Philadelphia Electric Company

LIMERICK GENERATING STATION
UNIT 1

Primary Reactor Containment
Integrated Leakage Rate Test

Final Report
August 1984

Bechtel Power Corporation

LIMERICK GENERATING STATION

PHILADELPHIA ELECTRIC COMPANY

REACTOR CONTAINMENT BUILDING
INTEGRATED LEAKAGE RATE TEST
UNIT 1
FINAL REPORT

NRC Docket No. 50-352

Bechtel Power Corporation

August 1984

SU-0065

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1.0 INTRODUCTION

Successful preoperational Integrated Leakage Rate Test (ILRT) and Drywell Bypass Tests were conducted on the Limerick Generating Station Unit 1 reactor containment building between August 1 and August 3, 1984. These tests were performed to demonstrate that the containment leakage and drywell bypass leakage area under prescribed post-accident conditions do not exceed the allowable values specified in the Limerick Generating Station Unit 1 FSAR (Reference 1) and Limerick Generating Station Technical Specification (Reference 2).

The ILRT and bypass tests were conducted in accordance with the requirements of the ILRT procedure (Reference 3), Appendix J to 10CFR50 (Reference 4), ANSI 56.8 (Reference 5), and BN-TOP-1 (Reference 6). Test results, which satisfied all acceptance criteria are summarized below.

	Test Results	Allowable
ILRT Mass Point Leakage Rate*	0.208%/day	0.375%/day
ILRT Mass Point UCL*	0.213%/day	0.375%/day
ILRT Total Time Leakage Rate*	0.191%/day	0.375%/day
ILRT Total Time UCL*	0.255%/day	0.375%/day
Verification Mass Point Rate	0.713%/day	0.582 to 0.832%/day
Verification Total Time Rate	0.711%/day	0.565 to 0.815%/day
Drywell Bypass Area (High Pressure)	0.00190 sq. ft.	0.046 sq. ft.
Drywell Bypass Area (Low Pressure)	0.00026 sq. ft.	0.046 sq. ft.

Note: UCL is 95% Upper Confidence Limit

* Does not include penalties for nonstandard alignment and water level changes of -0.0488%/day

A summary of the test events and test chronology are presented in Section 2.0, Test Synopsis. Plant information, technical data, test results, and measurement system information are presented in Section 3.0, Test Data Summary. Test results are compared to the Acceptance Criteria in Section 4.0, Analysis and Interpretation. Referenced documents are listed in Section 5.0, References.

2.0 TEST SYNOPSIS

The containment was isolated by aligning systems in the specified post-accident modes, except as noted in Section 3.C.13. The first pressurization of the containment for the Structural Integrity Test began at 1450 on July 28, 1984. Prior to pressurization for SIT the drywell sumps water levels were measured. The high pressure drywell area bypass test was conducted during SIT on July 30, 1984 between the hours of 0715 and 0915. The containment was depressurized after completing the SIT. Containment pressurization for ILRT started at 1130 on July 31, 1984. Pressurization rate was adjusted to 8 psi/hr. Test pressure (45.6 psig) was reached at 0122 on August 1, 1984. The pressurization line was isolated from containment and vented. The containment ventilation fans were stopped and the stabilization period started.

After reaching test pressure, the containment penetrations were searched for leaks. The following significant actions were taken prior to starting the stabilization period and ILRT.

1. Pressurized all four main steam pipes downstream of the MSIV to negate leakage through the MSIV. The pressure on main steam lines was maintained below containment pressure and this pressure was monitored and recorded every 15 minutes during the test.

2. Packing on the following containment purge supply and purge exhaust valves was tightened or sealed with plastic sealing compound. The plastic sealing compound was used on the valve packing only as temporary repair to allow completion of the ILRT. A permanent, testable repair to the valve was developed and implemented following the ILRT which required seal welding of the valve bonnets and an additional test tap connection on each valve to test these welds. The ILRT leakage rate total was affected by the additional leakage paths as follows:

a) The minimum verifiable leakage rate for each of the test tap connections (20 sccm) was added to the measured ILRT total. The actual measured leakage for these connection was approximately 2 sccm.

b) All welds were leak-tested at peak accident pressure using the "bubble emission" technique. No addition to the ILRT leakage rate total was necessary since no leakage was observed.

Penetration No.	Valve No.	
X-202	HV-57-103	Sealed
X-26	HV-57-113	Sealed
X-201A	HV-57-122	Sealed
X-25	HV-57-125	Sealed
X-26	HV-57-114	Packing tightened

3. Identified and fixed tubing leaks on hydrogen recombiner.

4. Tightened condensate supply valves to the suppression pool to reduce inleakage of the water.

5. CRD system vent valves were closed to reduce water loss from the reactor. The vent valves were reopened prior to starting the stabilization period. Leakage was measured at approximately 2.1 gpm.

6. Four out of nine dewcells were found malfunctioning. These dewcells were assigned a volume fraction of 0 and the containment volume was redistributed among the remaining five dewcells. Plots of malfunctioning sensors are given in Appendix H.

At 0600 hrs on August 2, 1984, the containment stabilization period started. The temperature stabilization criteria of References 5 and 6 were satisfied during the four-hour period from 0600 to 1000 on August 2, 1984.

The ILRT test period began at 1000 on August 2, 1984. Initial test pressure was 45.6 psig. Containment pressure, temperature and dew point temperature were measured at 15-minute intervals using precision devices. Reactor vessel and suppression pool water levels were measured at 15-minute intervals. After 8 hours of data had satisfied all leakage rate acceptance criteria, the ILRT was terminated at 1800 on August 2, 1984.

The verification test was initiated at 2015 on August 2, 1984, by continuously venting 5.74 SCFM of air from the containment through a flowmeter and allowing test conditions to stabilize for 1 hour. The new leakage rate calculated using 4 hours of data from 2115 on August 2, 1984, to 0115 on August 3, 1984, verified the performance of the instrumentation system.

The drywell and suppression pool were depressurized to Low Pressure Drywell Bypass Test pressure (4.75 to 5.0 psig). After isolating the drywell from the pressurization system, the suppression pool was depressurized to 0 psig and isolated. Following a 1-hour stabilization period the Drywell Bypass Test period began at 1015 on August 3, 1984. The test was terminated at 1415 on August 3, 1984 after 4 hours of data demonstrated an acceptable bypass area.

The High Pressure Drywell Bypass Test was conducted during the Structural Integrity Test between 0715 and 0915 hr on July 30, 1984.

3.0 TEST DATA SUMMARY

A. Plant Information

Owner:	Philadelphia Electric Company
Docket No.:	50-352
Plant:	Limerick Generating Station, Unit 1
Location:	Pottstown, PA
Containment Type:	Mark II, BWR
NSSS Supplier, Type:	General Electric, BWR
Date Test Completed:	August 3, 1984

B. Technical Data

1.	Drywell Net Free Air Volume (Low Reactor Water Level)	248,950 cu. ft.
2.	Suppression Pool Net Free Air Volume	159,540 cu. ft.

Free air volume corresponds to a suppression pool water level of 22' (Low water level).

3.	Design Pressure Design Temperature	55 psig 340°F
4.	Peak Accident Pressure, Pa Peak Accident Temperature	44 psig 330°F
5.	Containment ILRT Average Temperature Limits	60-120°F

C. Test Results - Type A Test

1.	Test Method	Absolute
2.	Data Analysis Techniques	Mass Point Leakage Rate Per ANSI/ANS 56.8-1981; Total Time Leakage Rate per BN-TOP-1
3.	Test Pressure	45.65 psig
4.	Maximum Allowable Leakage Rate, L_a	0.50%/day
5.	75% of La	0.375%/day

6. Integrated Leakage Rate Test Results	Leakage Rate	UCL*
Mass Point Analysis	0.208%/day	0.213%/day
Total Time Analysis	0.191%/day	0.255%/day

* 95% Upper Confidence Limit Using Student t distribution

7. CRD Leakage

CRD leakage varied between 2.14 and 2.08 gal/min at 0600 hrs and 1700 hrs on August 2, 1984 respectively. The CRD leakage is accounted for as the drop in reactor water level during the test period.

8. Imposed Verification Leakage Rate 0.50%/day (5.74 SCFM)

9. Verification Test Results

	Leakage Rate, %/day
Mass Point Analysis	0.713
Total Time Analysis	0.711

10. Verification Test Limits:

	Test Limits, %/day
Mass Point Analysis	
Upper Limit (Lo+Lam+0.25La)	0.832
Lower Limit (Lo+Lan-0.25La)	0.582
Total Time Analysis	
Upper Limit (La+Lam+0.25La)	0.815
Lower Limit (La+Lam-0.25La)	0.565

11. Report Printouts:

The Report printouts and data plots for the ILRT and verification test calculations are provided in Appendices B through F.

12. Containment Water Level Changes

a. Suppression Pool

Start @ 1000 hrs 8/2/84 level = 22' 7-5/8"
End @ 1600 hrs on 8/2/84 level = 22' 7-13/16"

b. Reactor Water Level

Start @ 1000 hrs 8/2/84 level = 34"
End @ 1800 hrs 8/2/84 level = 28.5"

c. Equipment Drain Tank, and drywell floor drain sump. The total volume was measured by drawing and measuring the amount in 20 gallon drums.

Total volume = 200 gallons at start of test
Total volume = 1250 gallons at end of test

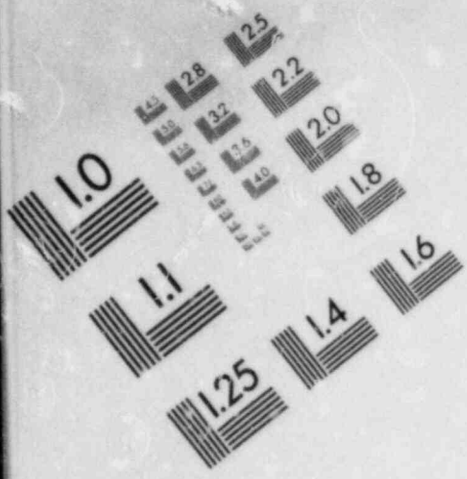
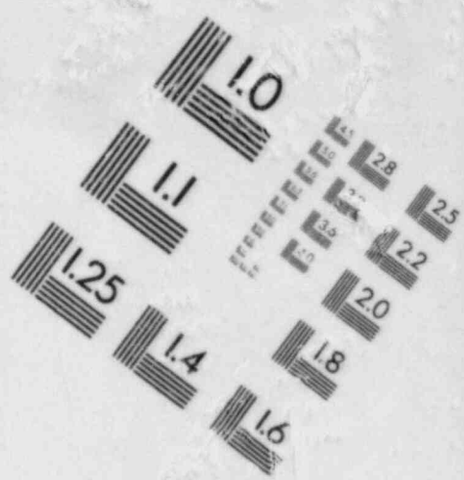
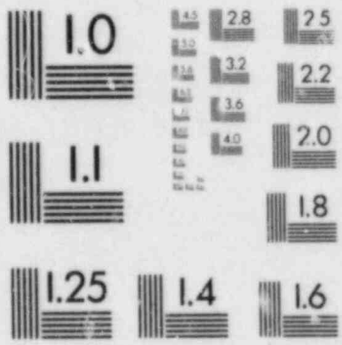
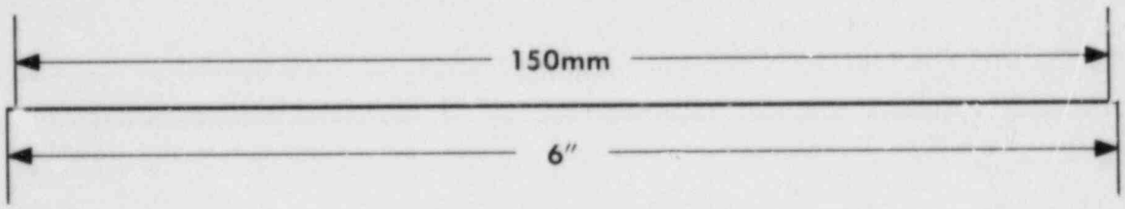
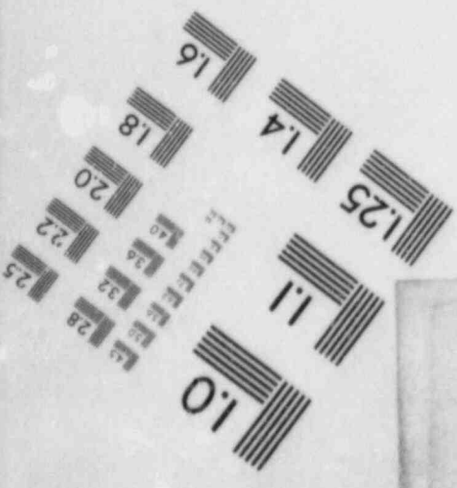


IMAGE EVALUATION
TEST TARGET (MT-3)









