THREE MILE ISLAND NUCLEAR STATION

UNIT 1

REACTOR CONTAINMENT BUILDING PREOPERATIONAL INTEGRATED LEAK RATE TEST

METROPOLITAN EDISON COMPANY

SUBSIDIARY OF GENERAL PUBLIC

UTILITIES CORPORATION

1408 055

PREPARED BY

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READING, PENNSYLVANIA

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1.0 SYNOPSIS

The Three Mile Island Nuclear Station Unit 1 reactor containment building was subjected to a preoperational integrated leak rate test during the period from March 19, 1974 to March 22, 1974. The purpose of this test was to demonstrate the acceptability of building leakage rates at internal pressures of 55 psig (Pd) and 30 psig (Pt). Testing was performed in conformance with the requirements of 10 CFR 50, Appendix J and ANSI N45.4-1972.

Leakage rates based on the total time method of analysis were found to be 0.043 percent per day at 50.6 psig and 0.031 percent per day at 30 psig. These leakage rates are well below the allowable leakage rates of 0.075 percent per day at 50.6 psig and 0.058 percent per day at 30 psig.

Ltm/Lam was therefore established at 0.720. In accordance with the Three Mile Island Nuclear Station Unit 1 FSAR, Section 15.4.4.1, Amendment 47 (Technical Specifications), all subsequent integrated leakage rate tests at Pt shall be performed at the maximum allowable value of La $(Pt/Pa)^{1/2}$ since Ltm/Lam is greater than 0.7. Therefore, these retests may not exceed the 0.75 Lt value of 0.058 percent per day.

The final leakage rate of 1.13 lb/hr at 30 psig was obtained after the reactor containment building was depressurized, adjustments made and the building again pressurized (prior rate was 20 lb/hr). The adjustments made consisted of tightening mechanical joints and packing in the main steam system and adjustments to purge valves AH-V1A, AH-V1B, AH-VIC and AH-VID.

Since the industrial cooler system was in operation during the leakage rate tests, addition of the local leakage rate of the system isolation valves (RB-V2* and RB-V7) to the measured values of Lam and Ltm could be considered. However, the combined local leakage rate of both these isolation valves was only 0.00008 percent per day. Hence, there is no point in adding this negligible value to the measured leakage rates.

The supplemental instrumentation verification at Pa and Pt was 10 percent and 1.3 percent, respectively; well within the 25 percent requirement of 10 CFR 50, Appendix J, Section III A.3.b.

All testing was performed by Metropolitan Edison Company/General Public Utilities Corporation with the technical assistance of Gilbert Associates, Inc. Gilbert Associates, Inc., has previously supplied technical direction for seven integrated leak rate tests.

Procedural and calculational methods were witnessed by Atomic Energy Commission (AEC) personnel, a NELIA representative and auditied by the General Public Utilities Corporation site quality assurance audit staff.

2.0 INTRODUCTION

The objective of the preoperational integrated leak rate test was the establishment of the degree of overall leak tightness of the reactor containment building at the design pressure of 55 psig and to establish a reference test for subsequent periodic integrated leak rate tests at 30 psig. The allowable leakage is defined by the design basis accident applied in the safety analysis in accordance with site exposure guidelines specified by 10 CFR 100. For Three Mile Island Nuclear Station Unit 1, allowable integrated leak rates are as follows:

Conditions		Allowable Integrated Leak Rate (Percent per day)
Design (55 psig, Pd),	Ld	0.100
Peak Calculated (50.6 psig, Pa),	La	0.100
Reduced Pressure (30 psig, Pt),	Lt	0.058

Testing was performed in accordance with Gilbert Associates, Inc., procedural requirements as stated in Three Mile Island Unit 1 Test Procedure, TP 150/3, TCN-1[1]. This procedure was approved by the Three Mile Island Nuclear Station Unit 1 Test Working Group prior to the commencement of test.

Prior to the accomplishment of the preoperational integrated leak rate test the structural integrity test of the reactor containment building was performed at an internal containment building pressure of 63.? psig. The results of the structural integrity test are reported in a separate document (GAI Report No. 1838).

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The combined local leakage rates from reactor containment building isolation valves and penetrations tested was less than 60 percent of the maximum allowable leakage rate at 55 psig prior to commencement of the integrated leak rate test.

Leakage rate testing was accomplished at each pressure level of 30 psig and 55 psig for a period of 24 hours. Each 24 hour period was followed by a 12 hour supplemental test for a verification of the test instrumentation. During each 36 hour period of testing reactor containment building internal temperature was maintained at 71.5±0.3°F, except for hour 8 at Pd.

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3.0 ACCEPTANCE CRITERIA AND CONCLUSIONS

3.1 ACCEPTANCE CRITERIA

Acceptance criteria (prerequisites, arrangements, methods and analyses), established prior to the test and specified by 10 CFR 50, Appendix J[2]; ANSI N45.4-1972[3]; and the Three Mile Island Nuclear Station Unit 1 FSAR, Section 15.4.4.1, Amendment 47, are as follows:

a. The measured leakage rate (Lam) at the peak calculated pressure of 50.6 psig (Pa) shall be less than 75 percent of the maximum allowable leakage rate (La), specified as 0.1 weight percent of the building atmosphere per day by the Three Mile Island Nuclear Station Unit 1 FSAR, Section 15.4.4.1. The acceptance criteria is then determined as follows:

$$La = 0.1\%/day$$

$$0.75La = 0.075\%/day$$

b. The measured leakage rate (Ltm) at the reduced pressure of 30 psig (Pt) shall be less than 75 percent of the maximum allowable leakage rate (Lt) at Pt. For purposes of the preoperational integrated leak rate test at reduced pressure, Lt was determined as follows:

$$Lt = La\ (Pt/Pa)^{\frac{1}{2}}$$

$$Lt = (0.1)(30/50.6)^{\frac{1}{2}}$$

$$Lt = 0.077\%/day$$

The acceptance criteria for the leakage rate at Pt then was determined as follows:

$$Lt = 0.077\%/day$$

$$0.75Lt = 0.058\%/day$$

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c. The acceptance criteria that the test instrumentation be verified by means of a supplemental test within 25 percent La (or Lt) was established in accordance with 10 CFR 50, Appendix J.

3.2 CONCLUSIONS

a. The measured leakage rate (Ltm) at a containment internal pressure of 30 psig (Pt) was 0.031 percent per day. This value is well below the previously stated acceptance criterion of 0.058 percent per day. Therefore, reactor containment building leakage at reduced pressure (Pt) of 30 psig is considered to be acceptable.

b. The measured leakage rate (Lam) at a containment internal pressure of 50.6 psig (Pa) was 0.043 percent per day. This value is well below the previously stated acceptance criterion of 0.075 percent per day. Therefore, reactor containment building leakage at peak calculated pressure (Pa) of 50.6 psig is considered to be acceptable.

c. The conclusion as to the acceptability of the measured leakage rates (Ltm and Lam) is further strengthened by the fact that only four of the forty-eight measured leakage rates were outside the limits established by the 95 percent confidence level.

d. Verification of test accuracy at Pt and Pd was accomplished by means of a supplemental test in each case, during which a superimposed, controlled leakage rate from the containment was instituted. Appendix J of 10 CFR 50 requires that the results of supplemental tests be within 25 percent of La at peak pressure (Pa) and within 25 percent of Lt at reduced pressure (Pt).

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The following summary indicates values for these tests:

	L_v 24 Hour Leakage Rate (lb/hr)	L_v' Supplemental Test Leakage Rate (lb/hr)	Difference (lb/hr)	Difference (%/day)
Pd	5.87	9.24	3.37	0.011
Pt	1.13	1.00	0.13	0.001

A comparision of these results yields the following:

$$\text{At Pa:}\quad \frac{Lam}{La} = \frac{(0.011 \times 0.96)\%/day}{0.1\%/day} = 0.10, \text{ or } 10\% \text{ of } La$$

$$\text{At Pt:}\quad \frac{Ltm}{Lt} = \frac{0.001\%/day}{0.077\%/day} = 0.013, \text{ or } 1.3 \text{ of } Lt$$

These comparisons are both well below the 25 percent limit specified by Appendix J of 10 CFR 50. Therefore, the supplemental tests are considered to have satisfactorily verified the acceptability of the test instrumentation.

e. The conclusion as to test data accuracy based on supplemental tests is further strengthened by the fact that measured leakage rates during the supplemental tests were all within the limits established by the 95 percent confidence level, except one data point.

f. When the results of instrument calibration checks made following the completion of testing were compared with checks made prior to testing, it was concluded that no drift to the instrumentation had occurred.

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g. In accordance with 10 CFR 50, Appendix J, the following conclusion was reached concerning the value of Lt to be used for subsequent reactor containment building integrated leak rate tests:

$$Lt = La\ (Pt/Pa)^{1/2}$$

$$Lt = 0.1\ (30/50.6)^{1/2}$$

$$Lt = 0.077\%/day$$

This determination of Lt was used since (Ltm/Lam) was greater than 0.7 (i.e., Ltm/Lam = 0.72).

The acceptance criterion for subsequent integrated leak rate tests then becomes 0.033 percent per day. This value was determined as follows:

$$Lt = 0.077\%/day$$

$$0.75Lt = 0.058\%/day$$

From the above value of 0.058 percent per day, it will be necessary to subtract 0.025 percent per day (see Section 4.4 for derivation) to account for instrument error as required in Appendix J, 10 CFR 50, III.A.3.c. Hence the value for the acceptance criterion becomes 0.033 percent per day, as stated above.

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4.0 TEST INSTRUMENTATION

4.1 SUMMARY OF INSTRUMENTS

Test instruments employed are described, by system in the following subsections.

4.1.1 Temperature Indicating System

Overall system accuracy: ±0.34°F.

Overall system repeatability: ±0.34°F

Components:

a. Resistance Temperature Detectors

Number	24 (TE-6550, out of service prior to test)
Manufacturer	Rosemount
Type	Model 104 AAN, 100 ohm, platinum
Range, °F	65-115
Accuracy, °F	±0.1
Repeatability, °F	±0.1

b. Indicating Readout Devices

Number	3
Manufacturer	Leeds and Northrup
Type	Model 8064
Accuracy, °F	0.24
Repeatability, °F	0.24

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4.1.2 Dewpoint Indicating System

Overall system accuracy: ±1.0°F.

Overall system repeatability: ±0.50°F.

a. Dewcel Elements

Number	10
Manufacturer	Foxboro
Type	Model 2711 AG, 18 carat gold

b. Dewpoint Recorder

Number	1
Manufacturer	Foxboro-Yew
Type	Model Y/ERB12
Range	0-100°F

4.1.3 Pressure Monitoring System

Overall system accuracy: ±0.015% of indicated pressure.

Overall system repeatability: ±0.0005% of indicated pressure.

Precision Pressure Gauges

Number	2
Manufacturer	Texas Instruments
Type	Model 145-02
Range, psia	0-100

4.1.4 Supplemental Test Flow Monitoring System

Overall system accuracy: ±1% FSA

Flow Meter

Number	1

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Manufacturer	Brooks
Range, scfh, at 0 psig and 100°F	30.9-305

4.2 SCHEMATIC ARRANGEMENT

The basic arrangement of the four measuring systems summarized in Section 4.1 is depicted in Appendix A.

Temperature sensors (TE-655) were placed throughout the reactor containment building volume to permit monitoring of internal temperature variations at 24 locations. RTD TE-6550 was found to be shorted before the test and was therefore abandoned. Dewcels (TE-654) were placed in 10 locations as shown. No special orientation or location of these instruments was considered. Placement of temperature sensors and dewcels was as follows:

Location	No. of Temperature Indicators (TE-655)	No. of Dewcels (TE-654)
Basement floor	5	2
Mezzanine floor	5	2
Operating floor	4	2
Top of secondary shield	2	2
Crane hook	2	1
Crane bridge	4	0
Top of elevator	2	1

These 34 sensors, placed as indicated, made possible the most representative measurements of reactor containment building internal

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atmospheric conditions, especially since continuous mixing of the atmosphere was taking place through the two building recirculation units.

The precision gauges (PI-390 and PI-391) and the flow meter (FI-110) were located within 20 feet of the sensing line penetrations from the containment. Condensation and temperature effects on the sensing lines were thus minimized.

4.3 CALIBRATION CHECKS

Temperature and pressure measuring systems were checked for calibration before and after the test runs as recommended by ANSI N45.4-1972, Sections 6.2 and 6.3.

4.3.1 Temperature Indicating System Calibration Check

The temperature indicating system was checked by immersing a TE-655 RTD in a water bath which was temperature monitored by a second test RTD with an accuracy of ±0.34°F. The TE-655 RTD'S were connected to the Leeds and Northrup Model 8064 bridge with the test RTD (bath) temperature and each TE-655 RTD temperature being recorded. The test RTD (bath) temperature minus the TE-655 RTD temperature is the difference value shown in Table 1.

This same check was repeated following the test. Data are presented in Table 1. The acceptance criterion applied to each RTD checked was that the difference in measured temperatures should not exceed the sum of the accuracies of the two measuring systems, 0.34°F + 0.34°F, or 0.68°F.

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TABLE 1

TEMPERATURE INDICATING SYSTEM

CALIBRATION CHECK

RTD INDICATION DIFFERENCES BEFORE AND AFTER TEST

Instrument Number	Difference Before Test (°F)	Difference After Test (°F)
TE-655A	-0.22	+0.23
TE-655B	+0.35	-0.54
TE-655C	-0.55	-0.40
TE-655D	+0.30	-0.16
TE-655E	-0.60	+0.26
TE-655F	-0.11	+0.22
TE-655G	+0.30	0.00
TE-655H	+0.15	-0.30
TE-655I	+0.15	+0.30
TE-655J	-0.30	+0.27
TE-655K	+0.04	-0.32
TE-655L	+0.08	-0.40
TE-655M	+0.39	+0.53
TE-655N	+0.13	+0.32
TE-655O	N.A.	N.A.
TE-655P	-0.30	+0.57
TE-655Q	-0.10	-0.50
TE-655R	+0.05	-0.05
TE-655S	-0.50	+0.53

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TABLE 1 (Cont'd)

Instrument Number	Difference Before Test (°F)	Difference After Test (°F)
TE-655T	+0.05	+0.47
TE-655U	+0.30	+0.52
TE-655V	+0.40	-0.52
TE-655W	-0.15	-0.19
TE-655X	-0.05	-0.32
TOTAL	-0.19°F	+0.52°F
Average = total/23	-0.01°F	+0.02°F

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The average differences of -0.01°F before the test and +0.02°F after the test are well within the e_T value of 0.071°F. (See Section 4.4.) This comparison validates the acceptability of the temperature monitoring system.

4.3.2 Dewpoint Indicating System

The dewpoint indicating system was checked by immersing a flushed TE-654 dewcel (RTD) in a water bath which was temperature monitored by a test RTD with accuracy of ±0.34°F. Bath temperature was converted to dewpoint temperature using Foxboro Calibration Curve, DI-2. The difference between the dewpoint indicated by the dewpoint recorder and that obtained from the test RTD, using Foxboro Calibration Curve, DI-2, was recorded for each dewcel RTD (i.e., bath dewpoint minus indicated dewpoint).

This same check was repeated following the test. Data are presented in Table 2. The acceptance criterion applied to each TE-654 dewcel checked was that the difference in dewpoints should not exceed the sum of the accuracies of the two methods used, 0.34°F + 1.0°F, or 1.34°F.

The average differences of +0.08°F before the test and 0.22°F after the test are well within the e_{Pt} value of 0.316°F (see Section 4.4). This comparision validates the acceptability of the dewpoint indicating system.

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TABLE 2

DEWPOINT INDICATING SYSTEM

CALIBRATION CHECK

DEWCEL INDICATION DIFFERENCES BEFORE AND AFTER TEST

Instrument Number	Difference Before Test (°F)	Difference After Test (°F)
TE-654A	0.00	+0.30
TE-654B	+0.13	+0.10
TE-654C	+0.03	-0.10
TE-654D	+0.13	+0.20
TE-654E	+0.30	+0.30
TE-654F	+0.03	+0.20
TE-654G	+0.30	+0.30
TE-654H	+0.03	+0.30
TE-654I	0.00	+0.40
TE-654J	-0.13	+0.20
TOTAL	+0.82°F	+2.20°F
Average = total/10	+0.08 °F	+0.22°F

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4.3.3 Pressure Monitoring System

The pressure monitoring system could only be checked against itself on-site due to the extreme system accuracy, ±0.015 percent of the indicated value. This system was checked before and after the test by comparing the indicated pressure from the two instruments (PI-390, PI-391) and determining the difference at various pressure levels. Data are presented in Table 3.

The acceptance criterion applied was that the difference in pressure (at 55 psig) indication between the two instruments should not exceed ±0.30 percent of the indicated pressure, or twice the accuracy of one instrument. The factor of two was based on the assumption that one instrument could be indicating +0.015 percent while the other indicated -0.015 percent of the true pressure.

This comparison validates the acceptability of the pressure monitoring system. Further confidence in the system was derived from review of differences in indicated pressures during the tests at 30 psig and 55 psig. The differences did not exceed 0.021 psia at 30 psig and 0.015 psia at 55 psig.

4.3.4 Supplemental Test Flow Monitoring System

The supplemental test flow monitoring system could not be checked for calibration at the site. It was assumed that factory calibration was valid.

