIP Flux Mon. Flange	0.00	05-08-84	0.00	05-08-84
X-35B	TIP Flux Mon. Flange	0.00	05-08-84	0.00	05-08-84

* Valves tested separately. Individual valve leak rates shown.

** Tested at 10 PSIG as allowed in Technical Specifications.

TABLE A-1
TYPE B AND C TEST RESULTS

VALVE(S) OR PENETRATION	TEST VOLUME	MEASURED LEAK RATE (SCFH) AS FOUND	DATE	AS LEFT	DATE
X-35C	TIP Flux Mon. Flange	0.00	05-08-84	0.00	05-08-84
X-35D	TIP Flux Mon. Flange	0.00	05-08-84	0.00	05-08-84
X-35E	TIP Flux Mon. Flange	0.00	05-08-84	0.00	05-08-84
X-35F	TIP Flux Mon. Flange	0.00	05-08-84	0.00	05-08-84
X-35G	TIP Flux Mon. Flange	0.00	05-08-84	0.00	05-08-84
X-200A	Suppression Chamber Access Hatch	0.00	03-06-84	0.00	07-23-84
X-200B	Suppression Chamber Access Hatch			*0.00	03-14-83
				*0.00	05-21-83
				*0.00	09-17-83
		0.00	03-06-84	0.00	08-17-84
Drywell Head	Drywell Head Flange	30.00	03-07-84	0.00	07-23-84
SL-1	Shear Lug Inspection Hatches	83.30	05-30-84	0.00	07-14-84
SL-2	Shear Lug Inspection Hatch	2.70	05-11-84	0.00	07-14-84
SL-3	Shear Lug Inspection Hatch	5.00	05-11-84	0.00	07-14-84
SL-4	Shear Lug Inspection Hatch	0.00	05-11-84	0.00	07-14-84
SL-5	Shear Lug Inspection Hatch	0.50	05-11-84	0.00	07-14-84
SL-6	Shear Lug Inspection Hatch	0.00	05-11-84	0.00	07-14-84
SL-7	Shear Lug Inspection Hatch	0.00	05-11-84	0.00	07-14-84

* LLRT performed after closure following entry into suppression chamber.

TABLE A-1
TYPE B AND C TEST RESULTS

VALVE(S) OR PENETRATION	TEST VOLUME	MEASURED LEAK RATE (SCFH) AS FOUND	DATE	AS LEFT	DATE
SL-8	Shear Lug Inspection Hatch	6.00	05-11-84	0.00	07-11-84
X-7A	Primary Steam	0.00	03-14-84	0.00	03-14-84
X-7B	Primary Steam	1.20	03-14-84	1.20	03-14-84
X-7C	Primary Steam	0.00	03-14-84	0.00	03-14-84
X-7D	Primary Steam	0.00	03-14-84	0.00	03-14-84
X-8	Primary Steam Drain Line	0.00	03-14-84	0.00	03-14-84
X-9A	Reactor Feedwater	0.00	03-14-84	0.00	03-14-84
X-9B	Reactor Feedwater	0.00	03-14-84	0.00	03-14-84
X-10	Steam to RCIC	0.10	03-14-84	0.10	03-14-84
X-11	HPCI to Steam Supply	0.30	03-14-84	0.30	03-14-84
X-12	RHRS Supply	6.00	03-14-84	6.00	03-14-84
X-13A	RHRS Return	0.10	03-14-84	0.10	03-14-84
X-13B	RHRS Return	0.00	03-14-84	0.00	03-14-84
X-14	Cleanup Supply	0.00	03-14-84	0.00	03-14-84
X-23	Cooling Water	1.80	03-14-84	1.80	03-14-84
X-24	Cooling Water Return	0.00	03-14-84	0.00	03-14-84

TABLE A-1
TYPE B AND C TEST RESULTS

VALVE(S) OR		MEASURED LEAK RATE (SCFH)			
PENETRATION	TEST VOLUME	AS FOUND	DATE	AS LEFT	DATE
X-25	Vent From Drywell	2.70	03-14-84	2.70	03-14-84
X-26	Vent to Drywell	0.20	03-14-84	0.20	03-14-84
X-36	CRD Hydraulic System Return	0.00	03-14-84	0.00	03-14-84
X-47	Standby Liquid Control	0.00	03-14-84	0.00	03-14-84
X-17	Reactor Vessel Head Spray	0.00	03-14-84	0.00	03-14-84
X-16A	Core Spray Inlet	21.00	03-14-84	*	
X-16B	Core Spray Inlet	8.00	03-14-84	8.00	03-14-84
X-100A	CRD Position Indication	0.30	05-21-84	0.30	05-21-84
X-100B	Power	0.00	05-21-84	0.00	05-21-84
X-100C	Neutron Monitor	0.00	05-18-84	0.00	05-18-84
X-100D	Neutron Monitor	0.00	05-18-84	0.00	05-18-84
X-100E	Neutron Monitor	0.00	05-18-84	0.00	05-18-84
X-100F	CRD Position Indication	0.00	05-18-84	0.00	05-18-84
X-100G	Power	0.00	05-18-84	0.00	05-18-84
X-101A	CRD Position Indication	0.30	04-17-84	0.30	04-17-84
X-101B	CRD Position Indication	0.30	04-17-84	0.30	04-17-84

** Two-ply bellows replaced with single bellows per approved modification. Second bellows will be added later to allow LLRT. Modification tested as part of the Type A test.

