CONSUMERS POWER COMPANY

PALISADES NUCLEAR PLANT

Special Report No 12

REACTOR CONTAINMENT BUILDING INTEGRATED LEAK RATE TEST

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PALISADES NUCLEAR PLANT

REACTOR CONTAINMENT BUILDING INTEGRATED LEAK RATE TEST

Report Contents

LIST OF FIGURES

LIST OF TABLES

1.0 SUMMARY

1.1 INTRODUCTION

Consumers Power Company's Palisades Nuclear Plant completed its fifth (in a series from 1970) reduced pressure Containment Integrated Leak Rate Test (Type A). An accounting of the past Type A tests is presented in Section 1.2, History, and summarized in Table A. The results of all Local Leak Rate Tests (Types B and C), conducted since the previous Type A test, are listed in Table B.

The containment enclosure has a net free volume of 1,640,000 cu ft designed for 55 psig with a calculated accident peak pressure of 55 psig. The cylindrical vessel is a steel-lined, steel-reinforced concrete construction; therefore, the contained air mass is, to a large degree, isolated from short-term daily changes in ambient conditions, including diurnal effects. Throughout the nearly 30-hour hold test phase, the ambient was sunny and windy with a temperature range of 20-31°F. During the verification phase of testing, the prevalent ambient condition was cloudy and windy with temperature between 25-38°F.

1.2 HISTORY

Preoperational leak rate acceptance testing of the Reactor Containment Building at Consumers Power Company's Palisades Nuclear Plant was completed in May of 1970. Two Type A tests were performed: A peak pressure test of 55 psig and a reduced pressure test of 28 psig. Results of these two tests are given in a report entitled, "Integrated Leak Rate Test of the Reactor Containment Building, Palisades Nuclear Plant, Consumers Power Company, July 30, 1970."

The first Postoperational Leak Rate Test was conducted in late April of 1974 at a reduced test pressure of 28 psig. This test was the subject of a special report entitled, "Reactor Containment Building Integrated Leak Rate Test 1974." The results were within technical specification limits.

The second Postoperational Leak Rate Test was conducted in March of 1978 at a reduced test pressure of 28 psig. The test was the subject of a special report entitled, "Reactor Containment Building Integrated Leak Rate Test 1978." During the pressurization phase a leak in Isolation Valve CV-1806 was identified, quantified and repaired, enabling successful completion of the Type A test. However, the quantified leak of 98.4 standard liters per minute, when added to the results thereof, resulted in failure of the "As Found" Type A test.

The third Postoperational Leak Rate Test was performed in November of 1981 at a reduced test pressure of 28 psig. The test was the subject of "Special Report Number 11, Reactor Containment Building Integrated Leak Rate Test," prepared in February of 1982 (Reference 4.1). During the refueling outage prior to the Type A test, several repairs were effected on Type B/C penetrations, which resulted in a significant reduction in the total of all Type B/C leakages. This action did permit successful completion of the Type A test in its "As Left" condition but resulted in failure in its "As Found" state.

A summation of the results of all Type A tests from preoperational onward is presented in Table A of this report.

1.3 RESULTS

In order to fulfill the requirements of Reference 4.3, a Type A test began with pressurization on January 21, 1986 and concluded with depressurization on January 25, 1986. A reduced test pressure (P_t) of 28.25 psig was recorded at the end of the 30-hour hold test.

At the reduced test pressure (P_t), the measured containment leak rate (L_{tm}) for the hold test was 0.0157 wt %/day with a 95% upper confidence limit (UCL) of 0.0187 wt %/day. After upward adjustment to accident pressure (P_a), the measured leak rate (L_{am}) was 0.0262 wt %/day at the 95% UCL. The calculated "As Left" total containment leak rate was 0.0290 wt %/day at the 95% UCL, following Type C test additions for systems not in their accident status during the conduct of the Type A test and after compensating for a 2% increase in the pressurizer level (equivalent to 0.0017 wt %/day).

Following the 30-hour hold test, a measured leakage verification test was performed employing the method suggested by Reference 4.7, Appendix 3, and adopted by Reference 4.3. A controlled leak (L_o) of 0.073 wt %/day was imposed on L_{tm}. Reference 4.2 states the measured composite leak rate (L_c) shall be bound by $L_{tm} + L_o \pm 0.25\ L_t$, ie, $0.0709 \leq L_c \leq 0.1065$ (wt %/day), where L_t is the maximum allowable leak rate at test pressure. The measured composite leak rate over the verification test period stabilized at 0.0795 wt %/day which met the requirements of Reference 4.2 and Reference 4.3, Section III.A.3.b, and thus confirmed the Type A test measured leak rate.

At the accident pressure (P_a) of 55 psig, the maximum acceptable leak rate for a Type A test is 0.075 wt %/day (0.75 L_a) per Reference 4.3, Section III.A.5.b.1. This includes the corrective additions to account for omitted systems and containment free volume changes previously discussed. Having met this acceptance criterion in the "As Left" state, the Palisades Plant was permitted to resume power operation without having to undergo corrective reparations and reperforming the Type A test.