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TABLE 3

PRESSURE MONITORING SYSTEM

CALIBRATION CHECK

PRESSURE INDICATOR DIFFERENCES BEFORE AND AFTER TEST

Approx. Pressure Level (psia)	Difference* Before Test (psia)	Difference* After Test (psia)	±0.030% of Indicated Pressure (psia)
29.7	0.025	0.006	0.009
44.7	0.015	0.009	0.013
54.7	0.015	0.009	0.016
69.7	0.011	0.015	0.021

*Difference = $TCP_{PI-390} - TCP_{PI-391}$ where TCP is the true corrected pressure derived from indicated counts using Texas Instrument interpolation tables.

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4.4 ERROR ANALYSIS

The basic sources of potential error in any leak rate test must be considered and evaluated, these being systematic and random error.

4.4.1 Systematic Error

Systematic error, in this test, is induced by the operation of the two temperature and the one pressure indicating system.

Justification of instrumentation selection was accomplished as follows, using manufacturer's accuracy and repeatability tolerances stated in Section 4.1, and listed below, and reference 3.

Instrument	Accuracy	Repeatability
PI-390, PI-391	±0.0015% of indicated pressure	±0.0005% of indicated pressure
TE-654A through TE-654J	±1.0°F	±0.5°F
TE-654A through TE-655X	±0.34°F	±0.34°F

The leakage rate, in percent per day (%/day), based on an interval or measurement of 24 hour duration is

$$L = 100 \left[1 - \frac{P_{24} \, T_o}{P_o \, T_{24}} \right] \% \text{ day}$$

where:

$P_o = P_{T_o} - P_{wvo}$, psia = partial pressure of air at start

$P_{24} = P_{T24} - P_{wv_{24}}$, psia = partial pressure of air at finish

T_o = building mean ambient temperature at start, ^oR

T_{24} = building mean ambient temperature at finish, ^oR.

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The change, or uncertainly level, in L due to uncertainties in the systematic measured variables is given by

$$\delta_L = 100\left[\left(\frac{\partial L}{\partial P_{24}}\,\tau P_{24}\right)^2 + \left(\frac{\partial L}{\partial P_o}\,\tau P_o\right)^2 + \left(\frac{\partial L}{\partial T_o}\,\tau T_o\right)^2 + \left(\frac{\partial L}{\partial T_{24}}\,\tau T_{24}\right)^2\right]^{\frac{1}{2}}$$

where τ is the systematic error for each variable. The error in L after differentiation is

$$e_L = 100\left[\left(\frac{T_o\; e_{P_{24}}}{P_o\; T_{24}}\right)^2 + \left(\frac{P_{24}\; T_o\; e_{P_o}}{P_o^{\,2}\; T_{24}}\right)^2 + \left(\frac{P_{24}\; e_T}{P_o\; T_{24}}\right)^2 + \left(\frac{P_{24}\; T_o\; e_T}{P_o\; T_{24}^{\,2}}\right)^2\right]^{\frac{1}{2}}$$

where:

e_{P_o} and $e_{P_{24}} = \tau P_{24}$

$e_T = \tau T_{24}$

Since the values of T_o and T_{24} are essentially the same, within 0.3^oF, and P_o and P_{24} are essentially the same, within 0.044 psia, let $T_o = T_{24}$ and $P_o = P_{24}$. The systematic error in L then becomes

$$e_L = 141.4\left[\left(\frac{e_P}{P_o}\right)^2 + \left(\frac{e_T}{T_o}\right)^2\right]^{\frac{1}{2}} \qquad (1)$$

where the error in pressure (e_P) may be expressed as

$$e_P = \left(e_{P_a}^{\;2} + e_{P_b}^{\;2}\right)^{\frac{1}{2}}$$

and

e_{Pa} = error induced by two precision gauges, or

$$e_{Pa} = \pm\,\frac{(0.00015)\;(65.3)}{(2)^{\frac{1}{2}}}\ \text{psia}$$

$e_{Pa} = \pm\ 0.0069$ psia

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and

e_{Pb} = error induced by Dewcels, or

$$e_{Pb} = \pm \frac{1.0}{(10)^{\frac{1}{2}}} \ {}^{o}F$$

$$e_{Pb} = \pm 0.316^{o}F$$

From steam tables, at a dewpoint of 40°F, the pressure equivalent to ± 0.316°F is

$$e_{Pb} = \pm 0.0028 \text{ psia}$$

Therefore,

$$e_p = [(0.0069)^2 + (0.0028)^2]^{\frac{1}{2}} \text{ psia}$$

$$e_p = \pm 0.0067 \text{ psia}$$

The error in temperature (e_T) may be expressed as

$$e_T = \pm \frac{0.34^{o}F}{(23)^{\frac{1}{2}}}$$

$$e_T = 0.071^{o}F$$

Hence, for the values at Pa,

$$P_o = 65.300 \text{ psia}$$

$$T_o = 531.41^{o}R$$

and substitution into equation (1) yields

$$e_{La} = 141.4 \left[\left(\frac{0.0067}{65.300} \right)^2 + \left(\frac{0.071}{531.41} \right)^2 \right]^{\frac{1}{2}}$$

$$e_{La} = \pm 0.024\%/\text{day.}$$

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At 30 psig (Pt) with

P_o = 44.661 psia

T_o = 531.02°R

e_{Lt} = ±0.025%/day

The maximum expected systematic errors of the test instrumentation package are e_{La} and e_{Lt}.

If equation (1) is solved using the previously stated repeatability values, the maximum expected error is calculated to be as follows:

$e_{LaR} = e_{LtR} = \pm 0.020\%/\text{day}$

A conclusion reached from the above calculations was that the instrumentation selected yielded an error value approximately 5 times less than the allowable leakage rate value of approximately 0.1 percent per day and that the instrumentation combination was of sufficient sensitivity for this test.

It was evident that use of accuracy or repeatability tolerances did not appreciably affect the value of e_L.

Following the establishment of the systematic error in the leakage rate, the uncertainty in the absolute value of the weight of reactor building air (W) was derived as follows:

$$W = \frac{KP}{T}$$

where,

W = Weight of air inside the reactor containment building in pounds mass (lbm)

K = Constant = V/R = 5.39 x 10^6 in.^{2} - °R

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P = Partial pressure of air inside the reactor containment building, psia

T = Mean reactor building temperature, ^{o}R

The error, based upon the Second Law of Propagation on W, is

$$e_W = \left[\left(\frac{\partial W}{\partial P}\ \tau_P\right)^2 + \left(\frac{\partial W}{\partial T}\ \tau_P\right)^2\right]^{\frac{1}{2}}$$

$$e_W = \left[\left(\frac{Ke_P}{T}\right)^2 + \left(\frac{-KP}{T^2}\ e_T\right)^2\right]^{\frac{1}{2}} \qquad (2)$$

where

e_P = Error induced by the pressure and dewcel systems.

e_P = ±0.0067 psia

and

e_T = Error induced by the temperature system

e_T = ±0.071°F

Without taking into account the exact minute changes of pressure and temperature at each reading, the values at time zero may be used as representative values, (i.e., P = 69.542 psia; T = 531.41°R). Therefore, upon solution of equation (2),

e_{Wd} = ±116 lbm, at 55 psig

e_{Wt} = ±82 lbm, at 30 psig

For each mass point on the graphs in Appendix F, e_W was plotted as the error bar. The consistency of the data was apparent since the least squares fit exceeded e_W at only hour 8 at 55 psig, and hour 7 at 30 psia.

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4.4.2 Random Error

Random error is somewhat of an intangible and, unlike systematic error, evaluated in Section 4.4.1, cannot be evaluated beforehand. After the experimental data are collected and each set of data is processed using the CLERCAL computer code, the following statistical parameters are available:

a. Least squares fit (L or W = $K_o + K_1 t$)

b. Standard deviation (σ)

c. Standard error of confidence for each data point (Se)

d. Limits of 95 percent confidence level for each leakage rate (C_{LM}, C_L)

The significance of the random error can then be evaluated by reviewing how many data points exceed the limits of the 95 percent level of confidence, and the similarity between the measured leakage rates and the limits of the 95 percent confidence levels for those leakage rates.

4.4.2.1 Least Squares Fit

The equation for a straight line fit is developed from the least squares analysis in the form

$$L \text{ or } W = K_o + K_1 t$$

where the constants K_o and K_1 are defined as follows:

$$K_o = \frac{\Sigma t_i^{\,2}\ \Sigma L_i - \Sigma t_i\ \Sigma L_i t_i}{N\Sigma t_i^{\,2} - (\Sigma t_i)^2}$$

$$K_1 = \frac{N\Sigma t_i L_i - \Sigma t_i \Sigma L_i}{N\Sigma t_i^{\,2} - (\Sigma t_i)^2}$$

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assuming the following:

a. Summation of each data point in the run, $\sum_{i=1}^{N}$.

b. L (leakage rate) and W (weight of reactor building air) are interchangeable.

c. N is equal to the number of data points.

The least squares equation provides a leakage rate which varies with time for the total time and point-to-point methods of analysis. If the mass point method is used, the least squares equation yields a single, fixed leakage rate which is constant and does not vary with time.

The least squares fit calculated from the data is presented in Sections 8.2, 8.3, and 8.4. Since the pressure differential across the reactor building decreased only 0.044 psi at 55 psig and 0.004 psi at 30 psig, there is no reason to believe that the leakage rate is time dependent. It may be assumed that the leakage rate of a reactor containment building is not a function of time over a period of 24 hours.

The finite values of K_1 (approximately 0.001%/day/hr) shown in Sections 8.2 and 8.4 increase confidence in the recorded data since ideally the slope should be zero. Therefore, if least squares is represented mathematically by

$$L = \Sigma (L_i - L_L)^2 \qquad (3)$$

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where,

L_i = observed values of leakage rate

L_L = constant leakage rate equal to K

equation (3) becomes, by substitution:

$$L = \Sigma\ (L_i - K)^2$$

Then, by minimizing L with respect to K, i.e.,

$$\frac{\partial L}{\partial K} = 0$$

the following results:

$$\frac{\partial L}{\partial K} = 0 = 2\Sigma(L_i - K)(-1)$$

$$0 = \Sigma(L_i - K)$$

$$\Sigma K = \Sigma L_i$$

$$KN = \Sigma L_i$$

$$K = \frac{\Sigma L_i}{N}$$

since i ranges from 1 to N-1, then

$$L_{mean} = \frac{\Sigma L_i}{N-1}$$

which yields the mean leakage rates reported in Sections 8.2 and 8.4. These two sections also compare the mean leakage rates to the average rates over the last 15 hours of each test run. This comparison demonstrates good agreement.

1408 086

4.4.2.2 Standard Deviation

Standard deviation (σ) is classically defined as

$$\sigma = \left[\frac{N\Sigma L_i^{\,2} - (\Sigma L_i)^2}{N(N-1)} \right]^{1/2}$$

and is an expression of the difference in the measurement (of a constant) of observed data points relative to the mean of the data points.

This statistical parameter can be directly applied to the total time and point-to-point methods of analysis since 24 leakage rates are available to determine one constant leakage rate.

Standard deviation cannot be applied in the mass point method of analysis since the data (mass) must decrease with time. Hence the key parameter measured is not a constant as it is in the total time and point-to-point methods.

In the mass point method, the standard error of confidence (S_e) is used. This value is expressed as follows:

$$S_e(lb_m) = \left\{ \frac{\Sigma[W_i - (K_o + K_1 t_i)]^2}{N-2} \right\}^{1/2}$$

This parameter is an expression of the difference between an observed and a calculated (least squares) mass point. This same expression may also be used to evaluate the total time and point-to-point data.

1408 087

4.4.2.3 Confidence Limit

As stated in a draft of Appendix J to 10 CFR 50, issued in August, 1971, a confidence limit of 95 percent was published as a representative guide to the acceptability of experimental data.

For the preceding least square fits, the 95 percent confidence limit of the <u>data</u> (W or L) is, by definition, the magnitude of 2Se.

Likewise, the definition of the 95 percent confidence limit (C_{LM}) for the mean value of the leakage <u>rates</u> determined by the total time and point to point methods may be expressed as follows:

$$C_{LM} = \frac{t_{95}\sigma}{(N-1)^{1/2}}$$

where,

t_{95} = the Student's t distribution with N-1 degrees of freedom

For the mass point method the 95 percent confidence limit (C_L) of the leakage rate is expressed in terms of Se rather than σ as previously mentioned and,

$$C_L = t_{95} \left[\frac{N}{N\Sigma t_i^2 - (\Sigma t_i)^2} \right]^{1/2} \times S_e$$

where,

t_{95} = the Student's t distribution with N-2 degrees of freedom.

1408 088

4.4.2.4 Evaluation

A compilation of the confidence limits associated with the two 24 hour leakage rate fits (at 55 psig and 30 psig) is presented below:

Pressure Plateau	C_{LM} Total Time	C_L Mass Point	C_{LM} Point-to-Point
55 psig	0.028%/Day	0.012	0.096
30 psig	0.025%/Day	0.012	0.144

The above stated confidence levels, when compared to measured leakage rates of 0.020 and 0.006 percent per day, demonstrate that the random uncertainty interval is well within the measured leakage rates and those calculated for systematic error (e_{La} = 0.024; e_{Lt} = 0.025) in Section 4.4.1. It may therefore be concluded that random error was not of any major significance.

A review of data points which were outside the confidence limit ($2S_e$) yielded the following:

Pressure Plateau	Number of Data Points Outside Confidence Limit		
	Total Time	Mass Point	Point-to-Point
55 psig	1	1	2
30 psig	3	1	2

It is quite evident that random error was minimal in that only four of forty-eight total time data points exceeded the confidence limit.

1408 089

For the 12 hour supplemental test verifications, the confidence limits were as follows:

Pressure Plateau	C_{LM} Total Time	C_L Mass Point	C_{LM} Point-to-Point
55 psig	0.002%/Day	0.016	0.085
30 psig	0.013%/Day	0.014	0.087

Using the $2S_e$ value, the number of data points which exceeded the confidence limit was as follows:

Pressure Plateau	Total Time	Mass Point	Point-to-Point
55 psig	1	0	0
30 psig	0	1	1

Again it can readily be seen that random error was not excessive in the analysis of this data since only one of 24 data points exceeded the confidence limit.

4.5 SUPPLEMENTAL VERIFICATIONS

In addition to the calibration checks described in Section 4.3, test instrumentation operation was verified by a supplemental test subsequent to the completion of the 24 hour leakage rate tests at pressures Pt and Pd. These tests consisted of imposing a known, calibrated leakage rate on the reactor containment building.

1408 090

Flowmeter, FI-110, was placed in service and a flow rate from the reactor containment building of 80% of FI-110 full scale deflection was established. This flow rate was equivalent to 18.81 lb/hr at pressure Pt and 18.66 lbm/hr at pressure Pd. After the flow rate was established it was not altered for the duration of the supplemental test.

During the supplemental test phases, reactor containment building leakage rate was

$$L_c = L_v' + L_o$$

where,

L_c = Composite total time leakage rate of the reactor building and the flow rate through FI-110.

L_o = Known leakage rate through FI-110.

L_v' = Leakage rate of the reactor building during this test phase.

Thus, at pressure Pt:

$$L_v' = L_c - L_o$$

$$L_v' = 19.81 - 18.81$$

$$L_v' = 1.00 \text{ lb/hr}$$

This value compares favorably with the measured leakage rate Ltm of 1.13 lb/hr with one data point exceeding the limits of the 95 percent confidence level. This agreement is 1.3 percent of Lt, well below the 25 percent of Lt which is allowable.

1408 091

Similarly, at pressure Pd:

$$L'_v = L_c - L_o$$

$$L'_v = 27.90 - 18.66$$

$$L'_v = 9.24 \text{ lb/hr}$$

This value compares favorably with the measured leakage rate of 5.87 lb/hr. This agreement is 10 percent of La, well below the 25 percent of La which is allowable.

This verification, through supplemental tests, combined with the post test calibration checks clearly established the acceptability of the test instrumentation.

The two measured leakage rate values (L_c), mentioned above, are L_{Mean} as determined by the total time method.

1408 092

5.0 TEST PROCEDURE

5.1 GENERAL

Following the satisfaction of seven basic prerequisites, stated in Section 5.2, reactor containment building pressurization was initiated at a rate of 2.5 psi per hour. Building temperature was maintained at approximately 70°F. Building pressure and temperature and the amperage required by recirculation unit fans (AH-E-1A, 1B and 1C) were monitored hourly.

Prior to stabilization of building pressure at a pressure plateu, precision gauges were equalized to the barometric pressure within the intermediate building. These gauges were then used to obtain data for use in calculating the reactor containment building internal gauge pressure. Leak rate testing was initiated at 30.2 psig and 55.2 psig.

A minimum of four hours elapsed between the stabilization of reactor containment building pressure and the taking of any official data. During this period and for the duration of the 24 hour leak rate test and 12 hour supplemental test (total 36 hour period) at each test pressure level (30.2 psig and 55.2 psig), industrial cooler cooling water flow rate and the number of operating industrial cooler air cooling fans were varied to maintain average internal containment temperature within a band of ±0.3°F. (See Appendix F)

1408 093

During each test the following occurred hourly:

a. Each of the ten Dewcel dewpoint values was recorded. The average of the ten values was converted to vapor pressure using steam tables [4].

b. Each of the twenty-four RTD temperatures was recorded and an average calculated (on the half hour) to permit computation of the weight of containment air. This average value also served as the variable controlled for the performance of the tests.

c. Pressures indicated by each of the two precision gauges were recorded and an average was calculated to permit correction to the total pressure of air by subtracting the vapor pressure for the weight of air calculation with partial pressure of air.

