REACTOR CONTAINMENT BUILDING

INTEGRATED LEAK RATE TEST

QUAD-CITIES NUCLEAR POWER STATION

UNIT ONE

FEBRUARY 19-22, 1979

397 296

7907190545

TABLE OF CONTENTS

TABLES AND FIGURES INDEX

INTRODUCTION

This report presents details of the Integrated Primary Containment of Leak Rate Test (IPCLRT) successfully performed on February 18 through 22, 1979 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.

The total primary containment integrated leak rate, adjusted to include penetrations not tested during the IPCLRT, was found to be 0.3175 wt %/day at a test pressure of 49 psig, which was within the 0.750 wt %/day acceptance criterion. The associated upper 95% confidence limit was 0.3219 wt %/day.

Excluding non-testable penetrations, the supplemental induced phase leakage test result was 0.537 wt %/day. This value should compare with the sum of the 24 hour phase result (0.301) and the induced leak rate of 3SCFM (0.342 wt %/day). The statistical value of 0.537 wt %/day lies within the allowable tolerance band of 0.643 ± 0.250 wt %/day.

397 299

SECTION A - TEST PREPARATIONS

A.1. Type A Test Procedure

The IPCLRT was performed in accordance with Procedure QTS 150-1, Revision 5, including checklists QTS 150-S1 through S13, subsections QTS 150-T1, T2, T3, T6, T7, and T8, and Approved Temporary Procedure 1186 allowing a valving change on an instrument and requiring measurement of drywell sump levels.

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

A.2. Type A Test Instrumentation

Table One show 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 One is an idealized view of the drywell and suppression chamber used to calculate the primary containment free air volumes.

A.2.a Temperature

Locations for RTD's were carefully chosen to avoid conflict with local temperature variation, while still satisfying sensor placement as dictated by results of the previous Unit One IPCLRT of March, 1976. Sensors were suspended to prevent direct thermal influence from any metal structures. Temperature of the reactor vessel air space was based upon the reactor water entering the RHR Heat Exchanger of the loop in operation for reactor shutdown cooling. Each RTD-bridge network was calibrated to yield an output of 0.0 mV to 100 mV over the range of $50^{\circ}F$ - $150^{\circ}F$. Observations were made by comparison with a Montedere Whitney platinum resistance thermometer, serial number TC 7G 100B 006D. The plant process computer sampled the output of each RTD-bridge network.

A.2.b Pressure

Two precision quartz bourdon tube pressure gauges were utilized. Each gauge had a local digital readout as well as 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 connected to a special one inch pipe penetration.

Each precision pressure gauge was calibrated over the range of 55 to 75 psig in approximately 5 psig increments using a Volumetric Inc. VMC 07726101 calibration standard. Since the digital readout was in "counts" or arbitrary units, only the computer calibration factors were corrected in the calibration and no mechanical calibration was performed.

397 300

A.2.c. Vapor Pressure

The dewcells were physically situated in the primary containment based upon the results of the Unit One IPCLRT performed in March, 1976. An assumption was made that the reactor vessel air space (subvolume 11) was saturated and at the same temperature as the reactor water entering the RHR heat exchanger.

A calibration curve was generated for each sensor over the range of 67-93°F. Calibration constants were derived from the curve to correlate the 0 mV to 150 mV output of the sensor to the actual dewpoint measured by a chilled mirror dewcell standard, Volumetrics, Inc. serial no. VMC 203/184. A Fluke model 8600A digital multimeter was used to measure the voltage output of the signal conditioner.

A.2.d. Flow

A rotameter flowmeter, Fischer-Porter serial no. 7706A9209 calibrated to within ± 1% by Fischer-Porter, was used for flow measurement. Tygon tubing connected the rotameter with the one inch pipe penetration to the primary containment.

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, calculate, and print results with minimal human input. The system was constructed in accordance with modification M-4-1-76-45, and was used during the previous Unit Two IPCLRT in October 1976.

A.4. Type A Test Pressurization

A 3000 scfm, 600 hp electric oil-free air compressor was used to pressurize the primary containment. An identical compressor was available as a standby.

The compressors were physically located outside the reactor building. The compressed air was piped into the Reactor Building through an existing 4" fire header penetration. For ease of handling a flexible 4" pipe was used within the reactor building.

The drywell was pressurized through the "A" containment spray header 10" flange with inboard valve MO-1-1001-26A open during the pressurization process.

397 301

TABLE ONE

INSTRUMENT SPECIFICATIONS

INSTRUMENT	MANUFACTURER	MODEL NO.	SERIAL NO.	RANGE	ACCURACY	REPEATABILITY
Precision Pressure Guage (2)	Volumetrics		1309 1311	0-100 psia	±0.015 psi	±0.001 psi
RTD's (29)	Burns Engineering Inc.	SPIA1-5 1/2-3A	44209 44224 44210 44225 44211 44226 44212 44227 44213 44228 44214 44229 44215 44230 44216 44231 44217 44232 44218 44233 44219 44234 44220 44235 44221 44236 44222 44237 44223 44238	50-200°F	±0.25°F	±0.10°F
Dewcell (7)	Veekay Limited	VK-36C	000444-1 76309 76310 76311 76312 000444-2 76313 76314 76315 76316	50-150°F	±1.0°F	±0.1°F
Thermocouple (1) (TE1-1046B)	Pall Trinity Micro	21A1026P6	--	0-600°F	±2.0°F	±0.10°F
Flowmeter (1)	Fischer & Porter	10A3555-S	7706A9209	0-11.1 scfm	0.11 scfm	--
Level Indicator LI 2-263-100A	Yarway	SCR/M	969	-60 to +60" H_2O	--	--

397 302

TABLE TWO

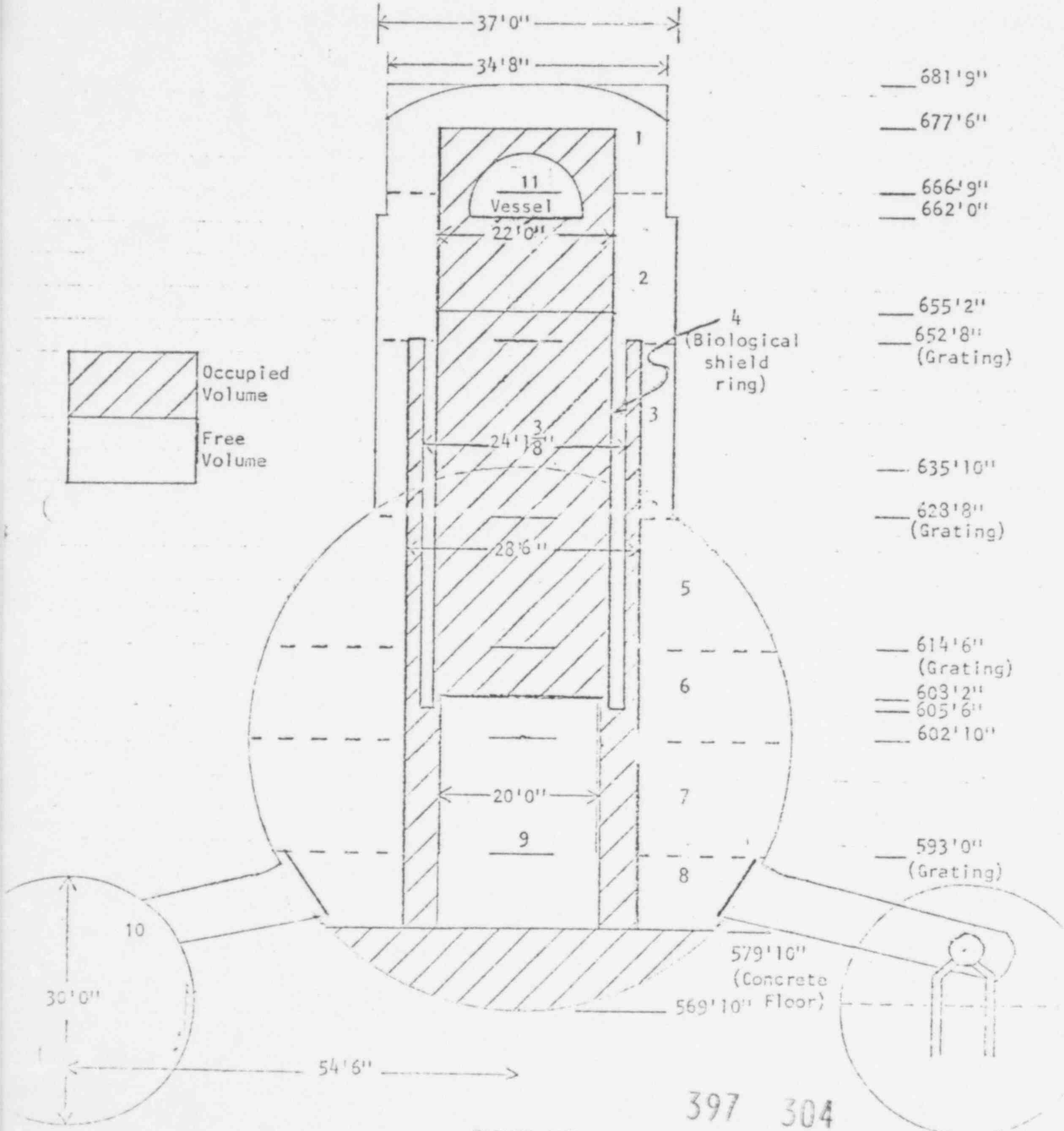
SENSOR PHYSICAL LOCATIONS

RTD NO.	SERIAL NO.	SUBVOLUME	ELEVATION	AZIMUTH
1	44209	1	670'0"	180°
2	44210	1	670'0"	0°
3	44211	2	657'0"	20°
4	44212	2	657'0"	200°
5	44213	3	634'0"	70°
6	44214	3	634'0"	265°
7	44215	4 (Annular Ring)	643'0"	45°
8	44216	4	615'0"	225°
9	44217	5	620'0"	5°
10	44218	5	620'0"	100°
11	44219	5	620'0"	220°
12	44220	6	608'0"	40°
13	44221	6	608'0"	130°
14	44222	6	608'0"	220°
15	44223	6	608'0"	310°
16	44224	7	598'0"	70°
17	44225	7	598'0"	160°
18	44226	7	598'0"	250°
19	44227	7	598'0"	340°
20	44228	8	587'0"	10°
21	44229	8	587'0"	100°
22	44230	8	587'0"	190°
23	44231	8	587'0"	280°
24	44232	9 (CRD Space)	586'0"	0°
25	44233	10	578'0"	0°
26	44234	10	578'0"	60°
27	44235	10	578'0"	120°
28	44236	10	578'0"	180°
30	44238	10	578'0"	300°
Thermocouple (RHR Hx Inlet)		11	-	-

DEWCELL NO.	SERIAL NO.	SUBVOLUME	ELEVATION	AZIMUTH
1	000444-1	2	657'0"	160°
2	000444-1	5	620'0"	340°
3	000444-1	7	598"0"	70°
5	000444-2	9 (CRD Space)	586'0"	0°
6	000444-2	10	578'0"	0°
7	000444-2	10	578'0"	120°
8	000444-2	10	578'0"	240°
Thermocouple (Vessel Saturated)		11	-	-

397 303

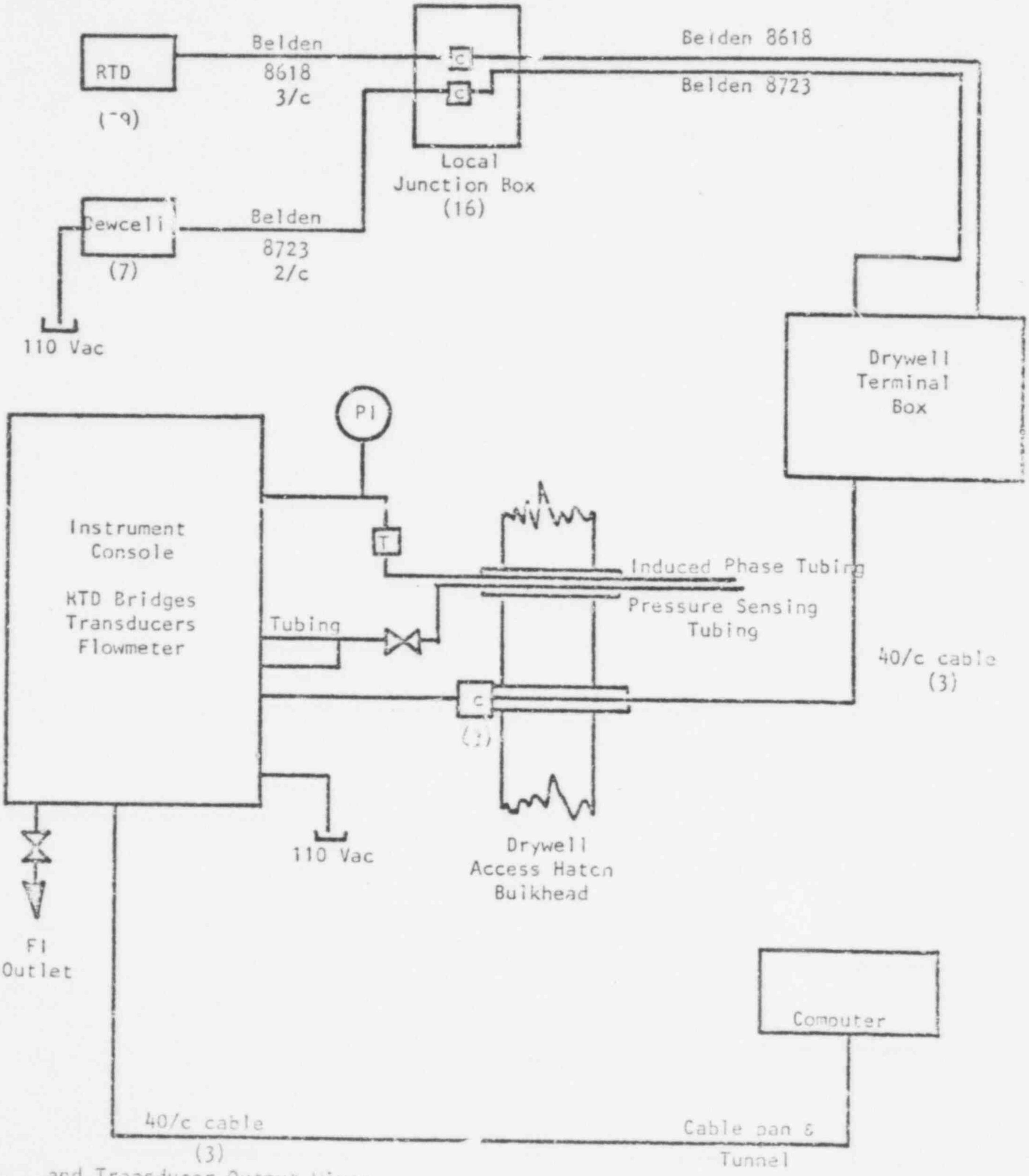
FIGURE ONE
Idealized View of Drywell and Torus
Used to Calculate Free Volumes



397 304

FIGURE ONE

FIGURE TWO
MEASUREMENT SYSTEM
SCHEMATIC ARRANGEMENT



397 305

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 with measured containment temperature, dew point and air pressure to determine dry air mass in the containment. The leak rate can then be determined from the rate of mass loss.

B.2. Supplemental Verification Test

The supplemental verification test superimposes a leak of approximately the same magnitude as that measured during the 24-hour phase of the test. The degree of detectability of the combined leak rate provides a basis for resolving any uncertainty associated with the 24-hour phase of the test.

B.3. Linear Regression Analysis

Leak rate is assumed to be constant during the testing period, ideally yielding a straight-line plot with negative slope. However, sampling techniques and test conditions are not perfect; consequently, the measured values will deviate from the ideal straight line situation.

