Bendix

Aerospace Systems Division

Analysis of Pressure Data Relating to the PSE SN03 Pneumatic Caging Subsystem Non-Conformance Status	ATM-920	A
	PAGE 1 OF	
Supplement 1	DATE 2 June 1971	

The report represented by this supplement to ATM 920 is an analysis of pressure data collected as a result of monitoring the pneumatic caging subsystem of the PSE, SN03, during the time interval extending from 10/30/70 to 4/27/71 (179 days). The data acquired in this time interval was pooled with the data originally displayed in ATM 920 since all the data represents a continuous collection process. Consequently, the total time span now represented in this analysis covers 229 days.

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INTRODUCTION

This supplement to ATM 920 describes the analysis of the pressure data extracted from the SN03 Operating Events Log (Exhibit A-S1) when pooled with the original set of data collected from the SN03 Operating Events Log. Corresponding temperature records are included in Exhibit B-S1 (Reference Exhibits C and F, ATM 920).

It will not be necessary to discuss any documentation other than that portion of the Operating Events Log utilized in the current analysis, since the documentation reviewed in ATM 920 still provides a valid basis for this supplement. These additional areas of the Operating Events Log are discussed later in this report.

SUMMARY

The principle conclusion reached in this report is: The symptoms exhibited by SN03 cannot be attributed to leakage. This conclusion was established in ATM 920, and the analysis of subsequent pressure data, together with an analysis of orifice size vs time to empty the system, performed in this supplement, re-validates the conclusions.

The principle recommendations are:

1. Initiate an investigation of the pressure transducer.

2. Up-date Engineering Procedures to reflect the pressure monitoring requirements in terms of when to monitor and recording of time and temperature with corresponding pressure readings.

In the case of the first recommendation, the pressure transducer is the one component in the caging system which would reflect the characteristics exhibited by the PSE, if the transducer developed a malfunction.

UNIT HISTORY

The unit history was reviewed in ATM 920 through 10/16/70. Since that time, the unit has been moved from and to the PSE Laboratory a total of nine times for various tests and operations in the Components Laboratory, Experiments Test Laboratory, EMI Chamber, and Thermal-Vacuum Chamber, in addition to fifteen interim moves between various of the above sites before returning to the PSE Laboratory. Through 4/14/71 the unit has changed location a total of 24 times. The immediate future of the instrument will be a continuation of the above activities.

DATA REVIEW

1. Review of the SN 03 Operating Events Log indicated that requirements for monitoring the caging subsystem pressure should be more rigidly enforced.

2. Using a calibrated thermometer, temperatures should always be measured and recorded when pressure readings are taken.

3. Record time when pressure and temperature are taken.

In the interval between 1-16-71 and 3-21-71 an apparent marked decrease in caging pressure took place. Since the pressure remained virtually constant after this change, it is difficult to attribute this to leakage. Even if it were assumed that a leak was initiated, and then the point at which the leak was taking place became stopped-up, the probability is remote that this would remain a stable condition. The instrument has been moved several times since the apparent change in pressure took place. If the original condition was a result of moving, it is just as probable it would be reproduced by further moving. Such has not proved to be the case.

As an additional piece of information, included in this report is a graphical relationship showing the time intervals that would be necessary for the system pressure to deplete itself through orifices of various diameters.

DATA ANALYSIS

Table 1-S1 lists the additional raw pressure data used in the analysis described in this supplement to ATM 920. The pressure data recorded through 11-24-70 were combined with the data in ATM 920 since the magnitude of these pressure data were representative of normally expected values in this time period. The pressure data recorded during T/V was eliminated from the analysis because the pressure system was unstable during this time period. From 12-12-70 to 3-21-71 no pressure data were recorded.

From 3-21-71 through 4-27-71, pressure data were recorded, but all readings did not have corresponding temperature readings and two pressure readings did not, remotely, correlate with the temperature recorded with them. Consequently, this entire data group was not considered with the other pressure data because of the above problem and because the magnitude of all the data group was such that they were normally expected values, but considerably lower. Therefore, these data were analyzed separately.

TABLE 1-S1

(Ref. - Exhibit A-S1)

RAW PRESSURE DATA WITH CORRECTIONS TO A STANDARD TEMPERATURE OF 70°F (529.4°, T_1)