The use of vapor pressure (P_{wv}), average temperature (T) and total pressure (P_T) is described in more detail in Section 8.1.

The plot of average temperature and weight of air was performed hourly.

An undesirable temperature ramp was counteracted by varying the heat removal capability of the industrial cooler system.

When convenient, the available hourly values of P_{wv}, T and P_T were transmitted to the Gilbert Associates, Inc., home office for further analysis using the CLERCAL computer program [5]. Computer program results were returned to the site via telephone which included a least squares fit of the observed on-site data.

A final computer run was made after data for a full 24 hour period was available.

1408 094

Following the 24th hour of each test, a superimposed leakage rate was established for an additional 12 hour period for instrument verification. See Section 4.5.

5.2 PREREQUISITES

Prior to commencement of reactor containment building pressurization, the following basic prerequisites were satisfied:

a. Proper operation of all test instrumentation was verified.

b. All reactor containment building isolation valves were closed using the normal mode of operation. All associated system valves were placed in post-accident positions.

c. Equipment within the reactor containment building, subject to damage, was protected from external differential pressures.

d. Portions of fluid systems which, under post-accident conditions become extensions of the containment boundary, were vented.

e. The penetration pressurization and fluid block systems were depressurized. Gauges were installed at penetration pressurization manifolds to provide means for detection of leakage into the system.

f. Pressure gauges were installed on closed systems within containment to provide means for detection of leakage into such systems.

g. Local leakage rate testing of containment isolation valves and penetrations were concluded.

1408 095

5.3 LEAKAGE RATE AT Pt

As required by 10 CFR 50, Appendix J, Section III. 4.1, a reduced pressure test was performed at a pressure, Pt, not less than 0.50 Pa, to measure a leakage rate Ltm. The value chosen for this test was 30 psig at 0.75 Lt as defined by La $(Pt/Pa)^{1/2}$, or 0.058 percent per day.

Following the determination of Ltm and Lam, leakage rates at pressures Pt and Pa, respectively, a new value of Lt is calculated for use in all subsequent integrated leakage rate tests.

5.3.1 Prerequisites for Leakage Rate at Pt

Upon completion of the seven basic prerequisites stated in Section 5.2, the reactor containment building was pressurized to 14 psig and an inspection of the building was performed. No significant effects were observed at this pressure and the building was pressurized to 30.2 psig (second time).

Within 12 hours the building internal ambient average temperature (T) had stabilized within an acceptable range and leakage rate testing commenced.

5.3.2 Test at Pt

During the test period, raw data was reduced and the weight of reactor building air was calculated every hour to obtain information concerning concurrent changes within the building.

1408 096

Since the weight of building air (W) was determined by:

$$W = K\left(\frac{P_T - P_{wv}}{T}\right)$$

only three variables can cause a variation in W. Those were:

a. A change in building total pressure, P_T.

b. A change in the water vapor pressure of the building air, P_{wv}.

c. A change in the average building temperature, T.

Changes in building temperature were controlled by operation of the industrial cooler system and dewpoint/vapor pressure was not a major variable since it increased only 0.007 psia over 24 hours. Hence, only the total pressure measurement affected the results of the tests as elaborated in Section 7.1 of ANSI 45.4-1972.

As the test progressed, plotting of W versus time was most useful in understanding the changes caused by the three variables discussed. When convenient, data was transmitted to the Gilbert Associates, Inc., computer for reduction using the CLERCAL code. This data reduction produced the results presented in Appendices D, F, and G.

Section 6.1 presents a discussion of test results.

5.4 LEAKAGE RATE AT Pd

As stated by 10 CFR 50, Appendix J, Section III. 4.a.ii, a second test was required at the calculated peak internal pressure, Pa, to measure a leakage rate Lam. However, this test was performed at the design pressure of 55 psig as required by Three Mile Island Nuclear Station Unit 1 FSAR, Section 15.4.4.1.1.3.a. vice the peak calculated pressures of 50.6 psig.

1408 097

It was therefore necessary to recalculate the leakage rate as follows:

$$Lam = L_{dm} \left(\frac{Pa}{Pd} \right)^{1/2}$$

$$Lam = 0.96\ L_{dm}$$

Where L_{dm} is the leakage rate at 55 psig.

The acceptance criterion for this test, as stated in Section 3.1, was that the measured value must be less than 75 percent of La, or 0.075 percent per day.

5.4.1 Prerequisites for Leakage Rate at Pd

Upon completion of the supplemental test at Pt (30.2 psig), the reactor containment building pressure was increased to 55.2 psig.

Within 6 hours, the building internal ambient average temperature (T) had stabilized within an acceptable range and leak rate testing commenced.

5.4.2 Test at Pd

As described in Section 5.3.2, average reactor building internal ambient temperature (T) was monitored and controlled and the weight of building air (W) was calculated and plotted hourly. Also, data was reduced by computer at convenient intervals to yield the results presented in Appendix E.

Section 6.2 presents a discussion of test results.

1408 098

6.0 DISCUSSION OF RESULTS

6.1 RESULTS AT Pt

Data obtained during the leak rate test at Pt indicated the following changes during the 24 hour test period:

Variable	Maximum Change
P_T	0.022 psia
P_{wv}	0.007 psia
T	$0.240^{\circ}F$

The methods used in calculating the leakage rate were as defined in Section 8.0. The results of the calculations were as follows for the methods indicated:

Method	Leakage Rate (%/day)
Total Time	0.006 (1.13 lb/hr)
Point-to-Point	0.007
Mass Point	0.007

Based upon the total time method of calculation, the leakage rate (Ltm) was determined as follows:

$$Ltm = 0.006 + a_{Lt} \ \%/day$$

$$Ltm = 0.006 + 0.025 \ \%/day$$

$$Ltm = 0.031 \ \%/day$$

1408 099

6.2 RESULTS AT Pa

Data obtained during the leak rate test at Pa indicated the following changes during the 24 hour test period:

Variable	Maximum Change
P_T	0.054 psia
P_{wv}	0.005 psia
T	0.430°F

The methods used in calculating the leakage rate were as defined in Section 8.0. Results of these calculations were as follows for the methods indicated:

Method	Leakage Rate, L_{dm} (%/day)
Total Time	0.020 (5.87 lb/hr)
Point-to-Point	0.038
Mass Point	0.032

Based upon the total time method of calculation, the leakage rate (Lam) was determined as follows:

$Lam = L_{dm} (50.6/55)^{1/2}$ %/day (See Section 5.4)

$Lam = 0.96 \, L_{dm}$

where,

L_{dm} = Leakage rate at 55 psig = 0.020 %/day

Then,

$$Lam = 0.020\ (0.96)\ \%/day$$

$$Lam = 0.0192\ \%/day$$

When the error e_{La} is accounted for, the leakage rate becomes

$$Lam = 0.0192 + 0.024\ \%/day$$

$$Lam = 0.043\ \%/day$$

1408 101

7.0 DEFICIENCIES

The following deficiencies were identified during this test:

Number	Deficiency
D-17	Purge supply valves (AH-V1C and AH-V1D) required limit switch adjustments to effect full seating. The seating surfaces of AH-V1A, AH-V1B, AH-V1C and AH-V1D were cleaned with emery cloth.
D-22	Reactor building emergency river water coolers exhibited communication with the reactor building atmosphere.
D-23	Fuel transfer tube flange exhibited communication with the reactor building atmosphere on the primary side of the gasket.

Of the preceding deficiencies, two (D-22 and D-23) were corrected via a General Public Utilities Corporation problem report. The third (D-17) was resolved prior to the final test at 30 psig.

Aside from the preceding deficiencies, the effects of leakage observed from the secondary plant within the reactor containment building did not constitute a deviation from 10 CFR 50, Appendix J, requirements, based on the fact that systems be in their post-accident mode during this test. Since the system was depressurized for the test and not at 900 psig, this overly conservative test approach was more than consistent with the post LOCA status requirements of 10 CFR 50, Appendix J. Continued secondary plant leakage was confirmed during the final 30 and 55 psig tests at relatively negligible rates.

The history of the leaking secondary plant was as follows:

a. The reactor building ambient was stabilized at 30.2 psig at 1600, March 11, 1974, and leakage rate data was recorded until 0500, March 14, 1974.

b. During this period the measured leakage rates were as follows:

Date	Time Interval	Leakage Rate (lb/hr)
3-11	1600-0800	20.74
3-11	2100-0800	21.11

c. With no doubt that the test was failing, an investigation into the valve alignment was undertaken at 1200, March 12, 1974.

d. The check of valve alignment revealed that valves IC-V3, IC-V4, IC-V6, MU-V3 and DH-V4A were in violation of the alignment. It was determined that the violation was due to a search being conducted to locate a dc ground. The valves were closed by the normal mode of operation.

e. Additional indications displayed leakage into the core flood tanks, gross seat leakage at AH-VID, and leakage into the reactor building emergency coolers.

The core flood tanks were equalized with the reactor building ambient after the free volume determination was completed.

Duxseal was temporarily applied to the seat of AH-V1D.

Leakage into the emergency coolers could not be investigated until access to the building interior was possible.

f. Steam generator B sample line emitted a 3/8 inch diameter bubble every 2 seconds, upon investigation. No further action was taken at that time.

g. Leakage rate measurements began again at 0400, March 13, 1974.

h. With the discrepancies discussed above resolved, additional leakage rate data yielded the following:

Date	Time Interval	Leakage Rate (lb/hr)
3-13	1700-0400	24.05
3-13	0400-0400	16.29

i. With an excessive leakage rate still present, the valve alignment was rechecked and the possibility of air flow through process piping (especially the secondary plant as witnessed at the steam generator B sample line mentioned previously). The valve alignment was verified as being correct.

The pressure indicators on each steam generator indicated an increase from 0.9 psig to 1.0 and 2.8 psig with reactor building pressures from 0 to 30 psig. This minimal increase in pressure was not thought to be a major point of concern since the system was closed.

j. At 2140, March 14, 1974, it was decided to increase reactor building pressure in an attempt to make the leakage path more obvious.

k. At 0045, March 15, 1974, rotometers with a range of 0 to 20,000 cc/min at standard temperature and pressure were installed on each steam generator.

l. At a reactor building pressure of 36.9 psig the flow indication of the rotometers increased to 400 cc/min. At 38.9 psig the rotometers indicated flow of 4400 cc/min. Building pressurization was stopped at 44.5 psig with rotometers associated with steam generator B indicating a flow rate of 19,000 cc/min.

This exercise had shown that gross leakage was occurring through the secondary plant. The initial pressure indications in statement i were not meaningful because the secondary plant was, unfortunately, not a closed system; i.e., the leakage rate from the secondary plant to the atmosphere or the condenser was of such proportions that a back pressure in the secondary plant could not develop and was not evident.

The rotometers proved conclusively that communication existed and the reactor building was depressurized starting at 2000, March 15, 1974.

m. The following adjustments were made between 0800, March 16, and 2400, March 17, 1974, to potential leakage paths inside the reactor building:

1. Purge supply valve limit switches were adjusted.
2. Seats of all four purge valves were cleaned.
3. Purge valves were cycled and each seat was satisfactorily leak tested.
4. All steam generator manways and hatches were retorqued. Accessible emergency feedwater system flanges were also torqued.
5. Missing bolts on fuel transfer tube flanges were replaced and retorqued.
6. Water leak from AH-E-1C was repaired. This unit was later shut down due to a motor cooling water leak.
7. Missing caps were installed on secondary plant vents and drains.
8. Missing flanges were installed on MS-V84A and MS-V84B.
9. Packing was tightened on valves CA-V4A, CA-V4B and CF-V1A.

n. On March 18, 1974, at 2030, reactor building pressure was stabilized at 30.2 psig for the second time. The 24 hour leakage rate test was initiated and a leakage rate of 1.13 lb/hr was observed. Steam generator A was under a vacuum. Steam generator B indicated no flow.

o. A subsequent check at a reactor building pressure of 55 psig (at 0640, March 22, 1974) indicated that steam generator A was still under a vacuum and that steam generator B was issuing water at a pressure of 7 psig. Communication did exist but with a flow rate which was not detrimental to the building leakage rate of 5.87 lb/hr.

8.0 METHODS OF ANALYSIS

8.1 GENERAL DISCUSSION

Two methods of computing the leakage rate from a reactor containment building by using the absolute method are recognized by ANSI 45.4-1972. These methods are point-to-point (PP) and total time (TT). Both methods use the equation

$$L,\ \%/\text{day} = \frac{2400}{h}\left[1 - \frac{T_1\ P_2}{T_2\ P_1}\right]$$

where,

h, = length of test interval, hours

T_1 = average absolute temperature of the reactor building at the start of each hourly test period (point-to-point method) or at the beginning of the test (total time method), ^{o}R

T_2 = average absolute temperature of the reactor building at the end of each hourly test period (point-to-point method and total time method), ^{o}R

P_1 = partial pressure of air in the reactor building at the same time stated for T_1, psia

P_2 = partial pressure of air in the reactor building at the same time stated for T_2, psia

The Gilbert Associates, Inc., CLERCAL computer code calculates the percent per day leakage rate for each hour by the point-to-point and total time methods. In addition, as reported in three previous

Gilbert Associates, Inc., integrated leakage rate test reports, [6] the weight of reactor building air is calculated for each hour as follows:

$$W = \frac{144\ VP}{RT} = \frac{KP}{T}$$

where,

W = mass of air in the reactor building, lbm

$K = 144\ V/R = 5.3983 \times 10^6$

P = partial pressure of air, psia

T = average absolute temperature of the reactor building, ^oR

The weight of air is plotted versus time for the 12 or 24 hour test period. The Gilbert Associates, Inc., CLERCAL computer code fits the locus of these points by least squares and a formula for leakage rate, in the form $W = K_o + K_1 t$ (t in hours) is made available. This method is called "Mass Point".

For the three methods mentioned, P and T are calculated as follows:

$$P = \frac{P_{T_1} + P_{T_2}}{2} - P_{wv}$$

where,

P_{T_1} = true corrected pressure of PI-390, psia

P_{T_2} = true corrected pressure of PI-391, psia

P_{wv} = partial pressure of water vapor determined by averaging the ten dewpoint temperatures and converting to vapor pressure with the use of steam tables [4], psia

and,

$$T = \frac{\text{sum of 23 RTD's}}{23} + 459.69^{\circ}R$$

The two methods from ANSI 45.4-1972 have distinct disadvantages in that each data point is dependent upon another and all data taken is time dependent.

For the point-to-point method, each hourly rate calculated is dependent upon the previous hour; therefore, a bad data point effects the remainder of the test and the results. Any deviation in the exact time of recording the data will cause major inconsistencies in the calculated hourly rates, e.g., 2 minutes delay on a half hour recording basis will effect the calculated rate by 2/30, or 6.7 percent.

The point-to-point leakage rate results are included herein for information only, to depict how uncertain the method is.

The total time method is entirely dependent on the first data point and, if it were a bad point (caused by instrumentation fluctuation) the entire run would be adversely affected. The method's dependence on time is another factor which must be monitored closely.

In essence, any point-to-point or total time data point is a function of 7 variables (2 pressure, 2 temperature, 2 dewpoint, and time) and the repeatability required from test instrumentation as 73 discretely measured variables for one pseudo data point is unnecessary and awkward. The methods are entirely relative.

The mass point method is entirely independent of any preceding state point. A bad data point during test is easily recognizable with any variation of the 3 variables (pressure, temperature, dewpoint). In addition, the mass point is entirely independent of time, as the calculation only requires a 24 or 12 hour duration. Within this time envelope a change in the frequency between state points has no effects on the results. This method deals completely with absolutes.

8.2 TOTAL TIME

The least squares total time analysis yielded the following equations:

At Pd, Ldm = -0.0203 + 0.00347t

At Pt, Ltm = -0.0130 + 0.00158t

Since the reactor building pressure decreased by only 0.044 psi during the 24 hour test at Pd and by only 0.004 psi during the 24 hour test at Pt, it proves that the pressure does not significantly decrease during the test and the reactor building leakage rate must be a constant. Since the leakage rate is constant, the least squares fit must be equivalent to a slope of zero.

By differentiating the least square relationship and equating it to zero, it can be shown that the result is the mean of the 24 data points as given in Section 4.4.2.

Therefore, the equations above at the mean leakage rate (L mean), are equivalent to

$$Ldm = 0.020\ \%/day$$

$$Ltm = 0.006\ \%/day$$

and the instrumentation error is added per Sections 6.1 and 6.2.

The average of the last 15 hours of data as shown in Appendix G reduces to 0.031 percent per day at Pd and to 0.009 percent per day at Pt. In reviewing the first 10 hours of data, it is obvious that no consistency is apparent, as with the first 10 hours of the mass point data which yielded excessive rates of

$$L_{dm} = 0.085\%/day$$

$$Ltm = 0.030\%/day$$

The supplemental verification leakage rates of L_c for the two pressure plateaus were

Pd $L_c = +0.112 - 0.003t$

Pt $L_c = +0.124 - 0.003t$

as shown in Appendix G.