A least squares fit statistical analysis was performed to determine a regression line for mass versus time after each set of data was acquired. The slope of this regression line was designated to be the statistically averaged leak rate. This quantity was compared to the Technical Specification allowable operational leak rate L_{to} (0.75 wt %/day).

Associated with the statistically averaged leak rate was the upper 95% confidence limit leak rate. The calculation of this upper limit was based upon the standard deviations from the regression line and the one-sided Students - T Distribution function. A procedural requirement specified the upper 95% confidence limit leak rate would be less than the Technical Specification maximum allowable leak rate Lp (1.0 wt %/day).

B.4. Instrumentation Error Analysis - Application

An instrumentation error analysis was performed prior to the test in accordance with ANSI N45.4-1972. The instrumentation system error was calculated in two parts. The first was to determine the system accuracy. The second and most important calculation was performed to determine the error due to system repeatability. The results were 0.0428 and 0.0101 wt%/day, respectively. A statistical combination of these two values yielded a total instrument uncertainty (2σ) of 0.0880 wt%/day.

The instrumentation uncertainty is used only to illustrate the system's compatability to measure the required parameters that are necessary for calculation of the primary containment leak rate. The instrumentation for uncertainty is always present in the data and is incorporated in the 95% upper confidence limit in the form of data scatter. Procedures required that the summation of the 24 hour statistical leak rate and the total instrument uncertainty (2σ) be less than Lp (1.0 wt%/day).

397 306

SECTION C - SEQUENCE OF EVENTS

C.1. Test Preparation Chronology

The pretest preparation phase and containment inspection were completed by February 18, 1979 with no visible structural deterioration being found. Major preliminary steps included:

1) Completion of all Type B and C tests, component repairs, and retests except for the 2A main steam isolation valve.

2) Completion of drywell equipment installation.

3) Completion of IPCLRT pre-test valve checklist including isolation of drywell and suppression chamber pressure sensors.

4) Blocking of three sets of drywell to suppression chamber vacuum breakers in the open position for pressure equilization between the drywell and suppression chamber volumes.

5) Venting of the reactor vessel to the primary containment via the manual head vent line and the drywell equipment drain sump.

6) Completion of pre-test data gathering system, including computer program, instrument console, and associated wiring.

397 307

C.2. Test Pressurization Chronology

DATE	TIME	EVENT
2-19-79	1530	Primary Containment pressurization initiated.
	1700	Several minute packing leaks on drywell O_2 sampling station were repaired.
	1840	5 scfh leak on drywell penetration X-44; could not be repaired.
	1853	Failed Dewcell #3 in subvolume 7 because of abnormal readings. Data from this sensor were not used for the test.
	2045	Some very small leaks on the T.I.P. system corrected.
	2345	Primary containment pressure at 64.1 PSIA; compressor was manually tripped and isolated.
	2350	Found leaks totaling approximately 15 scfh on drywell personnel interlocks, maintenance repaired these.
2-20-79	0415	Computer data sheets indicate a leak rate of approximately 1.2 weight per cent per day.
	0800	Found a major leakage path. Drywell cooler damper controls were leaking badly; the tubing inside the containment was probably broken causing the leakage. The controls were isolated at the penetrations by closing the manual valves.
	1100	Repressurization of the primary containment was begun.
	1130	Pressurization was complete; drywell pressure at 64.8 PSIA.

C.3. Temperature Stabilization Chronology

DATE	TIME	EVENT
2-20-79	1300	Data satisfactory, reactor temperature holding steady, reactor level slowly decreasing at about 0.6 inches per hour.
	1530	Ready to begin 24 hour leak rate test phase.

397 308

C.4. 24-Hour Phase of Leak Rate Test

DATE	TIME	EVENT
2-20-79	1530	Started 24 hour phase. Data sets taken at 15 minute intervals.
	1600	The blind flange on the "A" RHR Loop was replaced. (This was the line used for containment pressurization).
	1700	Torus level not at 0 inches; test will have to be restarted. Computer also averaging both RHRS loop temperatures; must delete temperature of RHRS loop not in service.
	1915	24 hour phase was restarted.
2-21-79	0208	Adjusted the Shut Down Cooling mode of RHR to control temperature more accurately.
	0210	Computer shutdown.
	0300	The computer was restarted. The failure was due to loss of printers in control room.
	0825	Shut Down Cooling mode of RHR again adjusted for better Reactor water cooling.
	1930	24 Hour Phase complete 95% upper confidence limit leak rate is 0.3055 wt %/day, well below the allowable leak rate of 1.0 wt %/day. The statistically averaged leak rate was 0.3011 wt %/day.

C.5. Induced Leakage Phase

397 309

DATE	TIME	EVENT
2-21-79	1944	Induced leak rate of 3 scfm initiated. (0.342 wt %/day)
2-22-79	0023	Upper limit of induced phase calculated to be 0.8931 wt %/day, lower limit 0.3931 wt %/day, with an ideal value of 0.3011 wt %/day (leakage of 24 Hour Phase) + 0.342 wt %/day (induced leakage) = 0.6431.
	0056	Final Induced Leakage Phase Results: Statistical Leak Rate: 0.5372 wt %/day 95% Upper Confidence Leak Rate: 0.5671 wt %/day Both values are well within the allowable upper and lower limits.

C.6. Blowdown Phase

DATE	TIME	EVENT
2-22-79	0130	Blowdown initiated through the Standby Gas Treatment System.
	1050	Primary Containment pressure at atmospheric; initial drywell entry made by technical staff. No visible damage observed as a result of the test. Drywell sump levels at about ½ inch, the same as at the beginning of the test.

397 310

SECTION D - TYPE A TEST DATA

D.1. 24 Hour Phase Data

Data for the 24 Hour Phase is illustrated in Tab e Three. Graphic record of this portion of the test is presented on graphs 1 through 7.

D.3.2. Induced Phase Data

Data for the Induced Phase is presented in Table Four. Graphic illustration of the major parameters is given on graphs 8 through 11.

SECTION E - TEST CALCULATIONS

Calculations for the test were based on Quad-Cities procedures QTS 150-T3. Reproductions of these procedures can be found in Appendix C. Sample instrument error analysis is also found in Apprendix C.

397 311

TABLE THREE
48 PSIG TYPE A TEST - 24 HOUR PHASE

QUAD CITIES UNIT 1 1931 02/21/79

****SUMMARY OF DATA SETS 61 THRU 154 ****

TEST DUR. HRS	TIME	DATE	TEMP (F)	CALC. MASS T=0	DRY AIR PRES (PSIA)	MEAS. LEAK RATE % / DAY TOTAL	MEAS. LEAK RATE % / DAY POINT	CALC. LEAK RATE % / DAY	UPPER 95% CONFID LIMIT
0.00	191433	2/20/79	88.52		64.101				
0.28	193114	2/20/79	88.46		64.095	-0.2883	-0.2883		
0.57	194835	2/20/79	88.42	0.9125652036E 05	64.093	-0.4232	-0.5528	-0.4241	-0.0538
0.78	200115	2/20/79	88.42	0.9125970248E 05	64.083	0.1672	1.7544	0.0577	0.9601
1.02	201556	2/20/79	88.48	0.9126077158E 05	64.090	0.1246	-0.0108	0.1635	0.6331
1.28	203138	2/20/79	88.45	0.9126115478E 05	64.085	0.1257	0.1300	0.1917	0.4755
1.53	204638	2/20/79	88.50	0.9126172168E 05	64.087	0.1728	0.4148	0.2254	0.4202
1.78	210108	2/20/79	88.51	0.9126368208E 05	64.079	0.3245	1.2881	0.3238	0.5037
2.03	211611	2/20/79	88.54	0.9126445328E 05	64.081	0.2994	0.1214	0.3571	0.4982
2.28	213105	2/20/79	88.51	0.9126443228E 05	64.077	0.2694	0.0249	0.3563	0.4570
2.52	214555	2/20/79	88.56	0.9126480428E 05	64.078	0.3065	0.6479	0.3689	0.4591
2.77	220036	2/20/79	88.53	0.9126481178E 05	64.073	0.2954	0.1606	0.3691	0.4435
3.02	221553	2/20/79	88.60	0.9126437008E 05	64.081	0.2704	-0.0010	0.3568	0.4204
3.27	223054	2/20/79	88.57	0.9126271958E 05	64.082	0.1850	-0.8456	0.3146	0.3840
3.52	224537	2/20/79	88.64	0.9126369258E 05	64.073	0.3509	2.5656	0.3424	0.4085
3.73	225813	2/20/79	88.62	0.9126336208E 05	64.078	0.2575	-1.3053	0.3306	0.3896
4.03	231530	2/20/79	88.64	0.9126225758E 05	64.081	0.2188	-0.2574	0.3080	0.3644
4.25	232947	2/20/79	88.70	0.9126213148E 05	64.080	0.2674	1.1554	0.3055	0.3556
4.52	234547	2/20/79	88.71	0.9126184378E 05	64.080	0.2576	0.1013	0.3003	0.3452
4.77	000049	2/21/79	88.70	0.9126141938E 05	64.078	0.2471	0.0581	0.2930	0.3339
5.02	001551	2/21/79	88.75	0.9126200348E 05	64.074	0.3062	1.4315	0.3025	0.3405
5.27	003039	2/21/79	88.75	0.9126192408E 05	64.076	0.2727	-0.4090	0.3013	0.3358
5.53	004634	2/21/79	88.77	0.9126182238E 05	64.075	0.2718	0.2531	0.2998	0.3313
5.76	005958	2/21/79	88.78	0.9126283808E 05	64.068	0.3157	1.4045	0.3085	0.3386
6.02	011548	2/21/79	88.85	0.9126304918E 05	64.067	0.3592	1.2860	0.3249	0.3569
6.24	012840	2/21/79	88.85	0.9126349608E 05	64.075	0.2375	-1.6984	0.3229	0.3525
6.50	014444	2/21/79	88.84	0.9126313798E 05	64.066	0.3173	1.0128	0.3272	0.3548
6.74	015852	2/21/79	88.91	0.9126474658E 05	64.064	0.3555	1.4101	0.3381	0.3660
7.86	030554	2/21/79	88.98	0.9126558848E 05	64.063	0.3470	0.2960	0.3470	0.3732
7.97	031220	2/21/79	88.97	0.9126531668E 05	64.068	0.3062	-2.4650	0.3442	0.3643
8.55	034722	2/21/79	89.02	0.9126578388E 05	64.060	0.3388	[illegible]	0.3438	0.3712
8.78	040009	2/21/79	89.04	0.9126612808E 05	64.060	0.3382	0.3130	0.3521	0.3730
9.03	041422	2/21/79	89.07	0.9126573518E 05	64.068	0.3066	-0.8618	0.3484	0.3680
9.25	042930	2/21/79	89.07	0.9126511198E 05	64.069	0.2924	-0.2125	0.3426	0.3616
9.52	044528	2/21/79	89.06	0.9126423258E 05	64.070	0.2752	-0.3239	0.3347	0.3538
9.75	045918	2/21/79	89.08	0.9126392218E 05	64.063	0.2988	1.2782	0.3320	0.3501
10.00	051432	2/21/79	89.14	0.9126372268E 05	64.067	0.3031	0.4665	0.3302	0.3474
10.26	053109	2/21/79	89.15	0.9126406358E 05	64.058	0.3317	1.4314	0.3331	0.3495
10.52	054450	2/21/79	89.13	0.9126421978E 05	64.058	0.3130	-0.4686	0.3327	0.3443
10.75	055929	2/21/79	89.19	0.9126368028E 05	64.066	0.2965	-0.4141	0.3303	0.3453
11.03	061618	2/21/79	89.22	0.9126377948E 05	64.060	0.3197	1.2097	0.3308	0.3450
11.28	062917	2/21/79	89.19	0.9126337138E 05	64.063	0.2918	-1.1418	0.3277	0.3418
11.53	064432	2/21/79	89.24	0.9126333098E 05	64.060	0.3128	1.1614	0.3274	0.3406
11.74	065907	2/21/79	89.26	0.9126321298E 05	64.062	0.3064	0.0979	0.3265	0.3392
12.00	071448	2/21/79	89.27	0.9126323088E 05	64.057	0.3118	0.6551	0.3267	0.3387
12.24	072914	2/21/79	89.28	0.9126289128E 05	64.062	0.2938	-0.7263	0.3243	0.3361
12.51	074537	2/21/79	89.28	0.9126276828E 05	64.053	0.3060	0.0815	0.3236	0.3349
12.74	075908	2/21/79	89.31	0.9126311118E 05	64.048	0.3317	1.6523	0.3258	0.3361
13.01	081459	2/21/79	89.31	0.9126277118E 05	[illegible]	0.2937	-1.4555	0.3236	0.3344
13.25	082926	2/21/79	89.30	0.9126257948E 05	[illegible]	0.3009	0.6949	0.3223	0.3328
13.48	084318	2/21/79	89.30	0.9126199028E 05	[illegible]	0.2769	-1.1019	0.3157	0.3294
13.77	090039	2/21/79	89.33	0.9126174838E 05	64.057	0.2951	1.1463	0.3172	0.3276
14.00	091424	2/21/79	89.35	0.9126166378E 05	64.047	0.3034	0.7991	0.3167	0.3268
14.26	093003	2/21/79	89.37	0.9126155958E 05	64.047	0.3021	0.2328	0.3151	0.3258

397 312

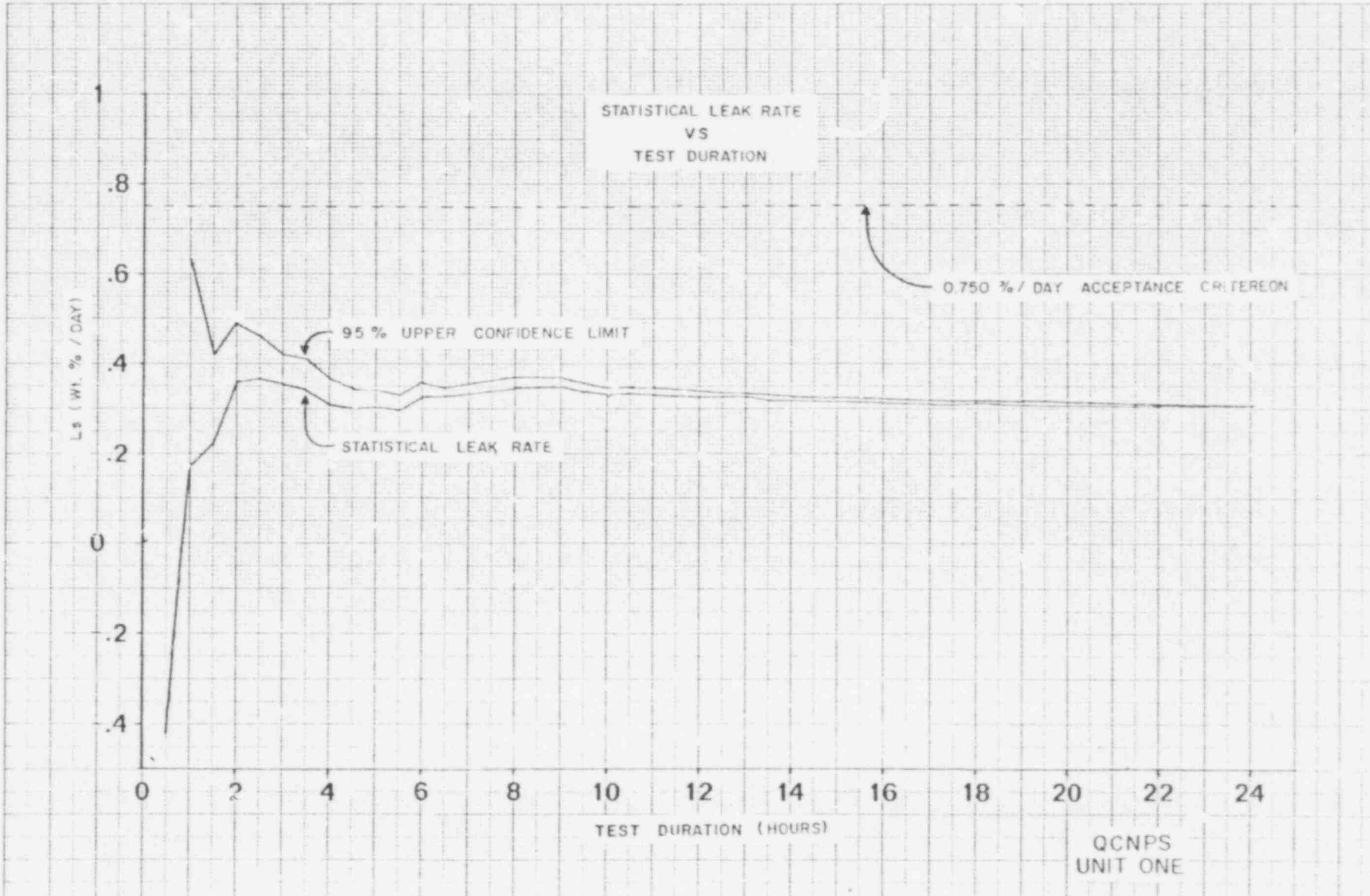
TABLE THREE (CONTINUED)