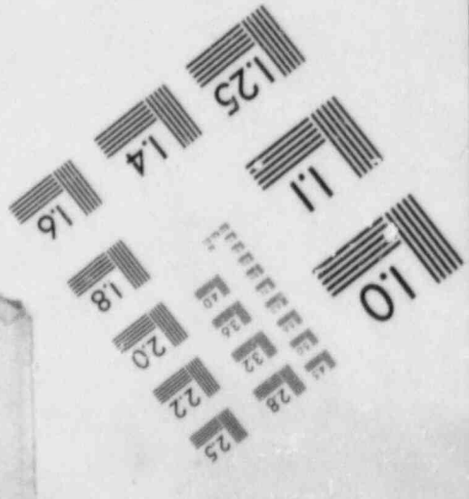
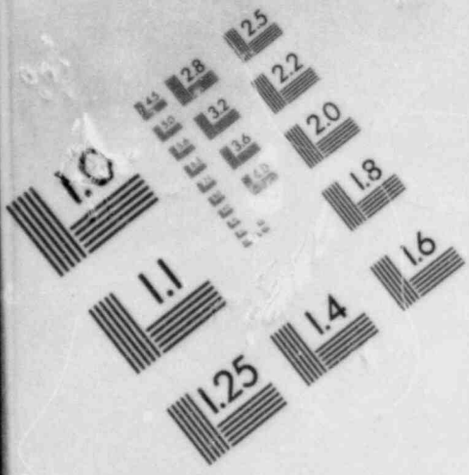
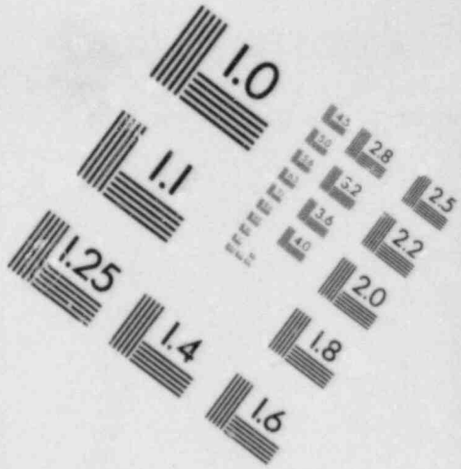
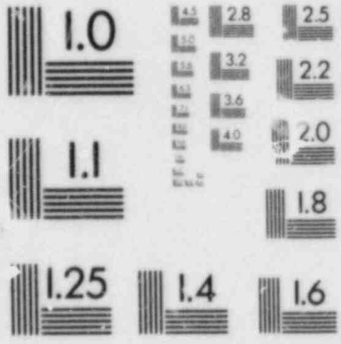
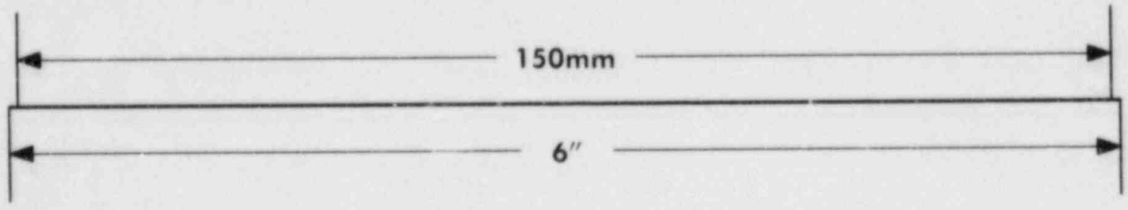


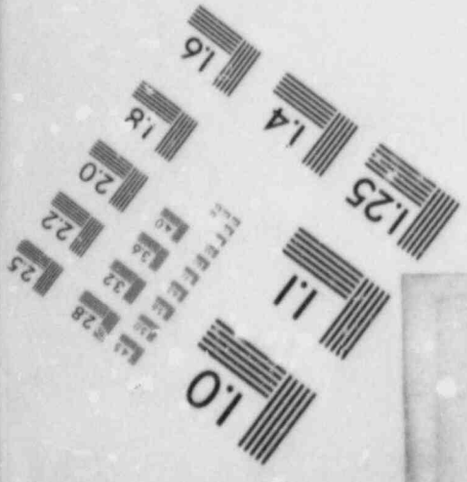
IMAGE EVALUATION TEST TARGET (MT-3)

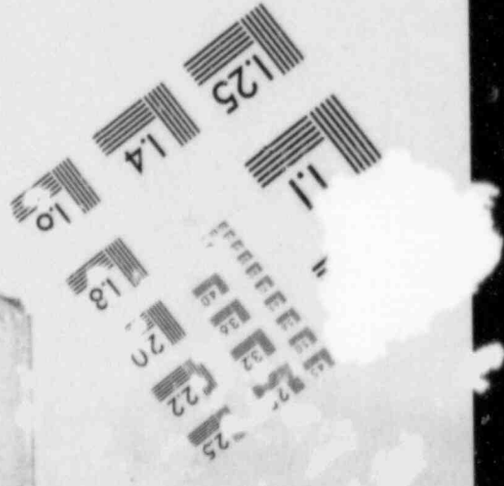












13. Penetrations not in Post-LOCA Alignment During ILRT

Penetration	System	Leakage Rate
X-235	Core Spray	0 (water test)
X-404	ILRT Pressure Sensor	20 sccm
X-227	ILRT Pressure Sensor	20 sccm
X-7A	MSIV 'A' Line	495.2 sccm
X-7B	MSIV 'B' Line	93 sccm
X-7C	MSIV 'C' Line	1063.2 sccm
X-7D	MSIV 'D' Line	371.68 sccm
X-26	HV-57-114	169.3 sccm
X-25	HV-57-125 (Packing Leak)	20 sccm
X-202	HV-57-103 (Packing Leak)	20 sccm
X-26	HV-57-113 (Packing Leak)	20 sccm
X-201A	HV-57-122 (Packing Leak)	20 sccm

D. Test Results - High Pressure Drywell Bypass Area Test

1. Test Method — Absolute

2. Data Analysis Technique — Total Time per Procedure 1P-59.2, Appendices T & N

3. Test Pressure

Drywell	54.9 psig
Suppression Pool	22.3 psig

4. Maximum Allowable Bypass Area — 0.046 sq. ft.

5. Calculated Bypass Area — 0.00190 sq. ft.

6. Report Printouts

The report printouts for the high pressure Drywell Bypass Area Test are provided in Appendix I.

E. Test Results - Low Pressure Drywell Bypass Area Test

1. Test Method — Absolute

2. Data Analysis Technique — Total Time per Procedure 1P-59.2, Appendix N

3. Test Pressure

Drywell	4.5 psig
Suppression Pool	0.0 psig

4. Maximum Allowable Bypass Area — 0.046 sq. ft

5. Calculated Bypass Area — 0.00026 sq. ft

6. Report Printouts

The report printouts for the low pressure Drywell Bypass Area Test are provided in Appendix J.

F. Test Results - Type B and C

A summary of preoperational local leakage rate test results is provided in Appendix K.

G. Integrated Leakage Rate Measurement System

Instrument (no. of sensors)	Descripton	Date	
1. Absolute Pressure (2)	Mensor Quartz Monometer Model No. CEC402	Range:	0-100 psia
		Accuracy:	0.020 psia
		Sensitivity:	0.002 psia
		Repeatability:	0.001 psia
		Calibration Date:	2/28/84
2. Drybulb Temperature (24)	Yellow Spring Instru. Model No. 138-AW	Range:	60-120°F
		Accuracy:	0.1°F
		Sensitivity:	0.1°F
		Repeatability:	0.01°F
		Calibration Date:	3/5/84
3. Dewpoint Temperature (9)*	EG&G Model No. 660-S2	Range:	32-120°F
		Accuracy:	0.54°F
		Sensitivity:	0.54°F
		Repeatability:	0.01°F
		Calibration Date:	7/13/84
4. Flow Meter (1)	TSI Model No. 2013	Range:	0-10 scfm
		Accuracy:	0.1 scfm
		Sensitivity:	0.04 scfm
		Repeatability:	0.01 scfm
		Calibration Date:	2/27/84

* Four dewcell sensors malfunctioned during the ILRT and were not used in the leakage rate calculations. Their volume fractions were redistributed to adjacent sensors.

Drybulb and dewpoint temperature sensor locations and volume fractions are provided in Table 1.

The calculated ISG for the test is 0.0295%/day.
The calculations are presented in Appendix G.

TABLE 1

DRYBULB AND DEWPOINT TEMPERATURE SENSOR LOCATIONS
(AS LOCATED DURING ILRT)

Sensor No.	Elevation (ft)	Azimuth (degrees)	Distance From Center (ft)	Volume Fractions (Procedure)	Volume** Fractions (ILRT)
			DRYBULB (RTDs)		
TE-015A	333	240	17	0.022	0.022
TE-015B	317	12	16	0.024	0.024
TE-015C	317	165	16	0.025	0.025
TE-015D	298	0	20	0.046	0.046
TE-015E	301	181	18	0.047	0.047
TE-015F	245	37	24	0.077	0.077
TE-015G	250	169	26	0.077	0.077
TE-015H	267	165	20	0.077	0.077
TE-015K	265	340	24	0.077	0.077
TE-015J	248	235	26	0.077	0.077
TE-015L	245	0	0	0.076	0.076
TE-016A	227	102	At Catwalk	0.070	0.070
TE-016B	227	169	At Catwalk	0.071	0.071
TE-016C	227	249	At Catwalk	0.071	0.071
TE-016D	227	318	At Catwalk	0.071	0.071
TE-016E	227	16	At Catwalk	0.071	0.071
TE-016F	220	0	0	0.022	0.022
			DEWPOINT		
ME-015A	317	12	16	0.071	0.071
ME-015B*	245	37	22	0.093	0.000
ME-015C	266	167	22	0.115	0.277
ME-015D*	265	340	22	0.115	0.000
ME-015E	299	13	20	0.115	0.277
ME-015F*	301	181	18	0.116	0.000
ME-016A	227	16	At Catwalk	0.125	0.187
ME-016B*	227	249	At Catwalk	0.125	0.000
ME-016C	227	169	At Catwalk	0.125	0.188

* Malfunctioning sensor - not used for leakage rate calculations.

** Volume fractions reflect the suppression pool free air volume during the ILRT (156,188 cu. ft.), and the redistribution of volume fraction for the malfunctioning sensors.

H. Information Retained at Plant

The following information is available for review at the facility:

1. Access control procedures that were established to limit ingress to containment during testing.

2. A listing of all containment penetrations, including penetration size, and function.

3. A listing of normal operating instrumentation used for the leakage rate test.

4. A system lineup (at time of test), showing required valve positions and status of piping systems.

5. A continuous, sequential log of events from initial survey of containment to restoration of all tested systems.

6. Documentation of instrumentation calibration and standards.

7. The working copy of test procedures that would include signature sign-off of procedural steps.

8. The procedure and all data that would verify completion of penetrations and local leakage testing (type B&C tests).

9. Computer printouts of Integrated Leakage Rate Test Data.

10. The Quality Assurance audit plan or checklist that was used to monitor ILRT with proper sign-offs.

11. A listing of all test exceptions including changes in containment system boundaries instituted to conclude successful testing.

12. Description of sensor malfunctions, repairs, and methods used to redistribute volume fractions to operating instrumentation.

13. Description of method of leak rate verification of instrument measuring system (superimposed leakage), with calibration information on flowmeters.

14. The P&IDs of pertinent systems penetrating the containment or affected by ILRT.

4.0 ANALYSIS AND INTERPRETATION

4.1 ILRT Test

During the ILRT, the following penetrations were not in post-LOCA alignment. The penetrations together with their Type C leakage rates are given below:

Penetration	System/Valve	Leakage Rate
X-235	Core Spray	0 (water test)
X-404	ILRT Pressure Sensor	20 sccm
X-227	ILRT Pressure Sensor	20 sccm
X-7A	MSIV 'A' Line	495.2 sccm
X-7B	MSIV 'B' Line	93 sccm
X-7C	MSIV 'C' Line	1063.2 sccm
X-7D	MSIV 'D' Line	371.68 sccm
X-26	HV-57-114	169.3 sccm
X-25	HV-57-125*	20 sccm
X-202	HV-57-103*	20 sccm
X-26	HV-57-113*	20 sccm
X-201A	HV-57-122*	20 sccm
	Total	= 2312.38 sccm

Local Leakage Correction to ILRT = 0.0072%/day

* These valves are not containment isolation valves. They are valves abondoned in place, and packing leaks were stopped with plastic sealing compound to allow completion of ILRT.

The following containment water level changes were measured at the start and end of the ILRT:

1. Reactor Vessel Level

Level at the start of test = 34"
Level at the end of test = 28.5"
Difference = -5.5"

Free air volume increase = 157.3 cu. ft.
(28.6 cu. ft./in.)

Correction = -0.117%/day

NOTE: The drop in reactor level is due to CRD leakage.

2. Suppression Pool

Start of Test = 271.625"
End of Test = 271.813"
Difference = 0.188"

Free air volume decrease (439.03 cu. ft./in.)= 83.538 cu. ft.

Correction = 0.061%/day

3. Equipment Drain Tank and Drywell Sumps

Equipment Drain Tank and Drywell Sump level changes did not change the ILRT results because the water that filled the tank and the sump came from within the containment boundry.

The total correction for water level equals the sum of corrections in 1, 2 and 3 above. Total correction = - 0.056%/day.

4.2 The total leakage rate correction for penetrations not in post-LOCA alignment and water level changes is (-0.056 + 0.0072) or correction = - 0.0488%/day.

The calculated leakage rates during the ILRT were 0.208%/day (mass point) and 0.191%/day (total time). The calculated 95% upper confidence levels were 0.213%/day (mass point) and 0.255%/day (total time). Adding the total leakage rate correction for penetrations not in post-LOCA alignment and containment water level changes yields the corrected leakage rates as follows:

Leakage Rates, %/day

	Mass Point		Total Time	
	Leakage Rate	UCL	Leakage Rate	UCL
Calculated	0.208	0.213	0.191	0.255
Corrections	-0.0488	-0.0488	-0.0488	-0.0488
Corrected	0.1592	0.1642	0.1422	0.2062

Since the corrected 95% upper confidence levels for both mass point and total time are less than 0.75La (0.375%/day), the test results demonstrate that the leakage through the primary containment and systems and components penetrating primary containment does not exceed the allowable leakage rate specified in the Limerick Generating Station, Unit 1 FSAR and Technical Specifications.

5.0 REFERENCES

1. Limerick Generating Station, FSAR.

2. Limerick Generating Station, Technical Specifications.

3. Limerick Generating Station, Procedure 1P-59.2, Rev. 0 Integrated Leakage Rate Test Procedure Preoperational Primary Reactor Containment.

4. Code of Federal Regulations, Title 10, Part 50, Appendix J, Primary Reactor Containment Leakage Testing For Water Cooled Power Reactors.

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

6. Bechtel Topical Report BN-TOP-1, Testing Criteria for Integrated Leakage Rate Testing of Primary Containment Structures for Nuclear Power Plants, Revision 1, 1972.