Containment pressure boundary systems which were not tested necessitating Type C additive corrections to the Type A test results, were:

Penetration Number	Description of Penetration	Leak Rate (SCCM)
15	Component Cooling Water in (CV-0911 and CV-0940)	82.7
17	Containment Pressure Instrument Line	0.0
36	Letdown to Purification Ion Exchange (CV-2009)	67.4
42	Demin to Quench Tank (CV-0155)	164.6
44	PCP Control Bleed (CV-2083)	6.9
48	Containment Pressure Instrument Line	0.0
52	Containment Sump Drain (CV-1103 and CV-1104)	736.8
66	ILRT Instrument Line	9.0
	Total Untested Leak Rate	1,068.3*

*Equivalent to 0.0011 wt %/day for an initial containment mass of 371,159.3 pounds

Following penalty additions for outage repairs resulting in improvements in Type B/C leak rates, the "As Found" Type A leak rate was 0.1061 wt %/day at the 95% UCL, which did not meet the acceptance criteria of 0.075 wt %/day (0.75 L_a). Two-thirds of the total penalty assessed was based on a conservative minimum pathway determination for penetration numbers 40 and 69, necessitated through replacement and/or repair of double isolation valves.

Type B/C test improvements in the minimum pathway leak rate for components which were repaired or replaced during the refueling outage prior to performing the Type A test, and required to be added to the results thereof for determining the "As Found" Type A leak rate, were:

Penetration Number	Description of Penetration	MPL Improvement (SCCM)
37	PS Drain Pump Discharge (403-CRW and CV-1001)	208.6
40	Decay Coil Sample (CV-1901 and CV-1911)	39,429.2
69	CWRT (CV-1044 and CV-1045)	10,091.4
NA	South Electrical	14,874.3
NA	"B" SG South Manway	10,252.7
	Total MPL Improvements	74,856.2*

*Equivalent to 0.0771 wt %/day for an initial containment mass of 371,159.3 pounds

The results of the Palisades Type A test in its "As Left" condition have verified the integrity of the containment structure and confirmed the effectiveness of the Type A testing program.

A compilation of all Type A test measured data and calculations of required Type C corrections thereto have been filed with the working copy of the CILRT procedure (Reference 4.5).

2.0 DISCUSSION

2.1 ANALYSIS TECHNIQUES

The weighting factors used to calculate the average containment dry bulb and dew point temperatures have been calculated based on the number of sensors within a subvolume. The containment vapor pressure is computed by converting the Foxboro dew point temperature sensor (dewcell) readings to vapor pressure readings through the use of the ASME steam tables for water and applying the appropriate weighting factors. The containment vapor pressure is subtracted from the absolute pressure to give the containment dry air partial pressure. The partial pressure of dry air and the weighted average containment temperature are then used to calculate the weight of the containment air mass.

The absolute method of determining the leak rate was used for this test and measurements were recorded every 15 minutes. The leak rate was computed using the mass point method of analysis which is recommended in Reference 4.2.

In the mass point method of analysis, data from an absolute system is reduced to a contained mass of dry air by application of the Ideal Gas Law. The test data consists of a time series of independent values of contained air mass. If the assumption is made that the leak rate is constant with time, the data lends itself to analysis by the method of linear least squares. The slope of this line represents the rate of change of air mass with respect to time, which is the leak rate. Because of its independent nature, a measurement error will result in only one bad data point and not materially affect the test results. The data rejection criteria found in Appendix D of Reference 4.2 was used by the computer program to check for anomalous data.

2.2 DATA ACQUISITION

The test procedure employed was the absolute method as endorsed by Reference 4.2, Section 5. The instrumentation system consisted of twenty-six (26) Resistance Temperature Detectors (RTDs), ten (10) dewcells and two (2) pressure sensors used to measure the average dry bulb and dew point temperatures and containment pressure, respectively. The weighting factors used to calculate the average containment air temperature were determined on the basis of the number of sensors within a subvolume. The maximum weighting factors were 8.189% for an RTD (following the loss of two RTDs which failed pretest calibration checks) and 18.102% for a dewcell. An in-place calibration check of all sensors was performed.

The sensitivities of the RTDs, dewcells and pressure gauges were within the requirements established by Reference 4.2, Section 4.3.1.

The calculated Instrument Selection Guide (ISG) for the instrumentation system is ±0.0034% per day which met the requirements of Reference 4.2, Section 4.1.2. This calculation was adjusted to ±0.0027% due to test duration extension. No further adjustment was necessary as no sensors were lost during the test.

Sensor data was collected by the ILRT panel purchased from Volumetrics (Model 14629) and transferred to the PDP 11/03 digital minicomputer after receiving the data. The minicomputer program performs the functions listed below:

1. Reduces raw data into weighted average temperatures, vapor pressures and containment pressure necessary for use in the leak rate calculations.

2. Calculates the leak rate in wt %/day using the mass point analysis method.

3. Determines the 95% upper confidence limit of the leak rate using the methods described in Reference 4.2, Appendix B.

4. Calculates the data outlier and the appropriate rejection level according to the criteria of Reference 4.2, Appendix D.

5. Provides plots of individual test parameters as well as containment average temperature, pressure, vapor pressure and mass as a function of time.

2.3 CONTAINMENT CONDITIONS

The average containment temperature fulfilled the stabilization requirements of Reference 4.2, Section 5.3.1.3, and Reference 4.5, Section 5.3.2, four hours after pressurization was completed. The containment was permitted to stabilize an additional 1 hour and 45 minutes before the hold test portion of the leak rate test was declared to start at 022/16:30:00. Following a perturbation in the data commencing at 1645, which indicated containment stability had been misjudged, the hold test start time was redeclared at 022/18:15:00.