1	2	3	4	5	6	7	8
Line Item	Date Read Day No. in ( ) 1970-71	Time Read	Temp (°F)	Recorded Pressure (MV)	Absolute Temperature (459.4 + °F)	Temperature Correction Factor T_1/T_2	Corrected Pressure (5) x (7)
1	10/30 (50)	1715	71	149.9 (1)	530.4	0.99811	149.6
2	10/31 (51)	1400	74	152.3 (1)	533.4	0.99250	151.2
3	11/2 (53)	1330	73	150.0 (2)	532.4	0.99501	149.2
4	11/3 (54)	1400	71	149.0 (2)	530.4	0.99811	148.7
5	11/4 (55)	1430	71	148.0 (2)	530.4	0.99811	147.7
6	11/5 (56)	1500	71	149.0 (2)	530.4	0.99811	148.7
7	11/6 (57)	1415	71	148.0 (2)	530.4	0.99811	147.7
8	11/9 (60)	----	72	151.0 (2)	531.4	0.99623	150.4
9	11/10 (61)	----	71	149.1 (2)	530.4	0.99811	148.8
10	11/10 (61)	----	--	150.0 (3)	-----	-------	-----
11	11/12 (63)	----	71	149.8 (2)	530.4	0.99811	149.5
12	11/13 (64)	----	70	149.2 (2)	529.4	1.00000	149.2
13	11/16 (67)	----	70	149.2 (2)	529.4	1.00000	149.2
14	11/19 (70)	----	72	149.3 (2)	531.4	0.99623	148.7
15	11/21 (72)	2240	--	(4) 148.3	-----	-------	-----
16	11/23 (74)	1320	--	(4) 152.8	-----	-------	-----
17	11/24 (75)	1105	68	(4) 148.0	527.4	1.00379	148.6
18	12/1 (82)	1527	--	(4) 151.6	-----	-------	-----
19	12/2 (83)	----	--	(4) 165.1	-----	-------	-----
20	12/7 (88)	----	--	(4) 165.1	-----	-------	-----
21	12/8 (89)	----	--	(4) 165.2	-----	-------	-----
22	12/9 (90)	----	--	(4) 165.7	-----	-------	-----
23	12/10 (91)	----	--	(4) 163.8	-----	-------	-----
24	12/11 (92)	----	--	(4) 164.7	-----	-------	-----
25	12/12 (93)	----	--	(4) 151.4	-----	-------	-----
26	Ref Fig. 3-S1 1/16/71 (128)	----	--	(5) 147.0 / 159.3	-----	-------	-----
27	(1) 3/21 (192)	----	69	(2) 141.0	528.4	1.00189	141.3
28	(8) 3/29 (200)	----	--	(3) 143.0	-----	-------	-----
29	(11) 4/1 (203)	----	--	(3) 143.0	-----	-------	-----
30	(15) 4/5 (207)	----	--	(1) 142.4	-----	-------	-----
31	(17) 4/7 (209)	----	--	(1) 142.6	-----	-------	-----
32	(22) 4/12 (214)	----	74	(1) 140.0	533.4	0.99250	138.9
33	(23) 4/13 (215)	----	76	(1) 139.6	535.4	0.98879	138.0
34	(24) 4/14 (216)	----	71	(1) 141.9	530.4	0.99811	141.6
35	(32) 4/22 (224)	----	70	(5) 142.0 (2)	529.4	1.00000	142.0
36	(37) 4/27 (229)	----	70	(5) 142.0 (2)	529.4	1.00000	142.0

(1) EMI Chamber
(2) PSE Laboratory
(3) Experiments Laboratory
(4) T/V Chamber
(5) Does Not Show on Log

The combined data from ATM 920 and pressure data recorded through 11-24-70 yielded the following modified regression equation which is plotted in Figure 1-S1:

$$Y' = 150.2 - 0.0169\ X \qquad (1)$$

where Y' = the dependent variable (pressure) (mv)

X = the independent variable (time)

150.2 = Y-axis intercept (mv)

0.0169 = slope of curve $\left(\frac{\text{millivolts}}{\text{day}}\right)$

The analytical methods were described earlier in ATM 920 and will not be repeated in this supplement. A change of 0.0008 mv/day in slope to a slightly smaller slope is observed when compared to the equation in ATM 920. This is not a significant change in slope, but merely represents an extremely small variation due to additional data points. New confidence limits are attached to the modified curve to accommodate the additional data. An approximate method is used for the calculation of the confidence limits. The error introduced by this method is the omission of the contribution made to the total variance, by the variance in the regression coefficient (slope), and considering only the variance due to the pressure. This results in a regression curve bounded by parallel straight lines, rather than parallel lines with a concave shape. Because of the amount of data that has been acquired to this point in time, the instrument pressurized caging system is characterized in a very acceptable manner. Therefore, a less conservative treatment of the confidence limits is justified. This approach is defined as follows:

$$\text{Confidence Limits} = Y \pm t\,\sigma_r \qquad (2)$$

where t = Students "t" statistic for n - 2 degrees of freedom and 5% level of significance