The mean rate (L_{mean}) gives

Pd $L_c = 0.095\%/day = 27.90\ lb/hr$

Pt $L_c = 0.105\%/day = 19.81\ lb/hr$

which are the values used in Section 4.5.

8.3 MASS POINT

As shown in Appendix F for the 24 hour test periods, the least squares calculations yielded the following fits:

Condition	Fit for W	Percent per Day*
Pd	705,208.8-9.45t	0.032
Pt	452,913.0-1.28t	0.007

$$\text{*Percent per day} = \frac{K_1(2400)}{W \text{ initial}}$$

8.4 POINT-TO-POINT

This method, included for information only, displays the complete randomness derived from perfectly consistent data as shown in Appendix F, Mass Point Data.

The least squares analysis yielded the following equations:

At Pd, Ldm = 0.0235 + 0.00123t

At Pt, Ltm = 0.0193 - 0.00107t

with a confidence limit which exceeded the total time method by a factor of 5 and the mass point method by a factor of 8.

The mean values of L_{mean} are equivalent to the following:

L_{dm} = 0.038%/day

Ltm = 0.007%/day

The average of the last 15 hours of data indicates leakage rates of

L_{dm} = 0.034%/day

Ltm = 0.0002%/day

9.0 REFERENCES

1. TP 150/3, TCN-1, "Initial Reactor Building Leak Rate Test," General Public Utilities Corporation Test Procedure.

2. Code of Federal Regulations, Title 10, Part 50, Appendix J.

3. ANSI N45.4-1972, Leakage Rate Testing of Containment Structures for Nuclear Reactors, American Nuclear Society, (March 16, 1972).

4. Steam Tables, American Society of Mechanical Engineers, (1967).

5. CLERCAL, Computer Code, Gilbert Associates, Inc.

6. Reports or previous Reactor Containment Building Integrated Leak Rate Tests prepared by Gilbert Associates, Inc.:

   a. "Preoperational Integrated Leak Rate Test of the Reactor Containment Building", Rochester Gas and Electric Corporation, Robert E. Ginna Nuclear Power Station, GAI Report No. 1721, (November 7, 1969).

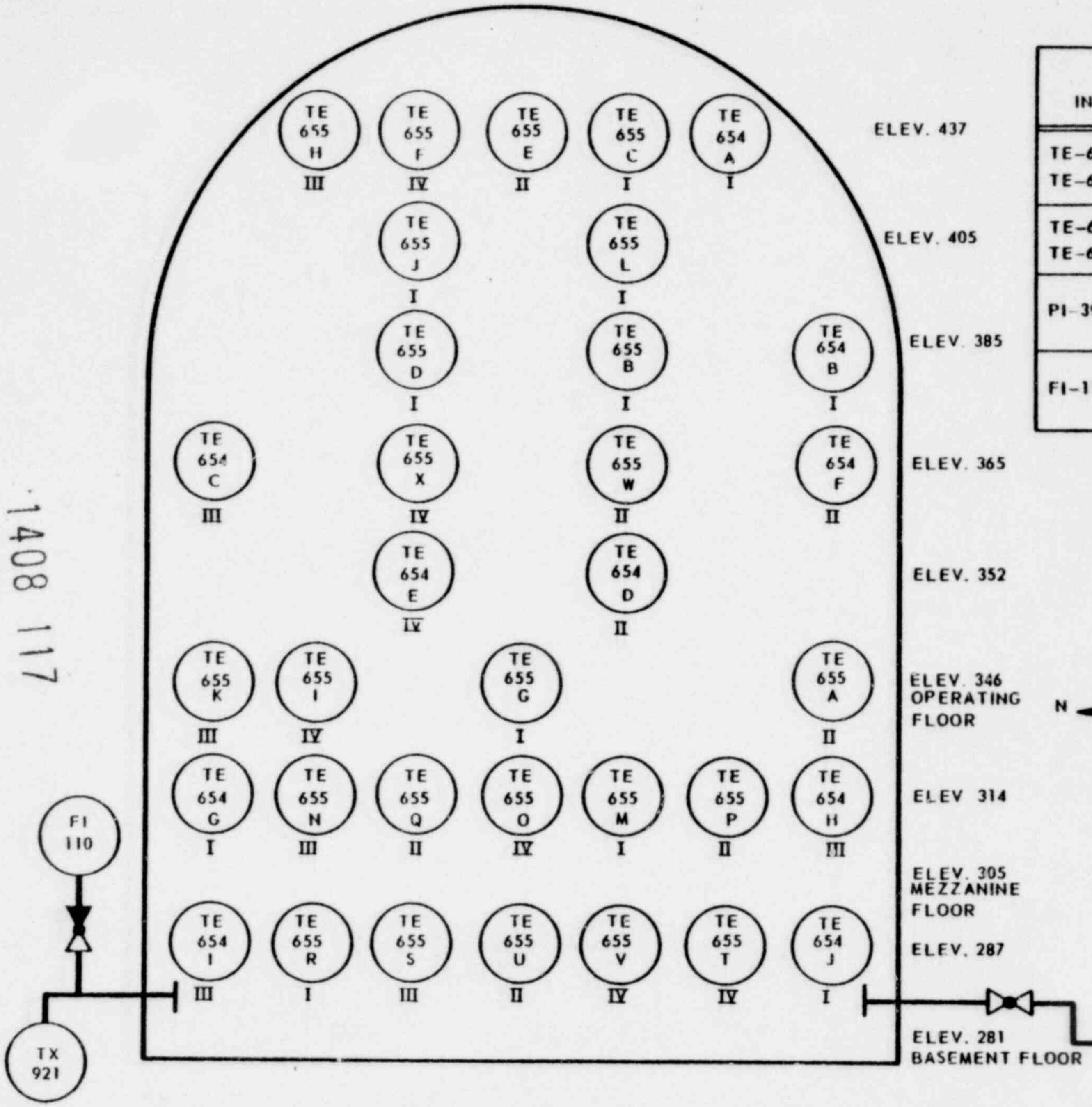
   b. "Preoperational Integrated Leak Rate Test of the Reactor Containment Building", Consolidated Edison Corporation, Indian Point Unit 2, GAI Report No. 1752, (June 4, 1971).

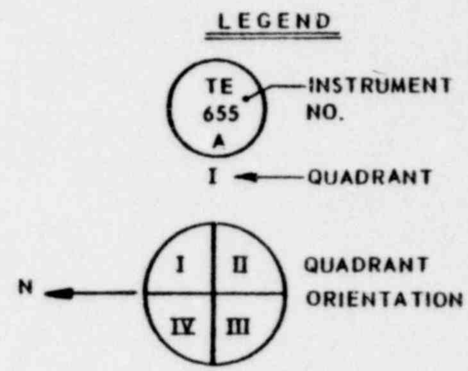
   c. "Type A Reactor Containment Building Periodic Retest and Type B and C Histories", Rochester Gas and Electric Corporation, Robert E. Ginna Nuclear Power Station, GAI Report No. 1783, (October 8, 1972).

APPENDICES

APPENDIX A

TEST INSTRUMENTS	DEVICE/ MANUFACTURER
TE-655A THROUGH TE-655X	RTD/ROSEMOUNT
TE-654A THROUGH TE-6545	DEWCELL/ FOXBORO
PI-390; PI-391	PRESSURE INDICATOR/ TEXAS INSTR.
FI-110	FLOW INDICATOR/ BROOKS





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APPENDIX A
SCHEMATIC ARRANGEMENT OF
TEST INSTRUMENTATION

APPENDIX B

1408 118

THREE MILE ISLAND NUCLEAR STATION
UNIT 1
INTEGRATED LEAK RATE TEST DATA

APPENDIX B
SUPPLEMENTAL LEAKAGE RATE DATA AT Pt (240 SCFH at 66°F)

Hour			0	1	2	3	4
Time			1000	1100	1200	1300	1400
Containment Pressure, psia		PI-390	44.666	44.663	44.661	44.659	44.657
		PI-391	44.646	66.644	44.642	44.640	44.639
Reactor Bldg. Ave. Press. (P_T), psia			44.656	44.653	44.651	44.649	44.648
Dewpoint Temperature, °F	1	TE-654A	35.0	34.0	35.5	33.5	35.0
	2	TE-654B	37.5	37.5	37.5	37.5	37.5
	3	TE-654C	36.0	36.5	36.0	35.5	36.0
	4	TE-654D	41.0	41.0	41.0	41.0	41.0
	5	TE-654E	41.0	43.0	41.0	40.5	42.0
	6	TE-654F	42.5	42.5	42.5	42.5	43.0
	7	TE-654G	40.0	40.0	40.0	40.0	40.0
	8	TE-654H	39.5	39.5	40.0	40.0	40.0
	9	TE-654I	43.0	42.5	43.5	42.5	42.5
	10	TE-654J	25.0	25.5	26.0	25.5	26.0
Reactor Bldg. Ave. Dewpoint Temp., °F			38.1	38.2	38.3	37.9	38.3
Water Vapor Pressure, (P_{wv}), psia			0.113	0.113	0.114	0.112	0.114
Drybulb Temperature, °F	1	TE-655A	71.02	71.02	71.07	70.98	71.00
	2	TE-655B	70.71	70.77	70.81	70.72	70.73
	3	TE-655C	70.34	70.39	70.33	70.32	70.29
	4	TE-655D	72.43	72.43	72.43	72.42	72.41
	5	TE-655E	71.39	71.52	71.41	71.43	71.34
	6	TE-655F	71.63	71.60	71.63	71.60	71.48
	7	TE-655G	71.52	71.56	71.64	71.58	71.47
	8	TE-655H	70.43	70.24	70.35	70.29	70.51
	9	TE-655I	69.48	69.38	69.47	69.47	69.51
	10	TE-655J	70.09	69.98	69.96	70.05	70.12
	11	TE-655K	71.16	71.15	71.15	71.19	71.21
	12	TE-655L	70.32	70.32	70.33	70.33	70.35
	13	TE-655M	71.42	71.45	71.45	71.41	71.44
	14	TE-655N	71.94	71.99	71.96	72.01	72.01
	15	TE-655O			INOPERATIVE		
	16	TE-655P	72.20	72.19	72.13	72.15	72.26
	17	TE-655Q	72.44	72.46	72.47	72.44	72.48
	18	TE-655R	71.77	71.79	71.80	71.77	71.77
	19	TE-655S	71.78	71.77	71.78	71.76	71.76
	20	TE-655T	71.68	71.70	71.70	71.70	71.70
	21	TE-655U	71.99	71.96	71.99	71.95	71.95
	22	TE-655V	71.75	71.75	71.81	71.75	71.75
	23	TE-655W	71.22	70.95	71.24	71.14	70.73
	24	TE-655X	70.69	70.74	70.76	70.08	70.63
Average Drybulb Temperature, °F			71.26	71.25	71.27	71.25	71.24
Reactor Bldg. Ave. Temperature (T), °R			530.95	530.94	530.96	530.94	530.93
Mass of Reactor Building Air (W), lbm x 10-5			4.52880	4.52860	4.52810	4.2830	4.52820

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THREE MILE ISLAND NUCLEAR STATION
UNIT 1
INTEGRATED LEAK RATE TEST DATA

APPENDIX B
SUPPLEMENTAL LEAKAGE RATE DATA AT Pt

Hour			5	6	7	8	9
Time			1500	1600	1700	1800	1900
Containment Pressure, psia		PI-390	44.654	44.654	44.653	44.653	44.653
		PI-391	44.637	44.636	44.635	44.635	44.635
Reactor Bldg. Ave. Press. (P_T), psia			44.645	44.645	44.644	44.644	44.644
Dewpoint Temperature, °F	1	TE-654A	33.0	34.5	35.0	35.0	34.0
	2	TE-654B	37.5	37.0	38.0	38.0	38.0
	3	TE-654C	36.0	38.0	36.0	36.0	37.0
	4	TE-654D	41.0	40.0	42.0	42.0	42.0
	5	TE-654E	42.0	41.5	43.0	43.0	43.0
	6	TE-654F	43.0	42.5	43.0	43.0	43.0
	7	TE-654G	39.5	40.0	40.0	41.0	41.0
	8	TE-654H	40.5	41.0	41.0	40.0	40.0
	9	TE-654I	43.0	43.0	43.0	43.0	43.0
	10	TE-654J	26.0	25.0	25.0	25.0	25.0
Reactor Bldg. Ave. Dewpoint Temp., °F			38.2	38.2	38.6	38.6	38.6
Water Vapor Pressure, (P_{WV}), psia			0.113	0.113	0.115	0.115	0.115
Drybulb Temperature, °F	1	TE-655A	71.03	71.06	71.16	71.15	71.02
	2	TE-655B	70.74	70.69	70.73	70.72	70.74
	3	TE-655C	70.35	70.34	70.32	70.36	70.36
	4	TE-655D	72.41	72.38	72.42	72.39	72.44
	5	TE-655E	71.38	71.44	71.36	71.06	71.43
	6	TE-655F	71.53	71.42	71.47	71.53	71.51
	7	TE-655G	71.62	71.58	71.54	71.64	71.64
	8	TE-655H	70.35	70.27	70.26	70.32	70.34
	9	TE-655I	69.54	69.56	69.40	69.58	69.39
	10	TE-655J	70.10	69.97	69.98	69.98	69.89
	11	TE-655K	71.16	71.16	71.11	71.05	71.04
	12	TE-655L	70.28	70.28	70.26	70.26	70.26
	13	TE-655M	71.41	71.41	71.38	71.40	71.42
	14	TE-655N	71.96	71.90	71.92	71.80	71.76
	15	TE-655O			INOPERATIVE		
	16	TE-655P	72.15	72.11	72.11	72.09	72.12
	17	TE-655Q	72.43	72.47	72.48	72.48	72.50
	18	TE-655R	71.77	71.82	71.83	71.85	71.89
	19	TE-655S	71.70	71.73	71.75	71.77	71.79
	20	TE-655T	71.72	71.75	71.76	71.82	71.86
	21	TE-655U	71.95	71.98	71.94	76.05	76.05
	22	TE-655V	71.75	71.81	71.82	71.91	7[illegible].91
	23	TE-655W	71.43	71.14	70.98	71.30	71.06
	24	TE-655X	70.54	70.59	70.59	70.58	70.77
Average Drybulb Temperature, °F			71.26	71.24	71.23	71.25	71.25
Reactor Bldg. Ave. Temperature (T), °R			530.95	530.93	530.92	530.94	530.94
Mass of Reactor Building Air (W), lbm x 10-5			4.52770	4.52780	4.52760	4.52750	4.52750

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THREE MILE ISLAND NUCLEAR STATION
UNIT 1
INTEGRATED LEAK RATE TEST DATA

APPENDIX B
SUPPLEMENTAL LEAKAGE RATE DATA AT Pt

Hour			10	11	12		
Time			2000	2100	2200		
Containment Pressure, psia		PI-390	44.652	44.651	44.650		
		PI-391	44.634	44.634	44.633		
Reactor Bldg. Ave. Press. (P_T), psia			44.643	44.642	44.642		
Dewpoint Temperature, °F	1	TE-654A	35.0	35.0	35.0		
	2	TE-654B	38.0	38.0	38.0		
	3	TE-654C	38.0	38.0	37.0		
	4	TE-654D	42.0	41.0	41.0		
	5	TE-654E	42.5	43.0	42.0		
	6	TE-654F	43.0	43.0	43.0		
	7	TE-654G	41.0	41.0	41.0		
	8	TE-654H	40.0	40.0	40.0		
	9	TE-654I	43.0	43.0	44.0		
	10	TE-654J	26.0	25.0	25.0		
Reactor Bldg. Ave. Dewpoint Temp., °F			38.8	38.8	38.7		
Water Vapor Pressure, (P_{WV}), psia			0.116	0.116	0.116		
Drybulb Temperature, °F	1	TE-655A	71.16	71.17	71.16		
	2	TE-655B	70.72	70.77	70.72		
	3	TE-655C	70.39	70.36	70.41		
	4	TE-655D	72.42	72.41	72.43		
	5	TE-655E	71.44	71.43	71.57		
	6	TE-655F	71.52	71.57	71.47		
	7	TE-655G	71.63	71.69	71.74		
	8	TE-655H	70.35	70.36	70.41		
	9	TE-655I	69.56	69.72	69.60		
	10	TE-655J	69.91	69.93	69.96		
	11	TE-655K	71.14	71.06	71.07		
	12	TE-655L	70.28	70.32	70.31		
	13	TE-655M	71.45	71.48	71.54		
	14	TE-655N	71.80	71.90	71.83		
	15	TE-655O		INOPERATIVE			
	16	TE-655P	72.13	72.15	72.14		
	17	TE-655Q	72.48	72.52	72.55		
	18	TE-655R	71.92	71.93	71.98		
	19	TE-655S	71.81	71.83	71.85		
	20	TE-655T	71.87	71.88	71.91		
	21	TE-655U	72.11	72.09	72.12		
	22	TE-655V	71.97	71.96	71.99		
	23	TE-655W	71.60	71.58	71.42		
	24	TE-655X	70.62	70.56	70.57		
Average Drybulb Temperature, °F			71.30	71.32	71.32		
Reactor Bldg. Ave. Temperature (T), °R			530.99	531.01	531.01		
Mass of Reactor Building Air (W), lbm x 10-5			4.52680	4.52660	4.52660		