Approximately 17 hours after commencing the hold test, a change in the containment condition resulted in a decreased leak rate. An unnatural basis for this occurrence could not be identified. The change was first sensed through a pressure deviation 4-5 hours prior to temperature and dew point deviations from what had been linear rates of change. In the short term, this created an apparent net in-leakage, which it was not but which can be explained. Containment leakage is derived from a linear leased squares fit of a series of independent calculations of containment mass through application of the Ideal Gas Law. A change, whatever its cause, will force the relationship between temperature and pressure out-of-phase to an extent dependent upon the significance of the change. If the Ideal Gas Law is applied during the ensuing transient period, an error will result. Inspection of Figure 5 graphs reveal that containment parameters do deviate from their previously linear trends out-of-phase. This situation not only constitutes instability, but also accounts (by calculation) for the apparent increase in containment mass between test hours 17-21. When containment stability was once again achieved, the hold test was continued for approximately 8 additional hours, resulting in a total hold test time of 29 hours, 45 minutes. The hold test was concluded at 023/24:00:00.

Parameters have been plotted to illustrate the average containment conditions throughout the complete hold test as shown in Figure 1. The nearly linear, negatively sloped temperature profile is telltale of the subfreezing ambient. Containment mass throughout the hold test is shown graphically in Figure 2. The juncture of change in containment leak rate can be seen at the 17-hour mark.

The verification imposed leak rate was initiated at 024/06:45:00. Following a one-hour stabilization period, verification began at 0745 hours. At the conclusion of the 4-hour verification test, the leak rate was within the acceptance band, although not stable as shown by Figure 3 (plot of the leak rate versus time). Consequently, the verification period was extended to ensure stability occurred within the specified limits. Graphs of containment average temperature and pressure, as well as calculated mass for the verification period are presented in Figure 4.

3.0 CONCLUSIONS

3.1 The Palisades containment structure leak rate satisfied the acceptance criteria stated in Reference 4.5, Paragraph 5.3.5 for the Type A test.

