PACIFIC GAS AND ELECTRIC COMPANY

DIABLO CANYON POWER PLANT

UNIT 1

REACTOR CONTAINMENT BUILDING INTEGRATED LEAK RATE TEST

CONDUCTED ON APRIL 14 AND 15, 1985

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1. SUMMARY

This report describes the data, results, and conclusions pertaining to a Type A Integrated Leak Rate Test (ILRT) of the Diablo Canyon Power Plant Unit 1 reactor containment. The purpose of the test was to verify containment integrity as required by the Technical Specifications of Operating License DPR-80. A successful 24-hour leakage test and a 5-hour instrument verification test were conducted above the containment design pressure at a test pressure of 48.1 psig on April 14 and 15, 1985. The test verified the containment integrity.

The following table summarizes the results of the tests in terms of weight per cent per day air leakage (Lam) using the absolute method (mass point) as outlined in ANSI/ANS 56.8-1981.

	Test Result	Acceptance Criteria
ILRT Lam	0.053	0.075
Verification Lam	0.142	0.128 to 0.178

The remaining sections give the background of the test, a chronology of events, a summary of technical data, and an analysis of test results. The appendices contain tabulations of data collected, plots of important test parameters, a description of the computer program and the mathematical basis of the leak rate calculations.

2. TEST SYNOPSIS

The reactor containment Integrated Leak Rate Test was performed to quantify air leakage through the containment boundary and penetrations, and verify that this leakage was below the limit required by the plant Technical Specifications at the specified test pressure. The absolute method of testing and calculation as described in ANSI/ANS 56.8-1981 was used. Air was supplied by oil-free compressors capable of providing 10,000 scfm of air to the containment. Moisture and temperature control of the supply air were maintained by dual refrigeration units at the outlet of the air compressors.

During the test, data was collected at 15 minute intervals using a system of 24 platinum resistance temperature detectors, 6 chilled mirror dew cells, 2 quartz bourdon tube absolute pressure gauges and a data acquisition station coupled with an IBM Personal Computer. Instrument calibration and evaluation were accomplished using the guidelines of ANSI/ANS 56.8-1981 and vendor procedures. Immediate reduction of the data was made possible by a computer program described in Appendix C. Both total time and mass point calculations were available for immediate analysis of test conditions.

Prior to the start of containment pressurization, a detailed lineup of penetration boundary valves was accomplished. All boundary valves requiring operation were operated normally and liquid lines were drained to reflect required accident conditions. No repairs or adjustments were made to the containment boundary between the establishment of the lineup and the performance of the Type A test.

A satisfactory visual inspection of the containment was made prior to the start of the test.

Pressurization of containment began at 2145 hours on April 8, 1985. Containment pressurization was stopped at 10 and 20 psig to perform leak checks of containment penetrations. The reduced test pressure of 26 psig was reached at 1438 hours on April 9. After a stabilization period, a leak rate test was initiated. An unexpectedly high leak rate (0.078%/day) was observed, which was eventually traced to leakage through the steam generator instrument lines. Containment pressure was then reduced to 10 psig for personnel entry to isolate the lines. In addition, the containment ventilation penetrations and the personnel air lock were found to be slowly pressurizing; blocks were placed on these penetrations. These blocks were removed prior to the subsequent full pressure test. The significance of their leakage was originally overestimated and the leakage was subsequently calculated to have negligible effect on the containment leak rate. No repairs or adjustments of these valves were made.

After repressurization to 25.2 psig and stabilization, a second test was begun at 0200 hours on April 12. A satisfactory 24-hour test was completed on April 13. However, due to difficulty with maintaining stable Reactor Coolant System parameters during the test and hence stable containment parameters, the resultant leak rate was greater than 75% of the reduced pressure test limit given in the Technical Specifications. Subsequently, the decision was made to perform the ILRT at the full containment test pressure of 47 psig.

The pressurization to full containment test pressure was complete at 1915 hours on April 13. Failure of a pressure sensing instrument and its subsequent repair delayed the start of the ILRT until 0615 hours on April 14. The test was successfully completed at 0615 hours on April 15. Following the ILRT, an instrument verification was conducted using the superimposed leakage rate method (References 1 and 2).

The conduct of this Type A test was observed by an inspector of the Nuclear Regulatory Commission, Region V. The results of the inspection are contained in Reference 5.

3. TEST DATA SUMMARY

a. Plant Information

Owner:	Pacific Gas and Electric Company
Plant:	Diablo Canyon Power Plant, Unit 1
Location:	Avila Beach, CA 93424
Containment Type:	Reinforced Concrete PWR
Test Date:	0615 April 14, 1985 to 1400 April 15, 1985

b. Technical Data

Containment Volume:	2,550,000 cu ft
Design Pressure:	47 psig
Calc Peak Accident Pressure:	46.9 psig

c. Test Data

Method:	Absolute	
Test Pressure:	Start:	48.2 psig
	End:	48.1 psig
	Allowed:	47-49 psig

Total Time Leak Rates:	Calculated:	Allowed:
24-hour Test	0.053 wt%/day	0.075 wt%/day
Verification	0.142 wt%/day	0.128-0.178 wt%/day

d. Summary of Type B and C Leakage Test Data

	Leakage Rate in lbs/day
Personnel Air Lock	2.524
Emergency Air Lock Overall	0.70
All Electrical Penetrations	0.4426
Equipment Hatch Seals	0.0673
Fuel Transfer Tube Seals	0.052
Personnel Air Lock Seals	0.975
Emergency Air Lock Seals	0.1303
Containment Penetration Totals	76.7339
Local Leak Rate Totals	81.6251 lbs/day or 0.0103 wt%/day
Acceptance Criteria	0.06 wt%/day(0.6 La)

e. Test Equipment

1) Absolute Pressure:

Type:	Precision Quartz Bourdon Tube
Quantity:	2
Range:	0-100 psia
Accuracy:	0.02% Full Scale
Sensitivity:	0.001% Full Scale
Repeatability:	0.005% Full Scale

2) Dry Bulb Temperature:

Type:	Chilled Mirror
Quantity:	24 (22 during test)
Range:	60 - 120°F
Accuracy:	0.1 °F
Sensitivity:	0.01°F
Repeatability:	0.01°F

3) Dewpoint Temperature:

Type:	Chilled Mirror
Quantity:	6
Range:	40 - 100°F
Accuracy:	+/- 0.54°F
Sensitivity:	0.1°F
Repeatability:	0.1°F

4) Instrument Selection Guide (See Ref. 1):

	ISG = 0.0084
Allowed:	ISG = 0.0250

4. ANALYSIS

The plot of total time leak rate during the 24-hour test is shown in Figure B-1; the mass point leak rate is shown in Figure B-2. Both plots show containment downward trend during the latter half of the 24-hour test. The early part of the test shows less stability; this is due in part to the large variations which result when only a few data points have been accumulated. The second effect concerns the response of the measured leak rate to minor temperature changes within the containment. This effect is minimized as more data points are accumulated.

Calculations using both total time and mass point methods for measurement of the containment leak rate agree well. In both cases measured containment leak rate is within the limit of 0.1 wt%/day as required by the Technical Specifications. In addition, the measured leak rate is less than 75% of the specified limit and therefore meets the requirements to maintain the current 40+/-10 month surveillance interval.

The verification test superimposed a leak rate of 0.100 wt%/day (1.0La) on the measured leak rate, as shown in Figures B-6 and B-7. The measured combined leak rate was within the allowed Lc of +/-0.25La.

The summary of Type B and C leak test data shows total leakage well below that required by the Technical Specifications. The reported total Type B and C leakage of 0.0103 wt%/day satisfies the Technical Specification limit of 0.06 wt%/day (0.6 La).

During the same outage and prior to performance of the Type A test, one containment isolation valve was repaired. Before the repair, a Type C test on the valve showed a local leak rate of 2.3×10^{-7} wt%/day. This value is an insignificant addition to the measured Type A leak rate of 0.053 wt%/day.

5. REFERENCES

1. ANSI/ANS 56.8-1981, Containment System Leakage Testing Requirements.

2. ANSI N45.4-1972, Leakage Rate Testing of Containment Structures for Nuclear Reactors.

3. 10 CFR 50, Appendix J, Primary Reactor Containment Leakage Testing for Water Cooled Power Reactors.

4. BN-TOP-1 Revision 1, November 1, 1972, Testing Criteria for Integrated Leakage Rate Testing of Primary Containment Structures for Nuclear Power Plants.