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APPENDIX C

THREE MILE ISLAND NUCLEAR STATION
UNIT 1
INTEGRATED LEAK RATE TEST DATA

APPENDIX C
SUPPLEMENTAL LEAKAGE RATE DATA AT Pd (240 SCFH at 68°F)

Hour			0	1	2	3	4
Time			1730	1830	1930	2030	2130
Containment Pressure, psia		PI-390	69.507	69.513	69.517	69.520	69.516
		PI-391	49.492	49.497	69.501	69.506	69.500
Reactor Bldg. Ave. Press. (P_T), psia			69.500	69.505	69.509	69.513	69.508
Dewpoint Temperature, °F	1	TE-654A	36.5	36.0	34.0	36.5	36.0
	2	TE-654B	39.0	40.0	39.5	40.0	40.0
	3	TE-654C	39.0	39.5	40.0	39.2	41.0
	4	TE-654D	42.0	42.0	41.0	42.0	42.5
	5	TE-654E	45.5	43.0	45.0	45.5	44.0
	6	TE-654F	46.0	45.0	45.5	46.0	46.0
	7	TE-654G	42.0	42.5	42.5	43.0	42.0
	8	TE-654H	43.0	42.0	42.0	44.5	44.0
	9	TE-654I	45.5	45.0	45.0	46.0	45.0
	10	TE-654J	26.5	26.0	26.0	26.0	26.0
Reactor Bldg. Ave. Dewpoint Temp., °F			40.5	40.1	40.1	40.9	40.7
Water Vapor Pressure, (P_{WV}), psia			0.124	0.122	0.122	0.126	0.125
Drybulb Temperature, °F	1	TE-655A	71.36	71.39	71.43	71.34	71.44
	2	TE-655B	70.99	71.02	71.10	71.15	71.13
	3	TE-655C	70.71	70.76	70.80	70.85	70.83
	4	TE-655D	72.61	72.60	72.62	72.68	72.62
	5	TE-655E	71.97	71.97	72.04	72.16	72.08
	6	TE-655F	71.81	71.84	71.90	72.02	71.96
	7	TE-655G	71.90	71.93	71.84	71.76	71.92
	8	TE-655H	70.64	70.69	70.69	70.72	70.68
	9	TE-655I	69.85	69.87	69.91	69.94	69.98
	10	TE-655J	70.36	70.34	70.59	70.43	70.43
	11	TE-655K	71.53	71.64	71.55	71.73	71.64
	12	TE-655L	70.71	70.67	70.73	70.80	70.72
	13	TE-655M	71.91	71.96	72.06	72.22	72.06
	14	TE-655N	72.06	72.23	72.21	72.39	72.34
	15	TE-655O			INOPERATIVE		
	16	TE-655P	72.15	72.16	72.19	72.19	72.19
	17	TE-655Q	72.39	72.48	72.52	72.49	72.52
	18	TE-655R	72.18	72.32	72.40	72.43	72.41
	19	TE-655S	72.07	72.18	72.26	72.31	72.30
	20	TE-655T	72.15	72.29	72.41	72.48	72.41
	21	TE-655U	72.22	72.33	72.40	72.45	72.40
	22	TE-655V	72.13	72.29	72.39	72.46	72.37
	23	TE-655W	71.18	71.66	71.26	71.17	71.28
	24	TE-655X	70.92	70.93	70.95	71.04	71.05
Average Drybulb Temperature, °F			71.54	71.62	71.66	71.71	71.69
Reactor Bldg. Ave. Temperature (T), °R			531.23	531.31	531.35	531.40	531.38
Mass of Reactor Building Air (W), lbm x 10-5			7.04990	7.04960	7.04940	7.04880	7.04860

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THREE MILE ISLAND NUCLEAR STATION
UNIT 1
INTEGRATED LEAK RATE TEST DATA

APPENDIX C
SUPPLEMENTAL LEAKAGE RATE DATA AT Pd

Hour			5	6	7	8	9
Time			2230	2330	0030	0130	0230
Containment Pressure, psia		PI-390	69.513	69.511	69.510	69.507	69.505
		PI-391	69.498	69.495	69.493	69.490	69.490
Reactor Bldg. Ave. Press. (P_T), psia			69.506	69.503	69.502	69.498	69.498
Dewpoint Temperature, °F	1	TE-654A	36.5	36.0	36.0	36.0	35.0
	2	TE-654B	39.0	39.2	39.0	40.0	40.0
	3	TE-654C	38.5	38.5	37.0	41.0	40.0
	4	TE-654D	43.0	41.8	44.0	41.0	41.0
	5	TE-654E	45.0	45.2	45.0	44.0	46.0
	6	TE-654F	45.5	46.2	46.0	46.0	45.5
	7	TE-654G	42.5	42.0	42.0	42.0	43.0
	8	TE-654H	43.0	43.0	43.0	44.0	43.0
	9	TE-654I	46.0	46.0	45.5	45.5	45.0
	10	TE-654J	26.0	26.0	26.5	26.5	26.5
Reactor Bldg. Ave. Dewpoint Temp., °F			40.5	40.4	40.4	40.6	40.5
Water Vapor Pressure, (P_{wv}), psia			0.124	0.124	0.124	0.124	0.124
Drybulb Temperature, °F	1	TE-655A	71.40	71.33	71.45	71.47	71.45
	2	TE-655B	71.10	71.13	71.15	71.14	71.13
	3	TE-655C	70.80	70.88	70.85	70.85	70.88
	4	TE-655D	72.62	72.68	72.69	72.69	72.69
	5	TE-655E	72.05	72.02	72.12	72.12	72.14
	6	TE-655F	71.95	71.97	71.96	71.99	71.99
	7	TE-655G	71.99	72.04	71.85	71.87	72.02
	8	TE-655H	70.66	70.76	70.72	70.73	70.71
	9	TE-655I	69.98	70.15	69.98	70.05	70.04
	10	TE-655J	70.39	70.49	70.39	70.39	70.44
	11	TE-655K	71.62	71.64	71.59	71.69	71.59
	12	TE-655L	70.79	70.73	70.74	70.80	70.73
	13	TE-655M	72.08	72.16	72.07	72.08	72.12
	14	TE-655N	72.25	72.35	72.31	72.30	72.17
	15	TE-655O			INOPERATIVE		
	16	TE-655P	72.14	72.19	72.19	72.17	72.16
	17	TE-655Q	72.50	72.51	72.42	72.50	72.50
	18	TE-655R	72.38	72.39	72.32	72.38	72.40
	19	TE-655S	72.28	72.29	72.22	72.28	72.28
	20	TE-655T	72.40	72.41	72.34	72.39	72.41
	21	TE-655U	72.40	72.40	72.36	72.38	72.39
	22	TE-655V	72.36	72.39	72.32	72.34	72.36
	23	TE-655W	71.77	71.70	71.70	71.70	71.72
	24	TE-655X	70.98	70.99	71.01	70.99	70.95
Average Drybulb Temperature, °F			71.67	71.73	71.64	71.68	71.69
Reactor Bldg. Ave. Temperature (T), °R			531.36	531.42	531.38	531.37	531.38
Mass of Reactor Building Air (W), lbm x 10-5			7.04880	7.04770	7.04810	7.04780	7.04770

THREE MILE ISLAND NUCLEAR STATION
UNIT 1
INTEGRATED LEAK RATE TEST DATA

APPENDIX C
SUPPLEMENTAL LEAKAGE RATE DATA AT Pd

Hour			10	11	12		
Time			0330	0430	0530		
Containment Pressure,		PI-390	69.504	69.502	69.498		
psia		PI-391	69.488	69.486	69.483		
Reactor Bldg. Ave. Press. (P_T), psia			69.496	69.494	69.490		
Dewpoint Temperature, °F	1	TE-654A	37.0	37.5	36.0		
	2	TE-654B	40.0	40.0	39.0		
	3	TE-654C	40.0	37.0	40.0		
	4	TE-654D	42.0	41.0	44.0		
	5	TE-654E	43.0	43.0	45.0		
	6	TE-654F	46.0	46.0	45.5		
	7	TE-654G	42.0	42.0	43.0		
	8	TE-654H	43.5	43.5	43.0		
	9	TE-654I	46.0	46.0	46.0		
	10	TE-654J	26.5	26.5	26.5		
Reactor Bldg. Ave. Dewpoint Temp., °F			40.6	40.3	40.8		
Water Vapor Pressure, (P_{wv}), psia			0.124	0.123	0.125		
Drybulb Temperature, °F	1	TE-655A	71.44	71.45	71.42		
	2	TE-655B	71.15	71.16	71.13		
	3	TE-655C	70.81	70.85	70.81		
	4	TE-655D	72.72	72.69	72.70		
	5	TE-655E	72.12	72.08	72.11		
	6	TE-655F	71.99	71.95	71.95		
	7	TE-655G	71.69	71.81	71.91		
	8	TE-655H	70.72	70.72	70.77		
	9	TE-655I	69.98	70.07	69.98		
	10	TE-655J	70.47	70.47	70.39		
	11	TE-655K	71.58	71.72	71.06		
	12	TE-655L	70.81	70.74	70.76		
	13	TE-655M	72.18	72.11	72.18		
	14	TE-655N	72.25	72.35	72.32		
	15	TE-655O		INOPERATIVE			
	16	TE-655P	72.15	72.19	72.19		
	17	TE-655Q	72.48	72.49	72.42		
	18	TE-655R	72.38	72.38	72.32		
	19	TE-655S	72.28	72.28	72.23		
	20	TE-655T	72.41	72.41	72.37		
	21	TE-655U	72.39	72.39	72.36		
	22	TE-655V	72.37	72.36	72.32		
	23	TE-655W	71.73	71.63	71.69		
	24	TE-655X	70.91	70.98	70.96		
Average Drybulb Temperature, °F			71.68	71.70	71.68		
Reactor Bldg. Ave. Temperature (T), °R			531.37	531.39	531.37		
Mass of Reactor Building Air (W), lbm x 10-5			7.04760	7.04730	7.04690		

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THREE MILE ISLAND NUCLEAR STATION
UNIT 1
INTEGRATED LEAK RATE TEST

APPENDIX C

SUPPLEMENTAL LEAKAGE RATE RESULTS AT Pd

Hour	Weight (Obs.-Calc.)	Observed Leakage Rate Point-to-Point (%/day)	Observed Leakage Rate Total Time (%/day)
0	19.7	2Se = 0.274	2Se = 0.035
1	7.7	0.119	0.119
2	18.2	0.042	0.081
3	-25.1	0.226	0.129
4	-16.3	0.048	0.109
5	23.1	-0.056	0.076
6	-64.0*	0.375*	0.126
7	1.9	-0.146	0.087
8	-2.6	0.093	0.088
9	7.2	0.045	0.083
10	23.1	0.024	0.077
11	9.4	0.125	0.081
12	-2.1	0.117	0.084
	2Se = 50.4 lbm	σ = 0.131	σ = 0.020

* Exceeded limits of 95% confidence

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APPENDIX D

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THREE MILE ISLAND NUCLEAR STATION
UNIT 1
INTEGRATED LEAK RATE TEST DATA

APPENDIX D
LEAKAGE RATE DATA AT Pt

Hour			0	1	2	3	4
Time			0800	0900	1000	1100	1200
Containment Pressure, psia		PI-390	44.671	44.668	44.668	44.669	44.672
		PI-391	44.650	44.648	44.648	44.650	44.652
Reactor Bldg. Ave. Press. (P_T), psia			44.661	44.658	44.658	44.655	44.662
Dewpoint Temperature, °F	1	TE-654A	31.5	31.8	31.0	31.0	32.5
	2	TE-654B	36.5	36.5	36.0	36.5	37.0
	3	TE-654C	35.5	35.0	35.0	35.0	34.5
	4	TE-654D	40.0	40.0	40.0	40.0	39.5
	5	TE-654E	40.0	39.0	39.5	40.0	39.0
	6	TE-654F	41.5	41.2	41.0	41.0	41.0
	7	TE-654G	39.0	39.0	38.5	38.5	39.5
	8	TE-654H	38.5	38.5	38.5	39.0	39.0
	9	TE-654I	41.5	41.0	41.0	41.5	41.0
	10	TE-654J	25.0	24.8	24.5	24.5	24.5
Reactor Bldg. Ave. Dewpoint Temp., °F			36.9	36.7	36.5	36.7	36.7
Water Vapor Pressure, (P_{wv}), psia			0.108	0.107	0.106	0.107	0.107
Drybulb Temperature, °F	1	TE-655A	71.14	71.10	71.09	71.09	71.09
	2	TE-655B	70.84	70.79	70.87	70.80	70.88
	3	TE-655C	70.49	70.50	70.50	70.44	70.46
	4	TE-655D	72.53	72.50	72.48	72.44	72.53
	5	TE-655E	71.62	71.60	71.52	71.54	71.60
	6	TE-655F	71.78	71.71	71.68	71.62	71.77
	7	TE-655G	71.82	71.77	71.66	71.79	71.72
	8	TE-655H	70.41	70.39	70.38	70.35	70.44
	9	TE-655I	69.96	69.47	69.39	69.73	69.64
	10	TE-655J	70.61	70.23	70.13	70.37	70.27
	11	TE-655K	71.36	70.99	70.70	71.17	71.06
	12	TE-655L	70.59	70.41	70.42	70.55	70.42
	13	TE-655M	71.37	71.25	71.30	71.47	71.36
	14	TE-655N	71.74	71.74	71.70	71.92	71.84
	15	TE-655O			INOPERATIVE		
	16	TE-655P	72.36	72.30	72.30	72.46	72.32
	17	TE-655Q	72.50	72.50	72.46	72.51	72.51
	18	TE-655R	71.67	71.62	71.64	71.72	71.00
	19	TE-655S	71.64	71.61	71.61	71.68	71.76
	20	TE-655T	71.54	71.50	71.54	71.03	71.71
	21	TE-655U	71.85	71.83	71.83	71.84	71.98
	22	TE-655V	71.66	71.63	71.64	71.74	71.87
	23	TE-655W	71.80	71.34	71.73	71.73	70.95
	24	TE-655X	70.81	70.76	70.79	70.72	70.68
Average Drybulb Temperature, °F			71.33	71.27	71.27	71.36	71.32
Reactor Bldg. Ave. Temperature (T), °R			531.02	530.96	530.96	531.05	531.01
Mass of Reactor Building Air (W), lbm x 10-5			4.52920	4.52950	4.52960	4.52840	4.52950

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THREE MILE ISLAND NUCLEAR STATION
UNIT 1
INTEGRATED LEAK RATE TEST DATA

APPENDIX D

LEAKAGE RATE DATA AT Pt

Hour			5	6	7	8	9
Time			1300	1400	1500	1600	1700
Containment Pressure,		FI-390	44.675	44.679	44.664	44.676	44.682
psia		PI-391	44.655	44.659	44.644	44.656	44.662
Reactor Bldg. Ave. Press. (P_T), psia			44.665	44.669	44.654	44.666	44.672
Dewpoint Temperature, ^oF	1	TE-654A	33.0	33.5	33.0	33.0	34.5
	2	TE-654B	37.0	37.0	37.0	37.0	37.0
	3	TE-654C	35.5	36.0	35.0	36.0	36.0
	4	TE-654D	40.0	40.0	40.0	41.0	40.0
	5	TE-654E	40.0	41.5	41.0	41.0	42.5
	6	TE-654F	41.0	41.5	41.5	41.0	41.5
	7	TE-654G	39.0	39.5	39.0	39.5	39.5
	8	TE-654H	39.0	39.0	39.0	39.0	39.0
	9	TE-654I	42.0	42.0	40.5	42.0	42.5
	10	TE-654J	24.5	25.0	25.0	25.0	25.0
Reactor Bldg. Ave. Dewpoint Temp., ^oF			37.1	37.5	37.1	37.8	37.8
Water Vapor Pressure, (P_{wv}), psia			0.108	0.110	0.108	0.112	0.112
Drybulb Temperature, ^oF	1	TE-655A	71.12	71.12	71.18	71.25	71.40
	2	TE-655B	71.04	70.94	70.91	70.43	70.98
	3	TE-655C	70.67	70.50	70.54	70.52	70.52
	4	TE-655D	72.52	72.53	72.60	72.58	72.61
	5	TE-655E	71.57	71.63	71.68	71.65	71.60
	6	TE-655F	71.71	71.76	71.79	71.65	71.77
	7	TE-655G	71.77	71.90	71.84	71.83	71.68
	8	TE-655H	70.41	70.44	70.54	70.41	70.47
	9	TE-655I	69.46	69.38	69.70	69.49	69.73
	10	TE-655J	70.73	70.10	70.30	70.11	70.17
	11	TE-655K	71.11	71.24	71.14	71.03	71.05
	12	TE-655L	70.47	70.65	70.50	70.38	70.39
	13	TE-655M	71.44	71.65	71.54	71.47	71.49
	14	TE-655N	71.91	72.02	71.89	71.77	71.91
	15	TE-655O			INOPERATIVE		
	16	TE-655P	72.33	72.36	72.42	72.34	72.31
	17	TE-655Q	72.60	72.66	72.71	72.57	72.74
	18	TE-655R	71.85	71.96	71.87	71.87	72.04
	19	TE-655S	71.79	71.86	71.89	71.80	71.98
	20	TE-655T	71.79	71.88	71.92	71.84	72.02
	21	TE-655U	72.04	72.11	71.85	72.06	72.22
	22	TE-655V	71.93	72.03	72.08	72.04	72.20
	23	TE-655W	71.20	71.41	71.50	71.22	71.70
	24	TE-655X	70.87	70.83	70.76	70.72	70.77
Average Drybulb Temperature, ^oF			71.38	71.42	71.43	71.33	71.45
Reactor Bldg. Ave. Temperature (T), ^oR			531.07	531.11	531.12	531.02	531.14
Mass of Reactor Building Air (W), lbm x 10^{-5}			4.52920	4.52910	5.52770	4.52930	4.52890