14.50	094434	2/21/79	89.38	0.912615735E	05	64.042	0.3096	0.6975	0.3162	0.3255
14.76	09595	2/21/79	89.37	0.912615506E	05	64.039	0.3067	0.1965	0.3160	0.3251
15.01	101526	2/21/79	89.38	0.912613211E	05	64.043	0.2948	-0.3796	0.3148	0.3236
15.23	102832	2/21/79	89.38	0.912614788E	05	64.032	0.3165	1.8078	0.3156	0.3242
15.56	104800	2/21/79	89.42	0.912613456E	05	64.019	0.3095	-0.4512	0.3149	0.3233
15.77	110028	2/21/79	89.38	0.912609534E	05	64.038	0.2852	-0.8646	0.3127	0.3212
16.01	111527	2/21/79	89.42	0.912607128E	05	64.037	0.2926	0.7637	0.3116	0.3198
16.27	113048	2/21/79	89.43	0.912607576E	05	64.028	0.3062	1.2878	0.3119	0.3198
16.50	114127	2/21/79	89.43	0.912604937E	05	64.034	0.2907	-0.9598	0.3105	0.3183
16.76	120021	2/21/79	89.46	0.912603724E	05	64.030	0.2982	0.7610	0.3100	0.3175
17.07	121837	2/21/79	89.45	0.912601650E	05	64.028	0.2931	0.0152	0.3090	0.3164
17.28	123122	2/21/79	89.45	0.912602781E	05	64.019	0.3106	1.7158	0.3095	0.3167
17.52	124528	2/21/79	89.47	0.912601048E	05	64.025	0.2948	-0.8698	0.3087	0.3157
17.76	130014	2/21/79	89.47	0.912602099E	05	64.016	0.3101	1.4028	0.3092	0.3160
18.03	131603	2/21/79	89.47	0.912602960E	05	64.013	0.3088	0.2238	0.3095	0.3162
18.27	133044	2/21/79	89.47	0.912603102E	05	64.012	0.3062	0.1122	0.3095	0.3161
18.52	135141	2/21/79	89.49	0.912602227E	05	64.011	0.3040	0.1910	0.3095	0.3159
18.76	140005	2/21/79	89.50	0.912604490E	05	64.005	0.3139	1.8154	0.3102	0.3164
19.01	141523	2/21/79	89.49	0.912601285E	05	64.015	0.2875	-1.6528	0.3089	0.3150
19.26	143016	2/21/79	89.50	0.912601621E	05	64.004	0.3065	1.7585	0.3090	0.3150
19.50	145038	2/21/79	89.51	0.912600772E	05	64.004	0.3001	-0.0526	0.3085	0.3145
19.77	150037	2/21/79	89.51	0.912597969E	05	64.007	0.2889	-1.0215	0.3075	0.3134
20.02	151541	2/21/79	89.49	0.912597135E	05	63.998	0.2992	1.1110	0.3072	0.3129
20.29	153149	2/21/79	89.53	0.912597017E	05	63.997	0.3030	0.5884	0.3071	0.3127
20.52	154547	2/21/79	89.54	0.912596687E	05	63.996	0.3018	0.2009	0.3070	0.3124
20.77	160035	2/21/79	89.49	0.912594343E	05	63.994	0.2706	-0.6450	0.3061	0.3115
21.06	161819	2/21/79	89.56	0.912590775E	05	64.003	0.2835	-0.2197	0.3047	0.3102
21.27	163033	2/21/79	89.59	0.912589041E	05	63.999	0.2926	1.2386	0.3041	0.3094
21.52	161546	2/21/79	89.62	0.912587944E	05	63.999	0.2757	0.5590	0.3037	0.3089
21.85	170540	2/21/79	89.65	0.912587161E	05	63.998	0.2973	0.3996	0.3034	0.3085
22.01	171458	2/21/79	89.67	0.912585745E	05	64.001	0.2935	-0.2339	0.3029	0.3079
22.25	172947	2/21/79	89.70	0.912586757E	05	63.995	0.3066	1.4756	0.3032	0.3082
22.55	174720	2/21/79	89.73	0.912584739E	05	64.005	0.2903	-0.9555	0.3025	0.3074
22.72	175749	2/21/79	89.77	0.912583263E	05	64.000	0.2927	0.6046	0.3020	0.3068
23.02	181531	2/21/79	89.77	0.912581640E	05	64.004	0.2916	0.2107	0.3014	0.3062
23.26	182954	2/21/79	89.79	0.912582591E	05	63.995	0.3053	1.6292	0.3018	0.3064
23.52	184558	2/21/79	89.81	0.912581221E	05	64.003	0.2929	-0.7901	0.3013	0.3059
23.76	185957	2/21/79	89.81	0.912579870E	05	64.001	0.2916	0.1613	0.3008	0.3053
24.00	191423	2/21/79	89.84	0.912580510E	05	63.994	0.3043	1.5551	0.3011	0.3055
24.25	192931	2/21/79	89.81	0.912578629E	05	63.998	0.2897	-1.1071	0.3005	0.3048