5. Nuclear Regulatory Commission, Region V, Inspection Report No. 50-275/85-15, June 27, 1985.

APPENDICES

A. ILRT and Verification Test Trend Data

B. ILRT and Verification Plots

C. Mathematical Basis for ILRT Calculations

***** ILRT TREND REPORT *****

DATA SET	CLOCK TIME	TTM MEASURED (%/DAY)	TTM CALC. LR (%/DAY)	TTM UCL LR (%/DAY)	MASS PT. LEAKRATE (%/DAY)	MASS PT. UCL LR (%/DAY)
1	06:15	0.000	0.000	0.000	0.000	0.000
2	06:30	0.160	0.000	0.000	0.160	0.000
3	06:45	0.177	0.000	0.000	0.177	0.239
4	07:00	0.107	0.122	0.464	0.116	0.219
5	07:15	0.067	0.075	0.213	0.069	0.149
6	07:30	0.106	0.080	0.207	0.084	0.134
7	07:45	0.077	0.068	0.166	0.073	0.109
8	08:00	0.080	0.064	0.150	0.071	0.097
9	08:15	0.046	0.047	0.121	0.052	0.080
10	08:30	0.061	0.043	0.113	0.049	0.072
11	08:45	0.054	0.037	0.103	0.045	0.064
12	09:00	0.063	0.037	0.103	0.047	0.063
13	09:15	0.054	0.034	0.099	0.045	0.058
14	09:30	0.053	0.032	0.095	0.044	0.055
15	09:45	0.034	0.026	0.085	0.036	0.049
16	10:00	0.056	0.027	0.087	0.039	0.050
17	10:15	0.069	0.031	0.095	0.045	0.056
18	10:30	0.048	0.030	0.092	0.043	0.054
19	10:45	0.064	0.032	0.095	0.047	0.056
20	11:00	0.057	0.032	0.095	0.048	0.056
21	11:15	0.056	0.033	0.095	0.048	0.056
22	11:30	0.071	0.036	0.099	0.052	0.061
23	11:45	0.048	0.035	0.097	0.050	0.058
24	12:00	0.066	0.037	0.099	0.053	0.060
25	12:15	0.062	0.038	0.100	0.054	0.061
26	12:30	0.065	0.040	0.101	0.056	0.063
27	12:45	0.065	0.041	0.102	0.057	0.064
28	13:00	0.071	0.043	0.104	0.060	0.066
29	13:15	0.061	0.044	0.104	0.060	0.066
30	13:30	0.054	0.043	0.102	0.058	0.064
31	13:45	0.072	0.045	0.104	0.061	0.066
32	14:00	0.071	0.047	0.105	0.062	0.068

DATA SET	CLOCK TIME	TTM MEASURED (%/DAY)	TTM CALC. LR (%/DAY)	TTM UCL LR (%/DAY)	MASS PT. LEAKRATE (%/DAY)	MASS PT. UCL LR (%/DAY)
33	14:15	0.075	0.049	0.107	0.064	0.070
34	14:30	0.059	0.049	0.106	0.064	0.069
35	14:45	0.064	0.049	0.106	0.064	0.068
36	15:00	0.064	0.050	0.105	0.064	0.069
37	15:15	0.063	0.050	0.105	0.064	0.068
38	15:30	0.066	0.051	0.105	0.064	0.068
39	15:45	0.064	0.051	0.105	0.064	0.068
40	16:00	0.069	0.052	0.105	0.065	0.069
41	16:15	0.068	0.053	0.105	0.065	0.069
42	16:30	0.069	0.053	0.106	0.066	0.070
43	16:45	0.069	0.054	0.106	0.066	0.070
44	17:00	0.065	0.054	0.106	0.066	0.070
45	17:15	0.068	0.055	0.106	0.067	0.070
46	17:30	0.067	0.055	0.106	0.067	0.070
47	17:45	0.072	0.056	0.106	0.068	0.071
48	18:00	0.070	0.057	0.106	0.068	0.071
49	18:15	0.067	0.057	0.106	0.068	0.071
50	18:30	0.066	0.057	0.106	0.068	0.071
51	18:45	0.067	0.058	0.105	0.068	0.071
52	19:00	0.068	0.058	0.105	0.068	0.071
53	19:15	0.069	0.058	0.105	0.068	0.071
54	19:30	0.068	0.059	0.105	0.069	0.071
55	19:45	0.065	0.059	0.105	0.068	0.070
56	10:00	0.063	0.059	0.104	0.068	0.070
57	20:15	0.065	0.059	0.104	0.068	0.070
58	20:30	0.066	0.059	0.104	0.068	0.070
59	20:45	0.061	0.059	0.103	0.067	0.069
60	21:00	0.061	0.058	0.102	0.066	0.068
61	21:15	0.059	0.058	0.102	0.066	0.068
62	21:30	0.060	0.058	0.101	0.065	0.067
63	21:45	0.057	0.058	0.100	0.064	0.067
64	22:00	0.061	0.057	0.100	0.064	0.066
65	22:15	0.061	0.057	0.099	0.064	0.066

DATA SET	CLOCK TIME	TTM MEASURED (%/DAY)	TTM CALC. LR (%/DAY)	TTM UCL LR (%/DAY)	MASS PT. LEAKRATE (%/DAY)	MASS PT. UCL LR (%/DAY)
66	22:30	0.057	0.057	0.099	0.063	0.065
67	22:45	0.058	0.057	0.098	0.063	0.065
68	23:00	0.060	0.057	0.098	0.063	0.065
69	23:15	0.059	0.056	0.097	0.062	0.064
70	23:30	0.056	0.056	0.096	0.062	0.064
71	23:45	0.057	0.056	0.096	0.061	0.063
72	00:00	0.059	0.056	0.095	0.061	0.063
73	00:15	0.057	0.056	0.095	0.060	0.062
74	00:30	0.057	0.055	0.094	0.060	0.062
75	00:45	0.056	0.055	0.094	0.060	0.062
76	01:00	0.058	0.055	0.093	0.059	0.061
77	01:15	0.058	0.055	0.093	0.059	0.061
78	01:30	0.060	0.055	0.093	0.059	0.061
79	01:45	0.058	0.055	0.092	0.059	0.061
80	02:00	0.058	0.054	0.092	0.059	0.060
81	02:15	0.057	0.054	0.091	0.058	0.060
82	02:30	0.059	0.054	0.091	0.058	0.060
83	02:45	0.058	0.054	0.091	0.058	0.060
84	03:00	0.059	0.054	0.090	0.058	0.060
85	03:15	0.060	0.054	0.090	0.058	0.060
86	03:30	0.057	0.054	0.090	0.058	0.059
87	03:45	0.056	0.054	0.090	0.058	0.059
88	04:00	0.059	0.054	0.089	0.058	0.059
89	04:15	0.062	0.054	0.089	0.058	0.059
90	04:30	0.057	0.054	0.089	0.058	0.059
91	04:45	0.060	0.054	0.089	0.058	0.059
92	05:00	0.059	0.054	0.089	0.058	0.059
93	05:15	0.059	0.054	0.088	0.058	0.059
94	05:30	0.057	0.054	0.088	0.057	0.059
95	05:45	0.055	0.054	0.088	0,057	0.059
96	06:00	0.056	0.053	0.087	0.057	0.058
97	06:15	0.058	0.053	0.087	0.057	0.058

***** ILRT TREND REPORT *****

DATA SET	CLOCK TIME	AIR MASS (lbm)	CONTAIN. PRESSURE (psia)	VAPOR PRESSURE (psia)	AIR PRESSURE (psia)	AVG. DRY BULB TEMP (DEG F)
1	06:15	792425	62.9320	0.3150	62.617	84.210
2	06:30	792412	62.9335	0.3149	62.619	84.232
3	06:45	792396	62.9360	0.3145	62.622	84.268
4	07:00	792399	62.9371	0.3145	62.623	84.275
5	07:15	792403	62.9245	0.3145	62.610	84.163
6	07:30	792381	62.9079	0.3142	62.594	84.037
7	07:45	792387	62.8928	0.3141	62.579	83.902
8	08:00	792379	62.8803	0.3142	62.566	83.798
9	08:15	792395	62.8707	0.3141	62.557	83.705
10	08:30	792380	62.8617	0.3140	62.548	83.638
11	08:45	792381	62.8541	0.3141	62.540	83.571
12	09:00	792368	62.8476	0.3139	62.534	83.525
13	09:15	729372	62.8396	0.3138	62.526	83.454
14	09:30	792369	62.8345	0.3139	62.521	83.411
15	09:45	792386	62.8315	0.3135	62.518	83.376
16	10:00	792356	62.8300	0.3139	62.516	83.380
17	10:15	792334	62.8285	0.3137	62.515	83.384
18	10:30	792357	62.8280	0.3131	62.515	83.369
19	10:45	792331	62.8260	0.3136	62.512	83.365
20	11:00	792332	62.8255	0.3140	62.512	83.354
21	11:15	792301	62.8250	0.3139	62.511	83.353
22	11:30	792339	62.8240	0.3135	62.510	83.368
23	11:45	792300	62.8235	0.3134	62.508	83.339
24	12:00	792301	62.8215	0.3134	62.507	83.349
25	12:15	792291	62.8200	0.3135	62.506	83.334
26	12:30	792286	62.8195	0.3140	62.506	83.333
27	12:45	792266	62.8195	0.3133	62.498	83.342
28	13:00	792283	62.8144	0.3144	62.493	83.285
29	13:15	792295	62.8069	0.3155	62.510	83.233
30	13:30	792248	62.8240	0.3136	62.519	83.372
31	13:45	792243	62.8325	0.3134	62.522	83.480
32	14:00	792226	62.8361	0.3139	62.523	83.509