TABLE A-1
TYPE B AND C TEST RESULTS

VALVE(S) OR PENETRATION	TEST VOLUME	MEASURED LEAK RATE (SCFH) AS FOUND	DATE	AS LEFT	DATE
X-101D	Recirc Pump Power	0.00	05-18-84	0.00	05-18-84
X-102A	Recirc Pump Power	0.30	04-17-84	0.30	04-17-84
X-103	Thermocouples	0.00	05-18-84	0.00	05-18-84
X-104B	CRD Position Indication	0.00	05-21-84	0.00	05-21-84
X-104C	Recirc Pump Power	0.00	04-17-84	0.00	04-17-84
X-104F	Power	0.00	05-18-84	0.00	05-18-84
X-105A	Power	0.00	05-21-84	0.00	05-21-84
X-105B	Power Drive Modules	0.00	05-18-84	0.00	05-18-84
X-105C	CRD Position Indication	0.00	05-18-84	0.00	05-18-84
X-105D	Recirc Pump Power	0.40	05-18-84	0.40	05-18-84
X-107A	Neutron Monitor	0.00	05-18-84	0.00	05-18-84
X-227A	ACAD/CAM	0.00	06-15-84	0.00	06-15-84
X-227B	ACAD/CAM	0.00	06-15-84	0.00	06-15-84
1-2252-81A/81B	H_2/O_2 Analyzer Panel	0.80/0.90	07-31-84	0.80/0.90	07-31-84
LT 1-1641-5A/5B	Torus Wide Range Level Inst. Lines	0.00/0.00	06-11-84	0.00/0.00	06-11-84

APPENDIX B

LEAK RATE CORRECTION DUE TO SUMP CHANGES

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

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

where P_i = dry air pressure in subvolume and

P_i = containment total pressure minus subvolume's vapor pressure;

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

T_i = 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 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:

$$L^t = - \frac{24}{H} \times 100 \times \left(\frac{W^t - W^o}{W^o} \right)$$

where W^o = dry air mass of containment at the start of the test;

W^t = dry air mass of containment at some time t;

H = duration of test from start to time t in hours;

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

In order to be most conservative, the calculations here will assume that the entire containment volume change due to sump level changes occurred during the 24 hours that the test was conducted. The sump conditions are given below:

PRE-TEST LEVELS: (0030 hours on 7-24-84)

DRYWELL EQUIPMENT DRAIN SUMP = 19-3/4" (Level)
DRYWELL FLOOR DRAIN SUMP = 18-1/2" (Level)

POST-TEST LEVEL: (0015 hours on 7-27-84)

DWEDS = 18" with 480 gallons pumped.
DWFDS = 17-1/2" with 270 gallons pumped.

The sumps were pumped after the test was over but prior to measuring the sump levels. Therefore, the containment free air space at the end of the test is reduced by the volume of water pumped and corrected for the sump level change. The sumps are located in subvolume no. 8 so the expressions for that subvolume's free air space is given by:

t = 0 (start of test)

$$V_8^o = 24{,}900 - \left(\frac{19.75}{42.0}\right) \times 1200 \times .13368 - \left(\frac{18.50}{42.0}\right) \times 1200 \times .13368 \ (ft^3)$$

NOTE: Both sumps are 1200 gallon capacity and 3.5 feet deep.

$$V_8^o = 24{,}753.9 \ ft^3$$

t = 24 (end of test)

$$V_8^{24} = 24{,}900 - \left(\frac{18.0}{42.0}\right) \times 1200 \times .13368 -$$

$$\left(\frac{17.5}{42.0}\right) \times 1200 \times .13368 - 750 \times .13368$$

$$V_8^{24} = 24{,}664.2 \ ft^3$$

The following table then lists the values for V_i at the start of the test and at the end of 24 hours.

SUBVOLUME NO. (i)	$V_i^{t=o}$	$V_i^{t=24}$
1	10,066	10,066
2	9,165	9,165
3	10,494	10,494
4	3,612	3,612
5	23,039	23,039
6	30,808	30,808
7	26,373	26,373
8	24,754	24,664
9	8,901	8,901
10	134,808	134,808
11*	6,251	6,347

* $V_{11}^i = 6571.7 - 25\ (LEVEL_i - 35)$, where LEVEL = Rx Water Level

The following table gives all of the data necessary to compute the total containment dry air mass at the start of the test (14:29:53 on 7-25-84):

SUBVOLUME NO. (i)	VAPOR PRESSURE (PSI)	DRY AIR PRESSURE (PSIA)	SUBVOLUME TEMPERATURE (°F)	DRY AIR MASS (lbs. M)
1	.64414	63.878	108.271	3,056.14
2	.36945	64.153	111.275	2,779.86
3	.369[illegible]	64.153	109.513	3,192.82
4	.36945	64.153	107.525	1,102.81
5	.55671	63.965	105.953	7,033.10
6	.57860	63.943	104.760	9,421.38
7	.57860	63.943	101.874	8,106.56
8	.59198	63.930	96.424	7,681.92
9	.59198	63.930	98.718	2,750.90
10	.73813	63.784	92.819	42,011.81
11	1.49549	63.027	115.586	1,848.77

$$W^o = \sum_1^{11} W_i = 88{,}986.1$$

Repeating the above process for the final data set in the 24 hour test gives the following results (14:35:47 on 7-26-84):