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THREE MILE ISLAND NUCLEAR STATION
UNIT 1
INTEGRATED LEAK RATE TEST DATA

APPENDIX D
LEAKAGE RATE DATA AT Pt

Hour			10	11	12	13	14
Time			1800	1900	2000	2100	2200
Containment Pressure,		PI-390	44.681	44.675	44.668	44.662	44.660
psia		PI-391	44.661	44.655	44.647	44.642	44.641
Reactor Bldg. Ave. Press. (P_T), psia			44.671	44.665	44.658	44.652	44.650
Dewpoint Temperature, °F	1	TE-654A	34.0	33.5	33.5	33.0	33.0
	2	TE-654B	36.5	37.0	37.0	37.0	37.0
	3	TE-654C	37.0	36.0	35.0	35.5	36.0
	4	TE-654D	40.0	41.0	40.5	40.5	40.0
	5	TE-654E	40.5	41.0	41.0	41.0	41.0
	6	TE-654F	42.0	42.0	42.0	42.0	41.5
	7	TE-654G	40.0	39.5	39.0	39.0	40.0
	8	TE-654H	39.5	39.5	39.5	39.0	39.5
	9	TE-654I	42.5	42.0	42.0	42.0	42.0
	10	TE-654J	25.0	25.5	25.0	25.0	25.0
Reactor Bldg. Ave. Dewpoint Temp., °F			37.7	37.7	37.4	37.4	37.5
Water Vapor Pressure, (P_{wv}), psia			0.111	0.111	0.110	0.110	0.110
Drybulb Temperature, °F	1	TE-655A	71.41	71.32	71.19	71.16	71.17
	2	TE-655B	70.93	70.91	70.84	70.84	70.76
	3	TE-655C	70.58	70.53	70.47	70.37	70.35
	4	TE-655D	72.62	72.60	72.56	72.52	72.48
	5	TE-655E	71.55	71.63	71.63	71.59	71.51
	6	TE-655F	71.69	71.78	71.71	71.68	71.60
	7	TE-655G	71.80	71.77	71.68	71.69	71.71
	8	TE-655H	70.49	70.46	70.47	70.40	70.32
	9	TE-655I	69.76	69.60	69.49	69.58	69.45
	10	TE-655J	70.29	70.26	70.23	70.19	70.04
	11	TE-655K	71.12	71.14	71.07	70.97	71.00
	12	TE-655L	70.43	70.41	70.39	70.38	70.30
	13	TE-655M	71.56	71.52	71.37	71.37	71.30
	14	TE-655N	71.81	71.90	71.83	71.67	71.73
	15	TE-655O			INOPERATIVE		
	16	TE-655P	72.24	72.26	72.21	72.12	72.13
	17	TE-655Q	72.66	72.59	72.46	72.35	72.39
	18	TE-655R	72.00	71.84	71.68	71.56	71.60
	19	TE-655S	71.95	71.86	71.72	71.60	71.63
	20	TE-655T	71.95	71.77	71.59	71.47	71.48
	21	TE-655U	72.16	72.03	71.87	71.75	71.79
	22	TE-655V	72.08	71.88	71.62	71.54	71.55
	23	TE-655W	71.30	71.15	71.69	71.53	71.25
	24	TE-655X	70.75	70.74	70.83	70.72	70.68
Average Drybulb Temperature, °F			71.43	71.37	71.31	71.25	71.21
Reactor Bldg. Ave. Temperature (T), °R			531.12	531.06	531.00	530.94	530.90
Mass of Reactor Building Air (W), lbm x 10-5			4.52910	4.52900	4.52890	4.52880	4.52890

THREE MILE ISLAND NUCLEAR STATION
UNIT 1
INTEGRATED LEAK RATE TEST DATA

APPENDIX D
LEAKAGE RATE DATA AT Pt

			15	16	17	18	19
Hour			15	16	17	18	19
Time			2300	2400	0100	0200	0300
Containment Pressure, psia		PI-390	44.665	44.667	44.667	44.667	44.667
		PI-391	44.645	44.647	44.647	44.647	44.647
Reactor Bldg. Ave. Press. (P_T), psia			44.655	44.657	44.657	44.657	44.657
Dewpoint Temperature, °F	1	TE-654A	33.0	32.5	32.5	32.5	32.0
	2	TE-654B	37.0	37.0	37.5	37.0	37.0
	3	TE-654C	36.0	36.5	35.5	36.0	36.0
	4	TE-654D	40.0	40.5	40.5	41.0	41.5
	5	TE-654E	41.0	41.0	40.0	40.5	42.0
	6	TE-654F	42.0	41.5	42.0	42.0	42.0
	7	TE-654G	39.0	40.0	40.0	40.0	39.0
	8	TE-654H	39.0	39.5	39.5	39.5	39.5
	9	TE-654I	42.0	42.5	42.5	42.0	42.5
	10	TE-654J	25.0	25.5	25.5	25.0	25.0
Reactor Bldg. Ave. Dewpoint Temp., °F			37.4	37.6	37.5	37.5	37.6
Water Vapor Pressure, (P_{wv}), psia			0.110	0.111	0.110	0.110	0.111
Drybulb Temperature, °F	1	TE-655A	71.07	71.16	71.16	71.18	71.18
	2	TE-655B	70.78	70.80	70.73	70.81	70.77
	3	TE-655C	70.36	70.47	70.46	70.36	70.39
	4	TE-655D	72.49	72.49	72.51	72.51	72.47
	5	TE-655E	71.51	71.55	71.57	71.55	71.44
	6	TE-655F	71.62	71.70	71.59	71.67	71.65
	7	TE-655G	71.73	71.62	71.71	71.63	71.63
	8	TE-655H	70.30	70.43	70.37	70.39	70.43
	9	TE-655I	69.13	69.51	69.73	69.53	69.70
	10	TE-655J	70.03	70.21	70.14	70.12	69.98
	11	TE-655K	70.44	71.05	71.09	71.13	71.14
	12	TE-655L	70.32	70.35	70.38	70.33	70.33
	13	TE-655M	71.32	71.40	71.37	71.35	71.38
	14	TE-655N	71.80	71.77	71.84	71.82	71.86
	15	TE-655O			INOPERATIVE		
	16	TE-655P	72.21	72.24	72.20	72.17	72.16
	17	TE-655Q	72.54	72.47	72.32	72.51	72.51
	18	TE-655R	71.82	71.77	71.80	71.81	71.82
	19	TE-655S	71.79	71.73	71.77	71.77	71.78
	20	TE-655T	71.72	71.63	71.70	71.71	71.72
	21	TE-655U	72.01	71.95	71.98	71.99	71.99
	22	TE-655V	71.82	71.76	71.80	71.80	71.80
	23	TE-655W	71.47	71.02	71.60	71.35	71.52
	24	TE-655X	70.89	70.81	70.77	70.74	70.71
Average Drybulb Temperature, °F			71.27	71.28	71.32	71.30	71.31
Reactor Bldg. Ave. Temperature (T), °R			530.96	530.97	531.01	530.99	531.00
Mass of Reactor Building Air (W), lbm x 10-5			4.52890	4.52890	4.52870	4.52890	4.52870

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THREE MILE ISLAND NUCLEAR STATION
UNIT 1
INTEGRATED LEAK RATE TEST DATA

APPENDIX D

LEAKAGE RATE DATA AT Pt

Hour			20	21	22	23	24
Time			0400	0500	0600	0700	0800
Containment Pressure, psia		PI-390	44.667	44.667	44.667	44.667	44.667
		PI-391	44.647	44.647	44.647	44.647	44.647
Reactor Bldg. Ave. Press. (P_T), psia			44.657	44.657	44.657	44.657	44.657
Dewpoint Temperature, °F	1	TE-654A	34.0	32.5	33.0	33.5	35.0
	2	TE-654B	37.0	37.5	37.5	37.5	37.0
	3	TE-654C	36.0	36.0	36.0	37.0	35.5
	4	TE-654D	41.0	40.5	41.0	41.0	41.0
	5	TE-654E	41.5	41.5	41.5	41.5	42.0
	6	TE-654F	42.0	42.0	42.0	42.0	42.5
	7	TE-654G	39.5	39.5	39.0	39.5	40.5
	8	TE-654H	39.5	39.5	39.5	39.5	39.5
	9	TE-654I	42.0	42.5	42.5	42.5	43.0
	10	TE-654J	24.5	25.5	25.0	25.0	25.0
Reactor Bldg. Ave. Dewpoint Temp., °F			37.7	37.7	37.7	37.9	38.1
Water Vapor Pressure, (P_{wv}), psia			0.111	0.111	0.111	0.112	0.113
Drybulb Temperature, °F	1	TE-655A	71.01	71.18	71.16	71.17	70.98
	2	TE-655B	70.72	70.82	70.74	70.72	70.71
	3	TE-655C	70.37	70.42	70.42	70.37	70.43
	4	TE-655D	72.42	72.48	72.45	72.48	72.44
	5	TE-655E	71.43	71.62	71.56	71.56	71.50
	6	TE-655F	71.63	71.71	71.70	71.64	71.59
	7	TE-655G	71.60	71.74	71.71	71.59	71.58
	8	TE-655H	70.35	70.34	70.37	70.32	70.38
	9	TE-655I	69.55	69.57	69.48	69.43	69.48
	10	TE-655J	69.44	70.12	70.09	70.10	70.12
	11	TE-655K	71.09	71.12	71.13	71.12	71.16
	12	TE-655L	70.30	70.35	70.38	70.34	70.36
	13	TE-655M	71.38	71.38	71.38	70.99	71.44
	14	TE-655N	71.86	71.86	71.94	71.91	71.91
	15	TE-655O			INOPERATIVE		
	16	TE-655P	72.19	72.19	72.21	72.19	72.17
	17	TE-655Q	72.36	72.50	72.50	71.80	72.48
	18	TE-655R	71.71	71.82	71.80	71.77	71.80
	19	TE-655S	71.68	71.78	71.78	71.70	71.78
	20	TE-655T	71.66	71.72	71.71	71.96	71.70
	21	TE-655U	71.92	71.98	71.98	71.78	71.97
	22	TE-655V	71.73	71.79	71.78	71.87	71.78
	23	TE-655W	70.86	71.74	70.98	70.79	70.91
	24	TE-655X	70.69	70.76	70.76	70.79	70.80
Average Drybulb Temperature, °F			71.22	71.31	71.29	71.25	71.26
Reactor Bldg. Ave. Temperature (T), °R			530.91	531.00	530.98	530.94	530.95
Mass of Reactor Building Air (W), lbm x 10-5			4.52940	4.52870	4.52880	4.52910	4.52900

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THREE MILE ISLAND NUCLEAR STATION
UNIT 1
INTEGRATED LEAK RATE TEST

APPENDIX D

LEAKAGE RATE RESULTS AT Pt

Hour	Weight (Obs.)-(Calc.)	Observed Leakage Rate Point-to-Point (%/day)	Observed Leakage Rate Total Time (%/day)
0	9.8	2Se = 0.682	2Se = 0.114
1	42.0	-0.164	-0.164*
2	53.4	-0.054	-0.109
3	-62.7	+0.622	+0.135*
4	43.8	-0.558	-0.038
5	14.3	+0.163	+0.021
6	1.8	+0.073	+0.014
7	-137.6*	+0.745*	+0.118*
8	30.3	-0.883*	-0.006
9	- 9.8	+0.219	+0.018
10	8.5	-0.090	+0.007
11	0.0	+0.052	+0.0[illegible]
12	- 8.6	+0.052	+0.015
13	-17.1	+0.052	+0.017
14	- 2.0	-0.073	+0.011

* Exceeded limits of 95% confidence level.

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THREE MILE ISLAND NUCLEAR STATION
UNIT 1
INTEGRATED LEAK RATE TEST

APPENDIX D

LEAKAGE RATE RESULTS AT Pt

Hour	Weight (Obs.)-(Calc.)	Observed Leakage Rate Point-to-Point (%/day)	Observed Leakage Rate Total Time (%/day)
15	-1.1	+0.001	+0.011
16	1.8	-0.008	+0.009
17	-20.9	+0.127	+0.016
18	-2.5	-0.090	+0.010
19	-19.9	+0.099	+0.015
20	58.1	-0.407	-0.006
21	-17.4	+0.407	+0.014
22	0.9	-0.090	+0.009
23	26.2	-0.127	+0.003
24	8.7	+0.099	+0.007
	2Se = 79.6 lb	σ = 0.334	σ = 0.057

APPENDIX E

THREE MILE ISLAND NUCLEAR STATION
UNIT 1
INTEGRATED LEAK RATE TEST DATA

APPENDIX E

LEAKAGE RATE DATA AT Pd

Hour			0	1	2	3	4
Time			1700	1800	1900	2000	2100
Containment Pressure,		PI-390	69.550	69.546	69.540	69.529	69.540
psia		PI-391	69.535	69.532	69.524	69.514	69.525
Reactor Bldg. Ave. Press. (P_T), psia			69.542	69.539	69.532	69.521	69.532
Dewpoint Temperature, ^oF	1	TE-654A	36.0	35.0	36.0	36.0	36.0
	2	TE-654B	38.5	38.5	38.0	39.0	39.0
	3	TE-654C	37.5	36.5	38.0	37.0	37.0
	4	TE-654D	42.5	42.5	42.0	42.5	42.5
	5	TE-654E	43.0	42.5	44.0	43.5	42.0
	6	TE-654F	47.0	45.0	45.0	45.0	46.0
	7	TE-654G	42.0	42.0	42.0	42.0	42.0
	8	TE-654H	41.5	41.5	42.0	42.0	42.0
	9	TE-654I	44.0	45.0	44.0	43.5	44.0
	10	TE-654J	26.0	26.0	26.0	26.5	26.0
Reactor Bldg. Ave. Dewpoint Temp., ^oF			39.8	39.4	39.7	39.7	39.6
Water Vapor Pressure, (P_{WV}), psia			0.121	0.119	0.120	0.120	0.120
Drybulb Temperature, ^oF	1	TE-655A	71.61	71.61	71.41	71.36	71.49
	2	TE-655B	71.28	71.25	71.24	71.16	71.18
	3	TE-655C	70.99	70.93	70.85	70.84	70.84
	4	TE-655D	73.01	72.93	72.91	72.86	72.83
	5	TE-655E	72.17	72.07	72.00	71.98	72.05
	6	TE-655F	72.19	72.12	72.07	72.05	72.93
	7	TE-655G	72.02	71.93	71.98	72.11	71.93
	8	TE-655H	70.98	70.94	70.89	70.91	70.80
	9	TE-655I	70.28	70.29	70.12	70.04	70.04
	10	TE-655J	70.61	70.58	70.54	70.71	70.45
	11	TE-655K	71.59	71.57	71.58	71.51	71.55
	12	TE-655L	70.88	70.84	70.82	70.73	70.72
	13	TE-655M	71.88	71.86	71.80	71.92	71.87
	14	TE-655N	72.23	72.23	72.18	72.14	72.14
	15	TE-655O			INOPERATIVE		
	16	TE-655P	72.38	72.26	72.26	72.23	72.24
	17	TE-655Q	72.50	72.47	72.41	72.34	72.52
	18	TE-655R	72.09	72.10	72.05	71.96	72.30
	19	TE-655S	72.06	72.03	72.00	71.89	72.11
	20	TE-655T	72.03	72.10	71.97	71.89	72.25
	21	TE-655U	72.14	72.16	71.96	72.03	72.36
	22	TE-655V	71.95	72.01	71.95	71.83	72.29
	23	TE-655W	71.68	71.07	71.26	71.10	71.68
	24	TE-655X	71.21	71.07	71.22	71.04	71.06
Average Drybulb Temperature, ^oF			71.72	71.66	71.61	71.58	71.66
Reactor Bldg. Ave. Temperature (T), ^oR			531.41	531.35	531.[illegible]	531.27	531.35
Mass of Reactor Building Air (W), lbm x 10-5			7.05210	7.05280	7.05260	7.05190	7.05200