DATA SET	CLOCK TIME	AIR MASS (lbm)	CONTAIN. PRESSURE (psia)	VAPOR PRESSURE (psia)	AIR PRESSURE (psia)	AVG. DRY BULB TEMP (DEG F)
33	14:15	792226	62.8371	0.3139	62.523	83.531
34	14:30	792263	62.8381	0.3135	62.525	83.517
35	14:45	792246	62.8376	0.3139	62.524	83.521
36	15:00	792240	62.8376	0.3135	62.524	83.528
37	15:15	792239	62.8376	0.3137	62.524	83.527
38	15:30	792224	62.8371	0.3138	62.523	83.532
39	15:45	792224	62.8366	0.3136	62.523	83.530
40	16:00	792202	62.8356	0.3137	62.522	83.536
41	16:15	792201	62.8356	0.3138	62.522	83.535
42	16:30	792191	62.8336	0.3139	62.520	83.524
43	16:45	792186	62.8330	0.3137	62.519	83.525
44	17:00	792194	62.8330	0.3135	62.520	83.521
45	17:15	792178	62.8330	0.3133	62.520	83.533
46	17:30	792175	62.8341	0.3136	62.520	83.541
47	17:45	792152	62.8341	0.3136	62.520	83.557
48	18:00	792154	62.8341	0.3135	62.521	83.557
49	18:15	792159	62.8341	0.3132	62.521	83.556
50	18:30	792158	62.8346	0.3133	62.521	83.561
51	18:45	792147	62.8346	0.3130	62.522	83.570
52	19:00	792140	62.8356	0.3130	62.523	83.584
53	19:15	792130	62.8361	0.3131	62.523	83.595
54	19:30	792127	62.8366	0.3136	62.523	83.597
55	19:45	792137	62.8371	0.3134	62.524	83.596
56	20:00	792140	62.8386	0.3130	62.526	83.611
57	20:15	792125	62.8386	0.3130	62.526	83.620
58	20:30	792116	62.8391	0.3134	62.526	83.628
59	20:45	792135	62.8381	0.3132	62.525	83.607
60	21:00	792129	62.8381	0.3131	62.525	83.613
61	21:15	792134	62.8386	0.3131	62.525	83.613
62	21:30	792125	62.8381	0.3132	62.525	83.615
63	21:45	792132	62.8371	0.3128	62.524	84.604
64	22:00	792108	62.8356	0.3129	62.523	83.608
65	22:15	792101	62.8351	0.3129	62.522	83.607

DATA SET	CLOCK TIME	AIR MASS (lbm)	CONTAIN. PRESSURE (psia)	VAPOR PRESSURE (psia)	AIR PRESSURE (psia)	AVG. DRY BULB TEMP (DEG F)
66	22:30	792117	62.8351	0.3128	62.522	83.598
67	22:45	792108	62.8351	0.3129	62.522	83.603
68	23:00	792093	62.8351	0.3130	62.522	83.612
69	23:15	792096	62.8356	0.3125	62.523	83.619
70	23:30	792104	62.8356	0.3129	62.523	83.610
71	23:45	792096	62.8371	0.3130	62.524	83.627
72	00:00	792077	62.8381	0.3127	62.525	83.652
73	00:15	792088	62.8376	0.3129	62.525	83.638
74	00:30	792084	62.8376	0.3130	62.525	83.640
75	00:45	792084	62.8376	0.3127	62.525	83.643
76	01:00	792067	62.8381	0.3125	62.526	83.661
77	01:15	792061	62.8386	0.3124	62.526	83.670
78	01:30	792047	62.8391	0.3127	62.526	83.681
79	01:45	792052	62.8416	0.3127	62.529	83.699
80	02:00	792045	62.8421	0.3126	62.529	83.709
81	02:15	792046	62.8421	0.3127	62.529	83.708
82	02:30	792031	62.8421	0.3126	62.530	83.719
83	02:45	792034	62.8426	0.3127	62.530	83.721
84	03:00	792023	62.8426	0.3126	62.530	83.729
85	03:15	792006	62.8426	0.3127	62.530	83.740
86	03:30	792027	62.8421	0.3127	62.529	83.721
87	03:45	792029	62.8416	0.3126	62.529	83.716
88	04:00	792005	62.8376	0.3128	62.525	83.696
89	04:15	791973	62.8336	0.3127	62.521	83.684
90	04:30	792008	62.8300	0.3123	62.518	83.633
91	04:45	791977	62.8260	0.3125	62.514	83.618
92	05:00	791980	62.8245	0.3126	62.512	83.602
93	05:15	791977	62.8225	0.3121	62.510	83.591
94	05:30	791988	62.8225	0.3123	62.510	83.582
95	05:45	791995	62.8225	0.3119	62.511	83.580
96	06:00	791985	62.8210	0.3121	62.509	83.571
97	06:15	791965	62.8205	0.3125	62.508	83.578

INSTRUMENT VERIFICATION TEST

***** ILRT TREND REPORT *****

DATA SET	CLOCK TIME	TTM MEASURED (%/DAY)	TTM CALC. LR (%/DAY)	TTM UCL LR (%/DAY)	MASS PT. LEAKRATE (%/DAY)	MASS PT. UCL LR (%/DAY)
1	09:00	0.000	0.000	0.000	0.000	0.000
2	09:15	0.222	0.000	0.000	0.222	0.000
3	09:30	0.175	0.000	0.000	0.175	0.346
4	09:45	0.191	0.180	0.429	0.184	0.223
5	10:00	0.226	0.207	0.357	0.216	0.262
6	10:15	0.133	0.164	0.308	0.160	0.234
7	10:30	0.157	0.155	0.263	0.153	0.203
8	10:45	0.184	0.162	0.260	0.166	0.205
9	11:00	0.162	0.158	0.242	0.161	0.191
10	11:15	0.156	0.153	0.228	0.156	0.180
11	11:30	0.146	0.146	0.214	0.149	0.169
12	11:45	0.156	0.145	0.208	0.149	0.166
13	12:00	0.151	0.143	0.202	0.147	0.161
14	12:15	0.150	0.141	0.196	0.145	0.158
15	12:30	0.142	0.137	0.190	0.141	0.153
16	12:45	0.145	0.136	0.186	0.140	0.150
17	13:00	0.150	0.136	0.184	0.141	0.150
18	13:15	0.155	0.137	0.185	0.143	0.151
19	13:30	0.160	0.139	0.187	0.146	0.154
20	13:45	0.164	0.141	0.190	0.150	0.158
21	14:00	0.158	0.142	0.190	0.151	0.159

INSTRUMENT VERIFICATION TEST

***** ILRT TREND REPORT *****

DATA SET	CLOCK TIME	AIR MASS (lbm)	CONTAIN. PRESSURE (psia)	VAPOR PRESSURE (psia)	AIR PRESSURE (psia)	AVG. DRY BULB TEMP (DEG F)
1	09:00	791949	62.8160	0.3119	62.504	83.554
2	09:15	791931	62.8145	0.3120	62.502	83.553
3	09:30	791920	62.8135	0.3117	62.502	83.554
4	09:45	791902	62.8130	0.3117	62.501	83.562
5	10:00	791875	62.8135	0.3116	62.502	83.586
6	10:15	791894	62.8140	0.3115	62.502	83.578
7	10:30	791871	62.8140	0.3116	62.502	83.593
8	10:45	791843	62.8130	0.3116	62.501	83.604
9	11:00	791843	62.8109	0.3119	62.499	83.584
10	11:15	791833	62.8099	0.3114	62.449	83.586
11	11:30	791829	62.8074	0.3119	62.496	83.563
12	11:45	791807	62.8059	0.3117	62.494	83.566
13	12:00	791800	62.8049	0.3116	62.493	83.563
14	12:15	791789	62.8034	0.3117	62.492	83.557
15	12:30	791786	62.8014	0.3116	62.490	83.543
16	12:45	791770	62.7999	0.3114	62.489	83.542
17	13:00	791751	62.7994	0.3115	62.488	83.550
18	13:15	791731	62.7984	0.3118	62.487	83.552
19	13:30	791711	62.7974	0.3119	62.486	83.556
20	13:45	791692	62.7974	0.3121	62.485	83.568
21	14:00	791688	62.7974	0.3118	62.486	83.573