SUBVOLUME NO. (i)	VAPOR PRESSURE (PSI)	DRY AIR PRESSURE (PSIA)	SUBVOLUME TEMPERATURE (°F)	DRY AIR MASS (lbs. M)
1	.59742	63.672	105.035	3,063.74
2	.55844	63.711	109.867	2,767.53
3	.55844	63.711	109.433	3,171.27
4	.55844	63.711	107.824	1,094.63
5	.50760	63.762	107.298	6,994.15
6	.54108	63.728	105.697	9,374.14
7	.54108	63.728	101.650	8,082.53
8	.56536	63.704	95.201	7,643.74
9	.56536	63.704	97.622	2,746.57
10	.71751	63.552	91.888	41,929.65
11	1.64761	62.622	119.036	1,853.98

$$W^{24} = \sum_1^{11} W_i = 88{,}721.9$$

The difference between the computer program, using volume weighted vapor pressure and a volume weighted containment temperature, and the Gogol/Reytblatt method with sump corrections is given below:

<u>END OF TEST</u> % difference in dry air mass $= \frac{88799.7 - 88721.9}{88721.9} \times 100\%$

$= 0.088\%$

<u>START OF TEST</u> % difference in dry air mass $= \frac{89006.4 - 88986.1}{88986.1} \times 100\%$

$= 0.023\%$

Using the above data to get a total time leak rate gives the following:

$$L^{24} = -\frac{24}{24.004} \times 100 \times \left(\frac{88721.9 - 88,986.1}{88,986.1}\right) = 0.2969 \text{ wt \%/day}$$

Comparing the above to the computer printout value of 0.2316 wt %/day gives the sump correction:

L^{24} =	0.2969	wt %/day
non-corrected value =	0.2316	wt %/day
difference =	0.0653	wt %/day

APPENDIX C

SELECTED DATA SETS FOR TYPE A TEST

Presented herein are data sets at arbitrarily selected points during the Type A test. Table B-1 has the data set at the start of the 24 hour test. Table B-2 has the data set after 12 hours of testing. Table B-3 has the data set at the conclusion of the 24 hour test. Table B-4 has the data set at the start of the induced phase of the test. Table B-5 has the data set at the conclusion of the induced phase of the test.

SET # 1 AT 001 14:29:53 BASE DATA SET = 1

FAILED SENSORS:

DEWCELL(1) IN S.V.# 4 = 55.445 DEG F HAS BEEN DELETED FROM SCAN & SET TO 0.0

PRESSURE 1	= 64.521 PSIA	PRESSURE 2	= 64.523 PSIA
DRY AIR PRESSURE	= 63.854 PSIA	VAPOR PRESSURE	= 0.669 PSIA
VOL WEIGHTED AVE DC	= 88.619 DEG F	VOL WEIGHTED AVERAGE RTD	= 98.894 DEG F
RX WATER LEVEL	= 47.834 INCHES	DRY AIR MASS	=8.9006421875E+04

RTDS:

S.V.# 1	108.101	108.440				
S.V.# 2	111.370	111.180				
S.V.# 3	109.241	109.786				
S.V.# 4	110.180	104.870				
S.V.# 5	106.249	105.572	106.036			
S.V.# 6	104.965	104.884	104.883	104.307		
S.V.# 7	101.178	102.534	101.220	102.564		
S.V.# 8	96.956	96.543	95.706	96.493		
S.V.# 9	98.718					
S.V.# 10	92.615	93.066	92.173	92.889	92.821	93.349
S.V.# 11	115.586	115.586				

DEWCELLS:

S.V.# 1	87.444	
S.V.# 4	0.000	85.577
S.V.# 5	82.883	
S.V.# 7	83.029	85.133
S.V.# 9	85.016	84.571
S.V.# 10	92.185	91.379

REVIEWED

ANI

DATE 07-30-84

TABLE C-1

QUAD CITIES UNIT 1   02:24:49   THU, 26 JUL 1984

SET # 70   AT 002 02:17:58   BASE DATA SET = 1

SUB VOL #	AVG TEMP (DEG F)	AVG DEWCELL (DEG F)	AVG VAP (PSIA)
1	106.904	86.162	0.61842
2	110.447	84.167	0.58020
3	109.547	84.167	0.58020
4	107.649	84.167	0.58020
5	106.683	81.356	0.52984
6	105.188	82.925	0.55746
7	101.717	82.925	0.55746
8	95.624	83.709	0.57173
9	98.091	83.709	0.57173
10	92.457	91.336	0.72795
11	118.361	118.361	1.61684

FAILED SENSORS:

DEWCELL(1) IN S.V.# 4 = 54.930 DEG F HAS BEEN DELETED FROM SCAN & SET TO 0.0

PRESSURE 1	= 64.395 PSIA	PRESSURE 2	= 64.398 PSIA
DRY AIR PRESSURE	= 63.744 PSIA	VAPOR PRESSURE	= 0.652 PSIA
VOL WEIGHTED AVE DC	= 87.838 DEG F	VOL WEIGHTED AVERAGE RTD	= 98.718 DEG F
RX WATER LEVEL	= 46.147 INCHES	DRY AIR MASS	=6.88948125 00E+04

RTDS:

S.V.# 1	106.759	107.049				
S.V.# 2	110.626	110.268				
S.V.# 3	109.062	110.033				
S.V.# 4	109.685	105.614				
S.V.# 5	106.873	106.367	106.811			
S.V.# 6	105.466	105.231	105.248	104.805		
S.V.# 7	100.899	102.385	101.020	102.564		
S.V.# 8	96.115	95.732	94.867	95.782		
S.V.# 9	98.091					
S.V.# 10	92.328	92.661	91.847	92.558	92.424	92.922
S.V.# 11	118.361	118.361				