THREE MILE ISLAND NUCLEAR STATION
UNIT 1
INTEGRATED LEAK RATE TEST DATA

APPENDIX E
LEAKAGE RATE DATA AT Pd

			5	6	7	8	9
Hour			5	6	7	8	9
Time			2200	2300	2400	0100	0200
Containment Pressure, psia		PI-390	69.547	69.538	69.542	69.541	69.530
		PI-391	69.533	69.523	69.528	69.526	69.515
Reactor Bldg. Ave. Press. (P_T), psia			69.540	69.530	69.535	69.534	69.522
Dewpoint Temperature, °F	1	TE-654A	35.0	37.0	35.7	36.0	36.5
	2	TE-654B	39.5	33.5	39.2	39.0	39.0
	3	TE-654C	37.0	37.5	38.5	37.0	37.2
	4	TE-654D	42.5	43.0	43.0	43.0	42.7
	5	TE-654E	46.0	44.0	45.5	43.5	43.5
	6	TE-654F	45.0	45.0	45.2	46.0	45.7
	7	TE-654G	42.0	42.0	42.2	42.3	41.7
	8	TE-654H	42.0	42.0	41.7	42.0	42.7
	9	TE-654I	45.0	44.5	45.2	44.5	44.7
	10	TE-654J	26.0	26.0	26.7	26.2	26.2
Reactor Bldg. Ave. Dewpoint Temp., °F			40.0	39.9	40.3	39.9	40.0
Water Vapor Pressure, (P_{WV}), psia			0.122	0.121	0.123	0.121	0.121
Drybulb Temperature, °F	1	TE-655A	71.49	71.56	71.47	71.53	71.39
	2	TE-655B	71.21	71.22	71.16	71.24	71.21
	3	TE-655C	70.54	70.94	70.88	70.89	70.89
	4	TE-655D	72.74	72.82	72.79	72.83	72.76
	5	TE-655E	72.12	72.04	72.11	72.12	72.00
	6	TE-655F	72.03	72.13	71.95	72.08	72.06
	7	TE-655G	71.87	71.99	72.02	71.88	71.94
	8	TE-655H	70.78	70.89	70.31	70.93	70.96
	9	TE-655I	69.97	70.13	70.19	70.58	70.44
	10	TE-655J	70.39	70.47	70.46	70.89	70.81
	11	TE-655K	71.61	71.58	71.66	72.00	71.87
	12	TE-655L	70.76	70.80	70.92	71.22	71.15
	13	TE-655M	72.07	71.85	72.05	72.27	72.13
	14	TE-655N	72.16	72.22	72.26	72.64	72.55
	15	TE-655O			INOPERATIVE		
	16	TE-655P	72.28	72.24	72.32	72.64	72.57
	17	TE-655Q	72.52	72.47	72.54	72.57	72.39
	18	TE-655R	72.51	72.12	72.48	72.30	72.08
	19	TE-655S	72.19	72.05	72.17	73.11	72.02
	20	TE-655T	72.63	72.05	72.58	72.26	72.05
	21	TE-655U	72.56	72.14	72.53	72.32	72.14
	22	TE-655V	72.72	71.96	72.71	72.20	71.98
	23	TE-655W	71.77	71.24	71.72	71.60	71.25
	24	TE-655X	71.16	71.20	71.01	71.15	71.03
Average Drybulb Temperature, °F			71.73	71.64	71.76	71.88	71.72
Reactor Bldg. Ave. Temperature (T), °R			531.42	531.33	531.45	531.57	531.41
Mass of Reactor Building Air (W), lbm x 10-5			7.05160	7.05190	7.05060	7.04920	7.05010

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THREE MILE ISLAND NUCLEAR STATION
UNIT 1
INTEGRATED LEAK RATE TEST DATA

APPENDIX E
LEAKAGE RATE DATA AT Pd

Hour			10	11	12	13	14
Time			0300	0400	0500	0600	0700
Containment Pressure,		PI-390	69.529	69.535	69.535	69.532	69.528
psia		PI-391	69.514	69.520	69.520	69.517	69.513
Reactor Bldg. Ave. Press. (P_T), psia			69.522	69.528	69.528	69.524	69.520
Dewpoint Temperature, °F	1	TE-654A	36.5	36.0	32.0	35.2	36.5
	2	TE-654B	39.0	38.5	40.2	39.2	39.5
	3	TE-654C	37.0	36.7	37.2	38.5	37.5
	4	TE-654D	42.5	42.5	42.2	42.5	41.7
	5	TE-654E	43.5	44.2	44.0	44.7	44.2
	6	TE-654F	45.5	45.7	45.5	45.2	45.2
	7	TE-654G	42.0	41.7	42.0	42.0	42.0
	8	TE-654H	43.0	43.0	43.0	42.2	42.7
	9	TE-654I	45.0	45.0	44.7	45.0	44.7
	10	TE-654J	26.0	26.0	26.5	26.3	25.8
Reactor Bldg. Ave. Dewpoint Temp., °F			40.0	39.9	40.3	40.1	40.0
Water Vapor Pressure, (P_{WV}), psia			0.121	0.121	0.123	0.122	0.121
Drybulb Temperature, °F	1	TE-655A	71.39	71.36	71.49	71.51	71.47
	2	TE-655B	71.15	71.20	71.19	71.18	71.19
	3	TE-655C	70.83	70.86	70.91	70.88	70.87
	4	TE-655D	72.76	72.76	72.73	72.75	72.76
	5	TE-655E	72.01	72.11	72.07	72.12	72.01
	6	TE-655F	71.90	72.05	72.10	72.07	72.03
	7	TE-655G	71.92	71.99	71.96	72.02	71.92
	8	TE-655H	70.80	70.86	70.86	70.85	70.77
	9	TE-655I	70.03	70.07	70.17	70.26	70.21
	10	TE-655J	70.43	70.49	70.47	70.46	70.44
	11	TE-655K	71.59	71.66	71.63	71.62	71.64
	12	TE-655L	70.75	70.81	70.72	70.83	70.75
	13	TE-655M	71.84	71.93	71.93	71.90	71.93
	14	TE-655N	72.18	72.26	72.25	72.23	72.25
	15	TE-655O			INOPERATIVE		
	16	TE-655P	72.19	72.24	72.28	72.23	72.26
	17	TE-655Q	72.43	72.52	72.51	72.49	72.48
	18	TE-655R	72.16	72.30	72.29	72.24	72.22
	19	TE-655S	72.09	72.19	72.17	72.14	72.13
	20	TE-655T	72.16	72.27	72.26	72.21	72.20
	21	TE-655U	72.26	72.33	72.31	72.28	72.26
	22	TE-655V	72.15	72.24	72.23	72.16	72.15
	23	TE-655W	71.43	71.80	71.52	71.60	71.31
	24	TE-655X	71.09	71.04	71.03	71.13	71.00
Average Drybulb Temperature, °F			71.62	71.70	71.69	71.69	71.65
Reactor Bldg. Ave. Temperature (T), °R			531.31	531.39	531.38	531.38	531.34
Mass of Reactor Building Air (W), lbm x 10-5			7.05140	7.05090	7.05090	7.05060	7.05080

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THREE MILE ISLAND NUCLEAR STATION
UNIT 1
INTEGRATED LEAK RATE TEST DATA

APPENDIX E

LEAKAGE RATE DATA AT Pd

Hour			15	16	17	18	19
Time			0800	0900	1000	1100	1200
Containment Pressure, psia		PI-390	69.526	69.523	69.519	69.520	69.517
		PI-391	69.511	69.508	69.504	69.505	69.504
Reactor Bldg. Ave. Press. (P_T), psia			69.518	69.516	69.512	69.513	69.511
Dewpoint Temperature, ^oF	1	TE-654A	36.0	36.5	36.0	36.0	36.5
	2	TE-654B	39.5	39.0	39.5	39.0	40.0
	3	TE-654C	37.0	38.0	38.5	39.0	38.5
	4	TE-654D	43.0	43.0	43.0	43.5	43.0
	5	TE-654E	45.0	44.0	44.0	46.0	44.5
	6	TE-654F	45.5	45.5	45.5	45.0	45.5
	7	TE-654G	42.0	42.0	42.0	42.0	42.5
	8	TE-654H	43.0	43.0	43.0	43.0	43.0
	9	TE-654I	45.0	45.0	44.5	45.0	45.5
	10	TE-654J	26.0	26.0	26.5	26.5	26.5
Reactor Bldg. Ave. Dewpoint Temp., ^oF			40.2	40.1	40.3	40.5	40.6
Water Vapor Pressure, (P_{WV}), psia			0.122	0.122	0.123	0.124	0.124
Drybulb Temperature, ^oF	1	TE-655A	71.34	71.30	71.30	71.27	71.30
	2	TE-655B	71.13	71.10	71.12	71.12	71.11
	3	TE-655C	70.89	70.79	70.75	70.75	70.78
	4	TE-655D	72.73	72.68	72.69	72.65	72.48
	5	TE-655E	72.01	71.95	72.04	72.04	71.99
	6	TE-655F	71.95	71.95	71.95	71.96	71.90
	7	TE-655G	71.92	71.98	71.94	71.88	71.93
	8	TE-655H	70.82	70.80	70.73	70.76	70.74
	9	TE-655I	70.67	70.01	69.97	69.96	70.06
	10	TE-655J	70.44	70.39	70.39	70.38	70.39
	11	TE-655K	71.62	71.61	71.61	71.57	71.66
	12	TE-655L	70.75	70.74	70.70	70.72	70.73
	13	TE-655M	71.85	71.87	71.93	71.86	71.90
	14	TE-655N	72.23	72.25	72.20	72.22	72.21
	15	TE-655O		INOPERATIVE			
	16	TE-655P	72.23	72.21	72.22	72.19	72.17
	17	TE-655Q	72.47	72.41	72.41	72.41	72.34
	18	TE-655R	72.18	72.16	72.15	72.15	72.14
	19	TE-655S	72.09	72.09	72.06	72.10	72.06
	20	TE-655T	72.16	72.11	72.10	72.16	72.16
	21	TE-655U	72.22	72.20	72.20	72.21	72.21
	22	TE-655V	72.09	72.05	72.08	72.09	72.12
	23	TE-655W	71.59	71.08	71.15	71.51	71.52
	24	TE-655X	71.05	70.99	70.99	70.95	70.92
Average Drybulb Temperature, ^oF			71.63	71.59	71.58	71.59	71.58
Reactor Bldg. Ave. Temperature (T), ^oR			531.32	531.28	531.27	531.28	531.27
Mass of Reactor Building Air (W), lbm x 10-5			7.05070	7.05110	7.05070	7.05060	7.05050

THREE MILE ISLAND NUCLEAR STATION
UNIT 1
INTEGRATED LEAK RATE TEST DATA

APPENDIX E
LEAKAGE RATE DATA AT Pd

Hour			20	21	22	23	24
Time			1300	1400	1500	1600	1700
Containment Pressure, psia		PI-390	69.505	69.497	69.494	69.501	69.506
		PI-391	69.490	69.482	69.482	69.486	69.491
Reactor Bldg. Ave. Press. (P_T), psia			69.498	69.490	69.488	69.494	69.498
Dewpoint Temperature, °F	1	TE-654A	37.0	36.5	36.0	37.0	36.5
	2	TE-654B	39.5	38.5	39.5	39.0	40.0
	3	TE-654C	38.5	36.5	37.5	38.0	37.0
	4	TE-654D	42.5	42.5	43.0	42.5	42.5
	5	TE-654E	43.5	44.0	43.0	46.0	45.0
	6	TE-654F	46.0	45.0	45.0	46.0	46.0
	7	TE-654G	42.0	42.0	42.0	42.0	42.5
	8	TE-654H	42.0	42.0	42.5	42.0	43.0
	9	TE-654I	45.0	44.5	45.0	45.0	45.0
	10	TE-654J	26.0	26.0	26.0	26.0	26.5
Reactor Bldg. Ave. Dewpoint Temp., °F			40.2	39.8	40.0	40.4	40.4
Water Vapor Pressure, (P_{wv}), psia			0.122	0.121	0.122	0.124	0.124
Drybulb Temperature, °F	1	TE-655A	71.25	71.17	71.15	71.33	71.33
	2	TE-655B	71.03	70.97	70.90	70.96	70.94
	3	TE-655C	70.72	70.67	70.67	70.63	70.70
	4	TE-655D	72.66	72.62	72.58	72.56	72.56
	5	TE-655E	71.89	71.75	71.79	71.75	71.92
	6	TE-655F	71.88	71.77	71.82	71.78	71.84
	7	TE-655G	71.65	71.88	71.80	71.80	71.89
	8	TE-655H	70.69	70.61	70.60	70.57	70.66
	9	TE-655I	69.91	69.98	69.97	70.11	69.98
	10	TE-655J	70.27	70.29	70.28	70.22	70.33
	11	TE-655K	71.50	71.46	70.50	71.53	71.49
	12	TE-655L	70.63	70.59	70.59	70.56	70.68
	13	TE-655M	71.69	71.69	71.68	71.77	71.88
	14	TE-655N	72.09	72.07	72.09	72.08	72.14
	15	TE-655O			INOPERATIVE		
	16	TE-655P	72.11	72.05	72.09	72.09	72.13
	17	TE-655Q	72.28	72.50	72.25	72.34	72.41
	18	TE-655R	71.99	71.93	71.96	72.10	72.18
	19	TE-655S	71.93	71.88	71.89	72.00	72.06
	20	TE-655T	71.93	71.88	71.93	72.08	72.15
	21	TE-655U	72.04	72.00	72.03	72.15	72.22
	22	TE-655V	71.86	71.81	71.84	72.04	72.12
	23	TE-655W	71.07	71.16	71.27	71.26	71.59
	24	TE-655X	70.92	70.92	70.88	70.88	70.91
Average Drybulb Temperature, °F			71.46	71.49	71.45	71 49	71.56
Reactor Bldg. Ave. Temperature (T), °R			531.15	531.18	531.14	531.18	531.25
Mass of Reactor Building Air (W), lbm x 10-5			7.05100	7.04990	7.05010	7.05000	7.04940

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THREE MILE ISLAND NUCLEAR STATION
UNIT 1
INTEGRATED LEAK RATE TEST

APPENDIX E

LEAKAGE RATE RESULTS AT Pd

Hour	Weight (Obs.)-(Calc.)	Observed Leakage Rate Point-to-Point (%/day)	Observed Leakage Rate Total Time (%/day)
0	2.6	2Se = 0.454	2Se = 0.124
1	81.5	-0.236	-0.236*
2	76.1	+0.051	-0.093
3	13.6	+0.245	+0.019
4	28.6	-0.019	+0.010
5	6.1	+0.109	+0.029
6	43.6	-0.095	+0.009
7	-75.7	+0.440	+0.070
8	-215.3*	+0.510*	+0.125
9	-115.5	-0.308	+0.076
10	26.6	-0.452*	+0.024
11	-9.1	+0.154	+0.036
12	-6.7	+0.024	+0.035
13	-27.7	+0.104	+0.040
14	4.3	-0.072	+0.032
15	9.8	+0.013	+0.031
16	52.0	-0.112	+0.022

* Exceeded limits of 95% confidence level.

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THREE MILE ISLAND NUCLEAR STATION
UNIT 1
INTEGRATED LEAK RATE TEST

APPENDIX E

LEAKAGE RATE RESULTS AT Pd

Hour	Weight (Obs.)-(Calc.)	Observed Leakage Rate Point-to-Point (%/day)	Observed Leakage Rate Total Time (%/day)
17	24.0	+0.128	+0.028
18	20.1	+0.045	+0.029
19	22.5	+0.024	+0.029
20	79.5	-0.162	+0.019
21	-22.0	+0.378	+0.036
22	10.0	-0.077	+0.031
23	7.0	+0.042	+0.032
24	-35.8	+0.178	+0.038
	2Se = 128.5 lbm	σ = 0.222	σ = 0.065

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APPENDIX F

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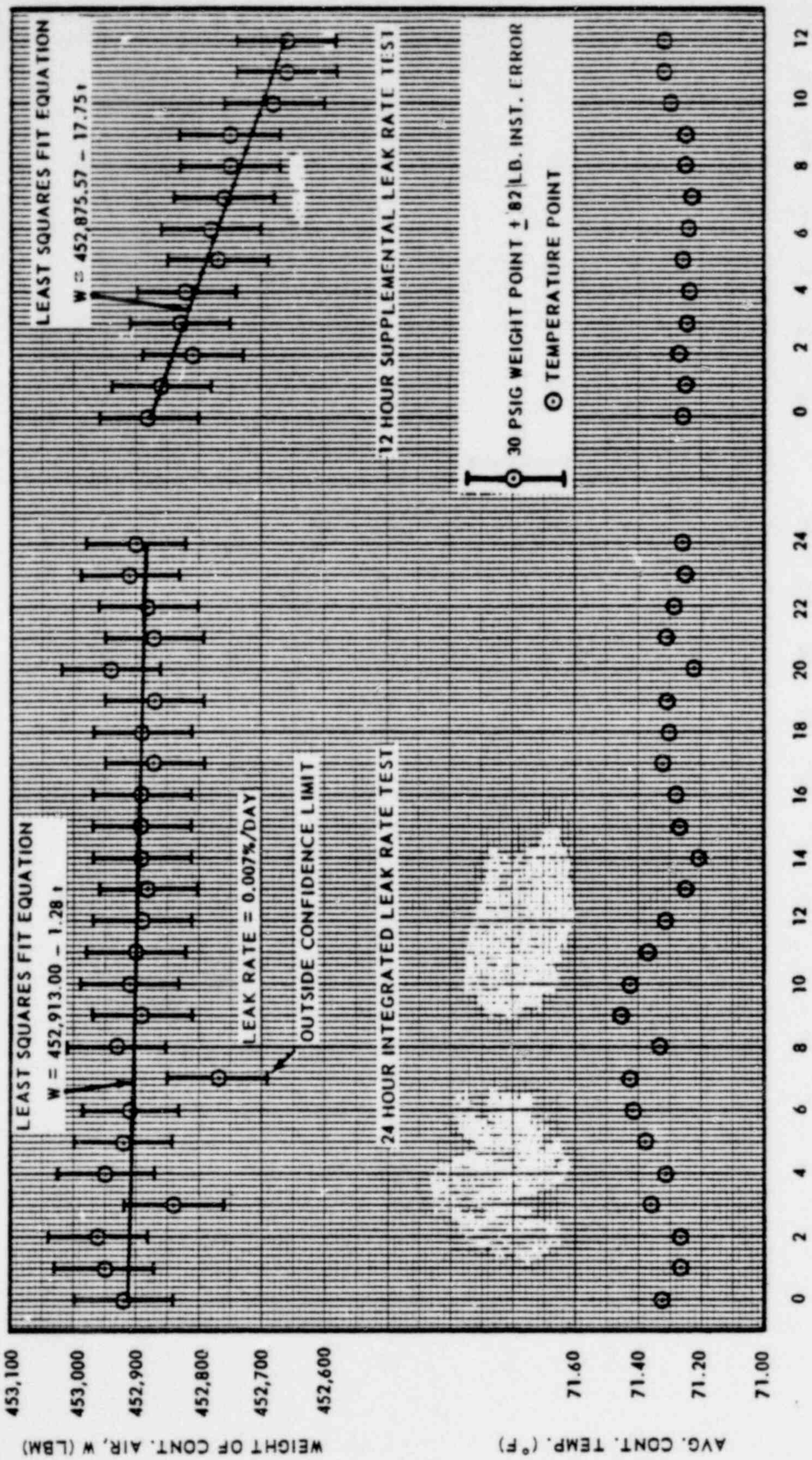