APPENDIX A

DESCRIPTION OF BECHTEL ILRT COMPUTER PROGRAM

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DESCRIPTION OF BECHTEL ILRT COMPUTER PROGRAM

A. PROGRAM AND REPORT DESCRIPTION

1. The Bechtel ILRT computer program is used to determine the integrated leakage rate of a nuclear primary containment structure. The program is used to compute leakage rate based on input values of time, free air volume, containment atmosphere total pressure, drybulb temperature, and dewpoint temperature (water vapor pressure). Leakage rate is computed using the Absolute Method as defined in ANSI/ANS 56.8-1981, "Containment System Leakage Testing Requirements" and BN-TOP-1, Rev 1, "Testing Criteria for Integrated Leakage Rate Testing of Primary Containment Structures for Nuclear Power Plants." The program is designed to allow the user to evaluate containment leakage rate test results at the jobsite during containment leakage testing. Current leakage rate values may be obtained at any time during the testing period using one of two computational methods, yielding three different report printouts.

2. In the first printout, the Total Time Report, leakage rate is computed from initial values of free air volume, containment atmosphere drybulb temperature and partial pressure of dry air, the latest values of the same parameters, and elapsed time. These individually computed leakage rates are statistically averaged using linear regression by the method of least squares. The Total Time Method is the computational technique upon which the short duration test criteria of BN-TOP-1, Rev 1, "Testing Criteria for Integrated Leakage Rate Testing of Primary Containment Structures for Nuclear Power Plant," are based.

3. The second printout is the Mass Point Report and is based on the Mass Point Analysis Technique described in ANSI/ANS 56.8-1981, "Containment System Leakage Testing Requirements." The mass of dry air in the containment is computed at each data point (time) using the Equation of State, from current values of containment atmosphere drybulb temperature and partial pressure of dry air. Contained mass is "plotted" versus time and a regression line is fit to the data using the method of least squares. Leakage rate is determined from the statistically derived slope and intercept of the regression line.

4. The third printout, the Trend Report, is a summary of leakage rate values based on Total Time and Mass Point computations presented as a function of number of data points and elapsed time (test duration). The Trend Report provides all leakage rate values required for comparision to the acceptance criteria of BN-TOP-1 for conduct of a short duration test.

5. The program is written in a high level language and is designed for use on a micro-computer. Brief descriptions of progrm use, formulae used for leakage rate computations, and program logic are provided in the following paragraphs.

B. EXPLANATION OF PROGRAM

1. The Bechtel ILRT computer program is written, for use by experienced ILRT personnel, to determine containment integrated leakage rates based on the Absolute Method described in ANSI/ANS 56.8-1981 and BN-TOP-1.

2. Information loaded into the program prior to or at the start of the test:

   a. Number of containment atmosphere drybulb temperature sensors, dewpoint temperature (water vapor pressure) sensors and pressure gages to be used in leakage rate computations for the specific test

   b. Volume fractions assigned to each of the above sensors

   c. Calibration data for above sensors

   d. Test title

   e. Test pressure

   f. Maximum allowable leakage rate at test pressure.

3. Data received from the data acquistion system during the test, and used to compute leakage rate:

   a. Time and date

   b. Containment atmosphere drybulb temperatures

   c. Containment atmosphere pressure (s)

   d. Containment atmosphere dewpoint temperatures

   e. Containment free air volume.

4. After all data at a given time are received, a Summary of Measured Data Report (refer to "Program Logic," Paragraph D, "Data" option command) is printed.

5. If drybulb and dewpoint temperature sensors should fail during the tests, the data from the sensor(s) are not used. The volume fractions for the remaining sensors are recomputed and reloaded into the program for use in ensuing leakage rate computations.

C. LEAKAGE RATE FORMULAE

1. Computaton using the Total Time Method

a. Measured leakage rate from data:

$$P_1V_1 = W_1RT_1 \quad (1)$$

$$P_iV_i = W_iRT_i \quad (2)$$

$$L_i = \frac{2400\ (W_i - W_1)}{\Delta t_i\ W_1} \quad (3)$$

Solving for W_1 and W_i and substituting equations (1) and (2) into (3) yields:

$$L_i = \frac{2400}{\Delta t_i}\left(1 - \frac{T_1P_iV_i}{T_iP_1V_1}\right) \quad (4)$$

where:

W_1, W_i = Weight of contained mass of dry air at times t1 and t_i respectively, lbm.

T_1, T_i = Contaiment atmosphere drybulb temperature at times t1 and t_i respectively, °R.

P_1, P_i = Partial pressure of the dry air component of the containment atmosphere at times t1 and t_i respectively, psia.

V_1, V_i = Containment free air volume at times t_1 and t_i respectively, (constant or variable during the test), ft^3.

t_1, t_i = Time at 1^{st} and i^{th} data points respectively, hours.

Δt_i = Elapsed time from t_1 to t_i, hours.

R = Specific gas constant for air = 53.35 ft.lbf/lbm.°R.

L_i = Measured leakage rate computed during time interval t1 to t_i, wt%/day.

To reduce truncation error, the computer program uses the following equivalent formulation:

$$L_i = \frac{-2400}{\Delta t_i}\left(\frac{\Delta W_i}{W_1}\right)$$

where:

$$\frac{\Delta W_i}{W_1} = \frac{W_i - W_1}{W_1}$$

$$= -\frac{\frac{\Delta P_i}{P_1} + \frac{\Delta V_i}{V_1} + \frac{\Delta P_i V_i}{P_1 V_1} - \frac{\Delta T_i}{T_1}}{1 + \frac{\Delta T_i}{T_i}}$$

$$\Delta P_i = P_i - P_1$$

$$\Delta V_i = V_i - V_1$$

$$\Delta T_i = T_i - T_1$$

b. Calculated leakage rate from regression analysis:

$$\bar{L} = a + b\,\Delta t_N$$

where:

$\bar{L}$ = Calculated leakage rate, wt%/day, as determined from the regression line.

$$a = (\Sigma L_i - b\Sigma \Delta t_i)/N \qquad (6)$$

$$b = \frac{N(\Sigma L_i \Delta t_i) - (\Sigma L_i)(\Sigma \Delta t_i)}{N(\Sigma t_i^2) - (\Sigma \Delta t_i)^2} \qquad (7)$$

N = Number of data points

$$\Sigma = \sum_{i=1}^{N}$$

c. Calculated leakage rate at the 95% confidence level.

$$\bar{L}_{95} = a + b\,\Delta t_N + S_{\bar{L}}$$

where:

$\bar{L}_{95}$ = Calculated leakage rate at the 95% confidence level, at elapsed time Δt_N.

For $\Delta t_N < 24$

$$S_{\bar{L}} = t_{0.025;N-2}[(\Sigma L_i^2 - a\Sigma L_i - b\Sigma L_i \Delta t_i)/(N-2)]^{1/2} \times$$

$$[1 + \frac{1}{N} + (\Delta t_N - \overline{\Delta t})^2 / (\Sigma \Delta t_i^2 - (\Sigma \Delta t_i)^2/N)]^{1/2} \quad (9a)$$

where:

$$t_{0.025;N-2} = 1.95996 + \frac{2.37226}{N-2} + \frac{2.82250}{(N-2)^2}$$

For $\Delta tN \geq 24$

$$S_{\bar{L}} = t_{0.025;N-2}[(\Sigma L_i^2 - a\Sigma L_i - b\Sigma L_i \Delta t_i)/(N-2)]^{1/2} \times$$

$$[\frac{1}{N} + (\Delta t_N - \overline{\Delta t})^2 / (\Sigma \Delta t_i^2 - (\Sigma \Delta t_i)^2/N)]^{1/2} \quad (9b)$$

where:

$$t_{0.025;N-2} = \frac{1.6449(N-2)^2 + 3.5283(N-2) + 0.85602}{(N-2)^2 + 1.2209(N-2) - 1.5162}$$

$$\overline{\Delta t} = \frac{\Sigma \Delta t_i}{N}$$

2. Computation using the Mass Point Method

   a. Contained mass of dry air from data:

$$W_i = 144 \frac{P_i V_i}{R T_i} \quad (10)$$

where:

All symbols as previously defined.

b. Calculated leakage rate from regression analysis, $W = a + b\ t$:

$$\bar{L} = -2400\ \frac{b}{a} \tag{11}$$

where:

$\bar{L}$ = Calculated leakage rate, wt%/day, as determined form the regression line

$$a = (\Sigma W_i - b\Sigma\Delta t_i)/N \tag{12}$$

$$b = \frac{N(\Sigma W_i \Delta t_i) - (\Sigma W_i)(\Sigma\Delta t_i)}{N(\Sigma\Delta t_i^2) - (\Sigma\Delta t_i)^2} \tag{13}$$

Δt_i = Total elapsed time at time i^{th} data point, hours

N = Number of data points

W_i = Contained mass of dry air at i^{th} data point, lbm, as computed from equation (10)

$$\Sigma = \sum_{i=1}^{N}$$

Inorder to reduce truncation error, the computer program uses the following equivalent formulation:

$$a = W_1 \left[1 + (\Sigma \frac{\Delta W_i}{W_1} - \frac{b}{W_1}\Sigma\Delta t_i)/N \right]$$

$$b = W_1 \left[\frac{N\ (\Sigma \frac{\Delta W_i}{W_1}\ \Delta t_i) - \Sigma \frac{\Delta W_i}{W_1}\ \Sigma\ \Delta t_i}{N(\Sigma\Delta t_i^2) - (\Sigma\Delta t_i)^2} \right]$$

where, $\frac{\Delta W_i}{W_1}$ is as previously defined.

c. Calculated leakage rate at the 95% confidence level.

$$\bar{L}_{95} = \frac{-2400}{a}\,(b - S_b) \qquad (14)$$

where:

$\bar{L}_{95}$ = Calculated leakage rate at the 95% confidence level, wt.%/day.

$$S_b = t_{0.025;N-2}\,\frac{SN^{1/2}}{[N\Sigma\Delta t_i^{\,2} - (\Sigma\Delta t_i)^2\,]^{1/2}} \qquad (15)$$

where, $t_{0.025;N-2} = \dfrac{1.6449(N-2)^2 + 3.5283(N-2)^2 + 0.85602}{(N-2)^2 + 1.2209(N-2) - 1.5162}$

$$S = \left(\frac{[W_i - (a + b\,\Delta t_i)]^2}{N-2} \right)^{1/2}$$

$$S = W_1 \left[\frac{1}{N-2} \left(\Sigma(\Delta W_i/W_1)^2 - [\Sigma\,(\Delta W_i/W_1)]^2/N - \frac{[\Sigma\,(\Delta W_i/W_1)\,\Delta t_i - \Sigma\,(\Delta W_i/W_1)(\Sigma\Delta t_i)/N\,]^2}{\Sigma(\Delta t_i^{\,2}) - (\Sigma\Delta t_i)^2/N} \right) \right]^{1/2}$$

D. PROGRAM LOGIC

1. The Bechtel ILRT computer program logic flow is controlled by a set of user options. The user options and a brief descripton of their associated function are presented below.

OPTION COMMAND	FUNCTION
	After starting the program execution, the user either enters the name of the file containing previously entered data or initializes a new data file.
DATA	Enables user to enter raw data. When the system requested values of time, volume, temperature, pressure and vapor pressure, the user enters the appropriate data. After completing the data entry, a summary is printed out. The user then verifies that the data were entered correctly. If errors are detected, the user will then be given the opportunity to correct the errors. After the user verifies that the data were entered correctly, a Corrected Data Summary Report of time, data, average temperature, partial pressure of dry air, and water vapor pressure is printed.
TREND	A Trend Report is printed.
TOTAL	A Total Time Report is printed.
MASS	A Mass Point Report is printed.
TERM	Enables user to sign-off temporarily or permanently. All data is saved on a file for restarting.
CORR	Enables user to correct previously entered data.
LIST	A Summary Data Report is printed.
PLOT	Enables user to plot summary data, individual sensor data, air mass or leakage rate versus time.
DELETE	Enables user to delete a data point.
INSERT	Enables user to reinstate a previously deleted data point.
VOLFRA	Enables user to change volume fractions.
TIME	Enables the user to specify the time interval for a report or plot.
VERF	Enables the user to input imposed leakage rate and calculated ILRT leakage rates at start of verification test.

APPENDIX B

ILRT STABILIZATION

LIMERICK GENERATING STATION UNIT 1 ILRT
TEMPERATURE STABILIZATION

FROM A STARTING TIME AND DATE OF: 600 802 1984

TIME (HOURS)	TEMP (R)	ANSI AVE T (4HRS)	ANSI AVE T (1HR)	DIFF	BN-TOP-1 AVE T (2HRS)
.00	541.73				
.25	541.74				
.50	541.75				
.75	541.74				
1.00	541.74				
1.25	541.75				
1.50	541.77				
1.75	541.77				
2.00	541.77				.019*
2.25	541.78				.021*
2.50	541.78				.018*
2.75	541.78				.016*
3.00	541.78				.020*
3.25	541.77				.009*
3.50	541.77				-.001*
3.75	541.83				.027*
4.00	541.83	.024	.047	-.02*	.014*

* INDICATES TEMPERATURE STABILIZATION HAS BEEN SATISFIED

APPENDIX C

ILRT SUMMARY DATA

LIMERICK GENERATING STATION UNIT 1 ILRT
SUMMARY DATA

ALMAX = .500 VOLUME = 405509.
VRATET = .690 VRATEM = .707

TIME	DATE	TEMP	PRESSURE	VPRS	VOLUME
1000	802	541.827	59.3583	.4597	405487.
1015	802	541.832	59.3566	.4604	405487.
1030	802	541.836	59.3542	.4607	405487.
1045	802	541.842	59.3542	.4608	405487.
1100	802	541.842	59.3526	.4614	405487.
1115	802	541.844	59.3513	.4617	405487.
1130	802	541.854	59.3509	.4610	405487.
1145	802	541.854	59.3503	.4617	405487.
1200	802	541.866	59.3495	.4615	405487.
1215	802	541.861	59.3482	.4617	405487.
1230	802	541.868	59.3480	.4619	405487.
1245	802	541.870	59.3462	.4628	405487.
1300	802	541.887	59.3461	.4628	405487.
1315	802	541.878	59.3456	.4624	405487.
1330	802	541.894	59.3441	.4629	405487.
1345	802	541.884	59.3446	.4624	405487.
1400	802	541.899	59.3445	.4625	405487.
1415	802	541.909	59.3430	.4629	405487.
1430	802	541.909	59.3409	.4641	405487.
1445	802	541.919	59.3417	.4632	405487.
1500	802	541.921	59.3397	.4642	405487.
1515	802	541.929	59.3393	.4637	405487.
1530	802	541.930	59.3382	.4647	405487.
1545	802	541.934	59.3382	.4647	405487.
1600	802	541.941	59.3378	.4652	405487.
1615	802	541.938	59.3377	.4643	405487.
1630	802	541.947	59.3357	.4653	405487.
1645	802	541.947	59.3350	.4649	405487.
1700	802	541.952	59.3345	.4655	405487.
1715	802	541.957	59.3328	.4661	405487.
1730	802	541.962	59.3320	.4659	405487.
1745	802	541.969	59.3318	.4661	405487.
1800	802	541.964	59.3318	.4651	405487.