DEWCELLS:

S.V.# 1	86.162	
S.V.# 4	0.000	84.167
S.V.# 5	81.356	
S.V.# 7	81.944	83.906
S.V.# 9	83.942	83.477
S.V.# 10	91.821	90.852

TABLE C-2

QUAD CITIES UNIT 1   14:35:47   THU, 26 JUL 1984

SET #139   AT 002 14:34:05   BASE DATA SET = 1

SUB VOL #	AVG TEMP (DEG F)	AVG DEWCELL (DEG F)	AVG VAP (PSIA)
1	105.035	85.079	0.59742
2	109.867	82.979	0.55844
3	109.433	82.979	0.55844
4	107.824	82.979	0.55844
5	107.298	80.040	0.50760
6	105.697	82.003	0.54108
7	101.650	82.003	0.54108
8	95.201	83.362	0.56536
9	97.622	83.362	0.56536
10	91.888	90.873	0.71751
11	119.036	119.036	1.64761

FAILED SENSORS:

DEWCELL(1) IN S.V.# 4 = 54.685 DEG F HAS BEEN DELETED FROM SCAN & SET TO 0.0

PRESSURE 1	= 64.273 PSIA	PRESSURE 2	= 64.266 PSIA
DRY AIR PRESSURE	= 63.631 PSIA	VAPOR PRESSURE	= 0.639 PSIA
VOL WEIGHTED AVE DC	= 87.176 DEG F	VOL WEIGHTED AVERAGE RTD	= 98.429 DEG F
RX WATER LEVEL	= 43.970 INCHES	DRY AIR MASS	= 0.8799718750E+04

RTDS:

S.V.# 1	104.988	105.081				
S.V.# 2	110.110	109.624				
S.V.# 3	108.943	109.924				
S.V.# 4	109.338	106.310				
S.V.# 5	107.426	106.993	107.476			
S.V.# 6	105.966	105.740	105.742	105.334		
S.V.# 7	100.780	102.434	100.821	102.564		
S.V.# 8	95.610	95.534	94.423	95.239		
S.V.# 9	97.622					
S.V.# 10	91.714	92.087	91.233	91.947	91.917	92.427
S.V.# 11	119.036	119.036				

DEWCELLS:

S.V.# 1	85.079	
S.V.# 4	0.000	82.979
S.V.# 5	80.040	
S.V.# 7	80.829	83.176
S.V.# 9	83.593	83.130
S.V.# 10	91.405	90.342

TABLE C-3

QUAD CITIES UNIT 1   15:48:19   THU, 26 JUL 1984

SET #146   AT 002 15:44:12   BASE DATA SET = 1

SUB VOL #	AVG TEMP (DEG F)	AVG DEWCELL (DEG F)	AVG VAP (PSIA)
1	104.950	85.079	0.59742
2	109.788	82.886	0.55676
3	109.404	82.886	0.55676
4	107.848	82.886	0.55676
5	107.335	79.981	0.50662
6	105.722	81.924	0.53969
7	101.657	81.924	0.53969
8	95.174	83.362	0.56536
9	97.592	83.362	0.56536
10	91.836	90.812	0.71614
11	119.448	119.448	1.66663

FAILED SENSORS:

DEWCELL(1) IN S.V.# 4 = 54.640 DEG F HAS BEEN DELETED FROM SCAN & SET TO 0.0

PRESSURE 1	= 64.240 PSIA	PRESSURE 2	= 64.233 PSIA
DRY AIR PRESSURE	= 63.599 PSIA	VAPOR PRESSURE	= 0.638 PSIA
VOL WEIGHTED AVE DC	= 87.129 DEG F	VOL WEIGHTED AVERAGE RTD	= 98.411 DEG F
RX WATER LEVEL	= 63.688 INCHES	DRY AIR MASS	=8.8759750000E+04

RTDS:

S.V.# 1	104.889	105.012				
S.V.# 2	110.031	109.544				
S.V.# 3	108.913	109.895				
S.V.# 4	109.338	106.359				
S.V.# 5	107.456	107.042	107.506			
S.V.# 6	105.986	105.778	105.792	105.334		
S.V.# 7	100.700	102.415	100.821	102.614		
S.V.# 8	95.600	95.514	94.373	95.210		
S.V.# 9	97.592					
S.V.# 10	91.645	92.048	91.204	91.887	91.847	92.387
S.V.# 11	119.448	119.448				

DEWCELLS:

S.V.# 1	85.079	
S.V.# 4	0.000	82.886
S.V.# 5	79.981	
S.V.# 7	80.698	83.150
S.V.# 9	83.593	83.130
S.V.# 10	91.344	90.281

TABLE C-4

QUAD CITIES UNIT 1   19:46:33   THU, 26 JUL 1984

SET #170   AT 002 [illegible]:44:39   BASE DATA SET = 146

SUB VOL #	AVG TEMP (DEG F)	AVG DEWCELL (DEG F)	AVG VAP (PSIA)
1	105.050	84.815	0.53239
2	109.743	82.701	0.55344
3	109.379	82.701	0.55344
4	137.933	82.701	0.55344
5	107.491	79.746	0.50275
6	105.884	81.736	0.53642
7	101.642	81.736	0.53642
8	95.125	83.375	0.56561
9	97.573	83.375	0.56561
10	91.858	90.734	0.71439
11	121.023	121.023	1.74111

FAILED SENSORS:

DEWCELL(1) IN S.V.# 4 = 54.605 DEG F HAS BEEN DELETED FROM SCAN & SET TO 0.0

PRESSURE 1	= 64.126 PSIA	PRESSURE 2	= 64.115 PSIA
DRY AIR PRESSURE	= 63.484 PSIA	VAPOR PRESSURE	= 0.636 PSIA
VOL WEIGHTED AVE DC	= 87.049 DEG F	VOL WEIGHTED AVERAGE RTD	= 98.483 DEG F
RX WATER LEVEL	= 42.824 INCHES	DRY AIR MASS	=0.8595562500E+04

RTDS:

S.V.# 1	104.988	105.111				
S.V.# 2	109.961	109.525				
S.V.# 3	108.913	109.845				
S.V.# 4	109.288	106.578				
S.V.# 5	107.607	107.191	107.675			
S.V.# 6	106.116	105.877	105.890	105.652		
S.V.# 7	100.730	102.385	100.771	102.684		
S.V.# 8	95.531	95.455	94.344	95.170		
S.V.# 9	97.573					
S.V.# 10	91.704	92.067	91.243	91.968	91.827	92.338
S.V.# 11	121.023	121.023				

DEWCELLS:

S.V.# 1	84.815	
S.V.# 4	0.000	82.731
S.V.# 5	79.746	
S.V.# 7	80.475	82.998
S.V.# 9	83.621	83.130
S.V.# 10	91.275	90.193

TABLE C-5

APPENDIX D

COMPUTATIONAL PROCEDURE

The procedure for computing the containment parameters, leak rates, and statistical confidence limits is given by Quad-Cities procedure QTS 150-T3, Revision 7. A copy of that procedure is presented here.

CALCULATIONS PERFORMED FOR IPCLRT DATA

Data collected from pressure sensors, dew cells and RTD's located in the containment are processed using the following calculations. If the test is concluded with a test period of < 24 hours, additional calculations given in QTS 150-T9 will be required.

A. Average Subvolume Temperature and Dewpoint.

$$T_j = \frac{\Sigma(\text{all RTD's in the jth subvolume})}{\text{Number of RTD's in jth subvolume}} \quad {}^{o}F \qquad (1)$$

$$D.P._j = \frac{\Sigma(\text{all dew cells in jth subvolume})}{\text{Number of dew cells in jth subvolume}} \quad {}^{o}F \qquad (2)$$

where T_j = average temperature of the jth subvolume

$D.P._j$ = average dewpoint of the jth subvolume

B. Average Primary Containment Temperature and Dewpoint.

$$T = \sum_{j=1}^{NVOL} (VF_j) * (T_j) \; {}^{o}F \qquad (3)$$

$$D.P. = \sum_{j=1}^{NVOL} (VF_j) * (D.P._j) \; {}^{o}F \qquad (4)$$

where T = average containment temperature

D.P. = average containment dewpoint

VF_j = volume fraction of the jth subvolume

NVOL = number of subvolumes

If T_j is undefined then

$T_j = T_{j+1}$ for $1 \leq j \leq (NVOL - 2)$

$T_j = T_{j-1}$ for $j = NVOL - 1$

T_j = estimate for j = NVOL

If $D.P._j$ is undefined

$D.P._j = D.P._{j+1}$ for $1 \leq j \leq (NVOL - 2)$

$D.P._j = D.P._{j-1}$ for $j = NVOL - 1$

$D.P._j$ = estimate for j = NVOL

C. Calculation of Dry Air Pressure.

$$D.P.(^{o}K) = 273.16 + \frac{D.P.(^{o}F) - 32}{1.8}$$

$$X = 647.27 - D.P.(^{o}K)$$

$$EXPON = \frac{X * (Y + Z * X + C * X^3)}{(D.P.(^{o}K))*(1 + D * X)}$$

$$P_v = \frac{(218.167) * (14.696)}{e^{(EXPON * \ln(10))}} \text{ (PSI)}$$

$$P = \frac{\Sigma(\text{all absolute pressure gauges})}{\text{Number of absolute pressure gauges}} - P_v \text{ (psia)} \quad (5)$$

where Y = 3.2437814

$Z = 5.86826 \times 10^{-3}$

$C = 1.1702379 \times 10^{-8}$

$D = 2.1878462 \times 10^{-3}$

P_v = volume weighted containment vapor pressure

P = containment dry air absolute pressure

C, D, X, Y, Z, and EXPON are dewpoint to vapor pressure conversion constants and coefficients.

D. Containment Dry Air Mass.

$$W = \frac{(28.97) * (144) * (P) * (288737 - 25 * (LEVEL - 35))}{1545.33 * (T + 459.69)} \quad (6)$$

where W = containment dry air mass

LEVEL = reactor water level

289506 = primary containment volume

NOTE

This volume is the summation of the subvolumes calculated in QTS 150-T2. These subvolumes were calculated using QTS 150-T8. Since the measured leak rate is a difference in air masses, this number is just as conservative as using the FSAR number.