3.2 Additions for leak rate improvements effected during the outage resulted in failure of the "As Found" Type A test.

3.3 The verification test results verified the hold test results.

3.4 The calculated ISG fulfilled the acceptance criteria of Reference 4.5, Paragraph 6.0.

4.0 REFERENCES

4.1 Consumers Power Company, "Special Report 11, Reactor Containment Building Integrated Leak Rate Test - 1982"

4.2 ANSI/ANS 56.8 - 1981, "American National Standard Containment System Leak Testing Requirements"

4.3 10 CFR 50, Appendix J

4.4 Palisades Technical Specifications, Sections 3.6.1, 3.6.2, 4.5.1

4.5 Palisades CILRT Procedure RT-36, Revision 12

4.6 NRC IE INFORMATION NOTICE 85-71: Containment Integrated Leak Rate Tests

4.7 ANSI N45.4-1972, "American National Standard Leak Rate Testing of Containment Structures for Nuclear Reactors"

FIG. 1

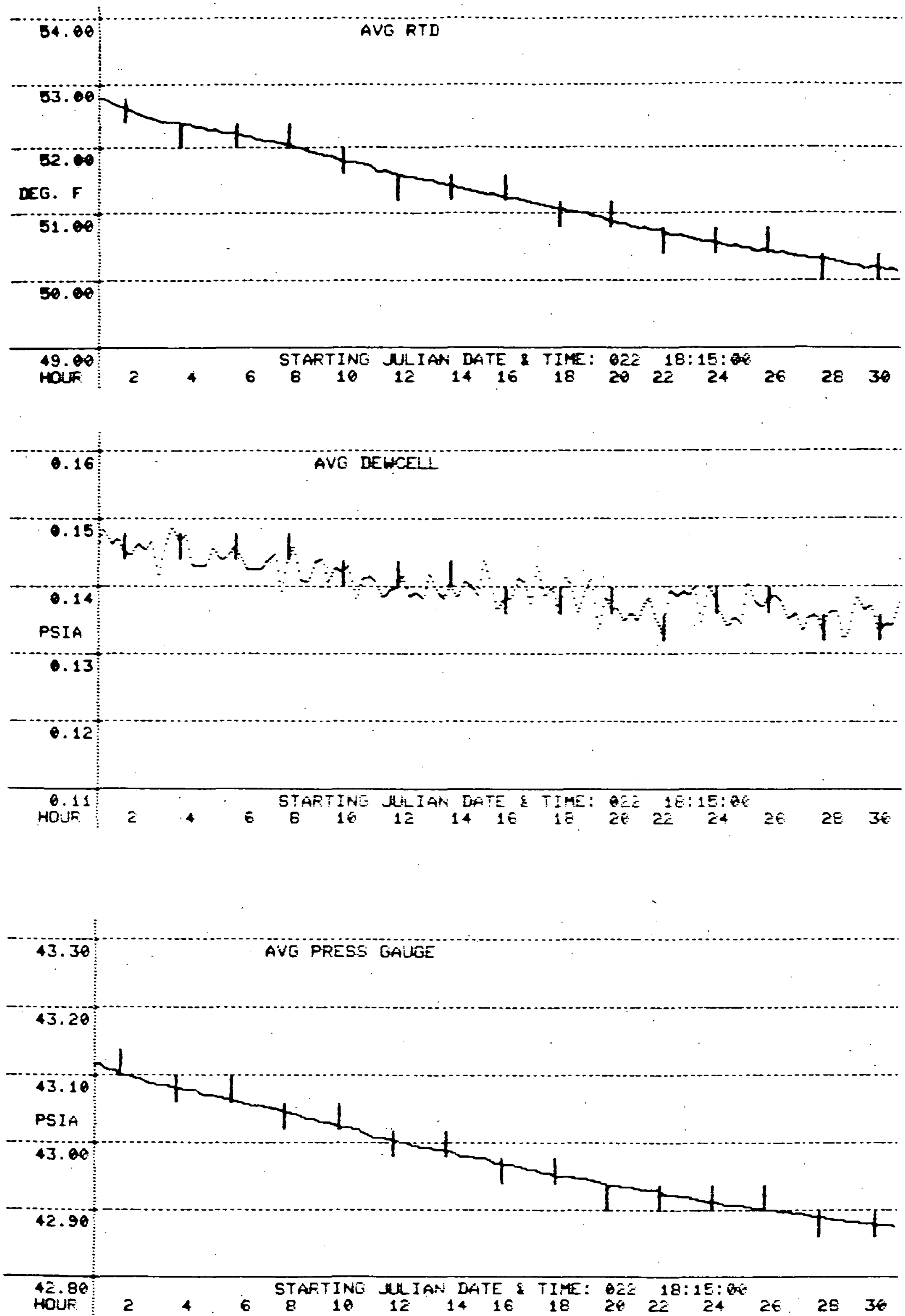
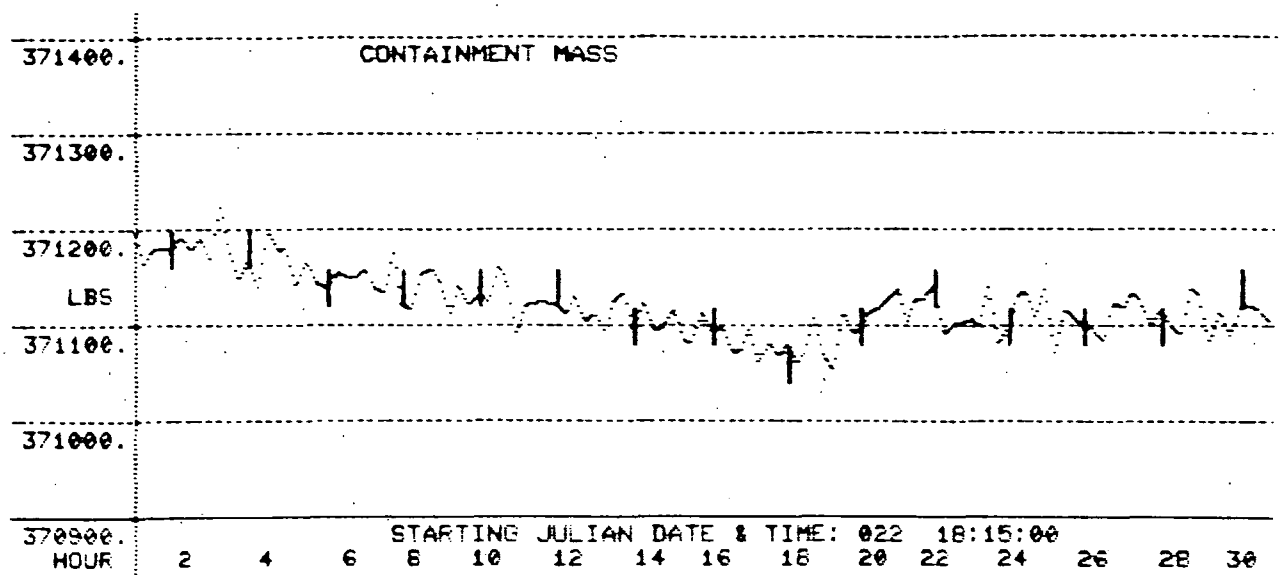
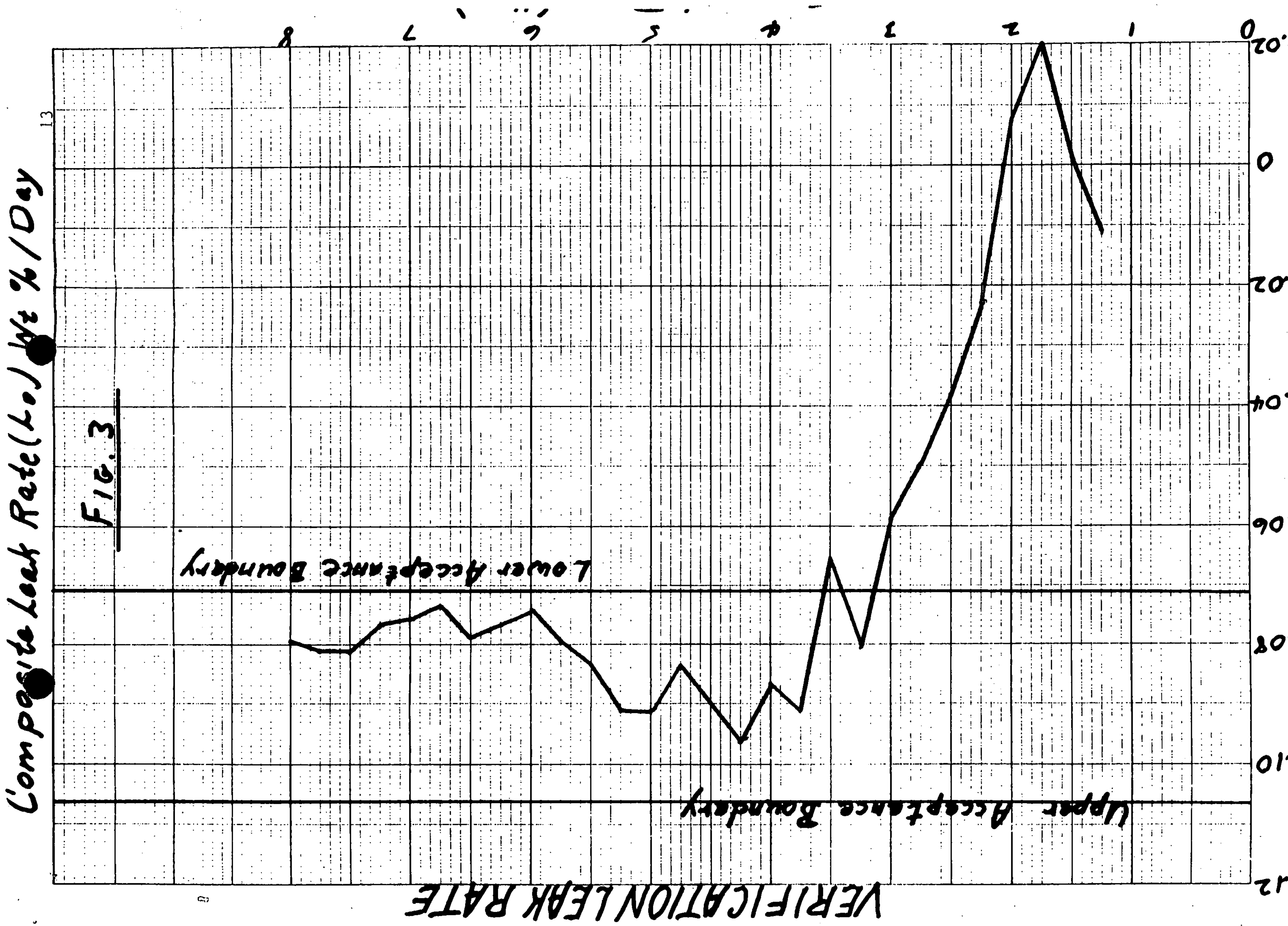