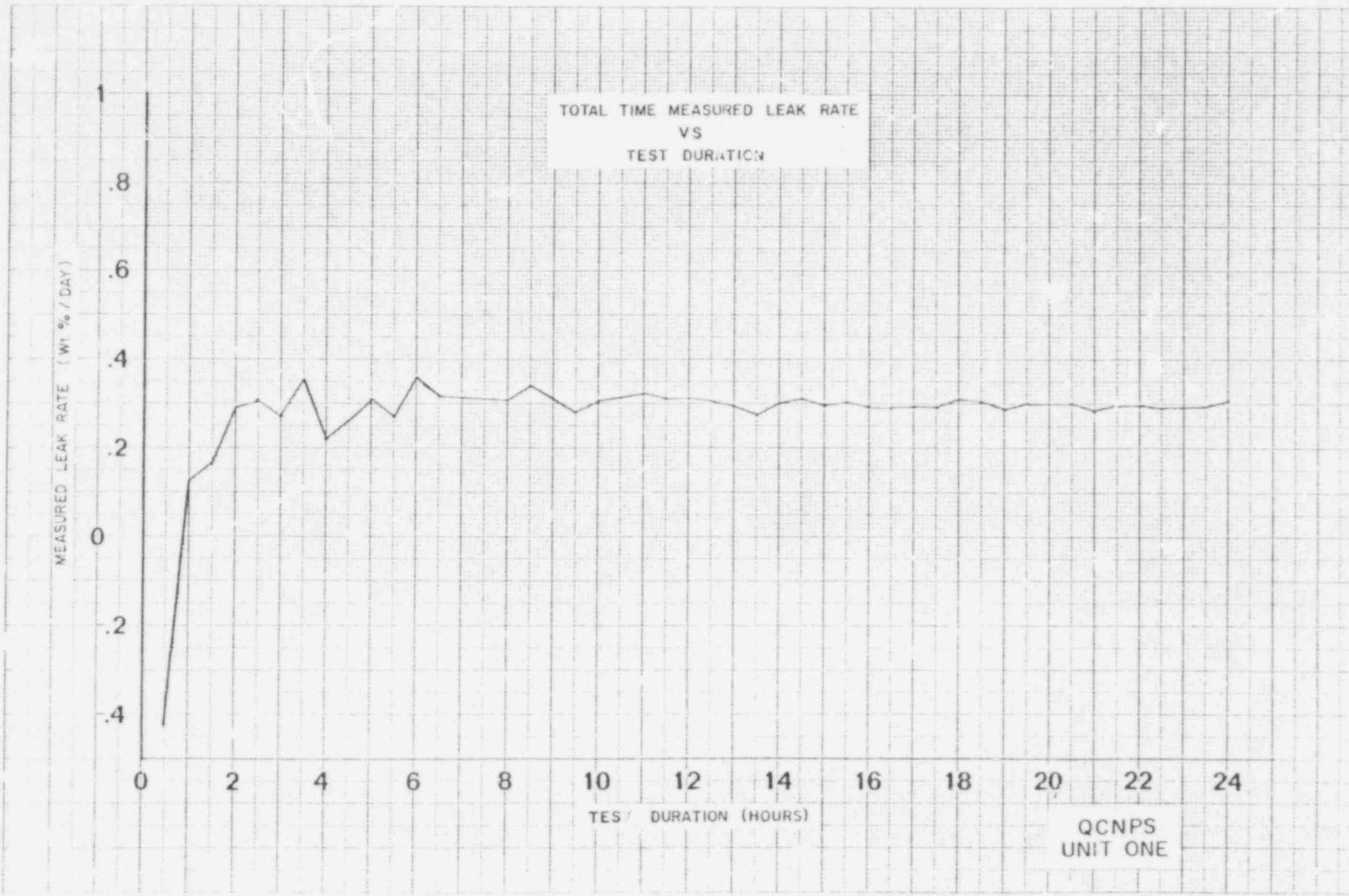
397 313

397 314

GRAPH 1

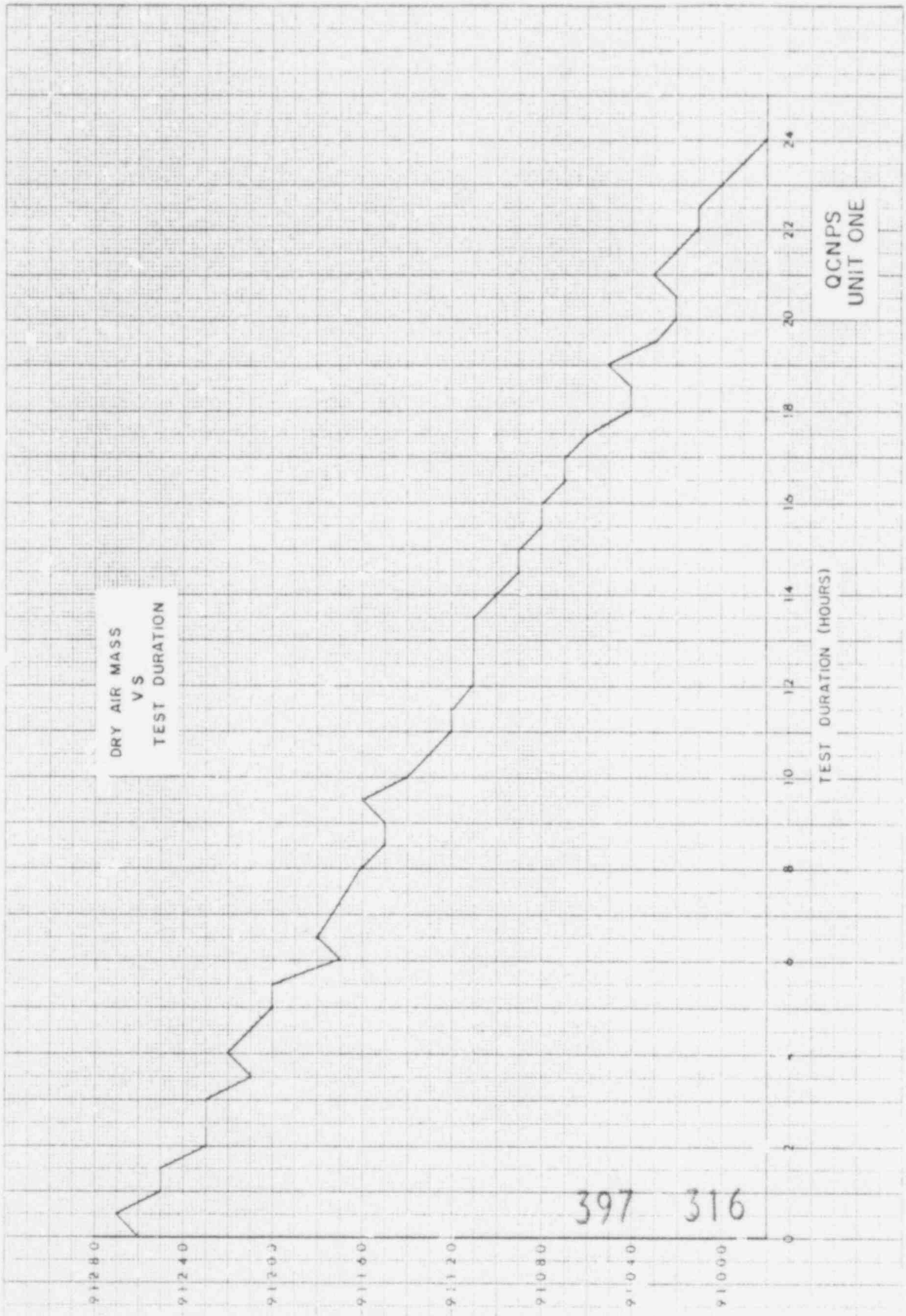


GRAPH 2

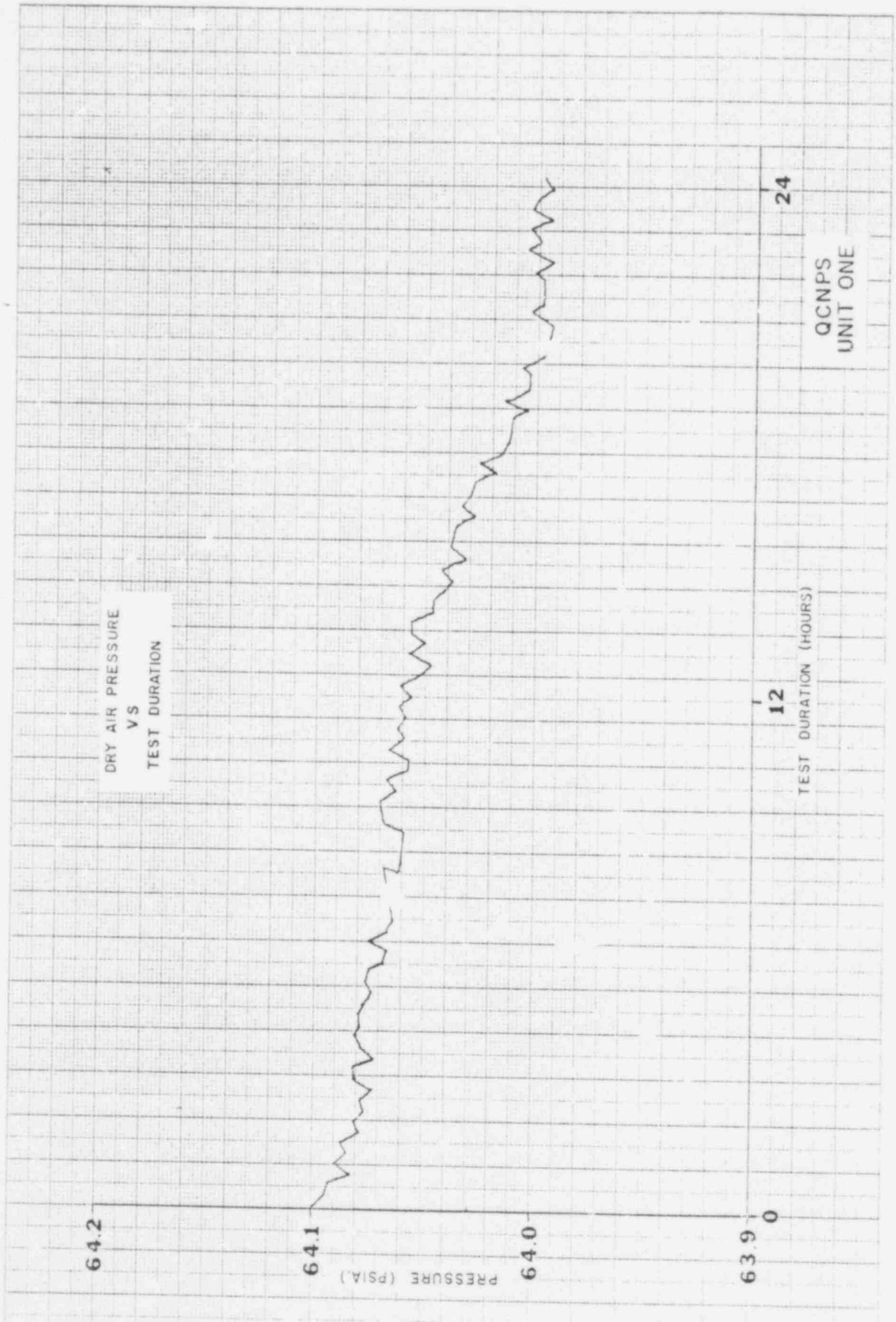


397 315

GRAPH 3

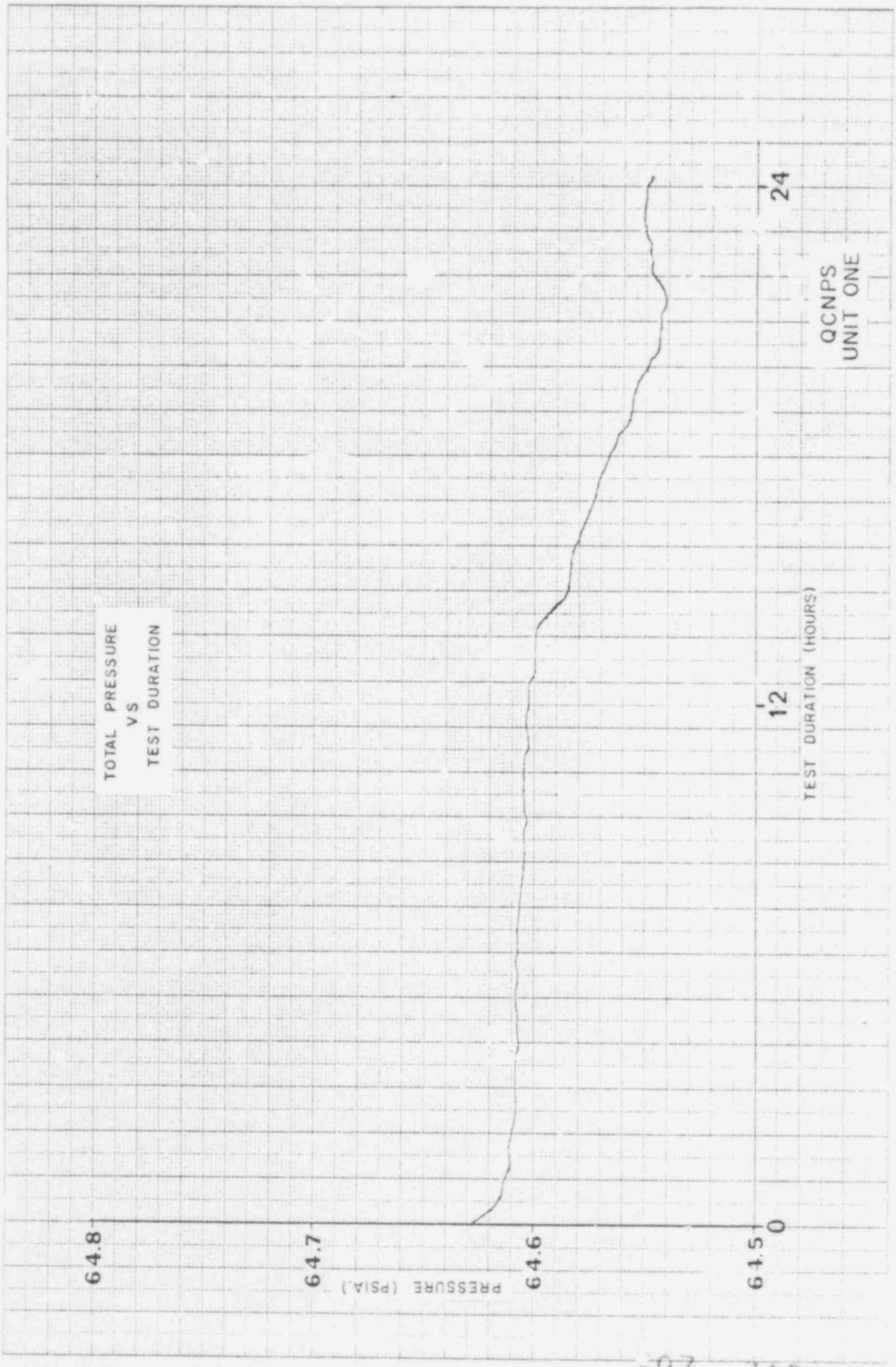

DRY AIR MASS
VS
TEST DURATION
QCNPS
UNIT ONE
TEST DURATION (HOURS)
0
2
4
6
8
10
12
14
16
18
20
22
24
DRY AIR MASS (Lbs.)
91280
91240
91200
91160
91120
91080
91040
91000
397 316

GRAPH 4



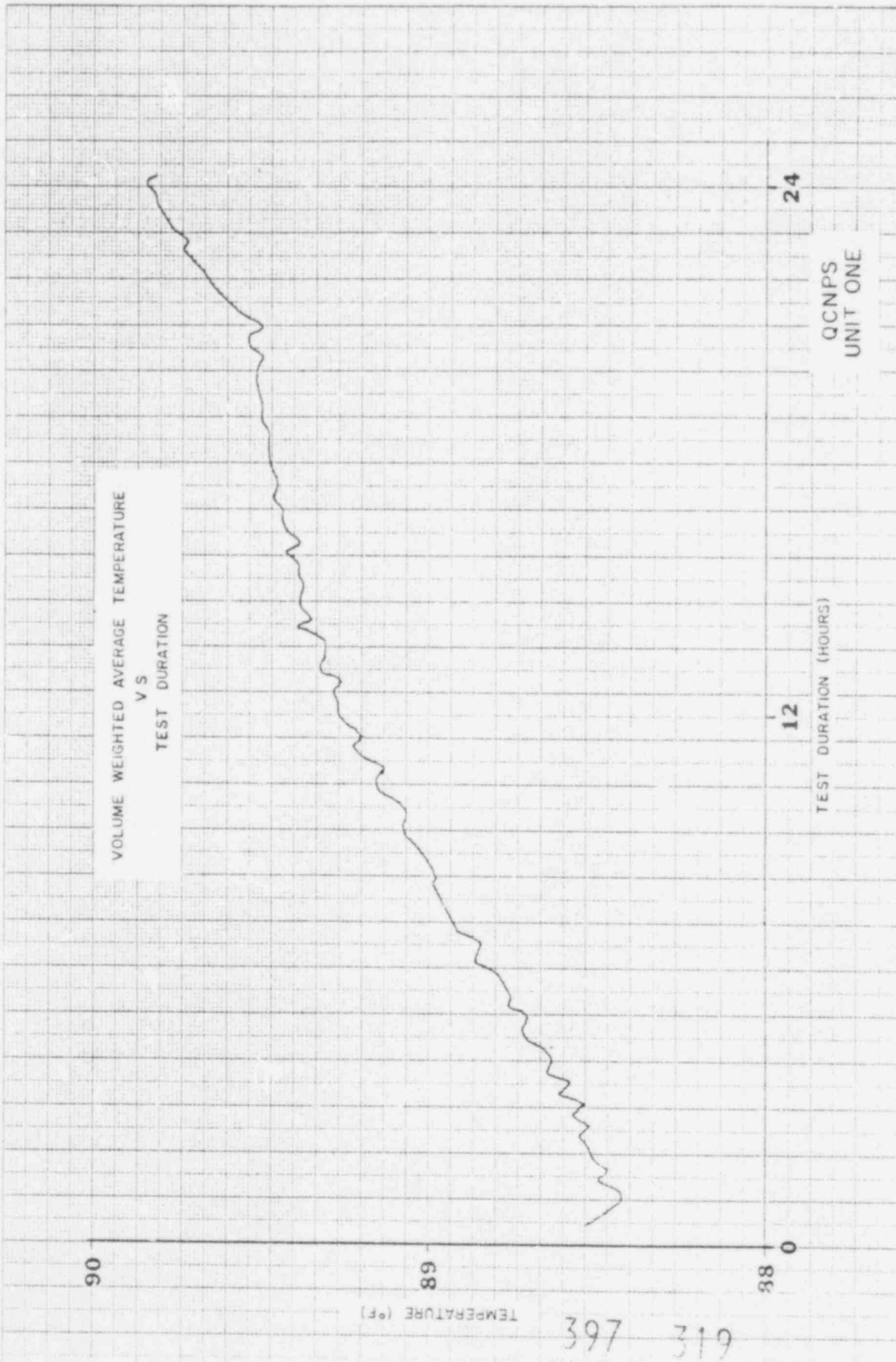
397 317

GRAPH 5

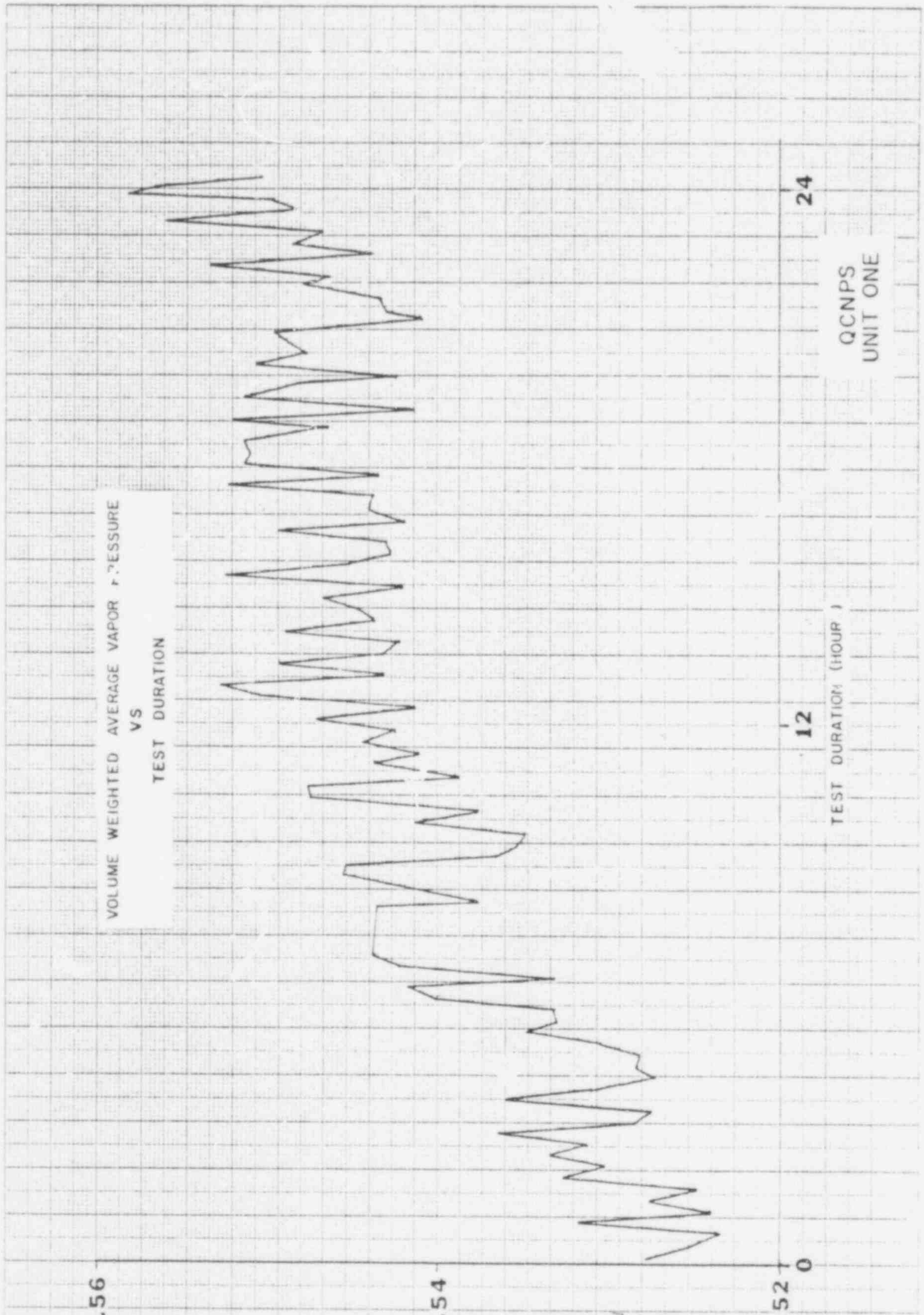


597 318

GRAPH 6


VOLUME WEIGHTED AVERAGE TEMPERATURE
VS
TEST DURATION
QCNPS
UNIT ONE
TEST DURATION (HOURS)
0
12
24
90
89
88
TEMPERATURE (°F)
397 319

GRAPH 7



VOLUME WEIGHTED AVERAGE VAPOR PRESSURE
VS
TEST DURATION
QCNPS
UNIT ONE
.56
.54
.52
VAPOR PRESSURE (PSI)
0
12
24
TEST DURATION (HOUR)
320