E. Measured Leak Rate.

$$L_m(TOTAL) = \frac{(W_{BASE} - W_i) * 2400}{t_i * W_{BASE}} \quad \%/DAY \qquad (7)$$

$$L_m(POINT) = \frac{(W_{i-1} - W_i) * 2400}{(t_i - t_{i-1}) * W_{i-1}} \quad \%/DAY \qquad (8)$$

where W_{BASE} = containment dry air mass at t = 0

t_i = time from start of test at ith data set

t_{i-1} = time from start of test at (i-1)th data set

W_i = dry air mass at ith data set

W_{i-1} = dry air mass at (i-1)th data set

L_m(TOTAL)= measured leakage from the start of test to ith data set

L_m(POINT)= measured leakage between the last two data sets

F. Statistical Leak Rate and Confidence Limit.

LINEAR LEAST SQUARES FITTING THE IPCLRT DATA

The method of "Least Squares" is a statistical procedure for finding the best fitting regression line for a set of measured data. The criterion for the best fitting line to a set of data points is that the sum of the squares of the deviations of the observed points from the line must be a minimum. When this criterion is met, a unique best fitting line is obtained based on all of the data points in the ILRT. The value of the leak rate based on the regression is called the statistically average leak rate.

Since it is assumed that the leak rate is constant during the testing period, a plot of the measured containment dry air mass versus time would ideally yield a straight line with a negative slope (assuming a non-zero leak rate). Obviously, sampling techniques and test conditions are not perfect and consequently the measured values will deviate from the ideal straight line situation.

Based on this statistical process, the calculated leak rate is obtained from the equation:

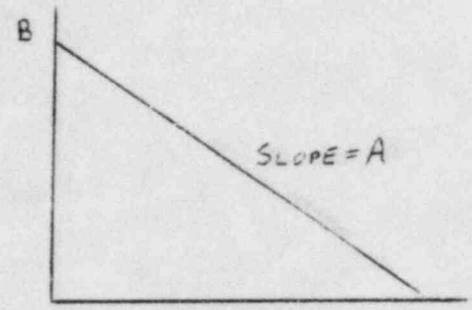
$W = At + B$

where W = contained dry air mass at time t

B = calculated dry air mass at time t = 0

A = calculated leak rate

t = test duration



The values for the Least Squares fit constants A and B are given by:

$$A = \frac{\{N * \Sigma(t_i) * (W_i) - \Sigma t_i * \Sigma W_i\}}{\{N * \Sigma(t_i)^2 - (\Sigma t_i)^2\}} = \frac{\Sigma(t_i - \bar{t}) * (W_i - \bar{W})}{\Sigma(t_i - \bar{t})^2}$$

$$B = \frac{\Sigma W_i - A * \Sigma t_i}{N} = \frac{\{\Sigma(t_i)^2 * \Sigma(W_i)\} - \{\Sigma(t_i) * (W_i)\}}{N * \Sigma(t_i)^2 - (\Sigma t_i)^2}$$

where $\bar{t}$ = the average time for all data sets

$\bar{W}$ = the average air mass for all data sets

The second formulas are used in the process computer program to reduce round-off-error.

By definition, leakage out of the containment is considered positive leakage; therefore, the statistically average leak rate is given by:

$$L_s = \frac{(-A) * (2400)}{B} \quad \text{(weight \%/DAY)} \qquad (9)$$

STATISTICAL UNCERTAINTIES

In order to calculate the 95% confidence limits of the statistically average leak rate, the standard deviation of the least squares slope and the student's TDistribution function are used as follows.

$$\sigma = \left\{\frac{1}{(N-2)} * \left(\frac{N * \Sigma(W_i)^2 - (\Sigma W_i)^2}{N * \Sigma(t_i)^2 - (\Sigma t_i)^2}\right) - A^2\right\}^{\frac{1}{2}}$$

When performing these calculations on the process computer, $\Sigma(W_i)^2$ and $(\Sigma W_i)^2$ become so large that they overflow. To avoid this problem ΔW_i is substituted for W_i. ΔW_i is the difference between W_i and W_{BASE}.

The single sided T-Distribution with 2 degrees of freedom is approximated by the following formula from NBS Handbook 91:

$$T.E. = 1.646698 + \frac{1.455393}{(N-2)} + \frac{1.975971}{(N-2)^2}$$

The upper confidence limit (UCL) is given by

$$UCL = L_s + \frac{\sigma * (TE) * 2400}{B} \quad \text{(weight \%/DAY)} \qquad (10)$$

APPENDIX E

ERROR ANALYSIS PROCEDURE

The procedure for computing the system accuracy uncertainty and the system repeatability uncertainty is given by Quad-Cities procedure QTS 150-T1, Revision 5. A copy of that procedure is presented here.

IPCLRT SAMPLE ERROR ANALYSIS

Uncertainty in the Measurement of Quad-Cities Primary Containment Leak Rates

A. INSTRUMENT ACCURACY ERROR ANALYSIS

Per ANSI N45.4-1972, the computation of the leak rate is given by the equation:

$$L(\%)=\left(\frac{24}{H}\right)(100)\left(\frac{W1 - W2}{W1}\right) = \frac{2400}{H}\left(1-\frac{T1P2}{T2P1}\right)$$

where	L	= primary containment leak rate	(%/day)
	H	= time interval between data sets #1 & #2	(hours)
	W1	= weight of the contained dry air mass at test data set #1	(lbs)
	W2	= weight of the contained dry air mass at test data set #2	(lbs)
	T1	= volume weighted primary containment temperature at test data set #1	(°R)
	T2	= volume weighted primary containment temperature at test data set #2	(°R)
	P1	= dry air absolute pressure at test data set #1	(PSIA)
	P2	= dry air absolute pressure at test data set #2	(PSIA)