Figure B-1

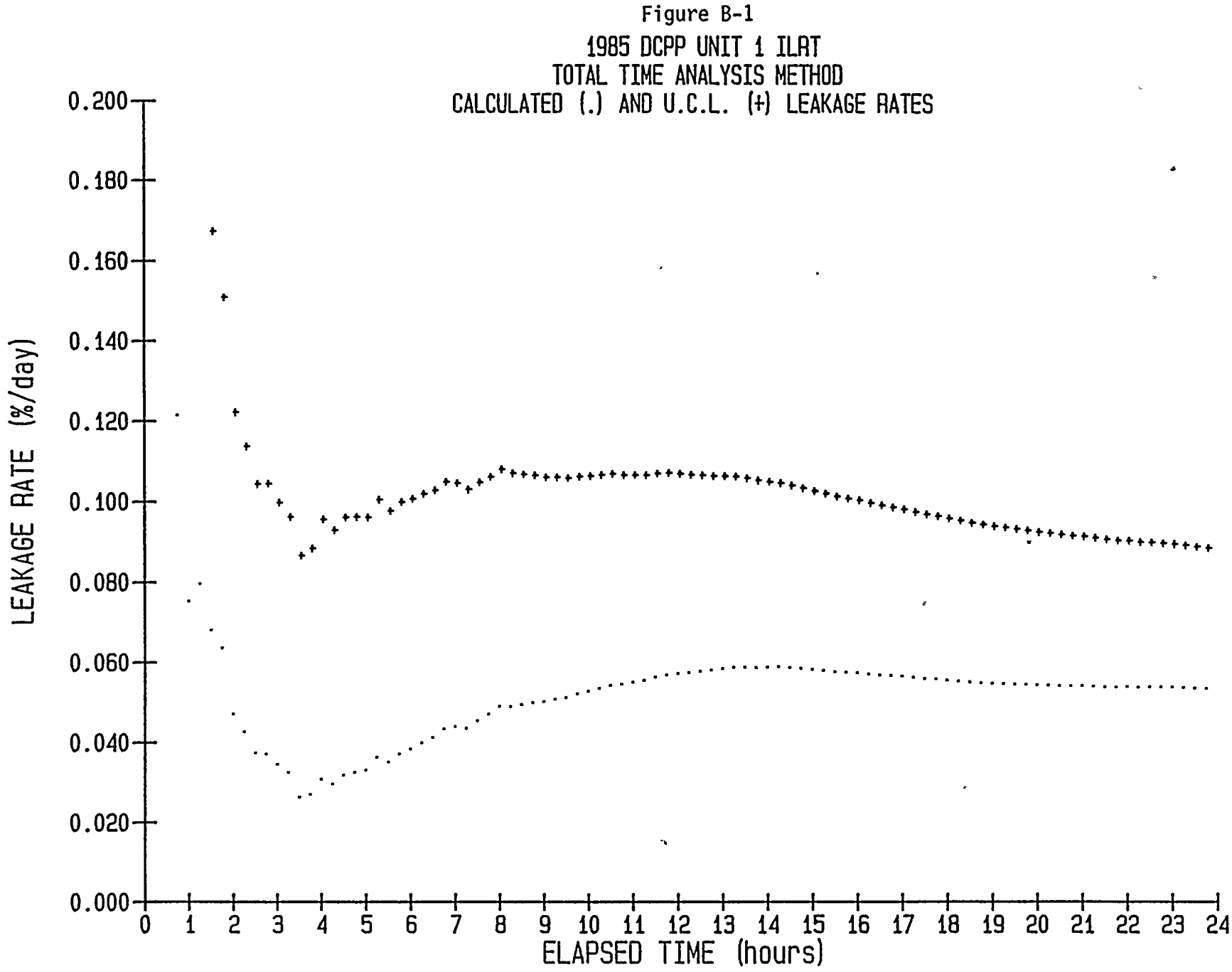

1985 DCPP UNIT 1 ILRT
TOTAL TIME ANALYSIS METHOD
CALCULATED (.) AND U.C.L. (+) LEAKAGE RATES
LEAKAGE RATE (%/day)
0.200
0.180
0.160
0.140
0.120
0.100
0.080
0.060
0.040
0.020
0.000
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
ELAPSED TIME (hours)

Figure B-2
1985 DCPP UNIT 1 ILRT
MASS POINT ANALYSIS METHOD
CALCULATED (.) AND U.C.L. (+) LEAKAGE RATES

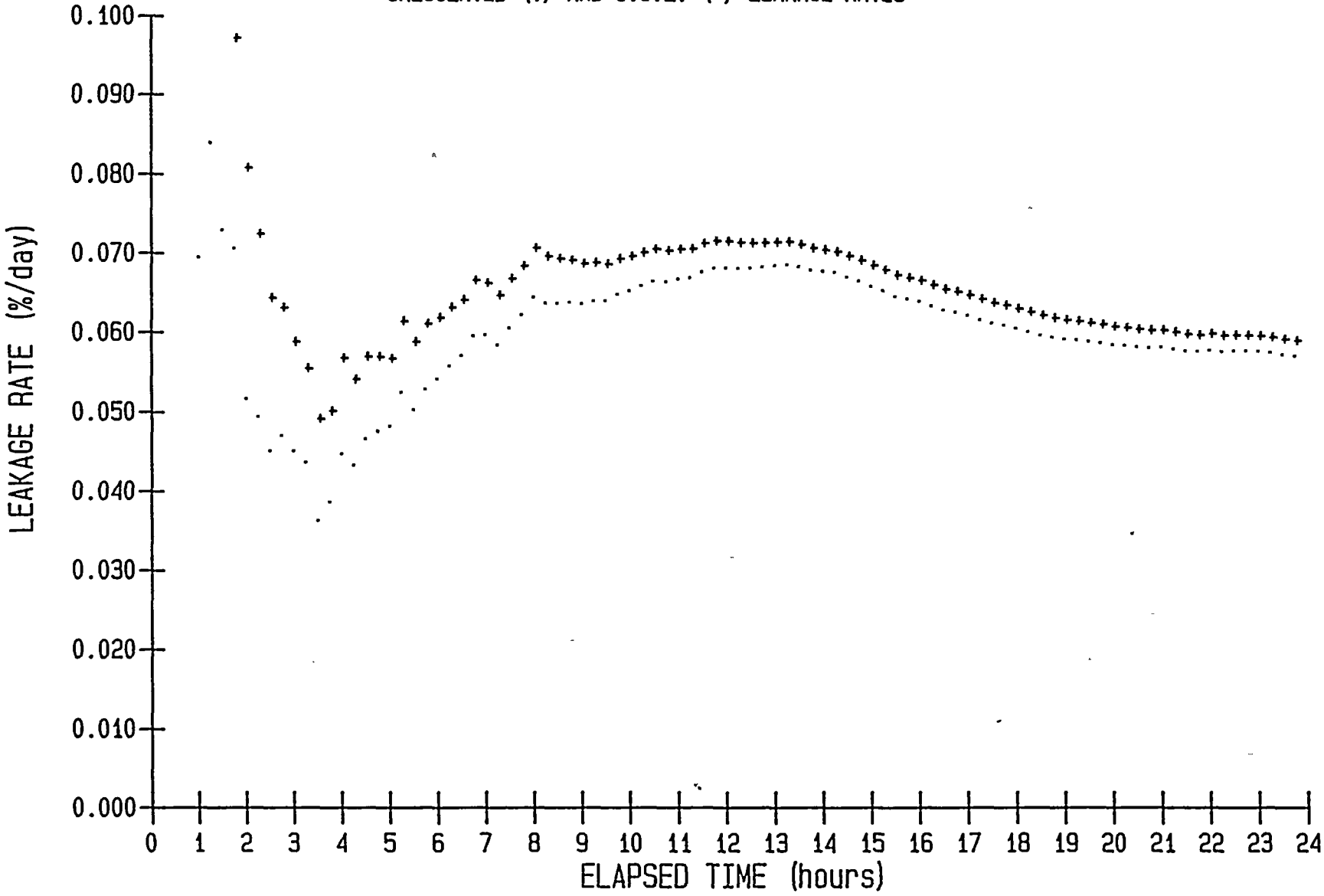


Figure B-3

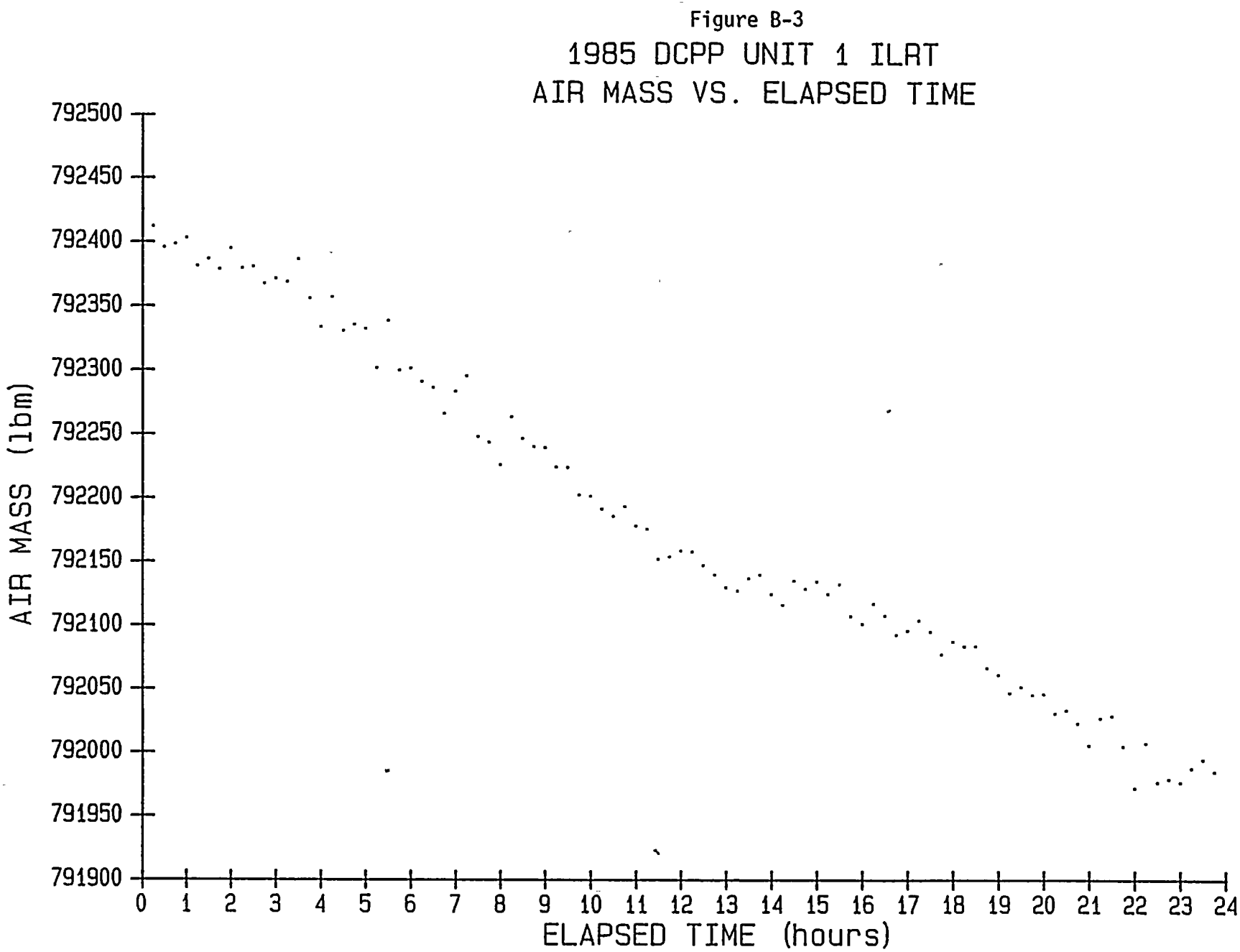

1985 DCPP UNIT 1 ILRT
AIR MASS VS. ELAPSED TIME
AIR MASS (lbm)
792500
792450
792400
792350
792300
792250
792200
792150
792100
792050
792000
791950
791900
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
ELAPSED TIME (hours)