TABLE 4

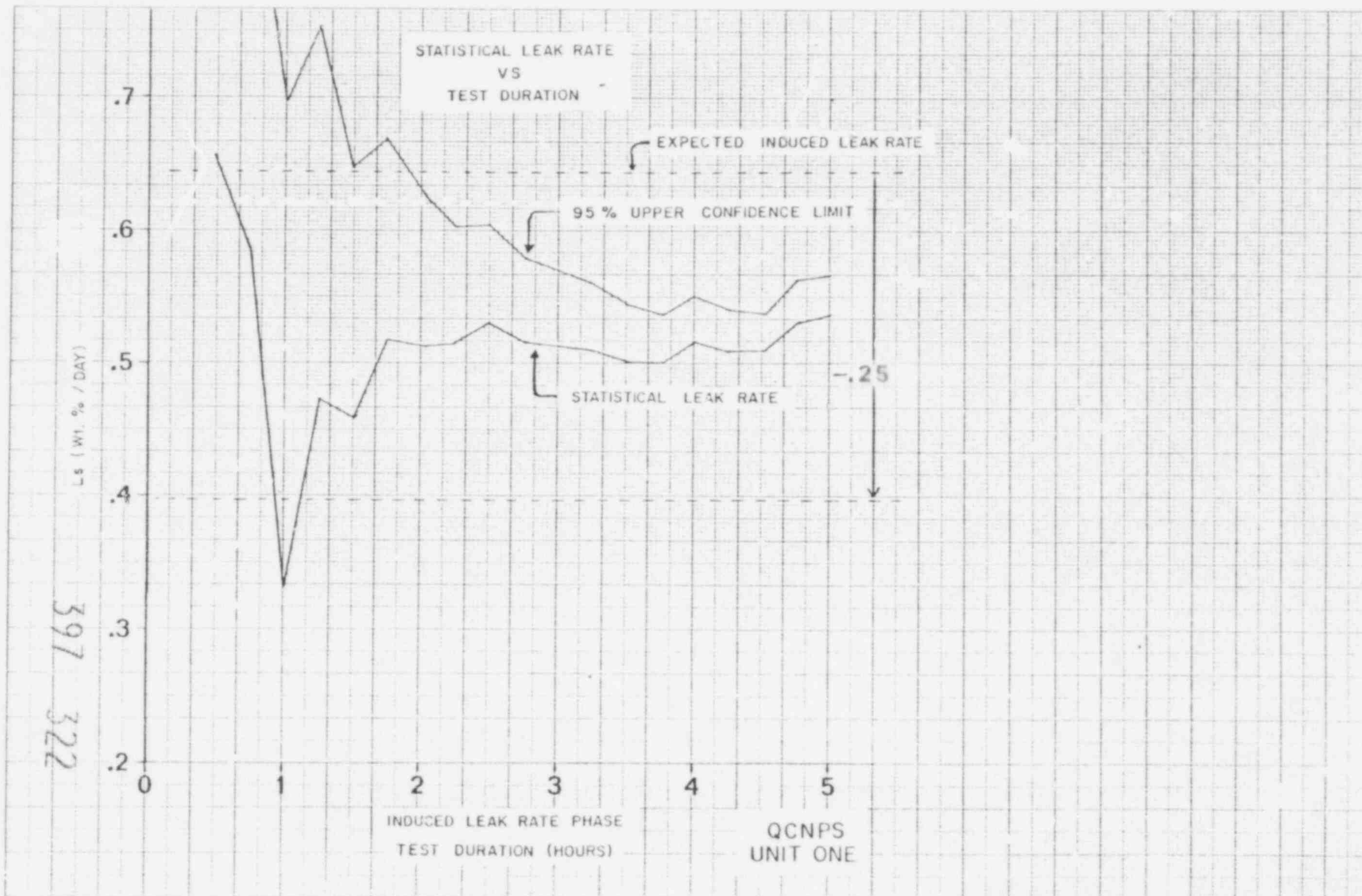
QUAD CITIES UNIT 1   0046   02/22/79

****SUMMARY OF DATA SETS 155 THRU 174 ****

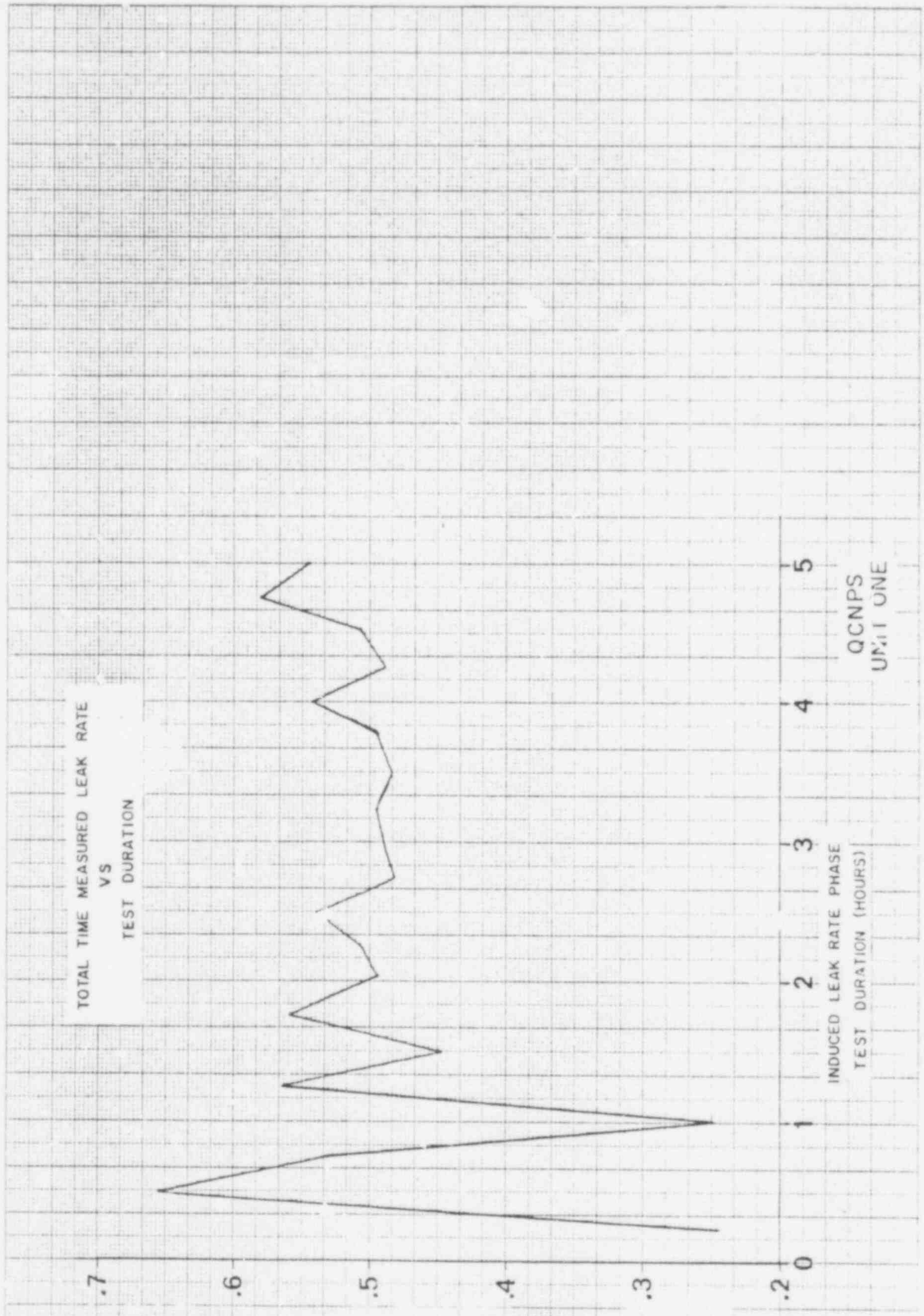
TEST DUR, HRS	TIME	DATE	TEMP (F)	CALC. MASS T=0	DRY AIR PRES (PSIA)	MEAS. LEAK RATE % / DAY TOTAL	MEAS. LEAK RATE % / DAY P[illegible]NT	CALC. LEAK RATE % / DAY	UPPER 95% CONFID LIMIT
0.00	194448	2/21/79	89.85		63.992				
0.24	195915	2/21/79	89.88		63.993	0.2461	0.2461		
0.49	201402	2/21/79	89.87	0.9097728756E 05	63.985	0.6555	1.0555	0.6571	1.7907
0.74	202921	2/21/79	89.8[illegible]	0.9097485277E 05	63.984	0.5352	0.3056	0.5870	0.8978
1.00	204447	2/21/79	89.[illegible]	0.9097446601E 05	63.988	0.2494	-0.5765	0.4319	0.6990
1.24	205927	2/21/79	89.90	0.9097623026E 05	63.976	0.5547	1.8553	0.4739	0.7539
1.49	211417	2/21/79	89.88	0.9097601126E 05	63.974	0.44[illegible]	-0.1383	0.4598	0.6442
1.75	212931	2/21/79	8[illegible].93	0.9097710776E 05	63.970	0.[illegible]4	1.2197	0.5143	0.668[illegible]
2.03	214652	2/21/79	89.96	0.9097693536E 05	63.973	0.4943	0.0951	0.5128	0.6253
2.25	215931	2/21/79	89.98	0.9097704926E 05	63.971	0.5069	0.6284	0.5154	0.6038
2.49	221429	2/21/79	89.99	0.9097749331E 05	63.966	0.5398	0.8368	0.5312	0.6045
2.75	222931	2/21/79	89.99	0.9097703031E 05	63.965	0.4819	-0.0964	0.5154	0.5739
3.23	225841	2/21/79	90.05	0.9097680566E 05	63.964	0.4748	0.5683	0.5103	0.5612
3.49	231425	2/21/79	90.05	0.9097618531E 05	63.962	0.4844	0.3570	0.5022	0.5453
3.76	233028	2/21/79	90.07	0.9097442886E 05	63.959	0.4954	0.6388	0.5008	0.5375
3.99	234426	2/21/79	90.09	0.9097711926E 05	63.953	0.5437	1.3258	0.5161	0.5513
4.24	235930	2/21/79	90.07	0.9097680785E 05	63.952	0.4888	-0.3837	0.5097	0.5412
4.52	001550	2/22/79	90.12	0.9097684275E 05	63.951	0.5073	0.7953	0.5103	0.5381
4.75	002934	2/22/79	90.14	0.9097797376E 05	63.941	0.5808	2.0341	0.5311	0.5635
5.00	004430	2/22/79	90.16	0.9097432896E 05	63.943	0.5443	-0.1533	0.5372	0.5671

397 321

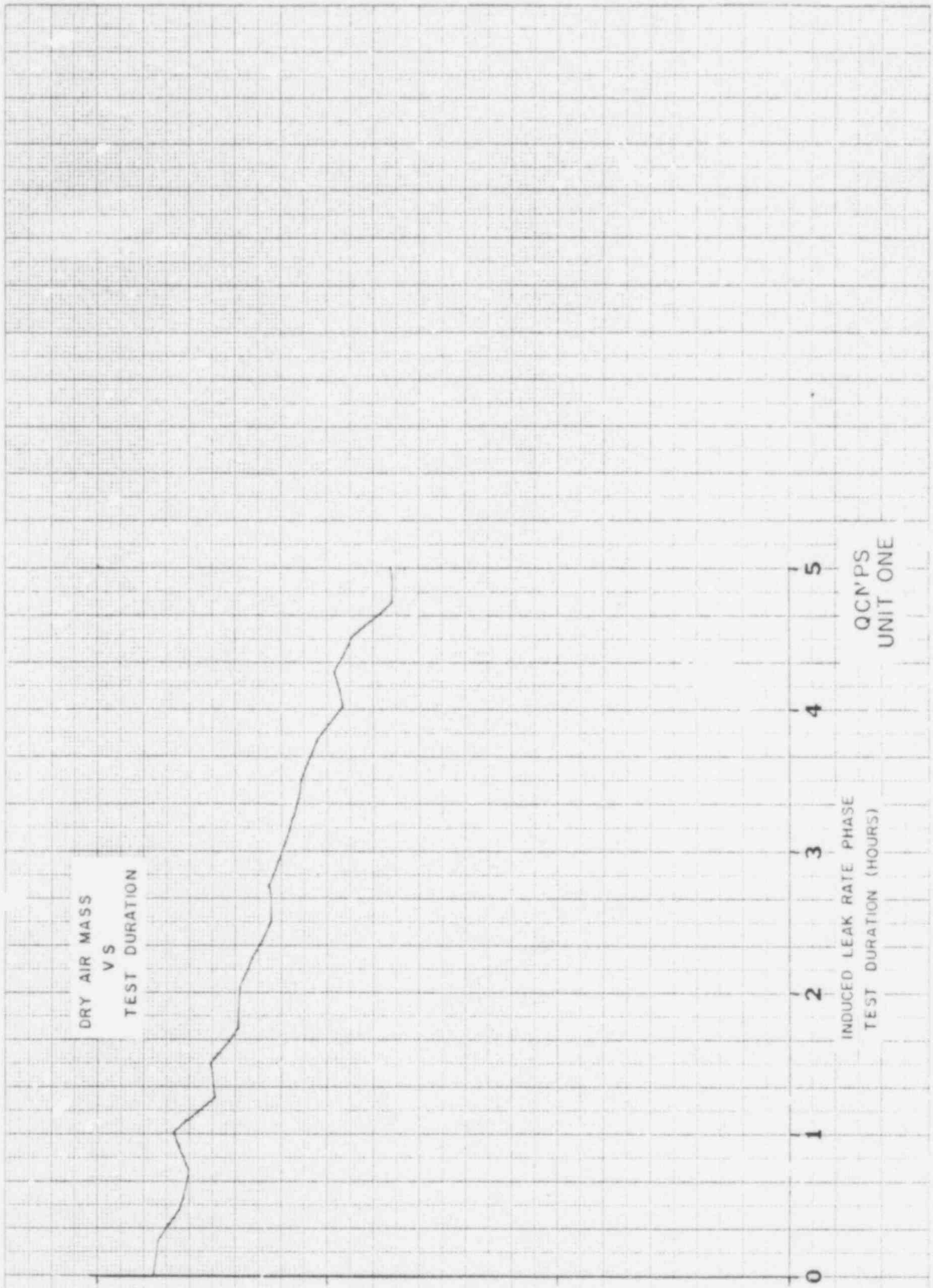
GRAPH 8



STATISTICAL LEAK RATE
VS
TEST DURATION
EXPECTED INDUCED LEAK RATE
95 % UPPER CONFIDENCE LIMIT
STATISTICAL LEAK RATE
-.25
Ls (Wt. % / DAY)
.7
.6
.5
.4
.3
.2
0
1
2
3
4
5
INDUCED LEAK RATE PHASE
TEST DURATION (HOURS)
QCNPS
UNIT ONE

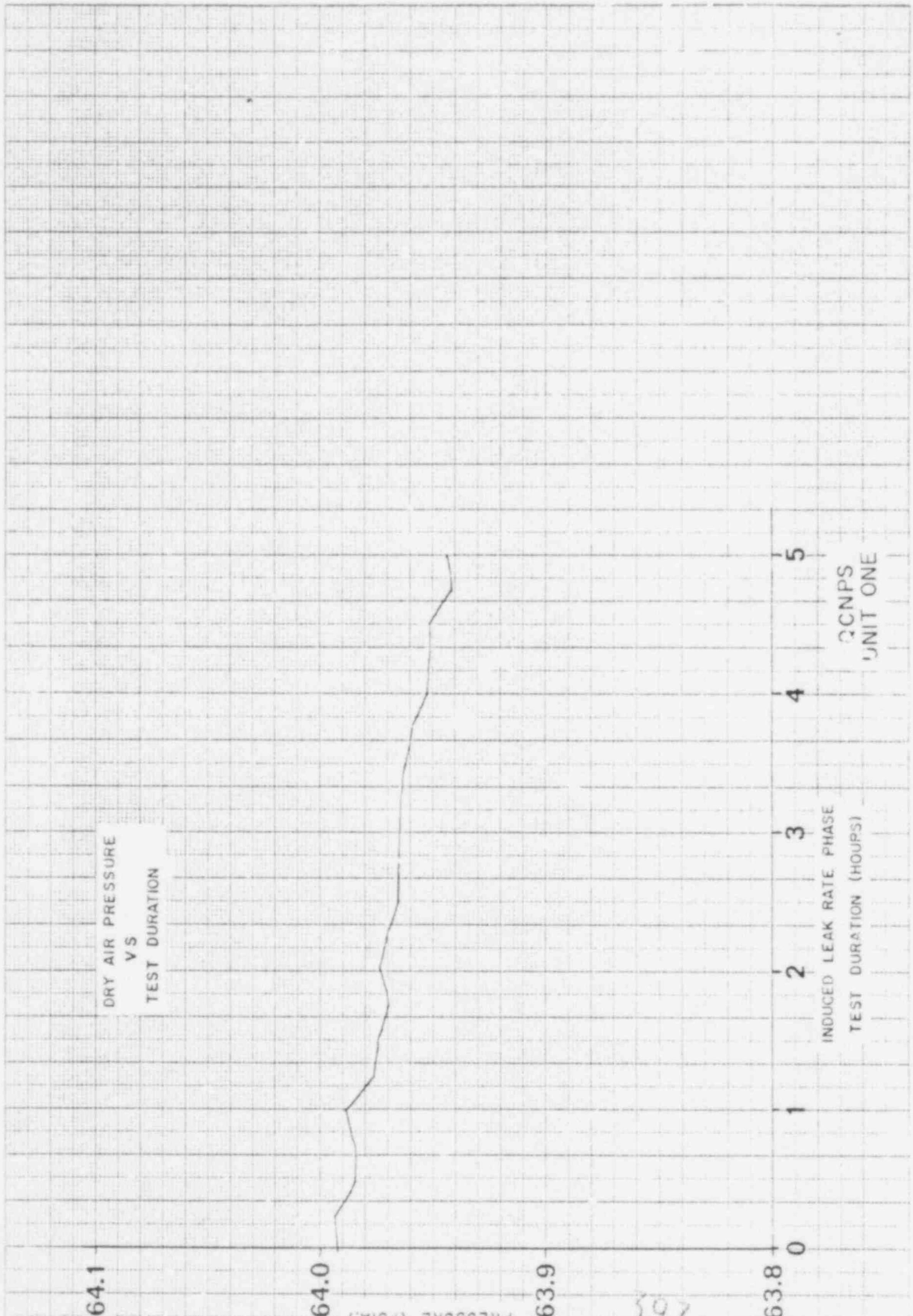

TOTAL TIME MEASURED LEAK RATE
VS
TEST DURATION
INDUCED LEAK RATE PHASE
TEST DURATION (HOURS)
0
1
2
3
4
5
QCNPS
.2
.3
.4
.5
.6
.7
MEASURED LEAK RATE (Wt. % / DAY)
323