54.00
AVG RTD
53.00
52.00
DEG. F
51.00
50.00
49.00
HOUR
STARTING JULIAN DATE & TIME: 022 18:15:00
2 4 6 8 10 12 14 16 18 20 22 24 26 28 30
0.16
AVG DEWCELL
0.15
0.14
PSIA
0.13
0.12
0.11
HOUR
STARTING JULIAN DATE & TIME: 022 18:15:00
2 4 6 8 10 12 14 16 18 20 22 24 26 28 30
43.30
AVG PRESS GAUGE
43.20
43.10
PSIA
43.00
42.90
42.80
HOUR
STARTING JULIAN DATE & TIME: 022 18:15:00
2 4 6 8 10 12 14 16 18 20 22 24 26 28 30

FIG. 2

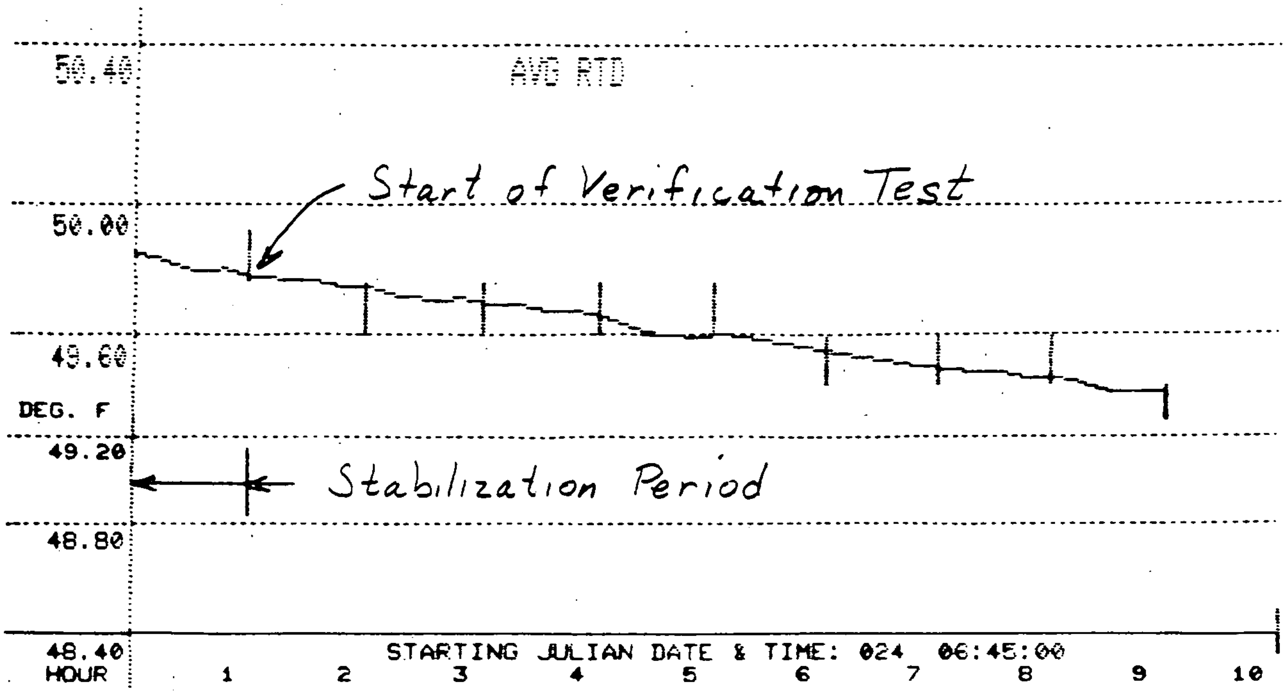

CONTAINMENT MASS
371400.
371300.
371200.
LBS
371100.
371000.
370900.
HOUR
2 4 6 8 10 12 14 16 18 20 22 24 26 28 30
STARTING JULIAN DATE & TIME: 022 18:15:00