Figure B-4

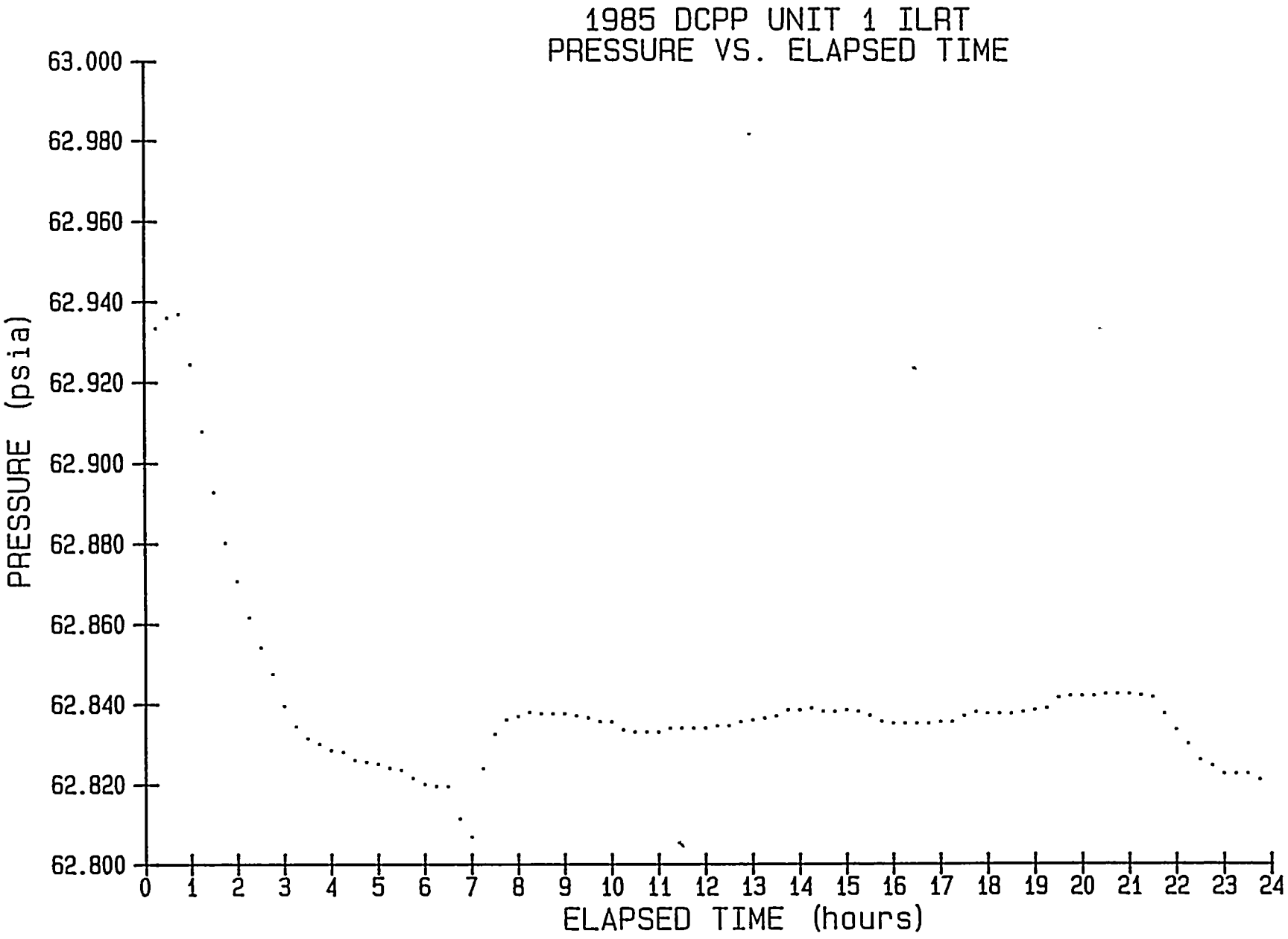

1985 DCPP UNIT 1 ILRT
PRESSURE VS. ELAPSED TIME
PRESSURE (psia)
63.000
62.980
62.960
62.940
62.920
62.900
62.880
62.860
62.840
62.820
62.800
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
ELAPSED TIME (hours)

Figure B-5

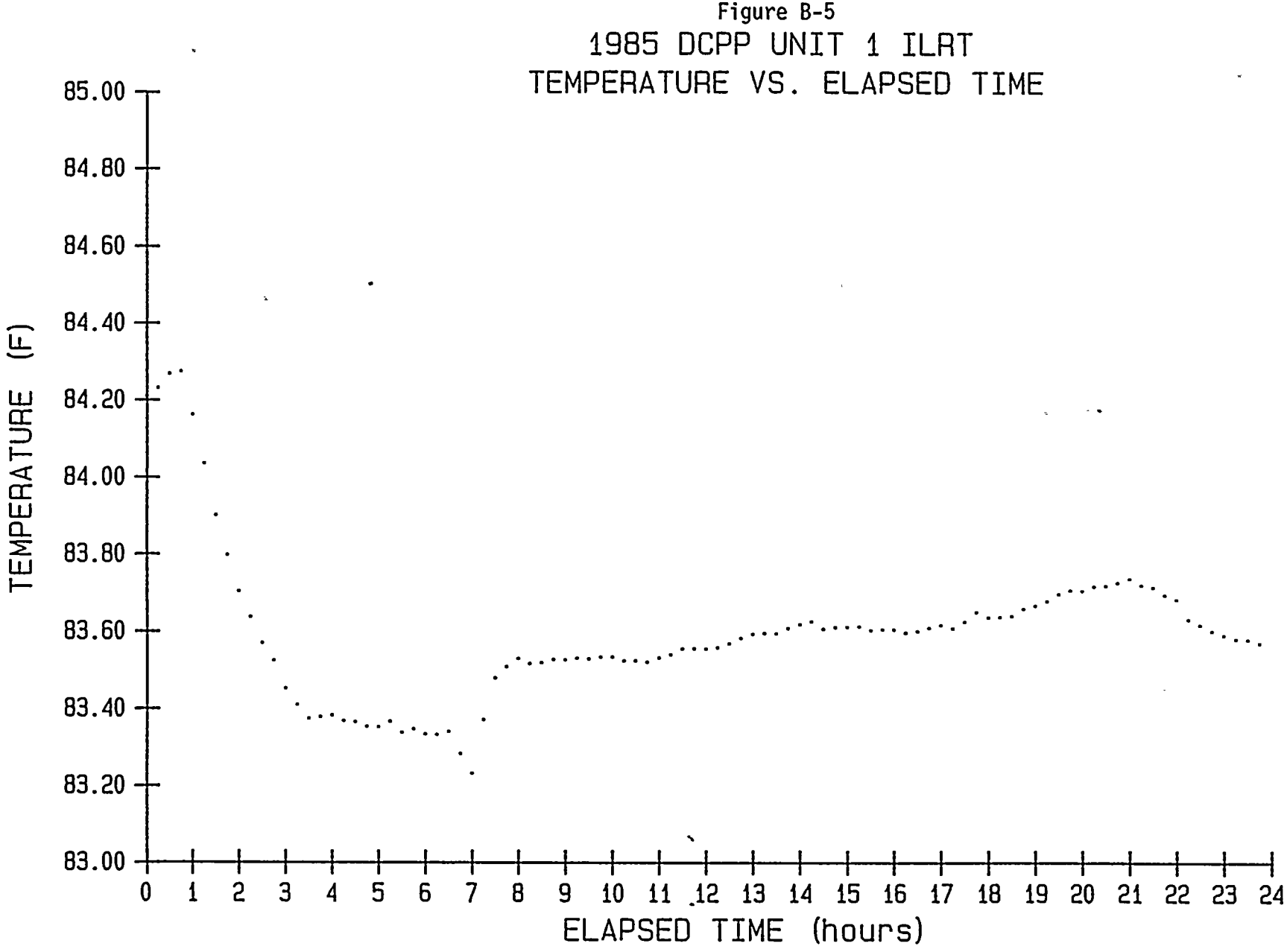

1985 DCPP UNIT 1 ILRT
TEMPERATURE VS. ELAPSED TIME
TEMPERATURE (F)
85.00
84.80
84.60
84.40
84.20
84.00
83.80
83.60
83.40
83.20
83.00
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
ELAPSED TIME (hours)