GRAPH 10



397 324

GRAPH 11


DRY AIR PRESSURE
VS
TEST DURATION
INDUCED LEAK RATE PHASE
TEST DURATION (HOURS)
QCNPS
UNIT ONE
PRESSURE (PSIA.)
64.1
64.0
63.9
63.8
0
1
2
3
4
5
397
325

SECTION F - TYPE A TEST RESULTS AND INTERPRETATION

F.1. 24 Hour Phase Test Results

Based upon data obtained during the 24 Hour Phase, the following results were determined:

	Actual Leak Rate (wt. %/day)	Acceptance Criterion (wt. %/day)
Total Time Measured Leak Rate	0.3043	≤ 0.750
Statistically Averaged Leak Rate	0.3011	≤ 0.750
Upper 95% Confidence Limit Leak Rate	0.3055	≤ 1.000

F.2. Induced Phase Test Results

A leak of 3.0 scfm (0.342 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:

	Actual Leak Rate (wt. %/day)	Acceptance Criterion (wt. %/day)
Total Time Measured Leak Rate	0.5443	≥ 0.3931 ≤ 0.8931
Statistically Averaged Leak Rate	0.5372	≥ 0.3931 ≤ 0.8931
Upper 95% Confidence Limit Leak Rate	0.5671	≥ 0.3931 ≤ 0.8931

F.3. Leak Rate Compensation For Non-Vented Penetrations

The Integrated Primary Containment Leak Rate Test was performed with the following penetrations not drained and vented as required by 10 CFR 50, Appendix J. The "as left" leak rate of each of these penetrations, as determined by Type C testing, is also listed:

Penetration	Function	scfh	(wt %/day)
X-9A	"A" Feedwater Line	2.6	0.0050
X-9B	"B" Feedwater Line	4.4	0.0084
X12	RHR Supply	1.55	0.0030
X14	Rx Water Cleanup Supply	0	0.0000
X-41	Primary System Sample	0	0.0000
		TOTAL	0.0164

This yields the following adjusted leak rates:

Statistically Averaged Leak Rate: 0.3175 wt %/day
Upper 95% Confidence Limit Leak Rate: 0.3219 wt %/day

397 326

[illegible].4. Pre-Operational Results vs. Test Results

The successful pre-operational IPCLRT, performed April 20 to April 21, 1971, demonstrated an average measured leak rate of 0.111 wt %/day. Although the instrument uncertainty for the pre-operational IPCLRT was calculated to be 0.096 wt %/day, a number of assumptions concerning accuracies and repeatabilities using present methods were made. Using present methods yields a revised uncertainty for the test of 0.314 wt %/day.

When this value was applied to the measured leak rate of the pre-operational IPCLRT, the result was found to be very close to the current test result (0.3011 wt %/day). Although the pre-operational IPCLRT uncertainty as calculated by present analysis was larger than previously reported, the pre-operational result was still well within the acceptable limits, and helps explain the leak rate variation from the present test.

Normal component and seal wear coupled with periodic repair of components could readily account for the small variation in leak rate values between the pre-operational test and the current test.

397 327

APPENDIX A
TYPE B AND TYPE C TESTS

Presented herein are the results of local leak rate test conducted on all testable penetrations, double-gasketed seals, and isolation valves since immediately preceeding previous IPCLRT in March, 1976. 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 Specif' ation limits. These results are listed in Table A-1.

397 323

TABLE A-1

TYPE B AND TYPE 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	1.85	3-20-77	1.85	3-20-77
	Isolation	174.9	1-19-79	1.2	2-11-79
	Valves				
AO 203-2A		1.85	3-20-77	1.85	3-20-77
		115.7	1-19-79	1.2	2-24-79
AO 203-1B		1.82	3-20-77	1.82	3-20-77
		285.3	1-19-79	2.2	2-18-79
AO 203-2B		1.82	3-20-77	1.82	3-20-77
		130.7	1-19-79	3.6	2-18-79
AO 203-1C		0.0	3-20-77	0.0	3-20-77
		631.2	1-19-79	0.0	2-18-79
AO 203-2C		0.0	3-20-77	0.0	3-20-77
		81.5	1-19-79	0.0	2-18-79
AO 203-1D		0.0	3-20-77	0.0	3-20-77
		104.5	1-19-79	10.0	1-21-79
AO 203-2D		0.0	3-20-77	0.0	3-20-79
		10.5	1-19-79	10.5	1-19-79
MO 220-1	Main Steam Line	50.9	3-20-77	5.0	4-14-77
MO 220-2	Drains	43.8	1-18-79	10.5	2-7-79
AO 220-44	Primary Sample	0.005	3-20-77	0.005	3-20-77
AO 220-45		0.0	2-15-79	0.0	2-15-79
CV 220-58A	Feedwater Inlet	>1000.	4-4-77	0.45	4-21-77
	Loop "A" Inboard	2.6	2-1-79	2.6	2-1-79
CV 220-62A	Feedwater Inlet	16.5	4-4-77	16.5	4-4-77
	Loop "A" Outboard	17.	2-1-79	17.	2-1-79
CV 220-58B	Feedwater Inlet	10.4	4-2-77	10.4	4-2-77
	Loop "B" Inboard	4.4	1-20-79	4.4	1-20-79
CV 220-62B	Feedwater Inlet	2.22	4-1-77	2.22	4-1-77
	Loop "B" Outboard	2558.	1-20-79	4.4	1-26-79

397 329

TABLE A-1

TYPE B AND TYPE 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	6.0 0.0	4-25-77 2-7-79	6.0 0.0	4-25-77 2-7-79
MO 1001-23A MO 1001-26A	RHRS Containment Spray - Loop "A"	6.56 3.4	4-11-77 1-23-79	6.56 3.4	4-11-77 1-23-79
MO 1001-23B MO 1001-26B	RHRS Containment Spray - Loop "B"	1.47 0.2	3-28-77 1-26-79	1.47 0.2	3-28-77 1-26-79
MO 1001-29A	RHRS Return - Loop "A"	0.0 0.0	4-11-77 1-23-79	0.0 0.0	4-11-77 1-23-79
MO 1001-29B	RHRS Return - Loop "B"	0.0 0.0	3-28-77 1-25-79	0.0 0.0	3-28-77 1-25-79
MO 1001-34A MO 1001-36A MO 1001-37A	RHRS Suppression Chamber Spray - Loop "A"	0.38 0.0	4-11-77 1-23-79	0.38 0.0	4-11-77 1-23-79
MO 1001-34B MO 1001-36B MO 1001-37B	RHR Suppression Chamber Spray - Loop "B"	163.2 3.6	3-28-77 1-25-79	0.7 3.6	4-20-77 1-25-79
MO 1001-47 1001-50	RHRS Shutdown Cooling Suction	3.9 3.1	4-5-77 2-16-79	3.9 3.1	4-5-77 MO 2-16-79
MO 1001-60 MO 1001-63	RHRS Head Spray	0.0 0.0	4-12-77 1-29-79	0.0 0.0	4-12-77 1-29-79
MO 1201-2 1201-5	Clean-up System Suction	5.75 0.0	4-5-77 2-1-79	5.75 0.0	4-5-77 MO 2-1-79
MO 1301-16 MO 1301-17	RCIC Steam Supply	0.08 0.17	3-20-77 1-18-79	0.08 0.17	3-20-77 1-18-79
CV 1301-41	RCIC Turbine Exhaust	0.0 396.3	3-20-77 1-19-79	0.0. 0.0	3-20-77 1-27-79
CV 1301-40	RCIC Condensate Drain	0.4 1.2	3-22-77 1-19-79	0.4 1.2	3-22-77 1-19-79
AO 1601-21 1601-22 AO 1601-55 AO 1601-56	Drywell and Suppression Chamber Purge	173.8 18.08 58.3	8-3-76 3-25-77 1-22-79	12.38 18.08 14.45	8-6-76 AO 3-25-77 1-24-79
AO 1601-20A CV 1601-31A	Suppression Chamber Vent Lines #1	0.74 14.3	3-23-77 1-24-79	0.74 14.3	3-23-77 1-24-79

397 330

TABLE A-1

TYPE B AND TYPE C TEST RESULTS

VALVE(S) OR PENETRATION	TEST VOLUME	MEASURED LEAK RATE (SCFH) AS FOUND	DATE	AS LEFT	DATE
AO 1601-20B	Suppression Chamber	1.78	3-23-77	1.78	3-23-77
CV 1601-31B	Vent Lines #2	147.7	1-24-79	0.67	2-9-79
AO 1601-57	Drywell and	1.25	3-24-77	1.25	3-24-77
AO 1601-58	Suppression Chamber	2.2	1-20-79	2.2	1-20-79
AO 1601-59	Supply Air Purge				
AO 1601-23	Drywell and	4.5	4-12-77	4.5	4-12-77
AO 1601-24	Suppression Chamber	45.0	2-16-79	14.2	2-18-78
AO 1601-60	Exhaust AO 1601-61 AO 1601-62 AO 1601-63				
AO 2001-3	Drywell Floor	2.6	3-24-77	2.6	3-24-77
AO 2001-4	Drain Sump	26.0	1-30-79	1.85	2-2-79
	Dishcarge				
AO 2001-15	Drywell Equipment	4.65	3-24-77	4.65	3-24-77
AO 2001-16	Drain Sump	2.85	2-2-79	2.85	2-2-79
	Discharge				
MO 2301-4	HPCI Steam Supply	3.47	3-20-77	3.47	3-20-77
MO 2301-5		0.00	1-19-79	0.00	1-19-79
CV 2301-45	HPCI Steam Exhaust	16.3	3-22-77	16.3	3-22-77
		190.3	1-19-79	0.0	2-5-79
CV 2301-34	HPCI Condensate	0.0	3-22-77	0.0	3-22-77
	Drain	1.9	1-19-79	1.9	1-19-79
AO 4720	Drywell Pneumatic	0.0	3-31-77	0.0	3-31-77
	Suction	0.05	2-2-79	0.05	2-2-79
AO 4721		0.0	3-31-77	0.0	3-31-77
		0.7	2-2-79	0.7	2-2-79
AO 8801A	O_2 Analyzer	0.3	3-31-77	0.3	3-31-77
	Suction	0.0	2-3-79	0.0	2-3-79
AO 8801B		0.5	3-31-77	0.5	3-31-77
		0.5	2-3-79	0.5	2-3-79
AO 8802B		0.0	3-31-77	0.0	3-31-77
		0.0	2-3-79	0.0	2-3-79
AO 8801C		0.0	3-31-77	0.0	3-31-77
		0.0	2-3-79	0.0	2-3-79

397 331

TABLE A-1

TYPE B AND TYPE C TEST RESULTS

VALVE(S) OR PENETRATION	TEST VOLUME	MEASURED LEAK RATE (SCFH) AS FOUND	DATE	AS LEFT	DATE
AO 8802C	O_2 Analyzer Suction	0.1 0.0	3-31-77 2-3-79	0.1 0.0	3-31-77 2-3-79
AO 8801D		1.1 0.1	3-31-77 2-3-79	1.1 0.1	3-31-77 2-3-79
AO 8802D		1.2 0.15	3-31-77 2-3-79	1.2 0.15	3-31-77 2-3-79
AO 8803 AO 8804	O_2 Analyzer Return	2.0 11.5	3-25-77 1-30-79	2.0 11.5	3-25-77 1-30-79
733 - #1	T.I.P. Line #1	15.0 5.1	4-20-77 1-31-79	9.0 5.1	4-20-77 1-31-79
733 - #2	T.I.P. Line #2	4.5 0.0	4-20-77 1-31-79	0.0 0.0	4-20-77 1-31-79
733 - #3	T.I.P. Line #3	2.1 1.85	4-20-77 1-31-79	2.1 1.85	4-20-77 1-31-79
733 - #4	T.I.P. Line #4	8.1 0.0	4-20-77 1-31-79	0.0 0.0	4-20-77 1-31-79
733 - #5	T.I.P. Line #5	0.4 0.25	4-20-77 1-31-79	0.4 0.25	4-20-77 1-31-79
700 - 743	T.I.P. Purge Line	2.8 2.7	4-20-79 1-31-79	2.8 2.7	4-20-77 1-31-79
S.O.-1-2499-1A S.O.-1-2499-2A	ACAD/CAM Calibration Gas Supply	0.0	2-14-79	0.0	2-14-79
S.O.-1-2499-3A S.O.-1-2499-4A	ACAD/CAM Calibration Gas Supply	0.0	2-14-79	0.0	2-14-79
S.O.-1-2499-1B S.O.-1-2499-2B	ACAD/CAM Calibration Gas Supply	0.0	2-14-79	0.0	2-14-79
S.O.-1-2499-3B S.O.-1-2499-4B	ACAD/CAM Calibration Gas Supply	0.0	2-14-79	0.0	2-14-79
FCV-1-2599-1A FCV-1-2599-1B	ACAD/CAM Drywell Air Control	0.55	2-14-79	0.55	2-14-79
A.O.-1-2599-2A C.V.-1-2599-23A	ACAD/CAM Drywell Air Isolation	0.0	2-14-79	0.0	2-14-79

397 332

TABLE A-1

TYPE B AND TYPE C TEST RESULTS

VALVE(S) OR PENETRATION	TEST VOLUME	MEASURED LEAK RATE (SCFH) AS FOUND	DATE	AS LEFT	DATE
X-200A	Torus Access Hatch 582' 120° (North)	0.00	5-9-77	0.00	5-9-77
		0.00	1-12-79	0.00	1-12-79
		0.35	2-18-79	0.35	1-18-79
		0.00	2-19-79	0.00	2-19-79
X-200B	Torus Access Hatch 582' 240° (South)	0.00	8-5-76	0.00	8-5-76
		0.00	5-9-77	0.00	5-9-77
		0.00	12-31-77	0.00	12-31-77
		0.00	1-12-79	0.00	1-12-79
		0.90	2-18-79	0.90	2-18-79
		1.40	2-24-79	1.40	2-24-79
Drywell Head	Drywell Head Flange	0.00	5-7-77	0.00	5-7-77
		730.	1-18-79	0.00	2-18-79
SL-1	Shear Lug Inspection Hatches	0.0	4-6-77	0.0	4-6-77
		0.0	1-31-79	0.0	1-31-79
SL-2		0.0	4-6-77	0.0	4-6-77
		0.0	1-31-79	0.0	1-31-79
SL-3		0.0	4-6-77	0.0	4-6-77
		0.0	1-31-79	0.0	1-31-79
SL-4		0.0	4-6-77	0.0	4-6-77
		0.0	1-31-79	0.0	1-31-79
SL-5		0.0	4-6-77	0.0	4-6-77
		0.0	1-31-79	0.0	1-31-79
SL-6		0.0	4-6-77	0.0	4-6-77
		0.0	1-31-79	0.0	1-31-79
SL-7		0.0	4-6-77	0.0	4-6-77
		0.0	1-31-79	0.0	1-31-79
SL-8		0.0	4-6-77	0.0	4-6-77
		0.0	1-31-79	0.0	1-31-79
X-7A	Primary Steam 595' 6°	0.00	3-29-77	0.00	3-29-77
		0.00	1-25-79	0.00	1-25-79
X-7B	Primary Steam 595' 15°	1.3	3-29-77	1.3	3-29-77
		0.65	1-25-79	0.65	1-25-79
X-7C	Primary Steam 595' 345°	0.00	3-29-77	0.00	3-29-77
		0.00	1-25-79	0.00	1-25-79
X-7D	Primary Steam 959' 355°	0.00	3-29-77	0.00	3-29-77
		0.00	1-25-79	0.00	1-25-79
X-8	Primary Steam Drain Line 592' 0°	0.00	3-29-77	0.00	3-29-77
		0.00	1-25-79	0.00	1-25-79