Composite Leak Rate (Lo) Wt %/Day
VERIFICATION LEAK RATE
Lower Acceptance Boundary
Upper Acceptance Boundary
0
1
2
3
4
5
6
7
8
.02
0
.02
.04
.06
.08
.10
.12

FIG. 3

FIG. 4


50.40
AVG RTD
Start of Verification Test
50.00
49.60
DEG. F
49.20
Stabilization Period
48.80
48.40
HOUR
STARTING JULIAN DATE & TIME: 024 06:45:00
1
2
3
4
5
6
7
8
9
10

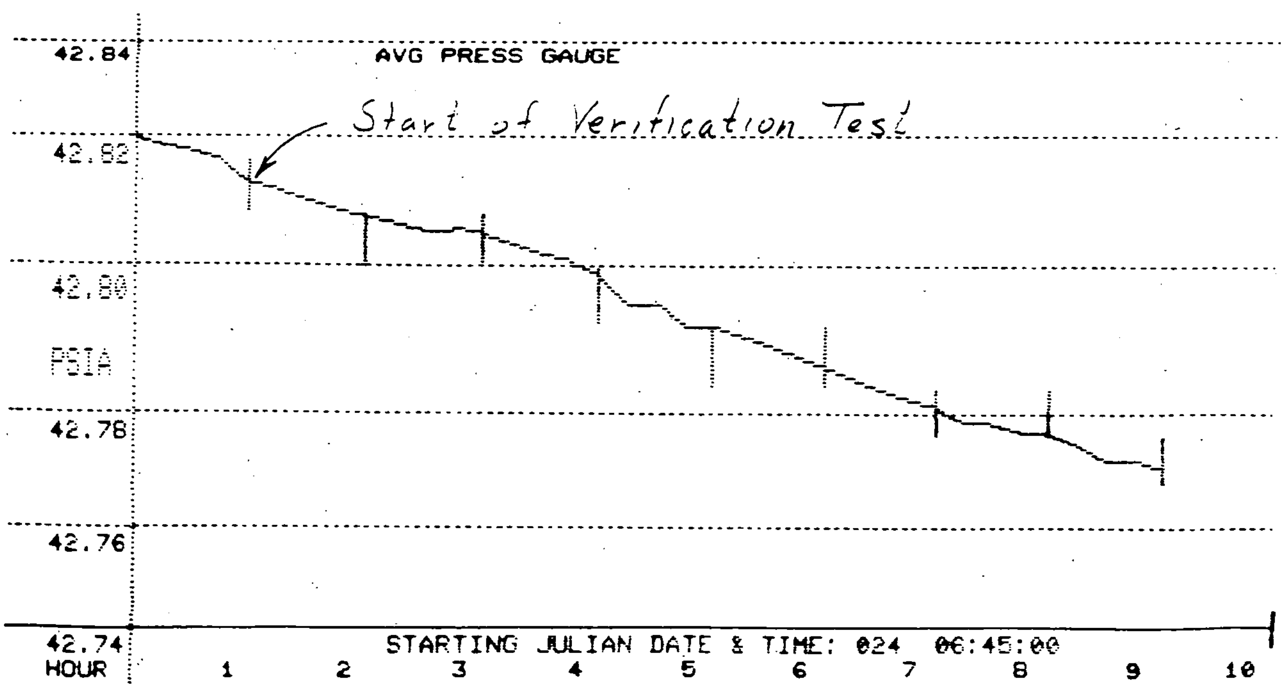

42.84
AVG PRESS GAUGE
Start of Verification Test
42.82
42.80
PSIA
42.78
42.76
42.74
HOUR
STARTING JULIAN DATE & TIME: 024 06:45:00
1
2
3
4
5
6
7
8
9
10

FIG. 4 (CONT.)