Figure B-6

1985 DCPP UNIT 1 ILRT - VERIFICATION TEST
MASS POINT ANALYSIS METHOD
CALCULATED (.) AND U.C.L. (+) LEAKAGE RATES

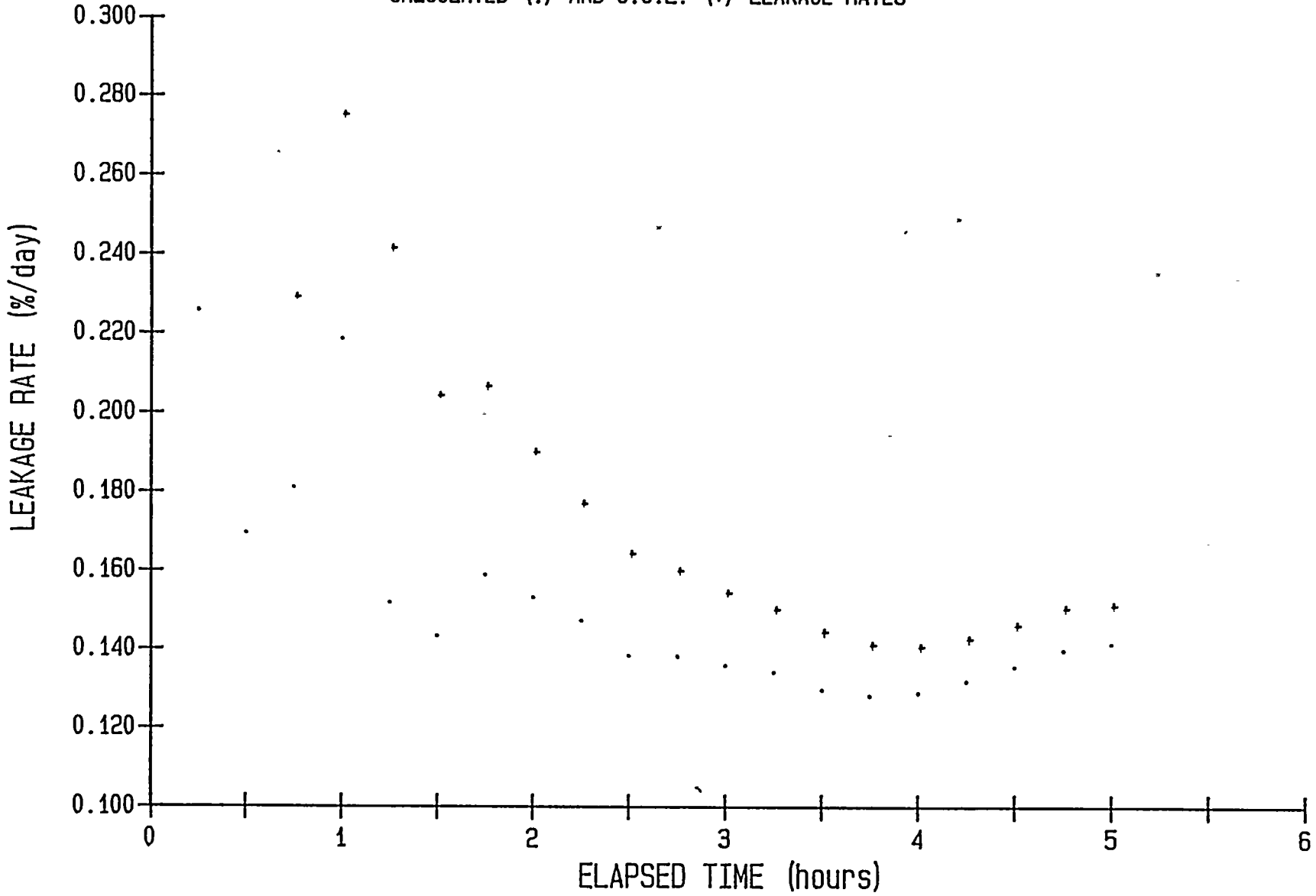


Figure B-7

1985 DCPP UNIT 1 ILRT - VERIFICATION TEST
TOTAL TIME ANALYSIS METHOD
CALCULATED (.) AND U.C.L. (+) LEAKAGE RATES

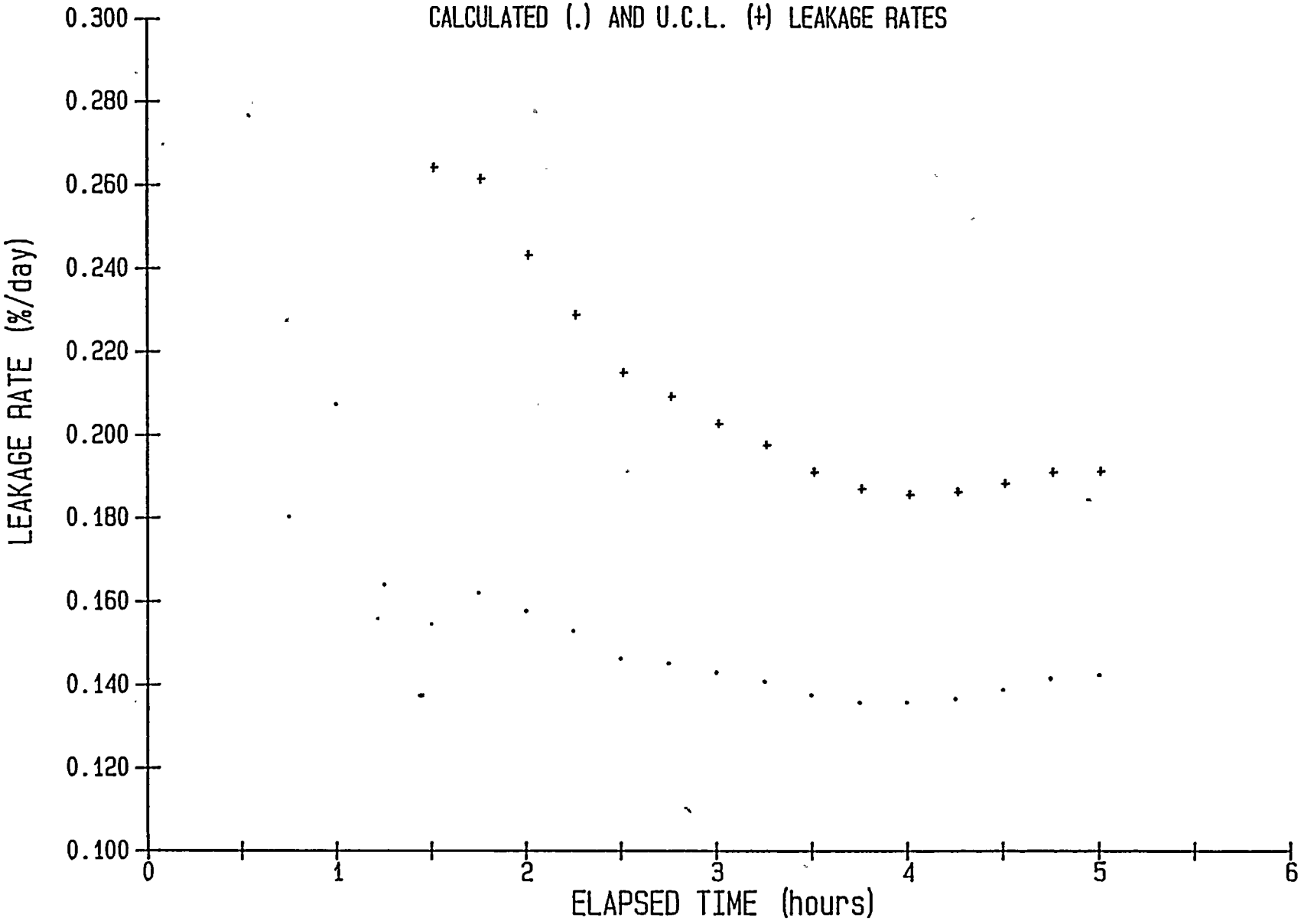


Figure B-8

1985 DCPP UNIT 1 ILRT - VERIFICATION TEST
AIR MASS VS. ELAPSED TIME

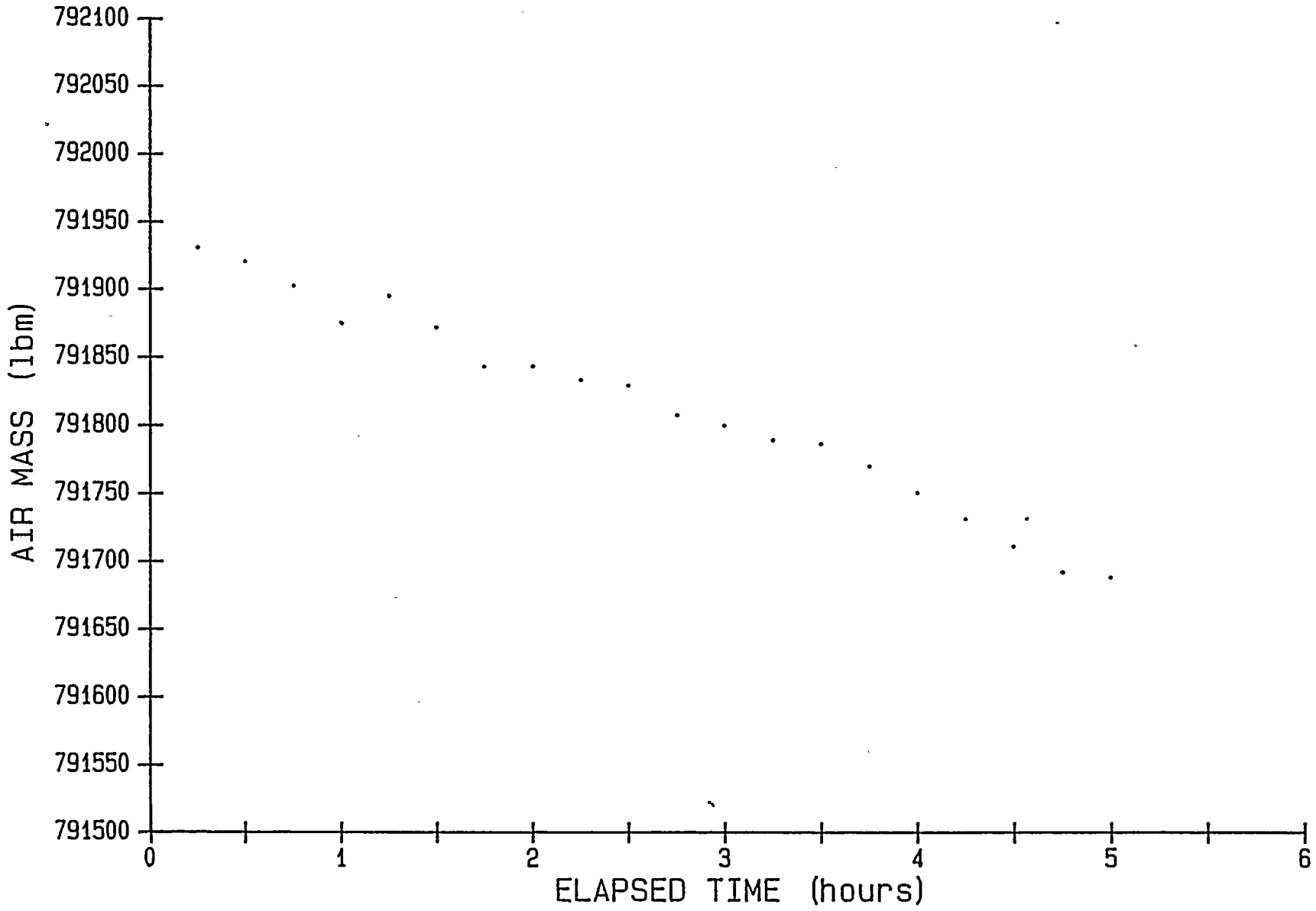


Figure B-9