APPENDIX D

ILRT CALCULATIONS

PERICK GENERATING STATION UNIT 1 ILRT
LEAKAGE RATE (WEIGHT PERCENT/DAY)
MASS POINT ANALYSIS

TIME AND DATE AT START OF TEST: 1000 802 1984
TEST DURATION: 8.00 HOURS

TIME	TEMP (R)	PRESSURE (PSIA)	CTMT. AIR MASS (LBM)	MASS LOSS (LBM)	AVERAGE MASS LOSS (LBM/HR)
1000	541.827	59.3583	119902.		
1015	541.832	59.3566	119898.	4.5	18.2
1030	541.836	59.3542	119892.	5.8	20.7
1045	541.842	59.3542	119890.	1.4	15.6
1100	541.842	59.3526	119887.	3.2	14.9
1115	541.844	59.3513	119884.	3.2	14.4
1130	541.854	59.3509	119881.	2.8	13.9
1145	541.854	59.3503	119880.	1.4	12.7
1200	541.866	59.3495	119875.	4.4	13.3
1215	541.861	59.3482	119874.	1.4	12.4
1230	541.868	59.3480	119872.	1.9	11.9
1245	541.870	59.3462	119868.	4.2	12.4
1300	541.887	59.3461	119864.	3.9	12.6
1315	541.878	59.3456	119865.	-.8	11.4
1330	541.894	59.3441	119858.	6.5	12.4
1345	541.884	59.3446	119862.	-3.0	10.8
1400	541.899	59.3445	119858.	3.3	11.0
1415	541.909	59.3430	119853.	5.1	11.5
1430	541.909	59.3409	119849.	4.4	11.9
1445	541.919	59.3417	119848.	.5	11.4
1500	541.921	59.3397	119844.	4.4	11.7
1515	541.929	59.3393	119841.	2.6	11.6
1530	541.930	59.3382	119839.	2.5	11.5
1545	541.934	59.3382	119838.	.9	11.2
1600	541.941	59.3378	119835.	2.5	11.1
1615	541.938	59.3377	119836.	-.4	10.6
1630	541.947	59.3357	119830.	6.0	11.1
1645	541.947	59.3350	119828.	1.3	10.9
1700	541.952	59.3345	119826.	2.1	10.8
1715	541.957	59.3328	119822.	4.5	11.1
1730	541.962	59.3320	119819.	2.6	11.1
1745	541.969	59.3318	119817.	2.0	11.0
1800	541.964	59.3318	119818.	-1.2	10.5

FREE AIR VOLUME USED (CU. FT.)	= 405509.
REGRESSION LINE	
INTERCEPT (LBM)	= 119898.
SLOPE (LBM/HR)	= -10.4
MAXIMUM ALLOWABLE LEAKAGE RATE	= .500
75% OF MAXIMUM ALLOWABLE LEAKAGE RATE	= .375
THE UPPER 95% CONFIDENCE LIMIT	= .213
THE CALCULATED LEAKAGE RATE	= .208
FREE AIR VOLUME AT TIME 1800	= 405487.

LIMERICK GENERATING STATION UNIT 1 ILRT
LEAKAGE RATE (WEIGHT PERCENT/DAY)
TOTAL TIME ANALYSIS

TIME AND DATE AT START OF TEST: 1000 802 1984
TEST DURATION: 8.00 HOURS

TIME	TEMP (R)	PRESSURE (PSIA)	MEASURED LEAKAGE RATE
1000	541.827	59.3583	
1015	541.832	59.3566	.364
1030	541.836	59.3542	.415
1045	541.842	59.3542	.313
1100	541.842	59.3526	.298
1115	541.844	59.3513	.289
1130	541.854	59.3509	.278
1145	541.854	59.3503	.254
1200	541.866	59.3495	.266
1215	541.861	59.3482	.249
1230	541.868	59.3480	.239
1245	541.870	59.3462	.248
1300	541.887	59.3461	.253
1315	541.878	59.3456	.229
1330	541.894	59.3441	.249
1345	541.884	59.3446	.216
1400	541.899	59.3445	.220
1415	541.909	59.3430	.231
1430	541.909	59.3409	.237
1445	541.919	59.3417	.227
1500	541.921	59.3397	.234
1515	541.929	59.3393	.232
1530	541.930	59.3382	.231
1545	541.934	59.3382	.224
1600	541.941	59.3378	.223
1615	541.938	59.3377	.213
1630	541.947	59.3357	.223
1645	541.947	59.3350	.219
1700	541.952	59.3345	.217
1715	541.957	59.3328	.222
1730	541.962	59.3320	.221
1745	541.969	59.3318	.219
1800	541.964	59.3318	.210

MEAN OF THE MEASURED LEAKAGE RATES	=	.249
MAXIMUM ALLOWABLE LEAKAGE RATE	=	.500
75% OF MAXIMUM ALLOWABLE LEAKAGE RATE	=	.375
THE UPPER 95% CONFIDENCE LIMIT	=	.255
THE CALCULATED LEAKAGE RATE	=	.191

LIMERICK GENERATING STATION UNIT 1 ILRT
TREND REPORT

TIME AND DATE AT START OF TEST: 1000 802 1984

NO. PTS	END TIME	TOTAL TIME ANALYSIS MEAS.	CALCULATED	UCL	MASS POINT ANALYSIS CALCULATED	UCL
4	1045	.313	.338	.942	.328	.480
5	1100	.298	.302	.525	.295	.378
6	1115	.289	.282	.425	.280	.333
7	1130	.278	.267	.378	.269	.306
8	1145	.254	.248	.339	.251	.284
9	1200	.266	.243	.329	.249	.274
10	1215	.249	.233	.312	.241	.263
11	1230	.239	.224	.297	.232	.252
12	1245	.248	.220	.293	.231	.247
13	1300	.253	.220	.295	.233	.247
14	1315	.229	.213	.284	.226	.240
15	1330	.249	.214	.287	.228	.241
16	1345	.216	.206	.276	.220	.233
17	1400	.220	.202	.269	.215	.228
18	1415	.231	.200	.268	.214	.226
19	1430	.237	.201	.270	.217	.227
20	1445	.227	.200	.268	.216	.225
21	1500	.234	.200	.269	.217	.225
22	1515	.232	.200	.269	.217	.225
23	1530	.231	.200	.269	.218	.225
24	1545	.224	.199	.267	.216	.223
25	1600	.223	.198	.266	.215	.222
26	1615	.213	.195	.262	.212	.219
27	1630	.223	.195	.261	.212	.218
28	1645	.219	.194	.260	.211	.217
29	1700	.217	.193	.258	.210	.215
30	1715	.222	.193	.258	.210	.215
31	1730	.221	.193	.258	.210	.215
32	1745	.219	.193	.257	.210	.214
33	1800	.210	.191	.255	.208	.213

APPENDIX E

VERIFICATION TEST SUMMARY DATA

LIMERICK GENERATING STATION UNIT 1 ILRT
SUMMARY DATA

ALMAX = .500 VOLUME = 405509.
VRATET = .690 VRATEM = .707

TIME	DATE	TEMP	PRESSURE	VPRS	VOLUME
2115	802	541.968	59.2711	.4688	405487.
2130	802	541.975	59.2673	.4687	405487.
2145	802	541.971	59.2623	.4696	405487.
2200	802	541.974	59.2566	.4703	405487.
2215	802	541.979	59.2529	.4700	405487.
2230	802	541.974	59.2495	.4694	405487.
2245	802	541.979	59.2435	.4715	405487.
2300	802	541.972	59.2397	.4712	405487.
2315	802	541.963	59.2355	.4714	405487.
2330	802	541.970	59.2313	.4716	405487.
2345	802	541.971	59.2257	.4722	405487.
0	803	541.965	59.2228	.4711	405487.
15	803	541.975	59.2179	.4720	405487.
30	803	541.973	59.2131	.4728	405487.
45	803	541.975	59.2100	.4719	405487.
100	803	541.980	59.2056	.4723	405487.
115	803	541.981	59.2014	.4725	405487.

LIMERICK GENERATING STATION UNIT 1 ILRT
LEAKAGE RATE (WEIGHT PERCENT/DAY)
MASS POINT ANALYSIS

TIME AND DATE AT START OF TEST: 2115 802 1984
TEST DURATION: 4.00 HOURS

TIME	TEMP (R)	PRESSURE (PSIA)	CTMT. AIR MASS (LBM)	MASS LOSS (LBM)	AVERAGE MASS LOSS (LBM/HR)
2115	541.968	59.2711	119695.		
2130	541.975	59.2673	119685.	9.3	37.1
2145	541.971	59.2623	119676.	9.2	36.9
2200	541.974	59.2566	119664.	12.2	40.9
2215	541.979	59.2529	119656.	8.5	39.2
2230	541.974	59.2495	119650.	5.7	35.9
2245	541.979	59.2435	119637.	13.3	38.8
2300	541.972	59.2397	119630.	6.1	36.7
2315	541.963	59.2355	119624.	6.5	35.4
2330	541.970	59.2313	119614.	10.1	35.9
2345	541.971	59.2257	119602.	11.6	37.0
0	541.965	59.2228	119598.	4.5	35.2
15	541.975	59.2179	119586.	12.1	36.3
30	541.973	59.2131	119577.	9.2	36.4
45	541.975	59.2100	119570.	6.7	35.7
100	541.980	59.2056	119560.	10.0	36.0
115	541.981	59.2014	119551.	8.6	35.9

FREE AIR VOLUME USED (CU. FT.) = 405509.
REGRESSION LINE
INTERCEPT (LBM) = 119693.
SLOPE (LBM/HR) = -35.5
VERIFICATION TEST LEAKAGE RATE UPPER LIMIT = .832
VERIFICATION TEST LEAKAGE RATE LOWER LIMIT = .582
THE CALCULATED LEAKAGE RATE = .713
FREE AIR VOLUME AT TIME 115 = 405487.

LIMERICK GENERATING STATION UNIT 1 ILRT
LEAKAGE RATE (WEIGHT PERCENT/DAY)
TOTAL TIME ANALYSIS

TIME AND DATE AT START OF TEST: 2115 802 1984
TEST DURATION: 4.00 HOURS

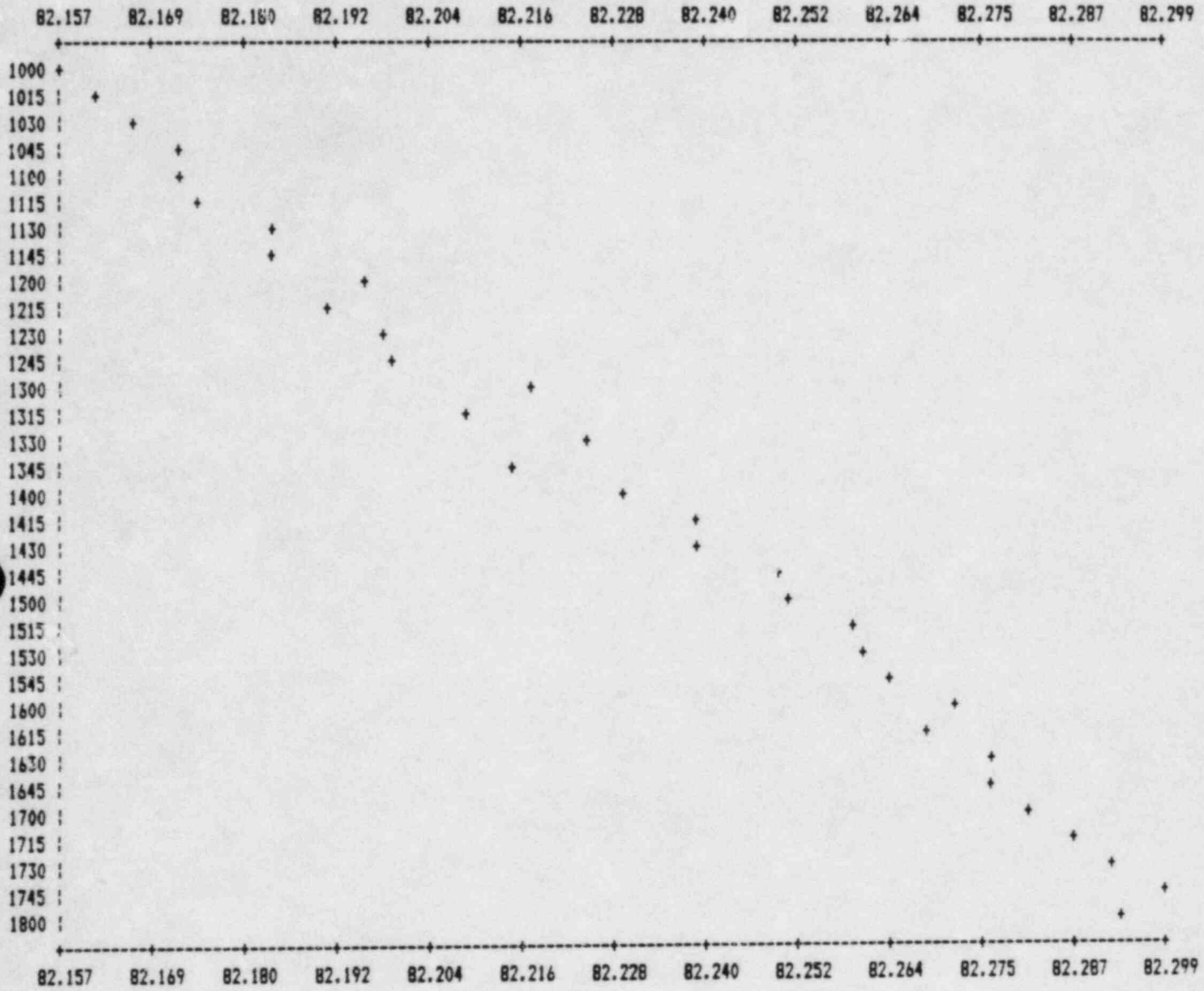
TIME	TEMP (R)	PRESSURE (PSIA)	MEASURED LEAKAGE RATE
2115	541.968	59.2711	
2130	541.975	59.2673	.743
2145	541.971	59.2623	.739
2200	541.974	59.2566	.820
2215	541.979	59.2529	.786
2230	541.974	59.2495	.720
2245	541.979	59.2435	.778
2300	541.972	59.2397	.736
2315	541.963	59.2355	.710
2330	541.970	59.2313	.720
2345	541.971	59.2257	.742
0	541.965	59.2228	.707
15	541.975	59.2179	.729
30	541.973	59.2131	.729
45	541.975	59.2100	.716
100	541.980	59.2056	.721
115	541.981	59.2014	.720