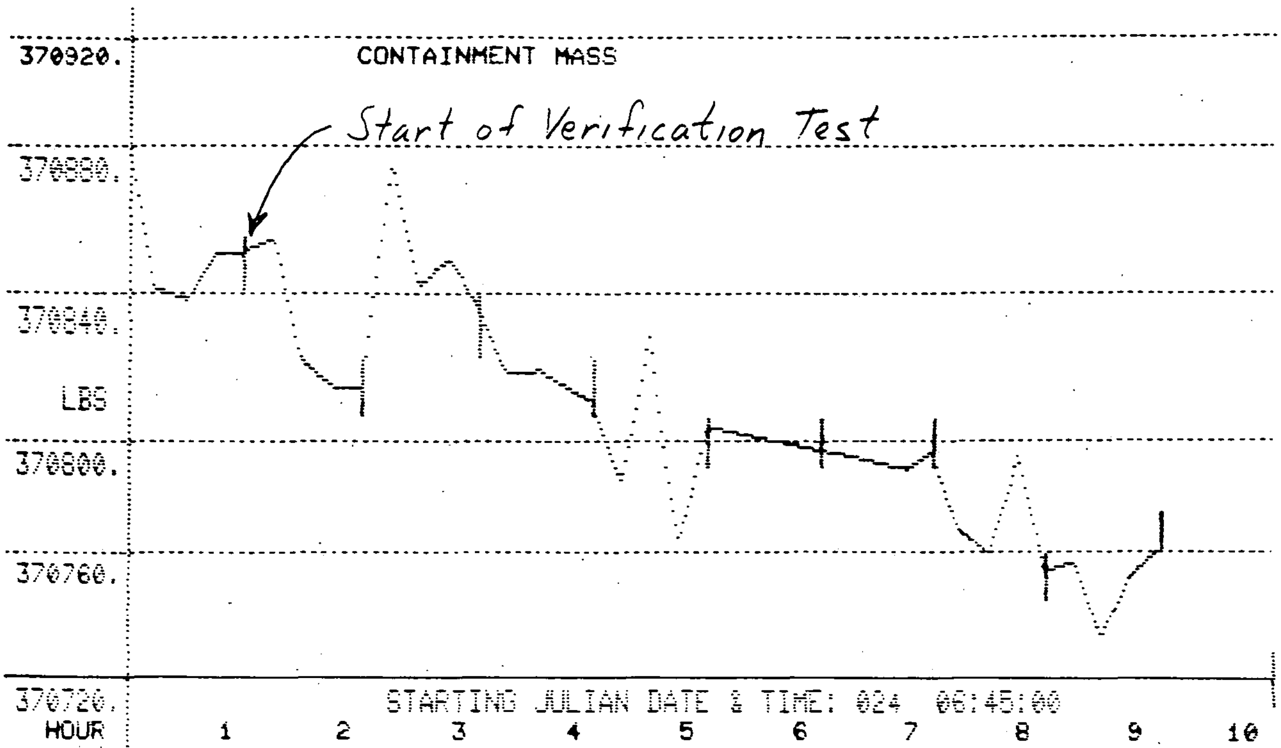

370920.
CONTAINMENT MASS
Start of Verification Test
370880.
370840.
LBS
370800.
370760.
370720.
HOUR
1
2
3
4
5
6
7
8
9
10
STARTING JULIAN DATE & TIME: 024 06:45:00