397 333

TABLE A-1

TYPE B AND TYPE C TEST RESULTS

VALVE(S) OR PENETRATION	TEST VOLUME	MEASURED LEAK RATE (SCFH) AS FOUND	DATE	AS LEFT	DATE
X-9A	Reactor Feedwater 598' 9°	0.00 0.00	3-29-77 1-25-79	0.00 0.00	3-29-77 1-15-79
X-9B	Reactor Feedwater 598' 350°	0.00 0.00	3-29-77 1-25-79	0.00 0.00	3-29-77 1-25-79
X-10	Steam to RCIC 605' 6°	0.1 0.0	3-29-77 1-25-79	0.1 0.0	3-29-77 1-25-79
X-11	HPCI Steam Supply 591' 95°	0.0 0.0	3-29-77 1-25-79	0.0 0.0	3-29-77 1-25-79
X-12	RHRS Supply 605' 343°	0.0 2.5	2-29-77 1-25-79	0.0 2.5	3-29-77 1-25-79
X-13A	RHRS Return 591' 85°	0.0 0.00	3-29-77 1-25-79	0.0 0.0	3-29-77 1-25-79
X-13B	RHRS Return 591' 265°	0.5 0.0	3-29-77 1-25-79	0.5 0.0	3-29-77 1-25-79
X-14	Clean-up Supply 625' 270°	0.0 0.0	3-29-77 1-25-79	0.0 0.0	3-29-77 1-25-79
X-23	Cooling Water Supply 591' 50°	0.15 0.3	3-29-77 1-25-79	0.15 0.3	3-29-77 1-25-79
X-24	Cooling Water Return 588' 50°	0.0 0.0	3-29-77 1-25-79	0.0 0.0	3-29-77 1-25-79
X-25	Vent From Drywell 649' 213°	0.0 0.05	3-29-77 1-25-79	0.0 0.05	3-29-77 1-25-79
X-26	Vent to Drywell 591' to 232°	0.3 0.05	3-29-77 1-25-79	0.3 0.05	3-29-77 1-25-79
X-36	CRD Hyd Sys Return 618' 195°	0.1 0.05	3-29-77 1-25-79	0.1 0.05	3-29-77 1-25-79
X-47	Standby Liquid Con- trol 641' 298°	0.0 0.0	3-29-77 1-25-79	70.0 0.0	3-29-77 1-25-79
X-17	Reactor Vessel Head Spray 605'0"	0.0 0.0	3-29-77 1-25-79	0.0 0.0	3-29-77 1-25-79
X-16A	Core Spray Inlet 642' 20°	0.0 0.7	3-29-77 1-25-79	0.0 0.7	3-29-77 1-25-79
X-16B	Core Spray Inlet 642' 155°	0.0 0.15	3-29-77 1-25-79	0.0 0.15	3-29-77 1-25-79
X-100A	CRD Position Indic. 611' 40°	0.0 0.0	4-1-77 1-31-79	0.0 0.0	4-1-79 1-31-79

397 331

TABLE A-1

TYPE B AND TYPE C TEST RESULTS

VALVE(S) OR PENETRATION	TEST VOLUME	MEASURED LEAK RATE (SCFH) AS FOUND	- DATE	AS LEFT	- DATE
X-100B	Power 611' 45°	0.0 0.0	4-1-77 1-31-79	0.0 0.0	4-1-77 1-31-79
X-100C	Neutron Monitor 609' 160°	0.0 0.0	3-29-77 1-27-79	0.0 0.0	3-29-77 1-27-79
X-100D	Neutron Monitor 611' 170°	0.0 0.0	3-29-77 1-27-79	0.0 0.0	3-29-79 1-27-79
X-100E	Neutron Monitor 611'220°	0.0 0.0	3-30-77 1-26-79	0.0 0.0	3-30-77 1-26-79
X-100F	CRD Position Indic. 610' 322°	0.0 0.0	3-29-77 2-26-79	0.0 0.0	3-29-77 2-26-79
X-100G	Power 610' 33°	0.0 0.0	3-29-77 2-2-79	0.0 0.0	3-29-77 2-2-79
X-101A	CRD Position Indic. 601' 142°	0.0 0.0	3-29-77 1-27-79	0.0 010	3-24-77 1-27-79
X-101B	CRD Position Indic. 601' 147°	0.0 0.0	3-29-77 1-27-79	0.0	3-29-77
X-101D	Recirc Pump Power 601' 127°	0.0 0.0	3-29-77 2-2-79	0.0 0.0	3-29-77 2-2-79
X-102A	Recirc Pump Power 609' 127°	0.0 0.15	3-31-77 1-27-79	0.0 0.15	3-31-77 1-27-79
X-103	Thermocouple 609' 130°	0.0 0.0	3-29-77 1-27-79	0.0 0.0	3-29-77 1-27-79
X-104B	CRD Position Indic. 611' 30°	0.0 0.0	4-1-77 1-31-79	0.0 0.0	4-1-77 1-31-79
X-104C	Recirc Pump Power 609' 125°	0.0 0.0	3-31-77 2-2-79	0.0 0.0	3-31-77 2-2-79
X-104F	Power 610' 337°	0.0 0.0	3-29-77 2-2-79	0.0 0.0	3-29-77 2-2-79
X-105A	Power 611' 52°	0.0 0.0	4-1-77 1-31-79	0.0 0.0	4-1-77 1-31-79
X-105B	Power Drive Modules 611' 20°	0.0 0.0	3-31-77 1-26-79	0.0 0.0	3-31-77 1-26-79
X-105C	CRD Position Indic. 611' 205°	0.0 0.0	3-31-77 1-26-79	0.0 0.0	3-31-77 1-26-79

397 335

TABLE A-1

TYPE B AND TYPE C TEST RESULTS

VALVE(S) OR PENETRATION	TEST VOLUME	MEASURED LEAK RATE (SCFH) AS FOUND	DATE	AS LEFT	DATE
X-105D	Recirc Pump Power 611' 300°	0.0	3-29-77	0.0	3-29-77
		0.0	2-2-79	0.0	2-2-79
X-107A	Neutron Monitor 611' 215°	0.0	3-30-77	0.0	3-30-77
		0.0	1-26-79		1-26-79
X-227A	ACAD-CAM 583' 292°	0.3	2-18-79	0.3	2-18-79
X-227B	ACAD-CAM	0.0	2-18-79	0.0	2-18-79

397 336

APPENDIX B

AS FOUND LEAK RATES

The As Found leak rate for primary containment isolation valves, excluding the Main Steam Isolation Valves and leakages identified during this IPCLRT, was 772.17 scfh which was in excess of the allowable Technical Specification Limit of 110.18 scfh. The total leak rates prior to and after the outage are as summarized as follows:

ITEM	AS FOUND LEAK RATE (SCFH)	AS LEFT LEAK RATE (SCFH)	TECHNICAL SPECIFICATION LIMIT (SCFH)
Isolation valves (except MSIV's)		772.12	57.41
and			Total 110.18
Testable Penetrations	4.9	4.9	
Double Gasketed Seals	<30	14.35	36.72
Main St Isolation Valves (tested at 25 psig)			
AO .03-1A	174.9	1.2	11.5
.0-20[illegible]A	115.7	1.2	11.5
AO-203-1B	285.3	2.2	11.5
AO-203-2B	130.7	3.6	11.5
AO-203-1C	631.2	0.0	11.5
AO-203-2C	81.5	0.0	11.5
AO-203-1D	104.5	10.0	11.5
AO-203-2D	10.5	10.5	11.5
Total Through Leakage @25 psig	338.4	13.9	
Total adjusted through leakage @48 psig	649.73	26.69	
Total through leakage @48 psig	1456.8	103.35	

397 337

Complete details of these local leak rate test results are contained in Reportable Occurrence Repo t RO-79-03/03L.

In addition to these LLRT results, the following leakages were identified and repaired while the primary containment was at 48 psig for the IPCLRT:

Item	AS FOUND LEAK RATE (SCFH)
Drywell cooler damper operator controls	approx. 440

This yields the following leakages:

IPCLRT Leak Rate (scfh)	147.42
As-Found Leak Rate (scfh)	1896.8
As-Left Leak Rate (scfh)	103.35
Difference of As-found and As-Left Leak Rates (scfh)	1793.45

Therefore, the total As-Found leak rate of the primary containment is the sum of the IPCLRT leak rate and the As-Found minus As-Left leak rate differential, equal to 1940 scfh. (3.964 wt %/day).

If only the leakage paths found during the IPCLRT are taken into account, the As-Found leak rate is 587.4 scfh (1.2 wt %/day) falling only 0.2 wt %/day outside the Technical Specification acceptance criteria of 1.0 wt %/day.

397 338

APPENDIX C

The following is a reproduction of the computational procedures used during the IPCLRT. Also included is a copy of the instrument error analysis.

397 339

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:

$$L(\%) = \left(\frac{24}{H}\right)(100)\left(\frac{W_1 - W_2}{W_1}\right) = \frac{2400}{H}\left(1 - \frac{T_1 P_2}{T_2 P_1}\right)$$

where L = primary containment leak rate (%/day)
H = time interval between data sets #1 & #2 (hours)
W_1 = weight of the contained dry air mass at test data set #1 (lbs)
W_2 = weight of the contained dry air mass at test data set #2 (lbs)
T_1 = volume weighted primary containment temperature at test data set #1 (^oR)
T_2 = volume weighted primary containment temperature at test data set #2 (^oR)
P_1 = dry air absolute pressure at test data set #1 (PSIA)
P_2 = 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:

$$\delta(L) = \frac{2400}{H}\left[\left(\frac{\partial L}{\partial P_1}\delta(P_1)\right)^2 + \left(\frac{\partial L}{\partial P_2}\delta(P_2)\right)^2 + \left(\frac{\partial L}{\partial T_1}\delta(T_1)\right)^2 + \left(\frac{\partial L}{\partial T_2}\delta(T_2)\right)^2\right]^{\frac{1}{2}}$$

substituting H = 24 hours

$$\frac{\partial L}{\partial P_1} = \frac{T_1 P_2}{T_2 P_1{}^2} \simeq \frac{1}{P_1}$$

$$\frac{\partial L}{\partial P_2} = -\frac{T_1}{T_2 P_1} \simeq -\frac{1}{P_1}$$

$$\frac{\partial L}{\partial T_1} = -\frac{P_2}{T_2 P_1} \simeq -\frac{1}{T_2}$$

$$\frac{\partial L}{\partial T_2} = \frac{T_1 P_2}{T_2{}^2 P_1} \simeq \frac{1}{T_2}$$

397 340

assuming $P_1 \simeq P_2 \simeq \bar{P}$ and $T_1 \simeq T_2 \simeq \bar{T}$

where $\bar{P}$ = average absolute dry air pressure (PSIA)
$\bar{T}$ = average volume weighted primary containment absolute temperature (^oR)

APPROVED
SEP 30 1976
Q.C.O.S.R.

Therefore,

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

1. Calculation of $\delta(\overline{T})$

$$\overline{T} = \sum_{j=1}^{11} (VF_j)(T_{ave,j})$$

where VF_j = the volume weighting factors

$T_{ave,j}$ = the average absolute temperature in the jth subvolume

$$T_{ave,j} = \sum_{i=1}^{N_j} \frac{T_{i,j}}{N_j}$$

where $T_{i,j}$ = the absolute temperature of the ith RTD in the jth subvolume

N_j = number of RTD's in the jth subvolume

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

$$\delta(\overline{T}) = \sum_{j=1}^{11} \frac{\partial\overline{T}}{\partial T_{ave,j}}\ \delta(T_{ave,j})$$

where $\frac{\partial\overline{T}}{\partial T_{ave,j}} = VF_j$

$$\delta(T_{ave,j}) = \frac{\text{RTD accuracy}}{(N_j)^{\frac{1}{2}}}$$

Therefore,

$$\delta(\overline{T}) = \sum_{j=1}^{11} (VF_j)(\frac{\text{RTD accuracy}}{(N_j)^{\frac{1}{2}}})$$

2. Calculation of $\delta(\overline{P})$

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

where P_T = total absolute primary containment pressure 397 341
P_V = partial pressure of water vapor in the primary containment

APPROVED
SEP 3 1976
Q. C. O. S. R.

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

$$\delta(P_V) = \sum_{j-1}^{11} (VF_j) \left(\frac{\text{dewcell accuracy}}{(N_j)^{\frac{1}{2}}}\right)$$

where PPG = precision pressure gauge

N_j = number of dewcells in the $j\underline{th}$ subvolume

Therefore,

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

3. Instrument Specifications

	RTD	PPG	Dewcell	Flowmeter
Range	32-250°F	0-100 PSIA		0-10 SCFM
Accuracy	± 0.50°F	± 0.015 PSI	± 1.0°F	± 0.1 SCFM
Repeatability	± 0.10°F	± 0.001 PSI	± 0.5°F	± 0.02 SCFM

4. Calculation of $\delta(L)$, Accuracy Analysis

Following are the designated volume fractions and sensor allocations:

Subvolume	Volume Fraction	No. of RTD's	No. of Dewcells
1	0.03477	2	0
2	0.03166	2	0
3	0.03625	2	1
4	0.01248	2	0
5	0.07958	3	0
6	0.10642	4	1
7	0.09110	4	0
8	0.08601	4	1
9	0.03075	1	1
10	0.46565	5	2
11	0.02533	2 T.C.'s	Sat.

Assume the following values:

$\overline{P}$ = 63.0 PSIA

$\overline{T}$ = 92°F = 551.7°R

Dewpoint = 80°F

397 342

APPROVED
SEP 30 1976
Q.C.O.S.R.