The standard variation on L due to the uncertainties in the measured variables is given by:

$$\delta(L) = \frac{2400}{H}\left[\left(\frac{\partial L}{\partial P1}\,\partial(P1)\right)^2 + \left(\frac{\partial L}{\partial P2}\,\delta(P2)\right)^2 + \left(\frac{\partial L}{\partial T1}\,\partial(T1)\right)^2 + \left(\frac{\partial L}{\partial T2}\,\delta(T2)\right)^2\right]^{\frac{1}{2}}$$

substituting

$H = 24$ hours

$$\frac{\partial L}{\partial P1} = \frac{T1\ P2}{T2\ P1^2} \cong \frac{1}{P1}$$

$$\frac{\partial L}{\partial P2} = -\frac{T1}{T2\ P1} \cong -\frac{1}{P1}$$

$$\frac{\partial L}{\partial T1} = -\frac{P2}{T2\ P1} \cong -\frac{1}{T2}$$

$$\frac{\partial L}{\partial T2} = \frac{T1\ P2}{T2^2 P1} \cong \frac{1}{T2}$$

assuming $P1 \cong P2 \cong \overline{P}$ and $T1 \cong T2 \cong \overline{T}$

where $\bar{P}$ = average absolute dry air pressure

$\bar{T}$ = average volume weighted primary containment absolute temperature

Therefore,

$$\delta(L) = 100 \left[2\left(\frac{\delta(\bar{P})}{\bar{P}}\right)^2 + 2\left(\frac{\delta(\bar{T})}{\bar{T}}\right)^2\right]^{\frac{1}{2}}$$

1. <u>Calculation of $\delta(\bar{T})$</u>

$$\bar{T} = \sum_{j=1}^{11} (VFj)\ (Tave,j)$$

where VFj = the volume weighting factors

Tave,j = the average absolute temperature in the <u>jth</u> sub-volume

$$Tave,j = \sum_{i=1}^{Nj} \frac{Ti,j}{Nj}$$

where Ti,j = the absolute temperature of the <u>ith</u> RTD in the <u>jth</u> subvolume

Nj = the number of RTD's in the <u>jth</u> subvolume

Now, $\delta(\bar{T})$ is calculated from

$$\delta(\bar{T}) = \sum_{J=1}^{11} \frac{\delta\bar{T}}{\partial Tave,j}\ \delta(Tave,j)$$

where $\frac{\delta\bar{T}}{\delta Tave,j} = VFj$

$$\delta(Tave,j) = \frac{\text{RTD accuracy}}{(Nj)^{\frac{1}{2}}}$$

Therefore,

$$\delta(\bar{T}) = \sum_{j=1}^{11} (VFj)\ \frac{(\text{RTD accuracy})}{(Nj)^{\frac{1}{2}}}$$

2. <u>Calculation of $\delta(\bar{P})$</u>

$$\delta(P) = [\delta(P_T)^2 + \delta(P_V)^2]^{\frac{1}{2}}$$

where P_T = total absolute primary containment pressure
P_V = partial pressure of water vapor in the primary containment

substituting $\delta(P_T) = \frac{\text{PPG accuracy}}{(\text{\# of PPG's})^{\frac{1}{2}}}$

$$\delta(P_V) = \sum_{j=1}^{11} (VFj) \; \frac{(\text{dewcell accuracy})}{(N_j)^{\frac{1}{2}}}$$

where PPG = precision pressure gauge

Nj = number of dewcells in the jth subvolume

Therefore,

$$\delta(\bar{P}) = \left[\left(\frac{\text{PPG accuracy}}{(\text{\# of PPG's})^{\frac{1}{2}}} \right)^2 + \left(\sum_{J=1}^{11} (VFj) \left(\frac{\text{dewcell accuracy}}{(N_j)^{\frac{1}{2}}} \right)^2 \right]^{\frac{1}{2}}$$

3. Instrument Specifications

(SEE TABLE ONE)

4. Calculation of δ(L), Accuracy Analysis

Following are the designated volume fractions and sensor allocations:

Subvolume	Volume Fraction	No. of RTD's
1	0.03486	2
2	0.03174	2
3	0.03634	2
4	0.01251	2
5	0.07979	3
6	0.10670	4
7	0.09134	4
8	0.08624	4
9	0.03083	1
10	0.46689	6
11	0.02276	1 T.C.

Subvolumes	Volume Fraction	No. of Dewcells
1	0.03486	1
2,3,4	0.08059	1
5	0.07979	1
6,7	0.19804	2
8,9	0.11707	2
10	0.46689	2
11	0.02276	Sat.

Assume the following values:

$\bar{P}$ = 63.0 PSIA

$\bar{T}$ = 85°F = 544.7°R

Dewpoint = 65°F

Therefore,

$$\delta(\bar{T}) = (0.03486 \times \frac{0.50}{(2)^{\frac{1}{2}}}) + (0.03174 \times \frac{0.50}{(2)^{\frac{1}{2}}}) + (0.03634 \times \frac{0.50}{(2)^{\frac{1}{2}}})$$

$$+ (0.01251 \times \frac{0.50}{(2)^{\frac{1}{2}}}) + (0.07979 \times \frac{0.50}{(3)^{\frac{1}{2}}}) + (0.10670 \times \frac{0.50}{(4)^{\frac{1}{2}}})$$

$$+ (0.09134 \times \frac{0.50}{(4)^{\frac{1}{2}}}) + (0.08624 \times \frac{0.50}{(4)^{\frac{1}{2}}}) + (0.03083 \times \frac{0.50}{(1)^{\frac{1}{2}}})$$

$$+ (0.46689 \times \frac{0.50}{(6)^{\frac{1}{2}}}) + (0.02276 \times \frac{2.0}{(1)^{\frac{1}{2}}})$$

$$\delta(\bar{T}) = 0.2912^{\circ}R$$

$$\delta(P_T) = \frac{0.015}{(2)^{\frac{1}{2}}} = 0.01061 \text{ PSIA}$$

For the subvolumes, other than the air space in the reactor, an accuracy of the dewcells of ± 1°F at an average dewpoint of 65°F corresponds to ± .011 PSI in vapor pressure. For subvolume #11 at an average temperature of 140°F, an accuracy of ± 2°F corresponds to ±.150 PSI.