FIG 5

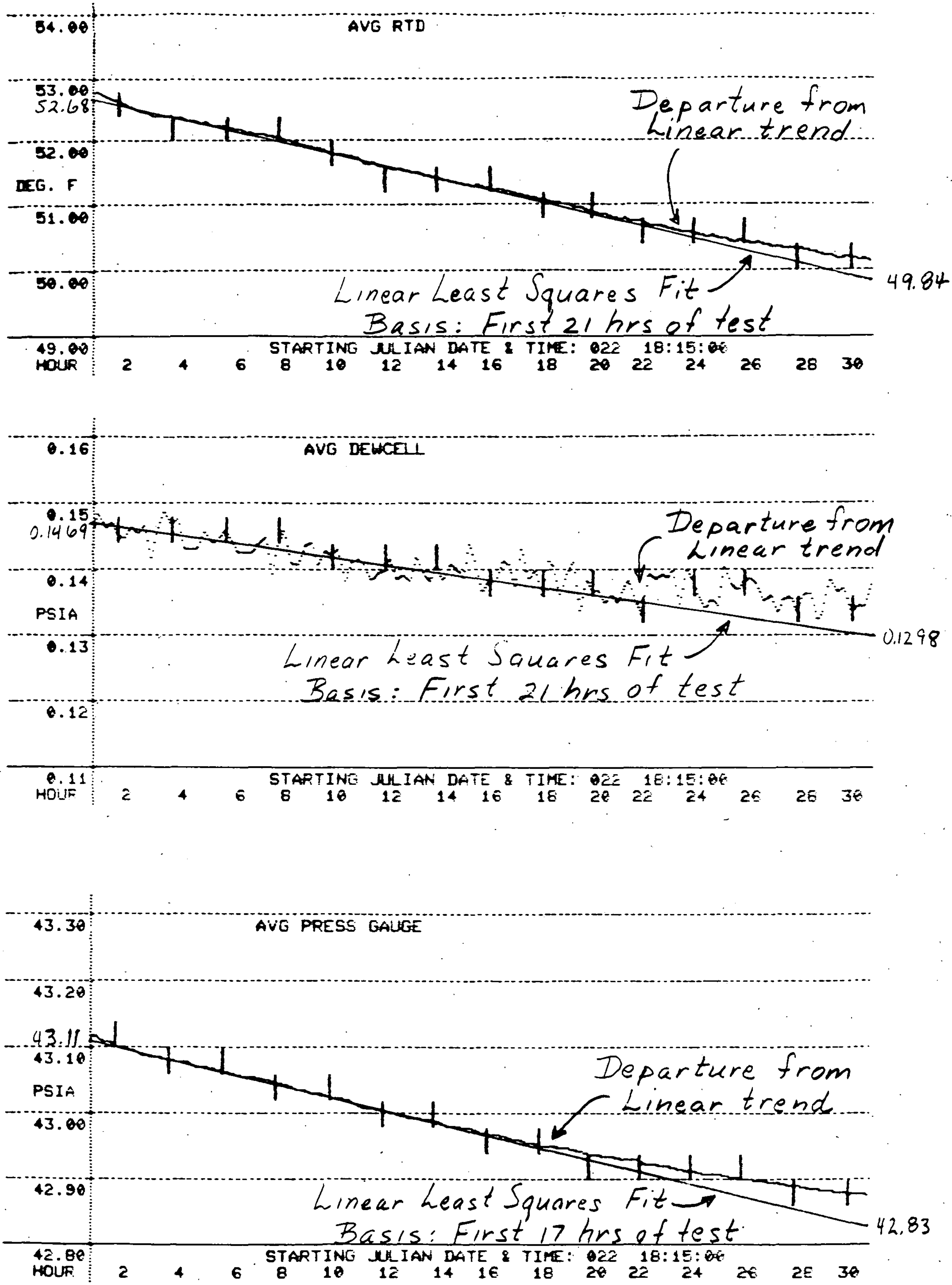

54.00
AVG RTD
53.00
52.68
52.00
DEG. F
51.00
50.00
49.00
HOUR 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30
STARTING JULIAN DATE & TIME: 022 18:15:00
Departure from Linear trend
Linear Least Squares Fit
Basis: First 21 hrs of test
49.84
0.16
AVG DEWCELL
0.15
0.1469
0.14
PSIA
0.13
0.12
0.11
HOUR 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30
STARTING JULIAN DATE & TIME: 022 18:15:00
Departure from Linear trend
Linear Least Squares Fit
Basis: First 21 hrs of test
0.1298
43.30
AVG PRESS GAUGE
43.20
43.11
43.10
PSIA
43.00
42.90
42.80
HOUR 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30
STARTING JULIAN DATE & TIME: 022 18:15:00
Departure from Linear trend
Linear Least Squares Fit
Basis: First 17 hrs of test
42.83

TABLE A

SUMMARY OF PALISADES CONTAINMENT INTEGRATED LEAK RATE TESTS

Date	(Pt) Nominal Test Pressure (psig)	(Ltm) Measured Leak Rate at Pt (wt %/Day)	(Lam) Measured Leak Rate Adjusted to Pa (wt %/Day)	(0.75 La) Plant Tech Spec Limit @ Lam (wt %/Day)	Comments
05/70	55 (Pa)	0.0048	0.0048	0.075	Pre-operational
05/70	28	0.0233	0.0327	0.075	Pre-operational
04/74	28	0.0342/0.0436*	0.0479/0.0611*	0.075	"As left" leak rate
03/78	28	-0.0071/0.0020*	0.0027*	0.075	"As left" leak rate
		0.0924	0.1295/0.1422*	0.075	"As found" leak rate
11/81	28	0.0328/0.0349*	0.0507*	0.075	Lam is "as left" Ltm is w/o penalties
			0.1175*	0.075	"As found" leak rate
01/86	28	0.0157/0.0187*	0.0290*	0.075	Lam is "as left" Ltm is w/o penalties
			0.1061*	0.075	"As found" leak rate

*Indicated data is the calculated 95% upper confidence limit.

TABLE B

SUMMARY OF LOCAL LEAK RATE TESTS PERFORMED SINCE 1981 ILRT

Date	Penetrations Tested	As-Found LLRT Total (CC/Min)	As-Left LLRT Total (CC/Min)	Sequence Number
February 7, 1982 - February 21, 1982	Penetrations 1a, 1b, 1c, 40 (TCS 82-15)	32,452.2	32,185.7	XVb
June 1, 1982	Penetrations 1a, 1b, 1c LLRT Update Due to Modification Pen 1a (2/25/82) (TCS 82-22)	32,185.7	34,748.0	XVc
April 7, 1982 - April 29, 1982	Penetration 1a, 1b, 1c, 21, 21a, 40a, 40b, 51 (TCS 82-19a)	31,584.7	32,128.7	XVd
May 6, 1982 - May 8, 1982	Escape Air Lock, Personnel Air Lock (Equalizing Valve on Inner Door) (TCS 82-19B)	684,149.0	34,748.0	XVe
June 23, 1982	Personnel Air Lock (TCS 82-26)	34,748.0	27,665.2	XVf
July 16, 1982 - August 19, 1982	Personnel Air Lock, Escape Air Lock (ERT 82-002)	25,177.6	29,145.7	XVg
March 16, 1983 - March 19, 1983	Personnel Air Lock, Escape Air Lock (TCS 83-009)	29,145.7	26,384.8	XVh
August 1983 - June 1984	All (Refueling Outage) (TCS 84-019)	85,162.7	44,926.9	XVI
July 10, 1984	Equipment Hatch, Personnel Air Lock (TCS 84-020)	44,926.9	46,308.1	XVIa
August 19, 1984	Escape Air Lock, Personnel Air Lock (ERT 84-013)	75,806.6	34,917.9	XVIb
November 20, 1984	Equipment Hatch (ERT 84-016)	N/A	34,903.9	XVIc
February 13, 1985 - February 15, 1985	Personnel Air Lock, Escape Air Lock (BK 85-002)	89,576.1	35,891.9	XVId
August 18, 1985 - August 19, 1985	Personnel Air Lock, Escape Air Lock, Equipment Hatch (RW 85-016)	35,891.9	32,335.2	XVIe
August 25, 1985	Equipment Hatch (RW 85-016)	32,335.2	32,344.8	XVIe
December 1985 - February 1986	All (Refueling Outage) (RW 86-006)	159,023.3	35,305.4	XVII