Therefore,

$$\delta(\overline{T}) = (0.\ \ 5477 \times \frac{0.50}{(2)^{\frac{1}{2}}}) + (0.03166 \times \frac{0.50}{(2)^{\frac{1}{2}}}) + (0.03625 \times \frac{0.50}{(2)^{\frac{1}{2}}})$$

$$+ (0.01248 \times \frac{0.50}{(2)^{\frac{1}{2}}}) + (0.07958 \times \frac{0.50}{(3)^{\frac{1}{2}}}) + (0.10642 \times \frac{0.50}{(4)^{\frac{1}{2}}})$$

$$+ (0.09110 \times \frac{0.50}{(4)^{\frac{1}{2}}}) + (0.08601 \times \frac{0.50}{(4)^{\frac{1}{2}}}) + (0.03075 \times \frac{0.50}{(1)^{\frac{1}{2}}})$$

$$+ (0.46565 \times \frac{0.50}{(5)^{\frac{1}{2}}}) + (0.02533 \times \frac{0.50}{(2)^{\frac{1}{2}}})$$

$$= 0.2630^{\circ}R$$

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

With an average dewpoint of 80°F, an accuracy of $\pm$ 1°F corresponds to $\pm$ 0.017 PSI.

$$\delta(P_V) = (0.06643 \times \frac{0.017}{(1)^{\frac{1}{2}}}) + (0.12831 \times \frac{0.017}{(1)^{\frac{1}{2}}}) + (0.19752 \times \frac{0.017}{(1)^{\frac{1}{2}}})$$

$$+ (0.11676 \times \frac{0.017}{(1)^{\frac{1}{2}}}) + (0.46565 \times \frac{0.017}{(2)^{\frac{1}{2}}}) + (0.02533 \times \frac{0.017}{(2)^{\frac{1}{2}}})$$

$$= 0.01456 \text{ PSI}$$

Therefore,

$$\delta(\overline{P}) = [(0.01061)^2 + (0.01456)^2]^{\frac{1}{2}}$$

$$= 0.01802$$

The accuracy uncertainty is then found to be

$$\delta(L) = 100 \quad [2(\frac{0.01802}{63.0})^2 + 2(\frac{0.2630}{551.7})^2]^{\frac{1}{2}}$$

$$= 0.0786 \text{ weight \%/day}$$

5. Calculation of $\delta(L)$, Repeatability Analysis

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

397 343

APPROVED

SEP 3 1976

Q. C. O. S. R.

$$\delta(\overline{T}) = (0.03477 \times \frac{0.10}{(2)^{\frac{1}{2}}})+(0.03166 \times \frac{0.10}{(2)^{\frac{1}{2}}})+(0.03625 \times \frac{0.10}{(2)^{\frac{1}{2}}})$$

$$+(0.01248 \times \frac{0.10}{(2)^{\frac{1}{2}}})+(0.07958 \times \frac{0.10}{(3)^{\frac{1}{2}}})+(0.10642 \times \frac{0.10}{(4)^{\frac{1}{2}}})$$

$$+(0.09110 \times \frac{0.10}{(4)^{\frac{1}{2}}})+(0.08601 \times \frac{0.10}{(4)^{\frac{1}{2}}})+(0.03075 \times \frac{0.10}{(1)^{\frac{1}{2}}})$$

$$+(0.46565 \times \frac{0.10}{(5)^{\frac{1}{2}}})+(0.02533 \times \frac{0.10}{(2)^{\frac{1}{2}}})$$

$$= 0.0526^{o}R$$

With an average dewpoint of 80°F, an accuracy of ± 1°F corresponds to ± 0.008 PSI.

$$\delta(P_V) = (0.06643 \times \frac{0.008}{(1)^{\frac{1}{2}}})+(0.12831 \times \frac{0.008}{(1)^{\frac{1}{2}}})+(0.19752 \times \frac{0.008}{(1)^{\frac{1}{2}}})$$

$$+(0.11676 \times \frac{0.008}{(1)^{\frac{1}{2}}})+(0.46565 \times \frac{0.008}{(2)^{\frac{1}{2}}})+(0.02533 \times \frac{0.008}{(2)^{\frac{1}{2}}})$$

$$= 0.00685 \text{ PSI}$$

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

Therefore,

$$\delta(\overline{P}) = [(0.00071)^2+(0.00685)^2]^{\frac{1}{2}}$$

$$= 0.00689$$

The repeatability uncertainty is then found to be

$$\delta(L) = 100\ [2(\frac{0.00689}{63.0})^2 + 2\ (\frac{0.0526}{551.7})^2]^{\frac{1}{2}}$$

$$= 0.0205 \text{ weight \%/day}$$

6. Total Instrument Uncertainty

$$\sigma(L)_{Total} = [(\sigma(L)_{Accuracy})^2 + (\sigma(L)_{Repeatability})^2]^{\frac{1}{2}}$$

$$= [(0.0786)^2 + (0.0205)^2]^{\frac{1}{2}}$$

$$= 0.0812 \text{ weight \%/day}$$

$$2\sigma(L)_{Total} = 0.1624 \text{ weight \%/day}$$

397 344

APPROVED
SEP 30 1976
Q. C. O. S. R.

DATA SHEETS USED AND CALCULATIONS MADE TO OBTAN HOURLY LEAK RATES

Calculations of Free Volumes and Weighting Factors

Torus

The calculated free volume of the torus is 116,937 ft^3. This free volume was calculated assuming a water height in the torus of +2.0 inches. For the IPCLRT, the water height should be 0.0 inches, which will add free air volume to the torus. This additional free volume can be calculated from:

$$V = \pi h (R^2 - r^2)$$

where V = the added free volume of the torus
h = the height change of the water in feet
R = the major radius of the torus in feet
r = the minor radius of the torus in feet

Therefore, V = +1437 ft^3.

For the purposes of this test, the torus internal vent pipe and vent header volumes have been subtracted from the torus free air volume since the air volume enclosed by the header is essentially independent of the remainder of the torus free air volume. This volume is found to be equal to 14,714 ft^3. The actual torus subvolume is found to be equal to:

116,937 + 1437 = 118,374 ft^3.

Drywell

Since the drywell and torus were divided into twelve separate subvolumes for the calculations, the FSAR numbers will serve as a comparison to the volumes calculated (see Figure 3). The total volume of the drywell was calculated to be:

V = 197,913 ft^3

this compared with the FSAR volume of the drywell of

V = 198,440 ft^3

Calculation of the shaded areas in Figure 4 gives the calculated occupied volume of the drywell. This occupied volume is

OV = 45,370 ft^3

this again, was compared to the FSAR volume. The FSAR volume for the occupied volume of the drywell is

OV = 40,204 ft^3.

397 345

APPROVED
SEP 30 1976
Q. C. O. S. R.

In this analysis, it is necessary to assume that internal drywell equipment such as pumps, piping, valves, etc. occupy an even distribution in the drywell such that the ratios are equal to the ratios of the free volumes calculated. This assumption eliminates this component from the occupied drywell volume calculation.

The free volume of each of the twelve regions in Figure 4 was then calculated according to the following volume formuli:

1. Volume of a sphere

   $V=4/3\pi r^3$

2. Volume of a right circular cylinder

   $V=\pi r^2 h$

3. Volume of a spherical segment

   $V=1/2\pi h^2(3r-h)$

The free volumes calculated are:

Free Volume #1 = 10,066 ft^3
Free Volume #2 = 9,165 ft^3
Free Volume #3 = 10,494 ft^3
Free Volume #4 = 3,612 ft^3
Free Volume #5 = 23,039 ft^3
Free Volume #6 = 30,808 ft^3
Free Volume #7 = 26,373 ft^3
Free Volume #8 = 24,900 ft^3
Free Volume #9 = 8,901 ft^3
Free Volume #10=134,808 ft^3
Free Volume #11= 7,340 ft^3

The volume weighting factors are then found to be

VF(1) = 0.03477
VF(2) = 0.03166
VF(3) = 0.03625
VF(4) = 0.01248
VF(5) = 0.07958
VF(6) = 0.10642
VF(7) = 0.09110
VF(8) = 0.08601
VF(9) = 0.03075
VF(10) = 0.46565
VF(11) = 0.02533

397 346

APPROVED
SEP 30 1976
Q.C.O.S.R.

From Figure 4, the subvolume #1 free volume is defined to be the air space above the vessel-drywell flange. The subvolume #2 free volume is the airspace between elevations 652'8" and 666'9". The subvolume #3 free volume is the airspace external to the biological shield between elevations 628'8" and 652'8". The subvolume #4 free volume is de[illegible] to be the annular airspace between the reactor vessel and the biological shield. The subvolume #5 free volume is the airspace external to the biological shield between elevations 614'6" and 628'8". The subvolume #6 free volume is the airspace external to the biological shield between elevations 602'10" and 614'6". The subvolume #8 free volume is the airspace external to the biological shield between elevations 593'0" and 602'10". The subvolume #7 free volume is the airspace external to the biological shield between elevations 579'10" and 593'0" in the drywell basement. The subvolume #9 free air volume is the airspace in the CRD pit below the reactor vessel. The subvolume #10 free air volume is the volume enclosed by the drywell-torus vent pipes, vent spheres, downcomers, torus internal vent header, and the torus airspace above 0". The subvolume #11 free air volume is the reactor vessel airspace above 35" minus the steam dryer volume and one-half of the moisture separator volume.

397 347

APPROVED
SEP 3[illegible] 1976
Q. C. O. S. R.

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.

A. Average Subvolume Temperature and Dewpoint.

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

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

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.

$$T = \sum_{j=1}^{NVOL} (VF_j) * (T_j) \; {}^oF$$

$$D.P. = \sum_{j=1}^{NVOL} (VF_j) * (D.P._j) \; {}^oF$$

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 $j = NVOL$

397 348

APPROVED
FEB 1 6 1979
Q.C.O.S.R.

C. Calculation of Dry Air Pressure.

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

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

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

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

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

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.

$$W = \frac{(28.97) * (144) * (P) * (289506 - 25 * (LEVEL - 30))}{1545.33 * (T + 459.69)}$$

where W = containment dry air mass

LEVEL = reactor water level

289506 = primary containment volume

E. Measured Leak Rate.

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

397 349

APPROVED
FEB 1 6 1979
Q.C.O.S.R.

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

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 sec

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 SQ_ARES FITTING THE IPCLRT DATA

The method of "Least Squares" is a statistical procedure for finding the best fitting regress . 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 statistic rocess, the calculated leak rate is obtained from the equation.

W = At + B

397 350

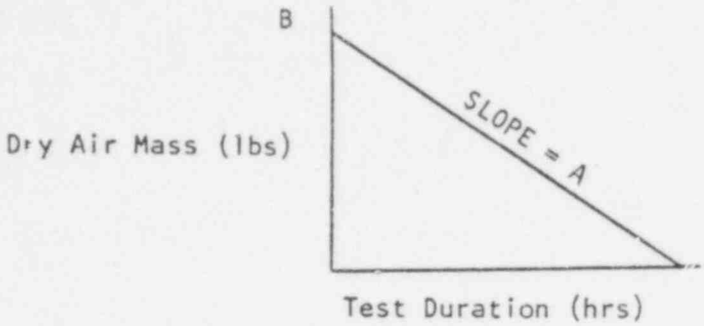
where W = contained dry air mass at time t

B = calculated dry air mass at time t = 0

A = calculated leak rate

t = test duration

APPROVED
FEB 1 6 1979
Q.C.O.S.R.



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:

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

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 T-Distribution function are used as follows.

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

397 351

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}.

APPROVED
FEB 16 1979
Q.C.Q.S.R.

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

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

397 352

APPROVED
FEB 1 6 1979
Q.C.O.S.R.

IPCLRT DEFINITIONS

(48 PSIG TEST PRESSURE)

*

Maximum Allowable Leakage Rate (L_p)

L_p = 1.0% of containment volume per day

= (0.01)(275,481 ft^3)/24 hrs. (FSAR)

= 2754.81 ft^3/24 hrs.

= 114.784 ft^3/hr.

$= (114.784\ ft^3/hr)\frac{(48 + 14.7)}{14.7} = \underline{489.59\ scfh}$

Maximum Allowable Operational Leakage Rate (L_t)

L_t = 75% of Maximum Allowable Leakage Rate

= 0.75 (114.784 ft^3/hr) = 86.088 ft^3/hr

= 0.75 (489.59 scfh) = 367.2 scfh

Maximum Allowable Leakage Rate for Double Gasketed Seals

(0.10)(367.2 scfh) = 36.72 scfh

Maximum Allowable Leakage Rate for Testable Penetrations & Isolation Valve

(0.30)(367.2 scfh) = 110.16 scfh

Maximum Allowable Leakage Rate for Any One Penetration or Isolation Valve except Main Steam Isolation Valves

(367.2 scfh)(5%) = 18.36 scfh

Maximum Allowable Leakage for any one Main Steam Isolation Valve

11.5 scfh @ 25 PSIG test pressure

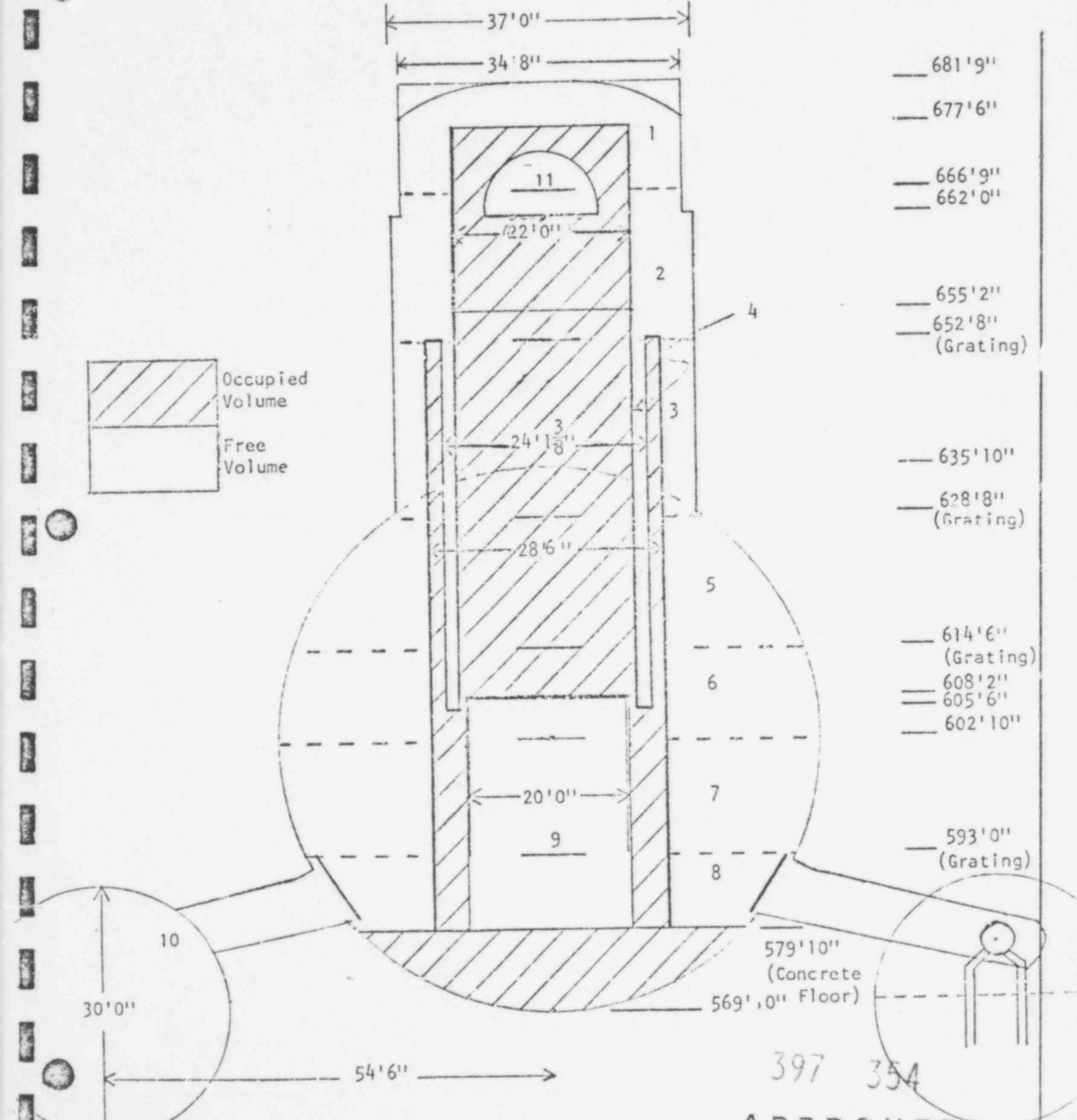
397 353

APPROVED

APR - 1977

Q. C. O. S. R.

Idealized View of Drywell and Torus
Used to Calculate Free Volumes



397 354

APPROVED
SEP 30 1976
Q. C. O. S. R.

Figure TWO