MEAN OF THE MEASURED LEAKAGE RATES = .738
VERIFICATION TEST LEAKAGE RATE UPPER LIMIT = .815
VERIFICATION TEST LEAKAGE RATE LOWER LIMIT = .565
THE CALCULATED LEAKAGE RATE = .711

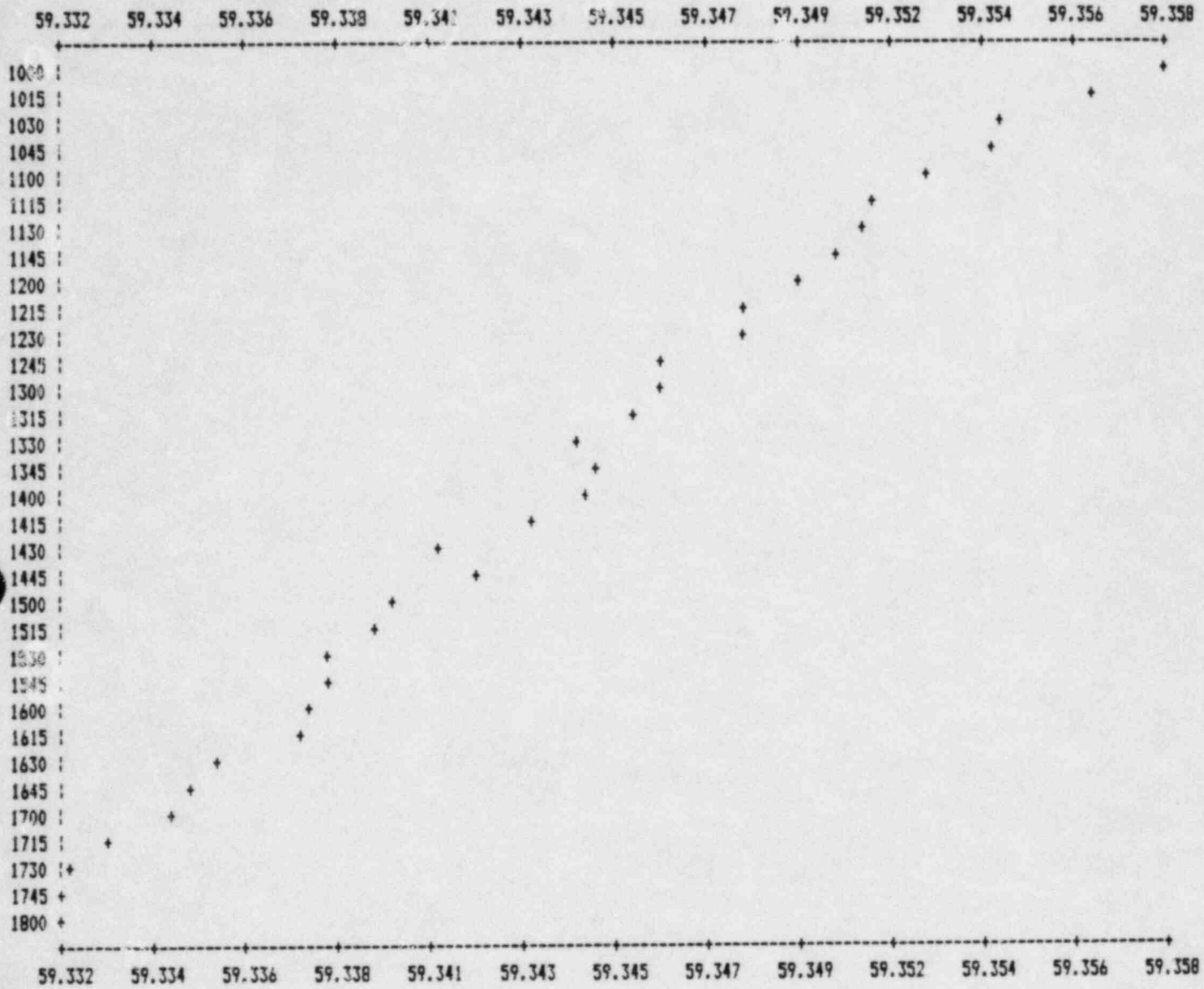
APPENDIX F

ILRT PLOTS

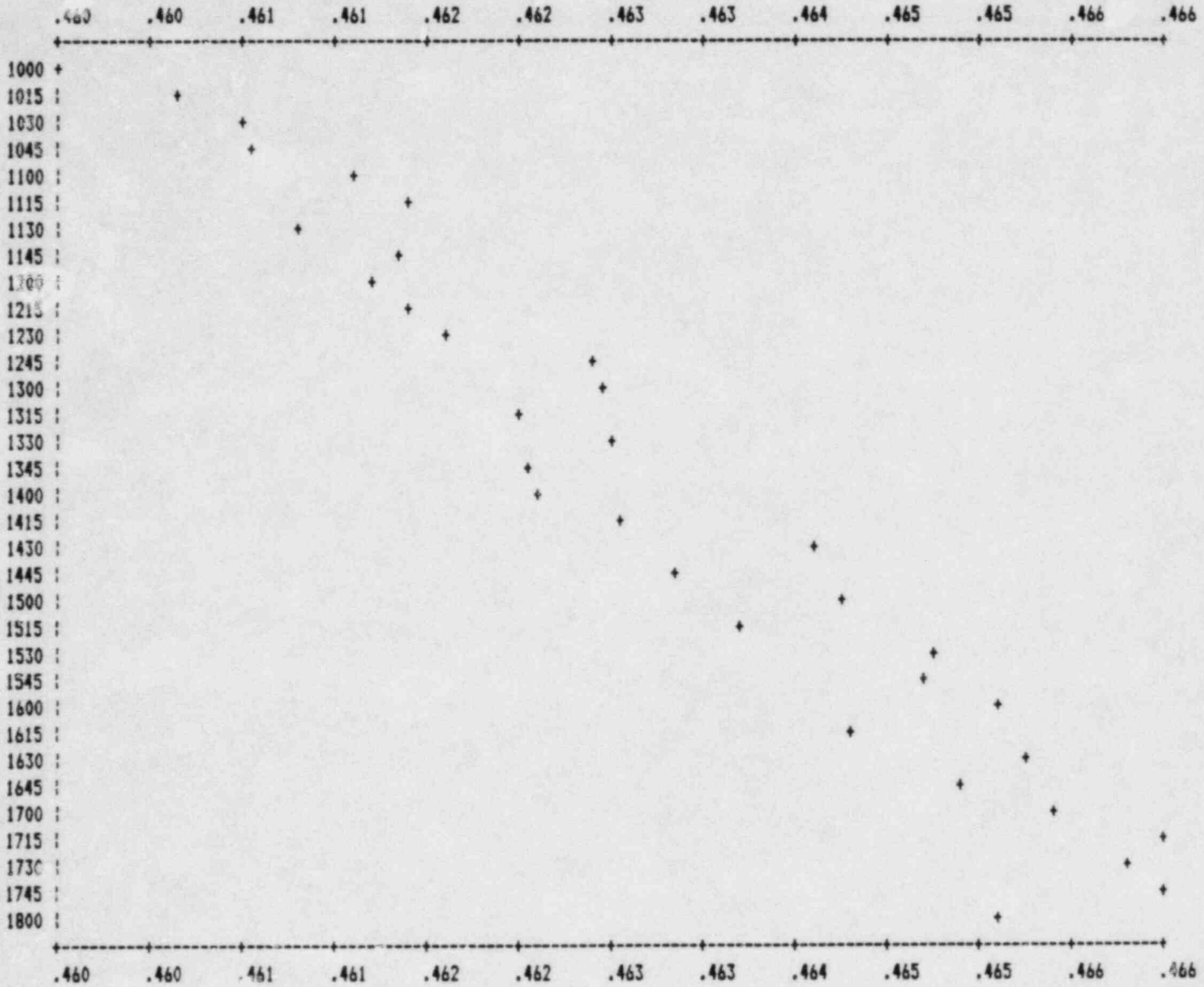
LIMERICK GENERATING STATION UNIT 1 ILRT
TEMPERATURE DEGREES F



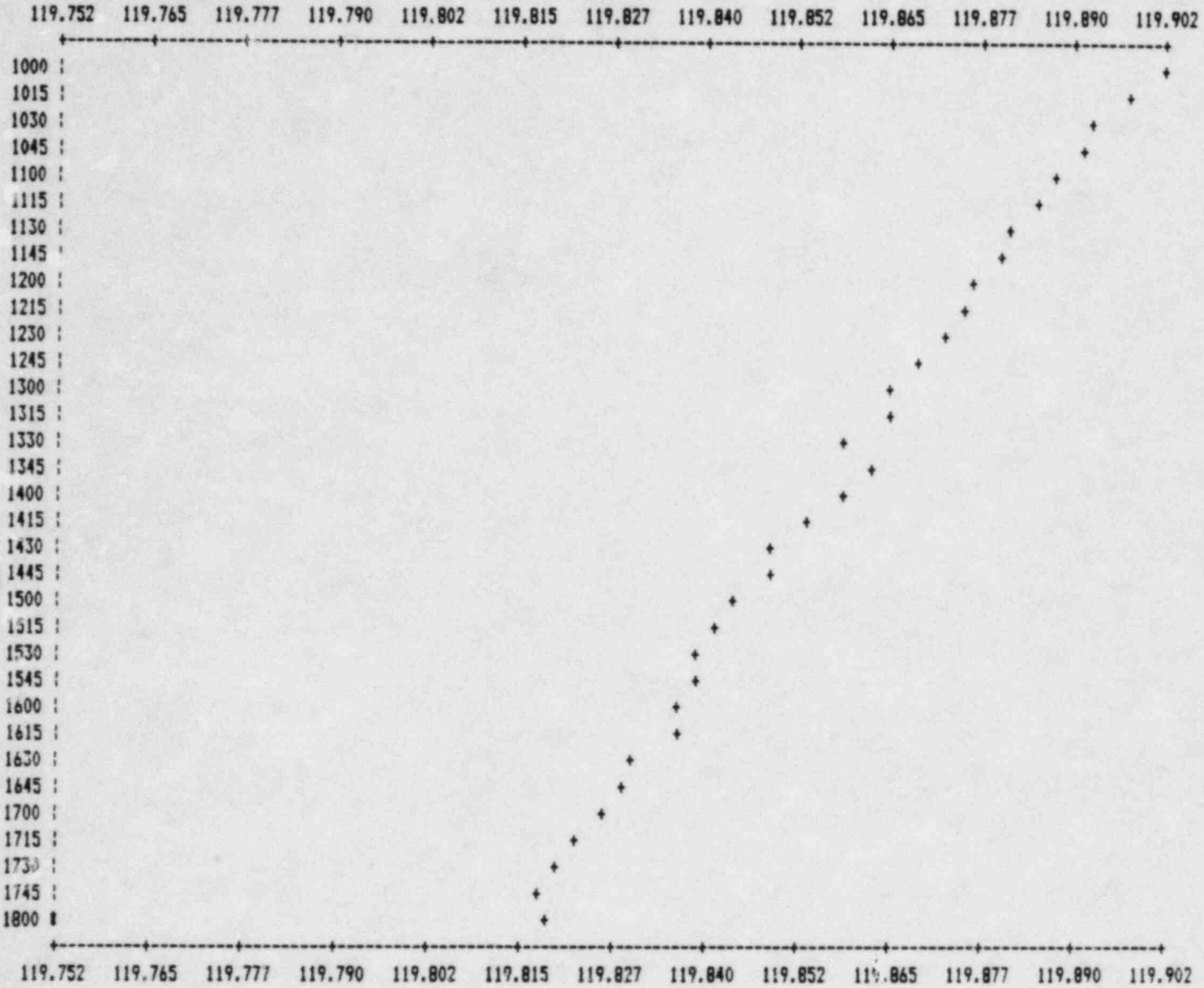
LIMERICK GENERATING STATION UNIT 1 ILRT
PRESSURE PSIA



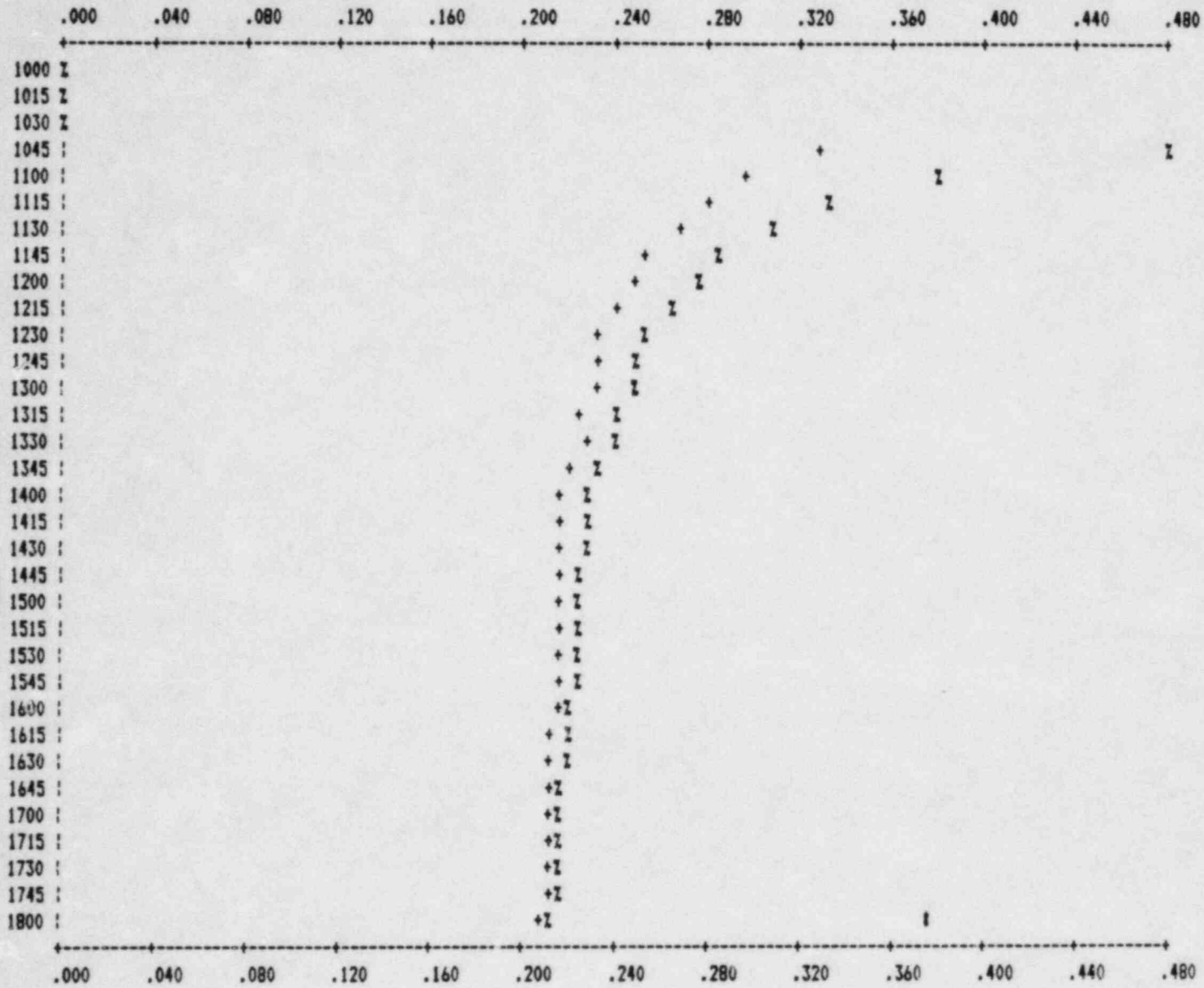
LIMERICK GENERATING STATION UNIT 1 ILRT
VAPOR PRESSURE PSIA



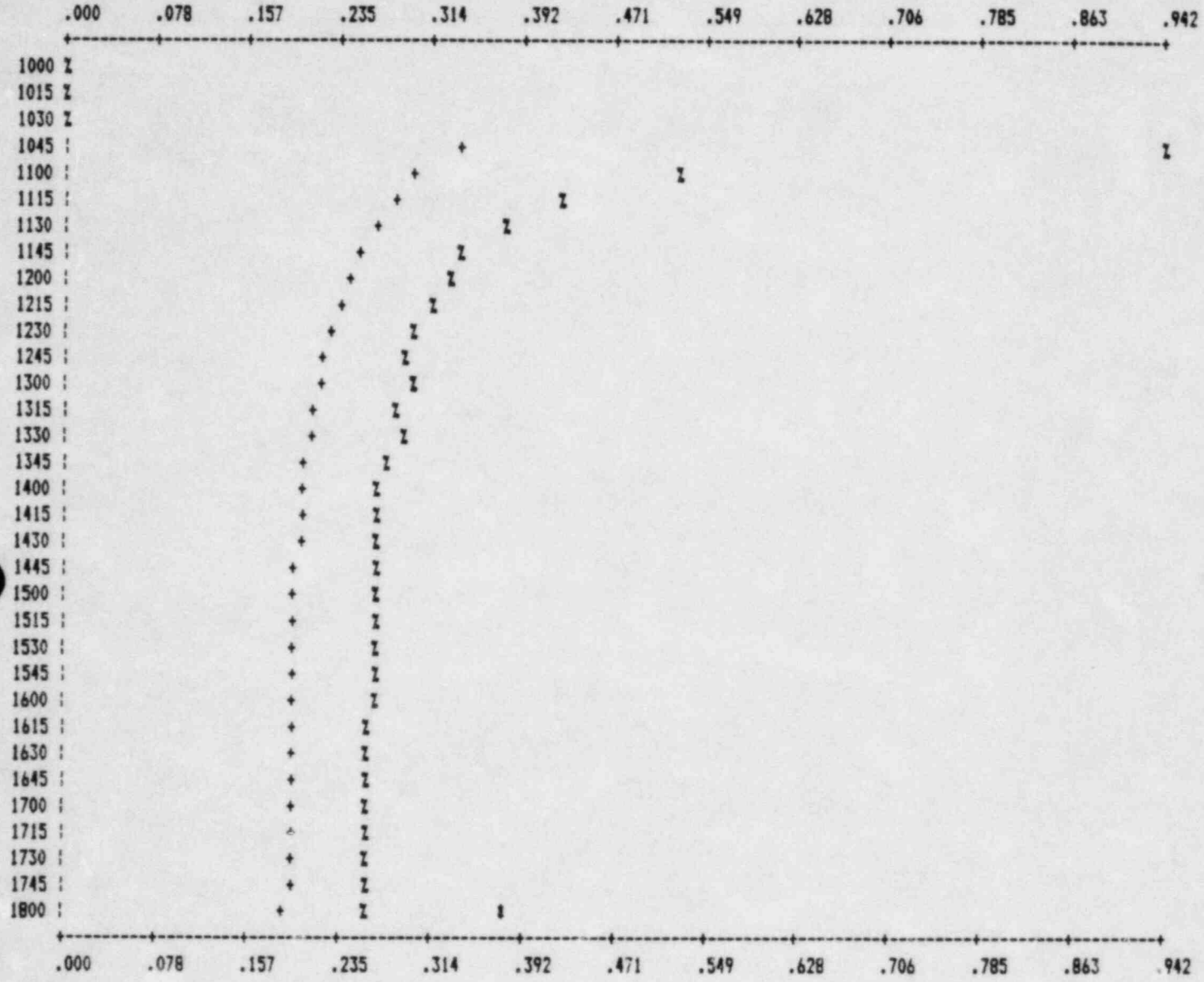
LIMERICK GENERATING STATION UNIT 1 ILRT
AIRMASS LBM X 1000



LIMERICK GENERATING STATION UNIT 1 ILRT
MASS POINT LEAKAGE RATE(+) AND UCL(%)



LIMERICK GENERATING STATION UNIT 1 ILRT
TOTAL TIME LEAKAGE RATE(+) AND UCL(%)



APPENDIX G

INSTRUMENT SELECTION GUIDE CALCULATIONS

INSTRUMENT SELECTION GUIDE
LIMERICK GENERATING STATION -- -- UNIT 1

TEST PARAMETERS:

La	=	0.5 %/day
P	=	58.7 psia
T	=	540 deg R drybulb
Tdp	=	65 deg F dewpoint
t	=	8 hours

INSTRUMENT PARAMETERS:

Total Absolute Press:

No. of sensors	2	
Range	100	psig
Sensitivity err	0.001	% of full scale
Meas system err	0.002	% of full scale

e
P = 0.001581 psia

Water Vapor Press:

No. of sensors	5	
Sensitivity err	0.5	deg F
Meas system err	0.01	deg F
Vapor Pres chng	0.012	psia/deg F @ 70 F

E
Pv = 0.006 psia

ep
Pv= 0.00012 psia

e
P = 0.002683 psia

Temperature:

No. of sensors	17	
Sensitivity err	0.1	deg F
Meas system err	0.01	deg F

e
T = 0.024374

ISG:

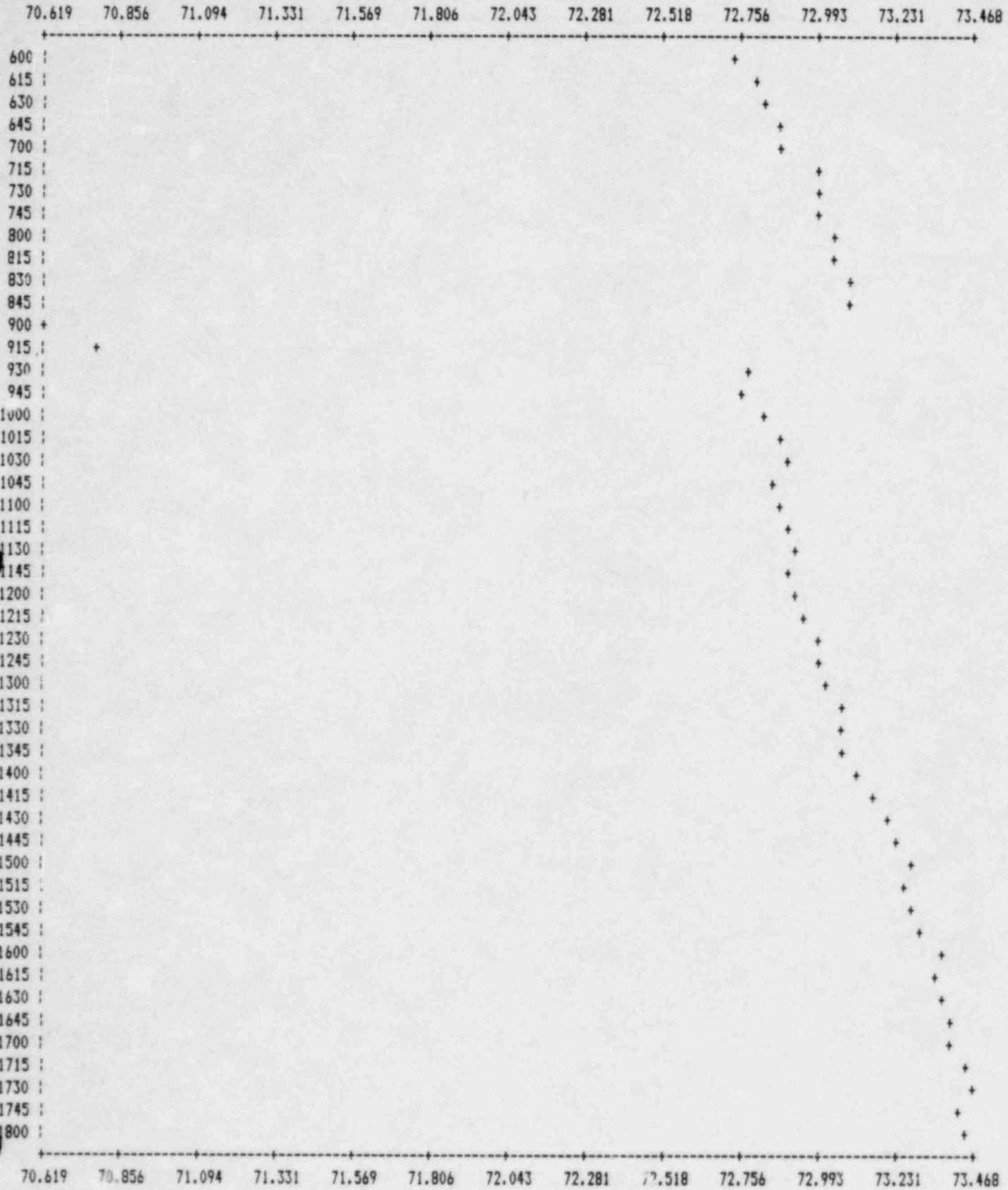
ISG = 0.029556 %/day

Acceptance Criteria: < 0.125 %/day

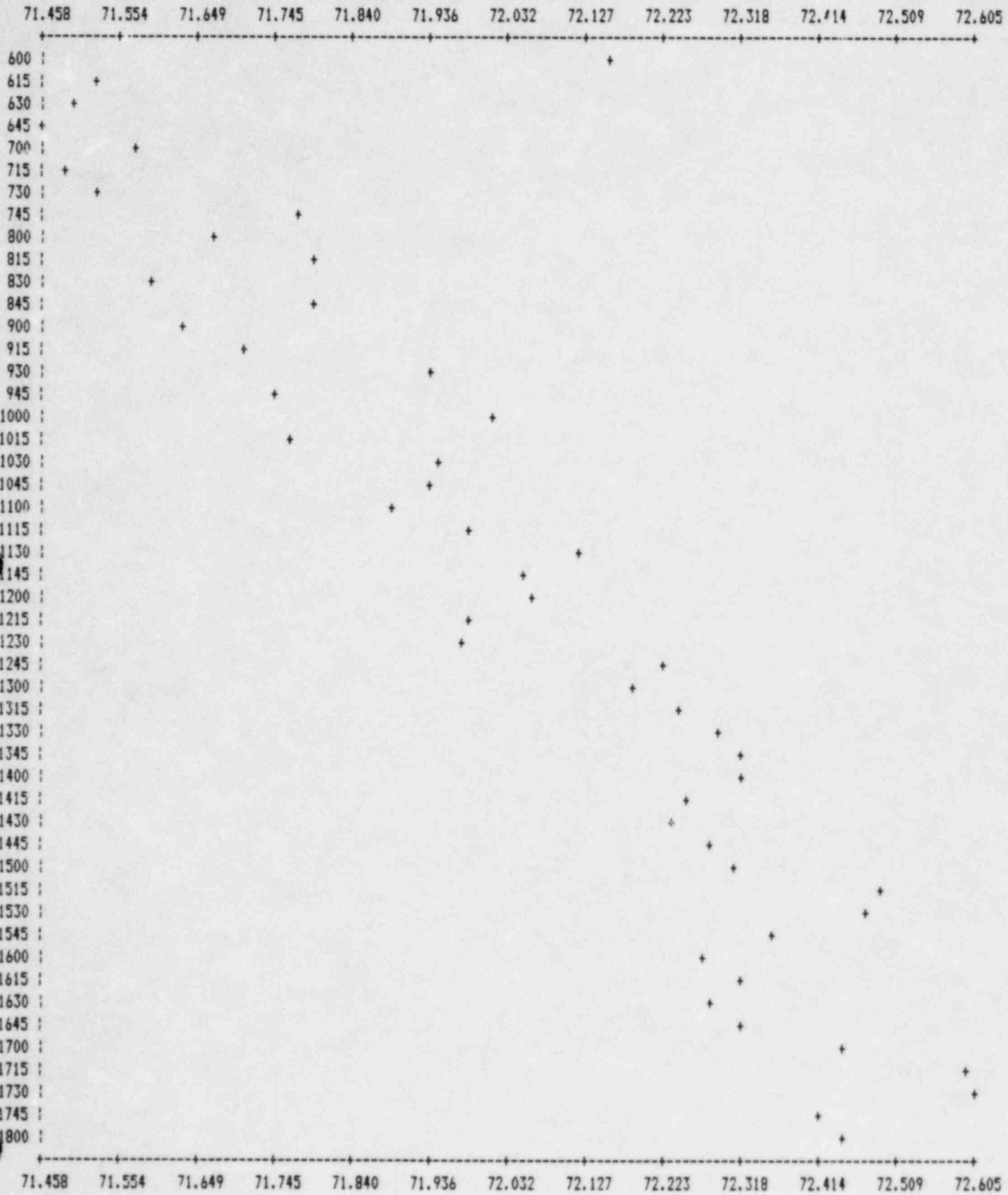
APPENDIX H

MALFUNCTIONING SENSOR PLOTS

LIMERICK GENERATING STATION UNIT 1 ILRT
DEWPOINT TEMPERATURE SENSOR 2 DEGREES F

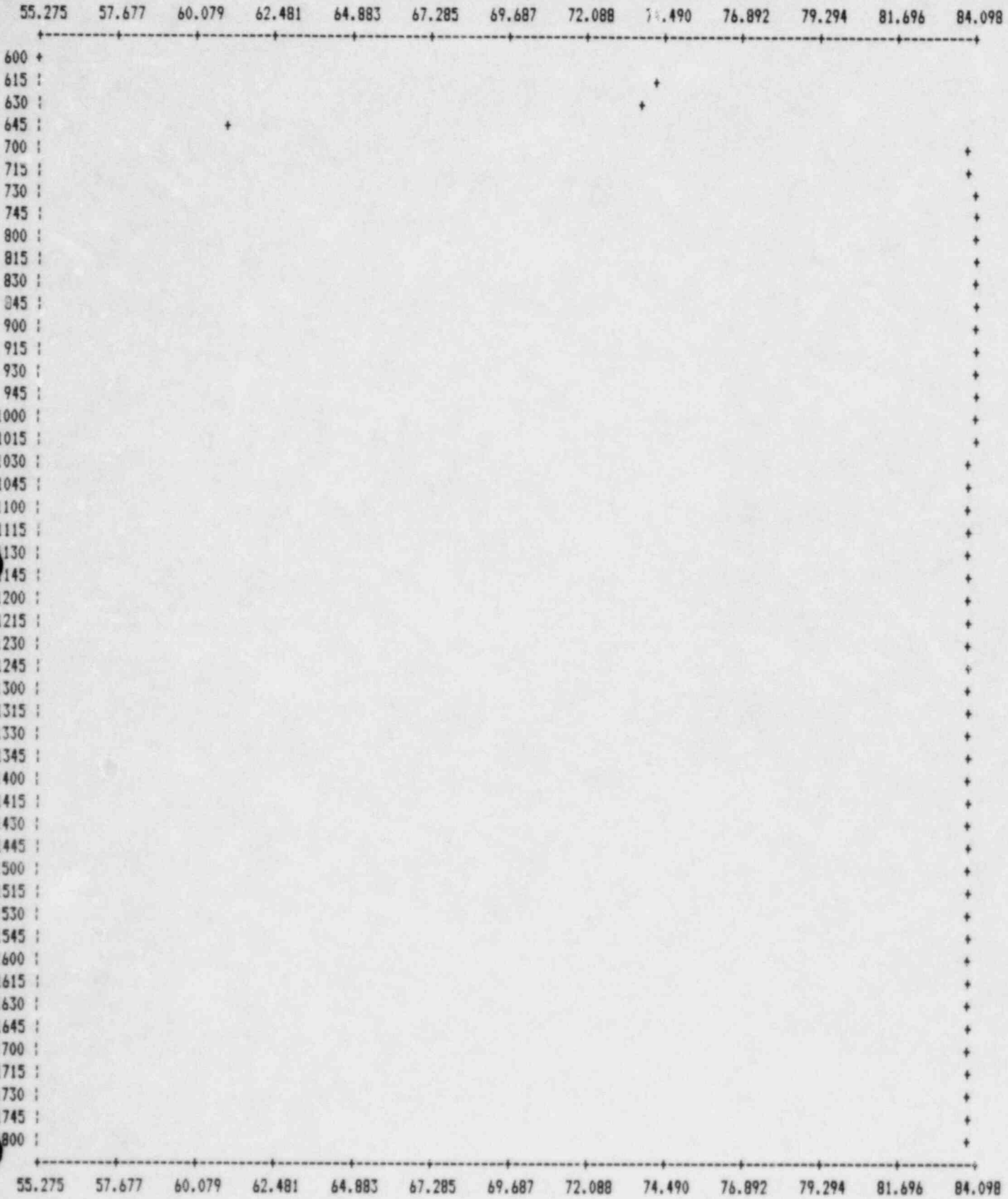


LIMERICK GENERATING STATION UNIT 1 ILRT
DEWPOINT TEMPERATURE SENSOR 4 DEGREES F



LIMERICK GENERATING STATION UNIT 1 ILRT
DEWPOINT TEMPERATURE SENSOR 6 DEGREES F

LIMERICK GENERATING STATION UNIT 1 ILRT
DEWPOINT TEMPERATURE SENSOR 8 DEGREES F



APPENDIX I

HIGH PRESSURE BYPASS TEST

HIGH PRESSURE BYPASS TEST: START @ 0715, END @ 0915

I. RAW DATA (FROM DATA ACQUISITION SYSTEM):

SUPPRESSION POOL RTDs

	Ts (F)	Te (F) (also T2)	VOL FRAC
12	84.811	85.936	0.1867
13	85.456	86.465	0.1867
14	85.824	86.967	0.1893
15	85.890	87.077	0.1893
16	85.855	86.988	0.1893
17	88.090	89.169	0.0587
WT AVG:	545.388	546.505	(=== DEGREES RANKINE

SUPPRESSION POOL PRESSURE (PSIA)

Ps = 36.429 Pe = 40.265

PRESSURES (PSIA) -- AT END OF TEST PERIOD

P1 = 67.265 P2 = Pe

II. CONSTANTS

GAS CONSTANT R = 1718 ft-lbf/slug-deg R

SPEC HEAT RATIO k = 1.4 for air

SQRT K = 0.60

DEGREES RANKINE = 459.67 + DEGREES FAHRENHEIT

SUPPR POOL VOLUME Vs= 149425 CU FT

DURATION (HRS) t = 2.00 HRS

III. CALCULATION OF VELOCITY, V (ft/sec)

$$V = 109.7 * SQRT(T2) * SQRT((P1/P2)^{0.286} - 1) \text{ ft/sec}$$

V = 1019.5943 ft/sec

IV. CALCULATION OF VOLUMETRIC FLOW RATE, Q (CU FT/SEC)

Q = (T2 * Vs / P2 * t) (Pe/Te - Ps/Ts)/7200

Q = 1.9387 CU FT/SEC

V. CALCULATION OF EQUIVALENT BYPASS AREA (SQ FT)

A / SQRT K = Q / V

A/SQRT K= 0.00190 SQ FT (======= (ACCEPT CRITERIA = .046)

SUMMARY OF MEASURED DATA AT 715 730

TEMP	1	536.6970	(77.027)
TEMP	2	538.6670	(78.997)
TEMP	3	538.1840	(78.514)
TEMP	4	538.5540	(78.884)
TEMP	5	538.7960	(79.126)
TEMP	6	536.7330	(77.063)
TEMP	7	534.1280	(74.458)
TEMP	8	535.5760	(75.906)
TEMP	9	534.8650	(75.195)
TEMP	10	536.0840	(76.414)
TEMP	11	533.5210	(73.851)
TEMP	12	544.4810	(84.811)
TEMP	13	545.1260	(85.456)
TEMP	14	545.4940	(85.824)
TEMP	15	545.5600	(85.890)
TEMP	16	545.5250	(85.855)
TEMP	17	547.7600	(88.090)
PRES	1	69.6612	(69611.0)
PRES	2	36.4288	(36193.0)
VPRS	1	.2728	(61.775)
VPRS	2	.2973	(64.225)
VPRS	3	.2844	(62.956)
VPRS	4	.2690	(61.387)
VPRS	5	.2715	(61.642)
VPRS	6	.2688	(61.360)
VPRS	7	.5430	(82.116)
VPRS	8	.0000	(.236)
VPRS	9	.5408	(81.994)

SUMMARY OF CORRECTED DATA
TIME = 715
DATE = 730

TEMPERATURE (DEGREES R.) =	545.3876
CORRECTED PRESSURE (PSIA) =	52.5031
VAPOR PRESSURE (PSIA) =	.5419
VOLUME (CU.FT.) =	408670.0
AIR MASS (LBM) =	106189.3

SUMMARY OF MEASURED DATA AT 915 730

TEMP	1 =	536.7510	(77.081)
TEMP	2 =	538.7240	(79.054)
TEMP	3 =	538.2720	(78.602)
TEMP	4 =	538.6430	(78.973)
TEMP	5 =	538.8890	(79.219)
TEMP	6 =	536.8610	(77.191)
TEMP	7 =	534.1510	(74.481)
TEMP	8 =	535.5730	(75.903)
TEMP	9 =	534.8980	(75.228)
TEMP	10 =	536.0670	(76.397)
TEMP	11 =	533.5820	(73.912)
TEMP	12 =	545.6060	(85.936)
TEMP	13 =	546.1350	(86.465)
TEMP	14 =	546.6370	(86.967)
TEMP	15 =	546.7470	(87.077)
TEMP	16 =	546.6580	(86.988)
TEMP	17 =	548.8390	(89.169)
PRES	1 =	67.2626	(67211.0)
PRES	2 =	40.2648	(40012.0)
VPRS	1 =	.2675	(61.228)
VPRS	2 =	.2911	(63.621)
VPRS	3 =	.2815	(62.666)
VPRS	4 =	.2645	(60.903)
VPRS	5 =	.2647	(60.926)
VPRS	6 =	.2639	(60.838)
VPRS	7 =	.5722	(83.738)
VPRS	8 =	.0000	(.227)
VPRS	9 =	.5741	(83.840)

SUMMARY OF CORRECTED DATA
TIME = 915
DATE = 730

TEMPERATURE (DEGREES R.)	=	546.5049
CORRECTED PRESSURE (PSIA)	=	53.1906
VAPOR PRESSURE (PSIA)	=	.5731
VOLUME (CU.FT.)	=	408670.0
AIR MASS (LBM)	=	107359.9

APPENDIX J

LOW PRESSURE BYPASS TEST

LOW PRESSURE BYPASS TEST: START @ 1015, END 1415

I. RAW DATA (FROM DATA ACQUISITION SYSTEM):

DRYWELL RTDs

	Td1 (F)	Td2 (F)	VOL FRAC
1	82.710	83.323	0.0352
2	80.423	80.891	0.0384
3	79.937	80.282	0.0400
4	80.700	81.269	0.0736
5	80.598	81.076	0.0752
6	79.748	80.725	0.1232
7	76.748	77.635	0.1232
8	77.717	78.414	0.1232
9	77.490	78.460	0.1232
10	78.324	78.988	0.1232
11	76.165	76.491	0.1216
WT AVG:	538.181	538.868	(=== DEGREES RANKINE

SUPPRESSION POOL RTDs

	Ts1 (F)	Ts2 (F)	VOL FRAC
12	82.360	83.612	0.1867
13	82.838	84.057	0.1867
14	83.261	84.553	0.1893
15	83.528	84.837	0.1893
16	83.309	84.640	0.1893
17	85.466	86.381	0.0587
WT AVG:	542.873	544.132	(=== DEGREES RANKINE

SUPPRESSION POOL PRESSURE (PSIA)

Ps1 = 14.629 Ps2 = 14.932

DRYWELL PRESSURE (PSIA)

Pd1 = 19.350 Pd2 = 19.4047

VAPOR PRESSURES PSIA

DRYWELL	Pvd1	Pvd2	VOL FRAC
1	0.2435	0.2712	0.1136
2	0.2627	0.2908	0.0000
3	0.2612	0.2911	0.4432
4	0.2450	0.2723	0.0000
5	0.2458	0.2767	0.4432
6	0.0000	0.0000	0.0000
WT AVG =	0.2524	0.2825	

SUPPRES	Pvs1	Pvs2	VOL FRAC
7	0.5245	0.5600	0.5000

8	0.5187	0.5512	0.0000
9	0.5180	0.5581	0.5000
WT AVG =	0.5213	0.5591	

II. CONSTANTS

GAS CONSTANT R = 1718 ft-lbf/slug-deg R

SPEC HEAT RATIO k = 1.4 for air

SQRT K = 0.60

DEGREES RANKINE = 459.67 + DEGREES FAHRENHEIT

SUPPR POOL VOLUME Vs= 149425 CU FT

DURATION (HRS) t = 4.00 HRS = 240 MINS

III. CALCULATION OF VELOCITY, V (ft/sec)

$$V = 4080\left(\left((Pd1 + Pd2 - (Ps1 + Ps2)) \,/\, ((Pd1 + Pd2)\right)^{1/2} \right.$$
$$\left. 0.378\,(Pvd1 + Pvd2))/(0.370(Td1 + Td2))\right)$$