1408 144

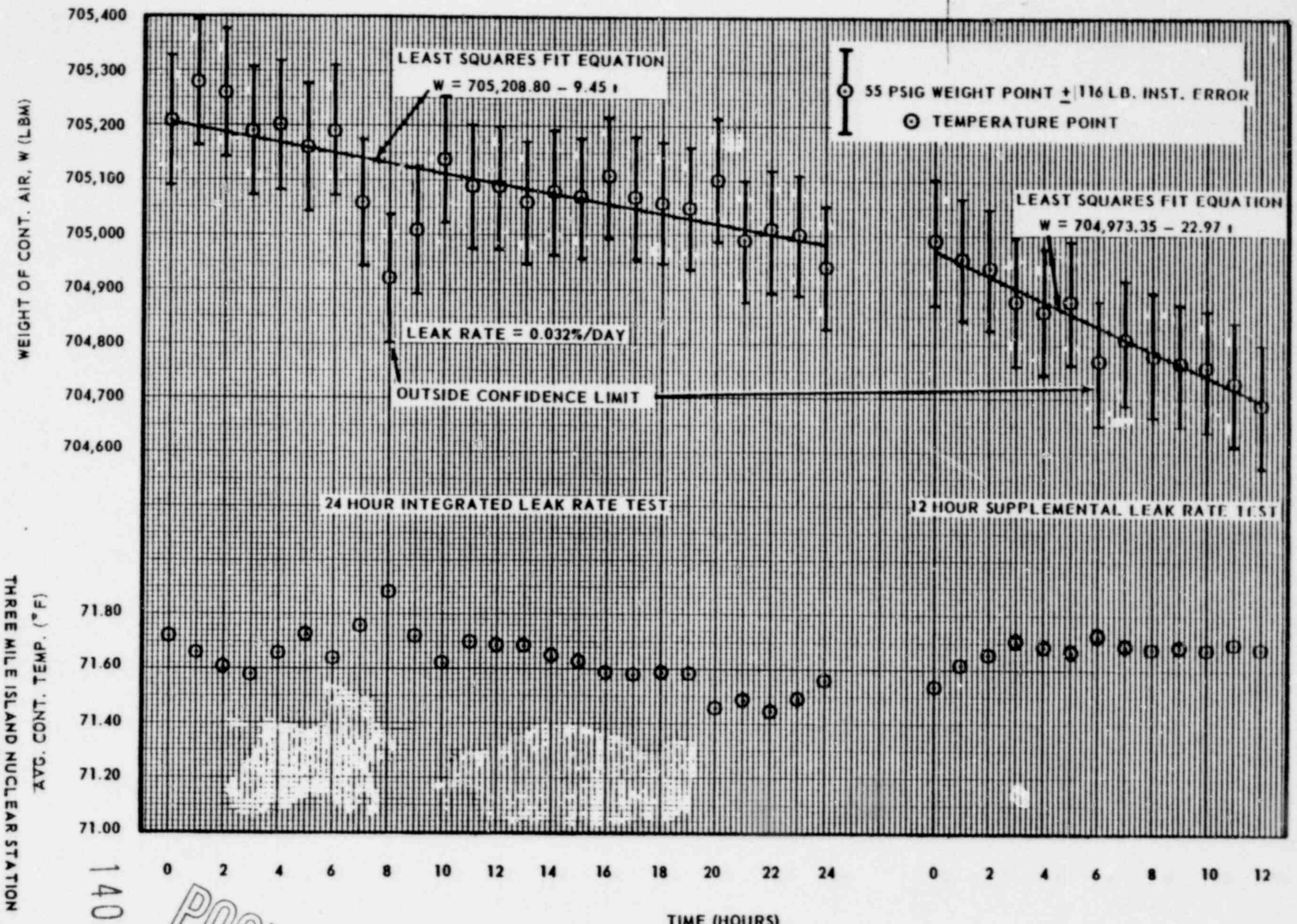
THREE MILE ISLAND NUCLEAR STATION

UNIT 1

INTEGRATED LEAK RATE TEST

APPENDIX F

WEIGHT OF CONTAINMENT AIR AND AVERAGE CONTAINMENT TEMP. VS. TIME AT 30 PSIG



THREE MILE ISLAND NUCLEAR STATION
UNIT 1
INTEGRATED LEAK RATE TEST
APPENDIX F
WEIGHT OF CONTAINMENT AIR AND AVERAGE
CONTAINMENT TEMP. VS. TIME AT 55 PSIG

APPENDIX G

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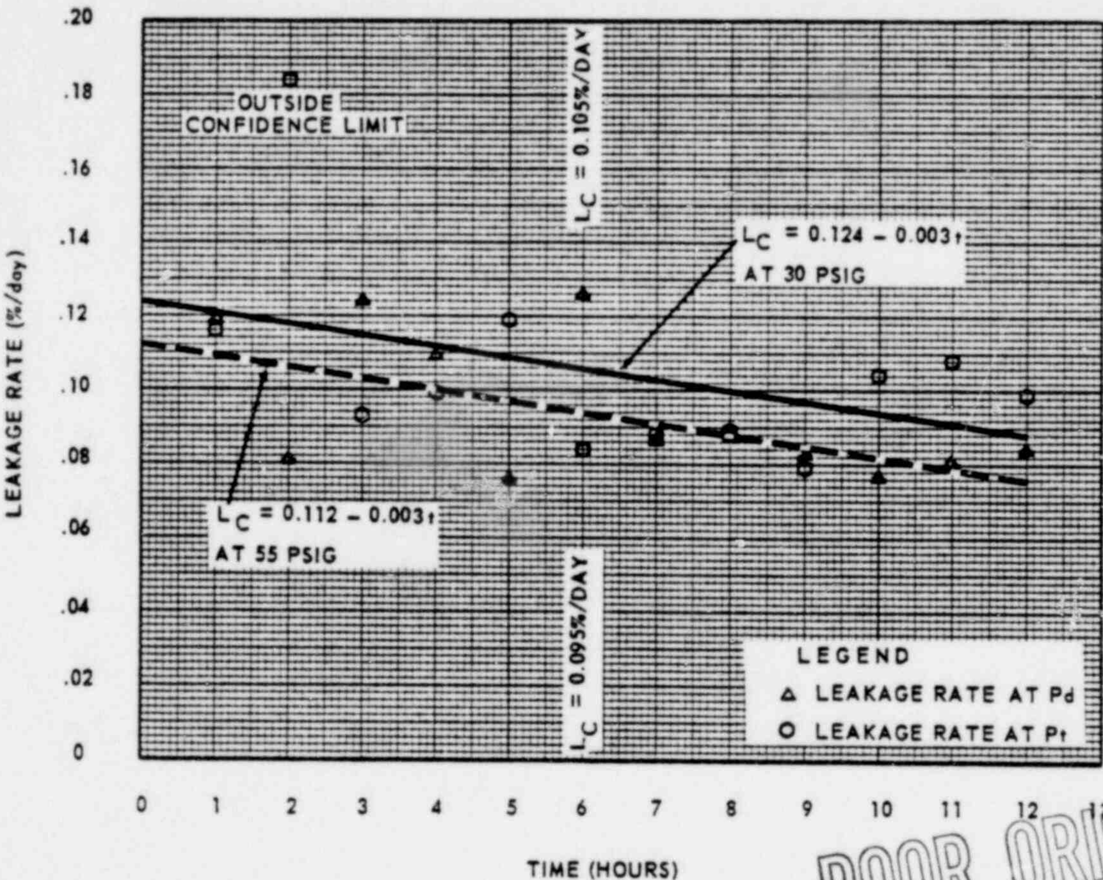
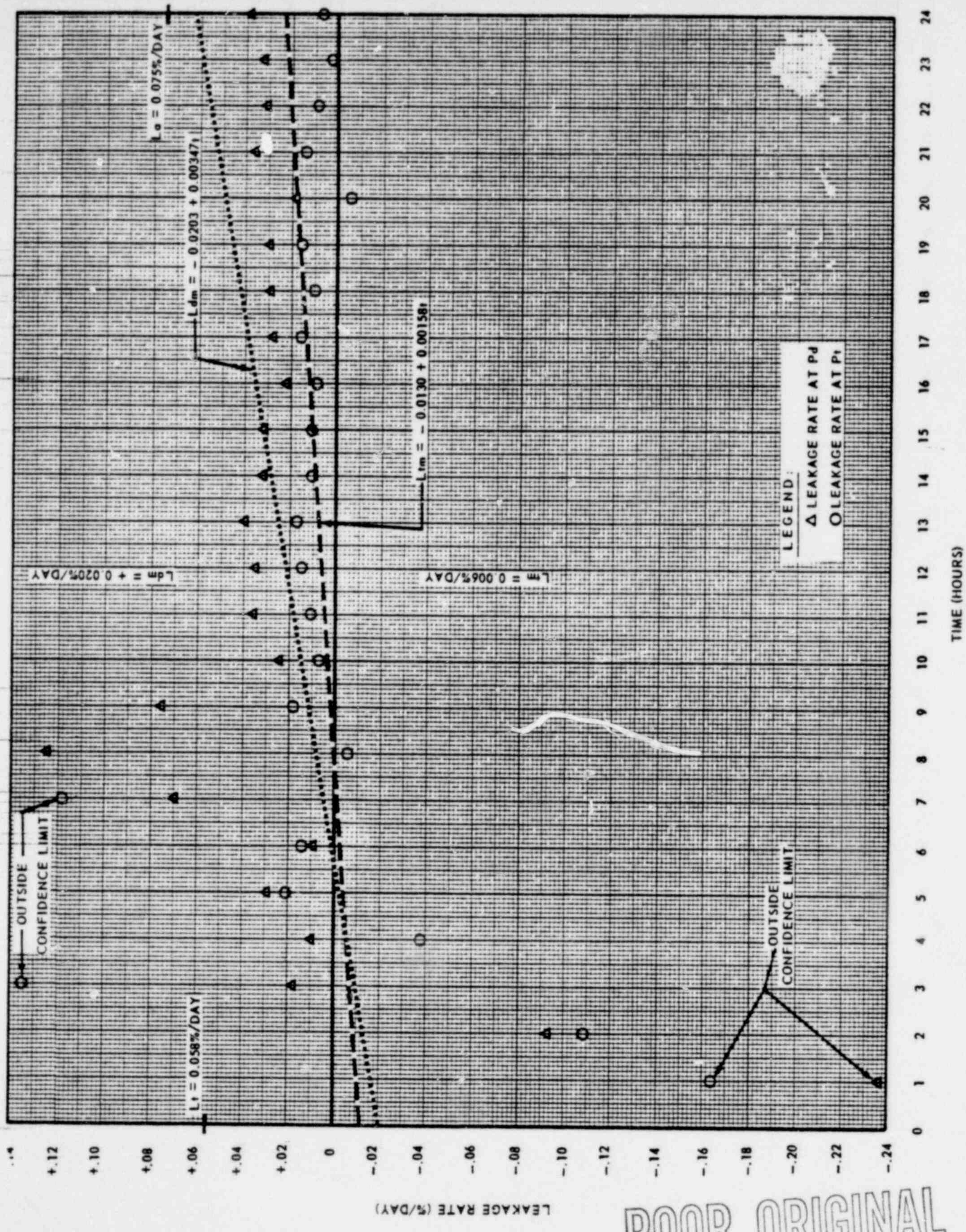


POOR ORIGINAL

THREE MILE ISLAND NUCLEAR STATION
UNIT 1
INTEGRATED LEAK RATE TEST
APPENDIX G
TOTAL TIME LEAKAGE RATE VS. TIME
FOR SUPPLEMENTAL TESTS

1408 147



POOR ORIGINAL

1408 148

THREE MILE ISLAND NUCLEAR STATION
UNIT 1
INTEGRATED LEAK RATE TEST

APPENDIX G
TOTAL TIME LEAKAGE RATE VS. TIME

POOR ORIGINAL

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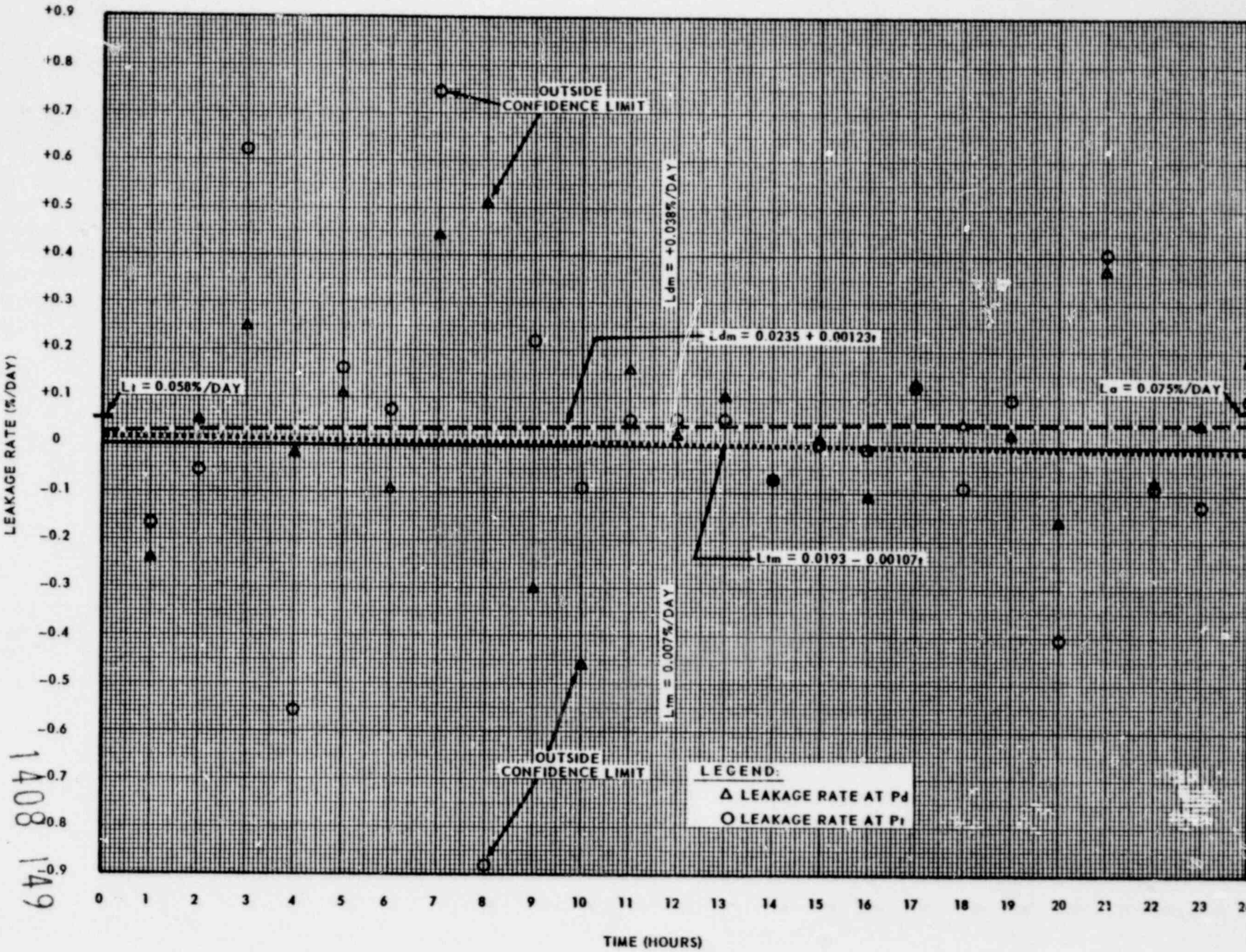

THREE MILE ISLAND NUCLEAR STATION
UNIT 1
INTEGRATED LEAK RATE TEST
APPENDIX G
POINT-TO-POINT LEAKAGE RATE VS. TIME