$$\delta(P_V) = (0.03486 \times \frac{0.011}{(1)^{\frac{1}{2}}}) + (0.08059 \times \frac{0.011}{(1)^{\frac{1}{2}}}) + (0.07979 \times \frac{0.011}{(1)^{\frac{1}{2}}})$$

$$+ (0.19804 \times \frac{0.011}{(2)^{\frac{1}{2}}}) + (0.11707 \times \frac{0.011}{(2)^{\frac{1}{2}}}) + (0.46689 \times \frac{0.011}{(2)^{\frac{1}{2}}})$$

$$+ (0.02276 \times \frac{0.150}{(1)^{\frac{1}{2}}})$$

$$= .00038 + .00089 + .00088 + .00154 + .00091 + .00363 + .00341$$

$$\delta(P_V) = 0.01164 \text{ PSI}$$

Therefore,

$$\delta(\bar{P}) = [(\ 0.01061\ )^2 + (\ 0.01164\ )^2\ ]^{\frac{1}{2}}$$

$$= 0.01575 \text{ PSI}$$

The accuracy uncertainty for a 24 hour test is then found to be

$$\delta(L)_a = 100\ [2(\ \frac{.01575}{63.0}\ )^2 + 2(\ \frac{.2912}{544.7}\ )^2\ ]^{\frac{1}{2}}$$

$$= 0.0835 \text{ weight \%/day}$$

5. Calculation of δ(L), Repeatability Analysis

Using the formulas developed previously, the repeatability error analysis is performed by substituting the instrument repeatability errors for the instrument accuracy errors.

$$\delta(\bar{T}) = (0.03486 \times \frac{0.10}{(2)^{\frac{1}{2}}}) + (0.03174 \times \frac{0.10}{(2)^{\frac{1}{2}}}) + (0.03634 \times \frac{0.10}{(2)^{\frac{1}{2}}})$$

$$+ (0.01251 \times \frac{0.10}{(2)^{\frac{1}{2}}}) + (0.07979 \times \frac{0.10}{(3)^{\frac{1}{2}}}) + (0.10670 \times \frac{0.10}{(4)^{\frac{1}{2}}})$$

$$+ (0.09134 \times \frac{0.10}{(4)^{\frac{1}{2}}}) + (0.08624 \times \frac{0.10}{(4)^{\frac{1}{2}}}) + (0.03083 \times \frac{0.10}{(1)^{\frac{1}{2}}})$$

$$+ (0.46689 \times \frac{0.10}{(6)^{\frac{1}{2}}}) + (0.02276 \times \frac{0.10}{(1)^{\frac{1}{2}}})$$

$$\delta(\bar{T}) = 0.0514^{\circ}R$$

$$\delta(P_T) = \frac{0.001}{(2)^{\frac{1}{2}}} = 0.00071 \text{ PSIA}$$

For the subvolumes other than the air space in the reactor, a repeatability uncertainty of the dewcells of 0.5°F at an average dewpoint of 65°F corresponds to ± .006 PSI in vapor pressure. For subvolume #11 at an average temperature of 140°F, a repeatability uncertainty of ± 0.1°F corresponds to ±.008 PSI in vapor pressure.

$$\delta(P_V) = (0.03486 \times \frac{0.006}{(1)^{\frac{1}{2}}}) + (0.08059 \times \frac{0.006}{(1)^{\frac{1}{2}}}) + (0.07979 \times \frac{0.006}{(1)^{\frac{1}{2}}})$$

$$+ (0.19804 \times \frac{0.006}{(2)^{\frac{1}{2}}}) + (0.11707 \times \frac{0.006}{(2)^{\frac{1}{2}}}) + (0.46689 \times \frac{0.006}{(2)^{\frac{1}{2}}})$$

$$+ (0.02276 \times \frac{.008}{(1)^{\frac{1}{2}}})$$

$$= .00021 + .00048 + .00048 + .00084 + .00050 + .00198 + .00018$$

$$\delta(P_V) = 0.00467 \text{ PSI}$$

Therefore,

$$\delta(\bar{P}) = [(0.00071)^2 + (0.00467)^2]^{\frac{1}{2}}$$

$$= 0.00473 \text{ PSI}$$

The repeatability uncertainty for a 24 hour test is then found to be

$$\delta(L)_r = 100 \; [2(\frac{0.00473}{63.0})^2 + 2 \; (\frac{0.0514}{544.7})^2]^{\frac{1}{2}}$$

$$= 0.0171 \text{ weight \%/day}$$

6. Total Instrument Uncertainty

$$\alpha(L) \text{ Total} = [(\delta(L)_a)^2 + (\delta(L)_r)^2]^{\frac{1}{2}}$$

$$= [(0.0835)^2 + (0.0171)^2]^{\frac{1}{2}}$$

$$= 0.0852 \text{ weight \%/day}$$

$$2\alpha(L) \text{ Total} = 0.1705 \text{ weight \%/day}$$