1985 DCPP UNIT 1 ILRT - VERIFICATION TEST
PRESSURE VS. ELAPSED TIME

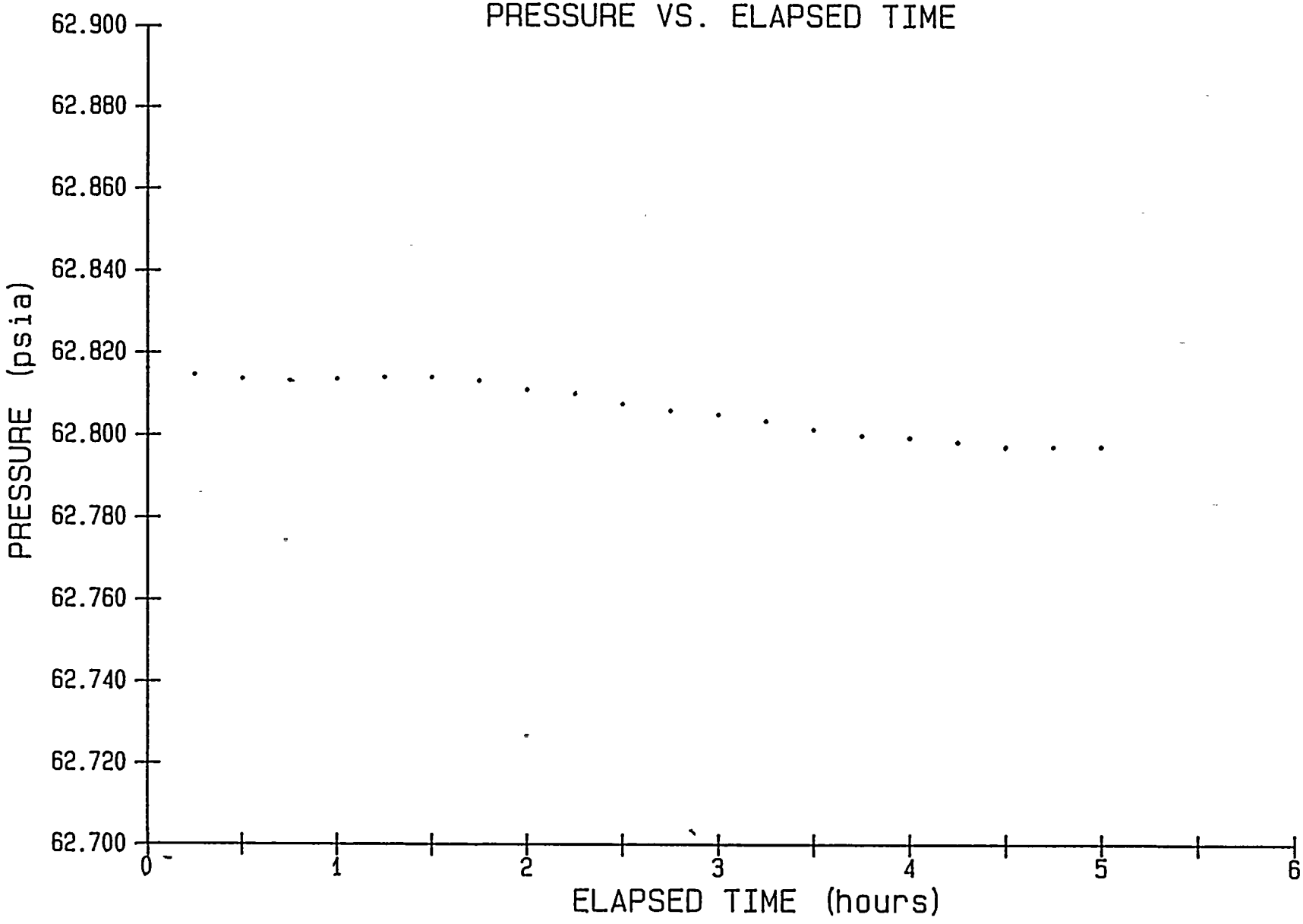
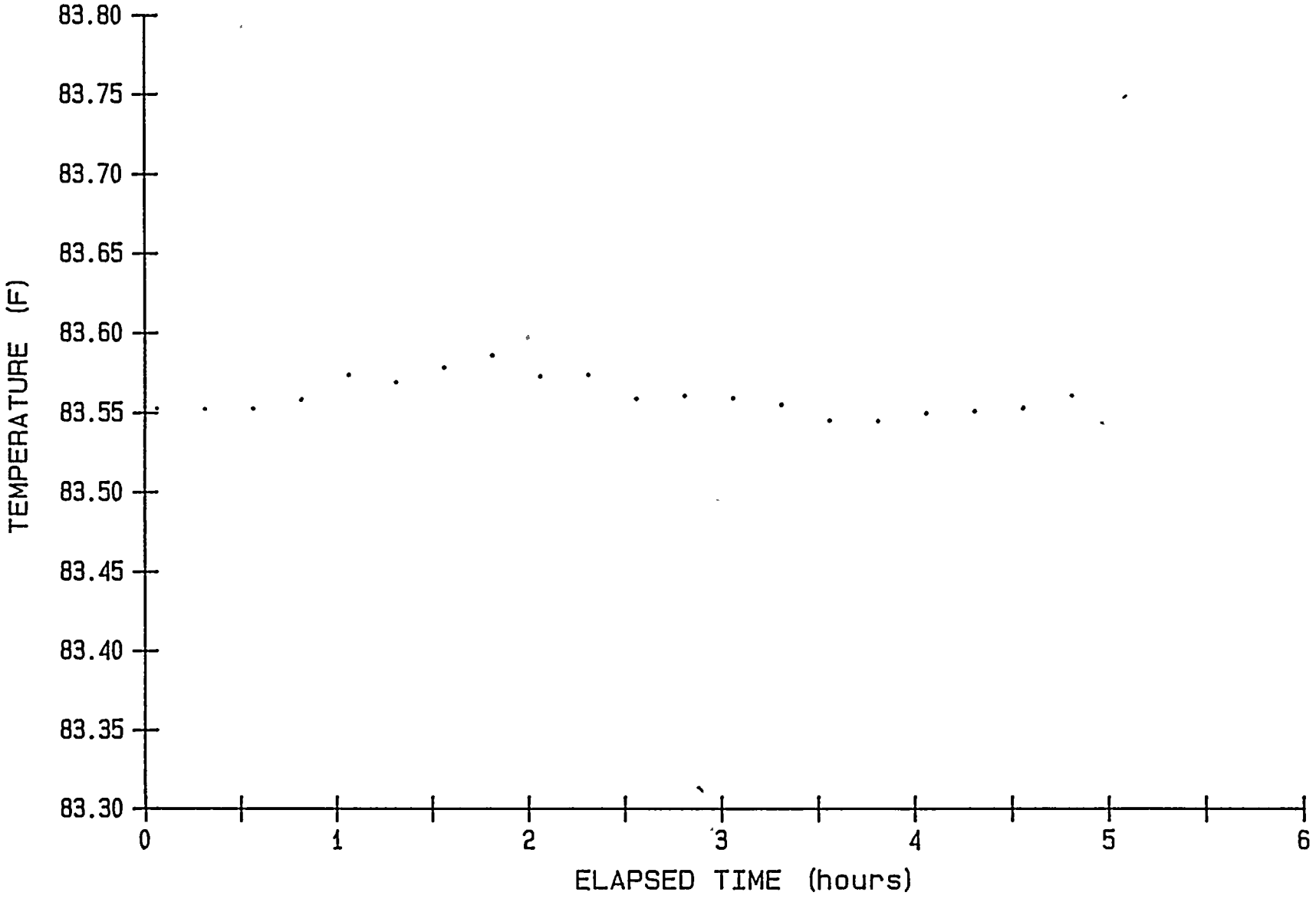


Figure B-10

1985 DCPP UNIT 1 ILRT - VERIFICATION TEST
TEMPERATURE VS. ELAPSED TIME



The ILRT code is an interactive BASICA program that performs data reduction and leak rate calculations for Surveillance Test Procedure M-7 on Integrated Leak Rate Tests, Type A. The ILRT program is written to run on an IBM 3270 PC which has graphics capability.