V = 39773.818 ft/sec S= 0.096741

IV. CALCULATION OF VOLUMETRIC FLOW RATE, Q (CU FT/SEC)

$$Q = (T2 * Vs \,/\, P2 * t\,)\;(\,Pe/Te - Ps/Ts\,)$$

Q = 10.1479 CU FT/SEC

V. CALCULATION OF EQUIVALENT BYPASS AREA (SQ FT)

$$A \,/\, SQRT\ K = Q \,/\, V$$

A/SQRT K= 0.00026 SQ FT <======= (ACCEPT CRITERIA = .046)

SUMMARY OF MEASURED DATA AT 1015 803

TEMP	1 = 542.3800	(82.710)
TEMP	2 = 540.0930	(80.423)
TEMP	3 = 539.6070	(79.937)
TEMP	4 = 540.3700	(80.700)
TEMP	5 = 540.2680	(80.598)
TEMP	6 = 539.4180	(79.748)
TEMP	7 = 536.4180	(76.748)
TEMP	8 = 537.3870	(77.717)
TEMP	9 = 537.1600	(77.490)
TEMP	10 = 537.9940	(78.324)
TEMP	11 = 535.8350	(76.165)
TEMP	12 = 542.0300	(82.360)
TEMP	13 = 542.5080	(82.838)
TEMP	14 = 542.9310	(83.261)
TEMP	15 = 543.1980	(83.528)
TEMP	16 = 542.9790	(83.309)
TEMP	17 = 545.1360	(85.466)
PRES	1 = 19.3496	(19322.0)
PRES	2 = 14.6289	(14504.0)
VPRS	1 = .2435	(58.589)
VPRS	2 = .2627	(60.714)
VPRS	3 = .2612	(60.553)
VPRS	4 = .2450	(58.758)
VPRS	5 = .2458	(58.844)
VPRS	6 = .0000	(22.111)
VPRS	7 = .5245	(81.053)
VPRS	8 = .5187	(80.708)
VPRS	9 = .5180	(80.670)

SUMMARY OF CORRECTED DATA
TIME = 1015
DATE = 803

TEMPERATURE (DEGREES R.) =	542.8729
CORRECTED PRESSURE (PSIA) =	14.1077
VAPOR PRESSURE (PSIA) =	.5213
VOLUME (CU.FT.) =	405487.0
AIR MASS (LBM) =	28442.1

SUMMARY OF MEASURED DATA AT 1415 803

TEMP 1 =	542.9930	(83.323)
TEMP 2 =	540.5610	(80.891)
TEMP 3 =	539.9520	(80.282)
TEMP 4 =	540.9390	(81.269)
TEMP 5 =	540.7460	(81.076)
TEMP 6 =	540.3950	(80.725)
TEMP 7 =	537.3050	(77.635)
TEMP 8 =	538.0840	(78.414)
TEMP 9 =	538.1300	(78.460)
TEMP 10 =	538.6580	(78.988)
TEMP 11 =	536.3980	(76.728)
TEMP 12 =	543.2820	(83.612)
TEMP 13 =	543.7270	(84.057)
TEMP 14 =	544.2230	(84.553)
TEMP 15 =	544.5070	(84.837)
TEMP 16 =	544.3100	(84.640)
TEMP 17 =	546.0510	(86.381)
PRES 1 =	19.4047	(19377.0)
PRES 2 =	14.9318	(14806.0)
VPRS 1 =	.2712	(61.613)
VPRS 2 =	.2908	(63.598)
VPRS 3 =	.2911	(63.623)
VPRS 4 =	.2723	(61.729)
VPRS 5 =	.2767	(62.185)
VPRS 6 =	.0000	(-24.754)
VPRS 7 =	.5600	(83.070)
VPRS 8 =	.5512	(82.583)
VPRS 9 =	.5581	(82.968)

SUMMARY OF CORRECTED DATA
TIME = 1415
DATE = 803

TEMPERATURE (DEGREES R.) =	544.1323
CORRECTED PRESSURE (PSIA) =	14.3728
VAPOR PRESSURE (PSIA) =	.5591
VOLUME (CU.FT.) =	405487.0
AIR MASS (LBM) =	28909.6

APPENDIX K

TYPE B AND C LEAKAGE RATE TEST RESULTS

APPENDIX K

LOCAL LEAKAGE RATE TEST SUMMARY

1. LOCAL LEAKAGE RATE TYPE 'B' TEST

Penetration Number	Penetration Description	Leakage (SCCM)
X-1	Equipment Access Door	2.625 ± 2
X-2	Equipment Access Door with Personnel Lock, Including: Flange, Barrel, Inner Door, and Outer Door	694.645 ± 22
X-4	Drywell - Head Access Manhole	7.725 ± 2
---	Drywell - Head Flange	11.2 ± 20
X-6	CRD Removal Hatch	2.85 ± 2
X-35C*	Tip Drives	40 ± 4
X-35D*	Tip Drives	40 ± 4
X-35E*	Tip Drive	40 ± 4
X-35F*	Tip Drives	40 ± 4
X-35G*	Tip Drives	40 ± 4
JX-100A	Neutron Monitoring System	20 ± 2
JX-100B	Neutron Monitoring System	20 ± 2
JX-100C	Neutron Monitoring System	20 ± 2
JX-100D	Neutron Monitoring System	2.1 ± 2
JX-101A	Recirculation Pump Power	8.15 ± 2
JX-101B	Recirculation Pump Power	20 ± 2
JX-101C	Recirculation Pump Power	20 ± 2
JX-101D	Recirculation Pump Power	8.175 ± 2
JX-103A	Temperature and Low Level Signal	20 ± 2
JX-103B	Temperature and Low Level Signal	4.1 ± 2
JX-104A	CRD Position Indicator	6.5 ± 2
JX-104B	CRD Position Indicator	20 ± 2
JX-104C	CRD Position Indicator	10 ± 10
JX-104D	CRD Position Indicator	20 ± 2

*Note: Penetration requires both Type B and Type C tests. Leakage rate listed is total penetration path leakage.

APPENDIX K

LOCAL LEAKAGE RATE TEST SUMMARY

1. LOCAL LEAKAGE RATE TYPE 'B' TEST (CONT'D)

Penetration Number	Penetration Description	Leakage (SCCM)
JX-105A	Miscellaneous Low Voltage	20 ± 2
JX-105B	Miscellaneous Low Voltage	20 ± 2
JX-105C	Miscellaneous Low Voltage	20 ± 2
JX-105D	Miscellaneous Low Voltage	20 ± 2
JX-105E	Miscellaneous Low Voltage	10 ± 10
JX-106A	Low Voltage Control	20 ± 2
JX-106B	Low Voltage Control	10 ± 10
JX-106C	Low Voltage Control	4.5 ± 20
X-200A	Access Hatch	81.325 ± 2
X-200B	Access Hatch	3.16 ± 2
JX-222	Indication and Control	2.35 ± 2
JX-230	Strain Gauge Instrument	4.5 ± 20
	Total Type B Test	1333.9

APPENDIX K

LOCAL LEAKAGE RATE TEST SUMMARY

2. LOCAL LEAKAGE RATE TYPE 'C' TEST

Penetration Number	Penetration Description	Leakage (GPM)	Leakage (SCCM)
X-3B	Instrument Gas Supply		20 ± 2
X-3D	Instrument Gas Supply		20 ± 2
X-7A*	Main Steam Line "A"		247.6 ± 20
X-7B*	Main Steam Line "B"		46.5 ± 2
X-7C*	Main Steam Line "C"		531.6 ± 20
X-7D*	Main Steam Line "D"		185.84 ± 2
X-8	Main Steam Line Drain		20 ± 2
X-9A	Feedwater		3045.95 ± 20
X-9B	Feedwater		1692.60 ± 20
X-10	Steam to RCIC Turbine		20 ± 2
X-11	Steam to HPCI Turbine		196.1 ± 2
X-12	RHR Shutdown Cooling Supply		133.67 ± 2
X-13A	RHR Shutdown Return		337.75 ± 20
X-13B	RHR Shutdown Return		20 ± 2
X-14	RWCU Supply		485.75 ± 20
X-16A	CS Pump Discharge		379.236 ± 20
X-16B	CS Pump Discharge		93.1 ± 2
X-17	RPV Head Spray		99.1 ± 2
X-21	Service Air		274.5 ± 20
X-23	Closed Cooling Wate Return		121.8 ± 20
X-24	Closed Cooling Water Return		194.775 ± 20
X-25	Drywell Purge Supply		675.31 ± 20
X-26	Drywell Purge Exhaust		508.25 ± 20
X-27A	Instrument Gas Supply		3.15 ± 2
X-28A	Recirculation Loop Sample		67.3 ± 2
X-28A	Drywell H2/O2 Sample		13.025 ± 20
X-28B	Drywell Air Sample		96.3 ± 2
X-35A	Instrument Gas to Tip Indexing Mechanisms		438 ± 20

*Note: Leakage not added into Type C leakage total.

APPENDIX K

LOCAL LEAKAGE RATE TEST SUMMARY

2. LOCAL LEAKAGE RATE TYPE 'C' TEST (CONT'D)

Penetration Number	Penetration Description	Leakage (GPM)	Leakage (SCCM)
X-38 A-D	CRD Withdraw		439.95 ± 20
X-39A	Drywell Spray		106.72 ± 2
X-39B	Drywell Spray		3494.1 ± 200
X-40F	Instrumentation - Gas Suction		995.8 ± 20
X-40G	ILRT DAS		20 ± 2
X-40H	Instrument Gas Supply		27 ± 20
X-42(116)	Standby Liquid Control		20 ± 2
X-43B	Main Ste m Sample		100.14 ± 2
X-44	RWCU Alternate Return		419.39 ± 10
X-45A	LPCI	0.0198 ± 0.0018	84.75 ± 20
X-45B	LPCI	0.01 ± 0.0014	363.75 ± 20
X-45C	LPCI	0.002 ± 0.0014	148 ± 200
X-45D	LPCI	0.0828 ± 0.0018	976.8 ± 20
X-53	Drywell Chilled Water Supply		170.5 ± 20
X-54	Drywell Chilled Water Return		556.2 ± 20
X-55	Drywell Chilled Water Supply		656.5 ± 20
X-56	Drywell Chilled Water Return		302.6 ± 20
X-61	Recirculation Pump Seal Purge		107.975 ± 4
X-62/X-220A	H2/02 Sample Return		95.4 + 2
X-117B	Drywell Radiation Monitoring		9.6 ± 2
X-201A	Suppression Pool Purge Supply		1210.80 ± 20
X-202	Suppression Pool Purge Exhaust		1041.96 ± 20
X-203A	RHR Pump Suction	0 ± 0.00144	
X-203B	RHR Pump Suction	0.0612 ± 0.0018	
X-203C	RHR Pump Suction	0.25 ± 0.0018	
X-203D	RHR Pump	1.15 ± 0.0072	
X-204A	RHR Pump Test Line	0.69 ± 0.0072	
X-204B	Containment Cooling	0.0194 ± 0.0018	

APPENDIX K

LOCAL LEAKAGE RATE TEST SUMMARY

2. LOCAL LEAKAGE RATE TYPE 'C' TEST (CONT'D)

Penetration Number	Penetration Description	Leakage (GPM)	Leakage (SCCM)
X-205A	Suppression Pool Spray		2.25 ± 20
X-205B	Suppression Pool Spray		20 ± 10
X-206A	CS Pump Suction	0 ± 0.0018	
X-206B	CS Pump Suction	0 ± 0.018	
X-206C	CS Pump Suction	0.004 ± 0.0018	
X-206D	CS Pump Suction	0.021 ± 0.0018	
X-207A	CS Pump Test and Flush	0.0036 ± 0.0018	
X-207B	CS Pump Test and Flush	0.0072 ± 0.0018	
X-208B	CS Pump Minimum Recirculation	0 ± 0.0018	
X-209	HPCI Pump Suction	0.13 ± 0.0018	
X-210	HPCI Turbine Exhaust	0.008 ± 0.0018	
X-212	HPCI Pump Test and Flush	0.0014 ± 0.0018	
X-214	RCIC Pump Suction	0 ± 0.0014	
X-215	RCIC Turbine Exhaust	0 ± 0.0018	
X-216	RCIC Minimum Flow	0 ± 0.0014	
X-217	RCIC Vacuum Pump Discharge		20 ± 2
X-218	Instrument Gas to Vacuum Relief Valves		78.275 ± 2
X-221A	Wetwell H2/O2 Sample		19.625 ± 2
X-221B	Wetwell H2/O2 Sample		8.05 ± 20
X-225	RHR Vacuum Relief Suction		400.2 ± 20
X-226A	RHR Minimum Recirculation		20 ± 2
X-226B	RHR Minimum Recirculation		0 ± 200
X-227	ILRT DAS		20 ± 2
X-228D	HPCI Vacuum Relief		255.4 ± 20

APPENDIX K

LOCAL LEAKAGE RATE TEST SUMMARY

2. LOCAL LEAKAGE RATE TYPE 'C' TEST (CONT'D)

Penetration Number	Penetration Description	Leakage (GPM)	Leakage (SCCM)
X-231A	Drywell Sump Drain	0.0468 ± 0.0014	
X-231B	Drywell Sump Drain	0.0378 ± 0.0018	
X-235	CS Pump Minimum Recirculation	0 ± 0.0018	
X-236	HPCI Pump Minimum	0 ± 0.0018	
X-237	Suppression Pool Cleanup Pump Suction	0.002 ± 0.0014	
X-238	'B' RHR Ht. Exch Relief		1150 ± 20
X-239	'A' RHR Ht. Exch Relief		15.75 ± 2
X-241	RCIC Vac Relief		1227.95 ± 20

Total Type C Hydraulic Test 2.654

Total Type C Pneumatic Test 23,541.131

Total of Type B and Type C Pneumatic Test 24,875.03 SCCM

0.0736%/day

Error Associated with Type 'B' and 'C Measure = ± 368.63 SCCM

= 0.0010%/day

Total type 'B' and Type 'C' Pneumatic Test Results: 0.0736 ± 0.001%/day

Error Associated with Hydraulic Test = 0.059 gpm

Total Type 'C' Hydraulic Test Results: 2654 ± 0.59 gpm