The ILRT program is an interactive menu driven program, meaning the user is prompted to choose from a list of options displayed on the computer screen. The primary menu includes options to input a new data set, display a summary of results (Trend Report), plot input or calculated data, correct input data or reset the calculation time window. In some cases, a second menu will be displayed after making a selection from the main menu. Also, where applicable, an option to print results will be given. The program is designed to alleviate the user from having to interact extensively with the program. In most cases, pressing a single key is all that is required to invoke an option. However, once started, the program provides its own backup such that no important data will be lost in the case of an abnormal program abort (such as loss of power).

The ILRT program is designed to read and analyze input data collected at 15 minute intervals during an ILRT. A single set of input data consists of dew cell temperatures, dry bulb temperatures, and containment pressure. The program will average the input data and then calculate values needed to evaluate the leakage rate.

There are two models used to calculate the leakage rate, the Total Time Method and the Mass Point Method. The Total Time Method is used the recognized standard for calculating leakage rates and is used to determine if an ILRT is successful. The Mass Point Method is based on an American National Standard and is currently used for information only.

MATHEMATICAL BASIS

1.0 Intermediate Values

The equations in this section are the first values calculated by the ILRT program after a new data set has been entered. These are subsequently used to calculate the leakage rate.

1.1 Containment True Pressure (P)

The containment true pressure is obtained from the gauge pressure (GAUGEP) using a linear correction:

$$P = A*GAUGEP + B$$

Where A and B are given on the gauge certificate of calibration. Typically 15 sets of values for A and B are given; each set is valid over a range of approximately 5 psia. The ILRT program determines which values to use for A and B based on the value of GAUGEP.

1.2 Average Weighted Vapor Pressure

The contribution of vapor pressure to the total containment pressure must be determined in order to find the dry air pressure. For each dew cell temperature, DCT(i), the vapor pressure is calculated using a polynomial equation derived from the 1967 ASME steam tables:

$$PV(i) = 0.120883 - 4.95677E\text{-}3*DCT(i) + 1.61527E\text{-}4*DCT(i)^2 - 1.28743E - 6*DCT(i)^3 + 9.96099E\text{-}9*DCT(i)^4$$

The equation is accurate over the range 50.0 - 130.0 °F.

Each of the dew cells is assigned a weight to account for its containment location and hence the amount of space "seen" by the sensor. The weighted average vapor pressure for the data set is calculated using:

$$PV = \frac{\sum_i PV(i) * WEIGHTdc(i)}{\sum_i WEIGHTdc(i)}$$

If a dew cell indicator is determined to be unreliable or it is desirable to disregard it, a value of 0.0 should be input. A value of 0.0 tells the program that the sensor is unreliable and shall not be used in the calculation of the weighted average.

1.3 Average Weighted Dry Bulb Temperature (TEMPW)

The dry bulb sensors [DBT(i)] average temperature is calculated using weighting factors:

$$TEMPW = \frac{\sum_i DBT(i) * WEIGHTdb(i)}{\sum_i WEIGHTdb(i)}$$

As with the weighted average vapor pressure calculation, an input value of 0.0 for a dry bulb sensor will tell the program not to use it in the calculation of TEMPW.

1.4 Air Mass in Containment (AMASS)

The dry air mass in containment is calculated using P, PV, TEMPW, and V (containment volume) in the ideal gas law:

$$AMASS = \frac{V * (P - PV) * 144.0}{R * (TEMPW + 459.67)}$$

Where V is in units of cubic feet, and R = 53.35 ft-lbf/lbm-^{0}R

2.0 Total Time Method Analysis

Total Time Method Analysis is started when the second data set has been entered. The measured leakage rate is calculated and subsequently used to evaluate other Total Time Method leakage rates.

2.1 Measured Leak Rate (TTMLR)

The Total Time Method measured leakage rate is based on the initial (I) and last (N) data set entered. The equation in general form is written:

$$TTMLR\ (\%/day) = \frac{2400}{t(N)-t(I)} * \left[1 - \frac{TEMPW(I) * (P(N) - PV(N))}{TEMPW(N) * (P(I) - PV(I))} \right]$$

If the interval between data collection is set constant to 15 minutes (0.25 hour), this equation becomes:

$$TTMLR\ (\%/day) = \frac{9600}{(N-1)} * \left[1 - \frac{TEMPW(I) * (P(N) - PV(N))}{TEMPW(N) * (P(I) - PV(I))} \right]$$

2.2 Calculated Leak Rate

A regression analysis is performed after three measured leakage rates have been calculated. The calculated leakage rate is a least squares generated linear curve fit with the form A*T + B; where A is the slope, B is the intercept and T is the elapsed time. Values for A and B are found using:

$$A = \frac{N * \sum_{I}^{N} [t(i)*TTMLR(i)] - \sum_{I}^{N} t(i) * \sum_{I}^{N} TTMLR(i)}{N * \sum_{I}^{N} t(i)^2 - [\sum_{I}^{N} t(i)]^2}$$

$$B = \frac{\sum_{I}^{N} TTMLR(i)}{N} - A* \frac{\sum_{I}^{N} t(i)}{N}$$

The calculated leakage rate at elapsed time (T) is found with

$$TTMCAL = A*T + B$$

2.3 Calculated Leak Rate at 24 Hours (TTM24)

The leakage rate at 24 hours from the start of the test is calculated with the same formulas used for the calculated leak rate. The only difference is that the analysis is performed, using just the last 20 measured leakage rates instead of all measured leak rates. The leakage rate at 24 hours is given by:

$$TTM24 = A*24.0 + B$$

2.4 Mean of Leak Rates (TTMME)

The mean, or average measured leakage rate is calculated using only the last 20 measured leakage rate values:

$$TTMME = [\sum_{N-19}^{N} TTMLR(i)] / 20.0$$

2.5 95% Upper Confidence Limit Leak Rate (TTMUCL)

The calculation of the Upper Confidence Limit Leak Rate involves the computation of several quantities:

The sum of the square of the differences:

$$SSQ = \sum_{I}^{N} [\ TTMLR(i) - (A*t(i) + B)\ ]^2$$

The variance of the measured and calculated leakage rates:

$$VAR = [\ SSQ\ /\ (N-2)\ ]^{\frac{1}{2}}$$

The elapsed time:

$$ET = (N-1) * 0.25$$

The mean time:

$$TBAR = \sum_{I}^{N} t(i)\ /\ N$$

The sum of the square of the time differences:

$$SST = \sum_{I}^{N} [\ t(i) - TBAR\ ]^2$$

The standard deviation of the leakage rates:

$$SIGMA = VAR * [\ 1.0 + \frac{1.0}{N} + \frac{(ET - TBAR)^2}{SST}\ ]^{\frac{1}{2}}$$

The value of the Student's T-distribution:

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

The upper limit at 95% confidence is then calculated using:

$$TTMUCL = TTMCAL + STU * SIGMA$$

3.0 Mass Point Analysis

Starting with the second data set, another method of calculating the leakage rate, the Mass Point Method (MP) is also performed. This method performs a least squares analysis on the air mass values to generate a leakage rate and a 95% UCL leakage rate. This method is recommended by Reference 1 and has been widely adopted as the preferred method of analyzing leakage rate test data. It is also judged to be the most sensitive technique for short duration tests (i.e., less than 24 hours).

The least squares line is given by:

$$\overline{W} = A*T + B$$

Where the slope and the intercept are given, respectively, by:

$$A = \frac{N * \sum_{I}^{N} [t(i)*W(i)] - \sum_{I}^{N} t(i) * \sum_{I}^{N} W(i)}{N * \sum_{I}^{N} t(i)^2 - [\sum_{I}^{N} t(i)]^2}$$

$$B = \frac{\sum_{I}^{N} W(i) * \sum_{I}^{N} t(i)^2 - \sum_{I}^{N} [t(i) * W(i)] * \sum_{I}^{N} t(i)}{N * \sum_{I}^{N} t(i)^2 - [\sum_{I}^{N} t(i)]^2}$$

Where index I refers to the initial value and N refers to the latest value. The value of N-I+1 is the number of measurements. Each t(i) is the elapsed time between a clock time at which the initial (I) reading is taken, and the clock time at which the nth (N) reading is taken. For a time of one quarter hour between data collections, this corresponds to:

$$t(i) = 0.25 * (N-I+1) \text{ [hrs]}$$

The leakage rate is expressed as the ratio of the change of mass in the containment at time t(i) = 0. The Mass Point leakage rate (MPLR) is then given:

$$\text{MPLR (\%/day)} = \frac{-2400 * A}{B}$$

To find the exact upper one-sided limit of a 95% confidence level for the leak rate, the following equations must be evaluated.

Common standard deviation of masses with respect to the line:

$$S = [\sum_{I}^{N} [W(i) - \overline{W}(i)]^2 / (N - 2)]^{\frac{1}{2}}$$

Where W(i) is the measured air mass at time t(i) and $\overline{W}(i)$ is the estimated mass at time t(i).

Setting:

$$KD = [\ N * \sum_{I}^{N} t(i)^2 - [\ \sum_{I}^{N} t(i)\ ]^2]^{\frac{1}{2}}$$

$$K = S / KD$$

The standard deviation of the slope is:

$$SA = K * N^{\frac{1}{2}}$$

The standard deviation of the intercept:

$$SB = K * [\ \sum_{N}^{I} t(i)^2\ ]^{\frac{1}{2}}$$