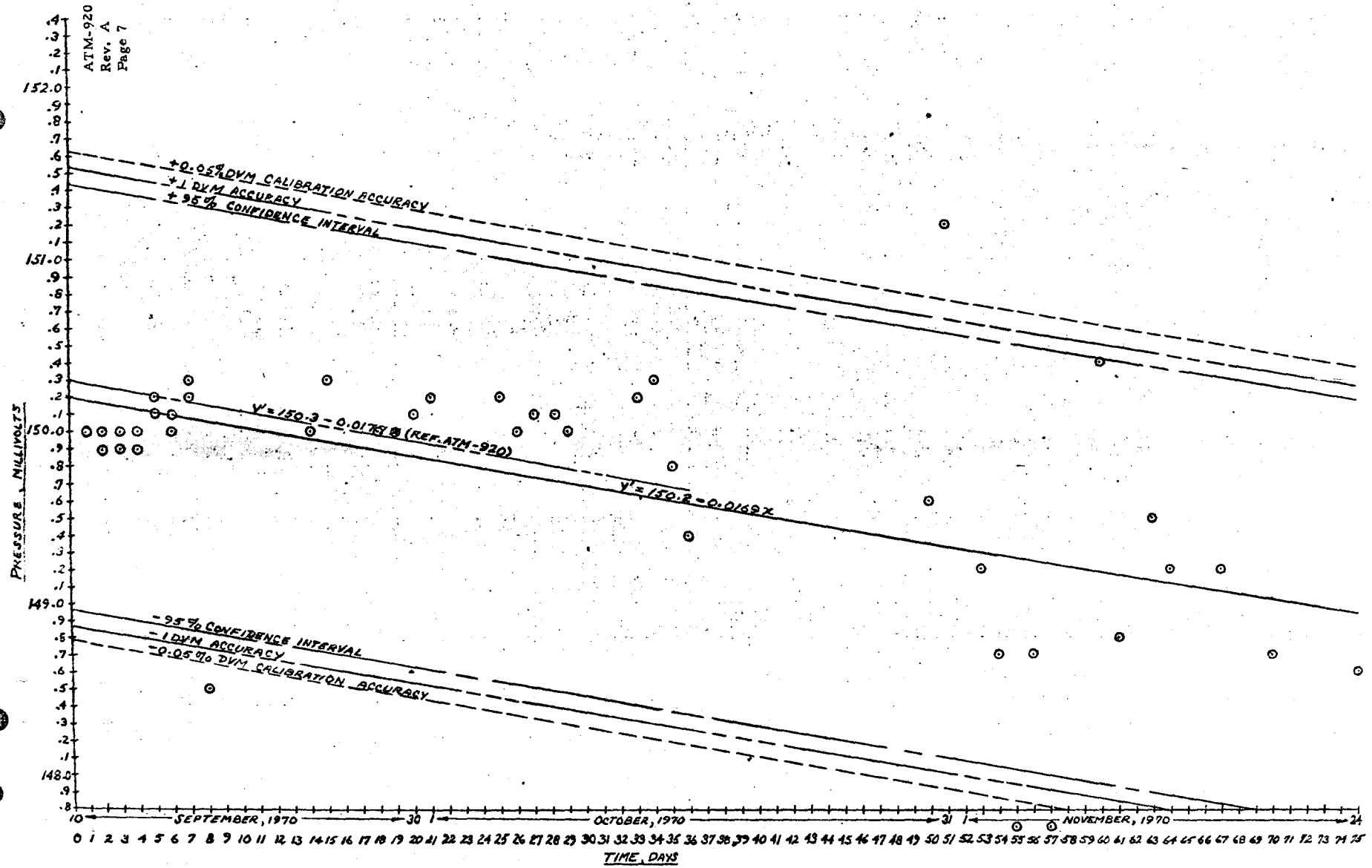

FIGURE 1-S1 - LINEAR REGRESSION CURVE FOR S/N-03 PSE

$t_{(.05)}$ = 2.02 (41 degrees of freedom)

n = number of observations (43)

σ_r = standard error about regression line measured in units of "Y" parallel to Y-axis.

A summary of this calculation is shown in Table 2-S1. The same tolerances associated with instrument calibrations and reading accuracy, still hold for this supplemental report and are shown in Figure 1-S1.

The pressure data accumulated from 3-21-71 through 4-27-71 were significantly different from all previous recorded pressure data as outlined earlier. The problem at this point was one of establishing an analytical procedure by which the degree of significance of these data could be reasonably assessed. The pressure data, without accompanying temperatures, could have been justifiably discarded, but such a procedure would have complicated the problem rather than simplified it. The total number of data points in this group (10) was already small. To discard at least five of this group for lack of temperature data, and two additional points for inconsistency, would have reduced any further attempts at analysis to a mere arithmetical exercise.

Therefore, the following method was utilized, and, on the basis of probability theory, is mathematically sound in all respects for this particular application.

The first step was one of determining what pressure changes could be expected from changes in temperature. This is not a difficult task if the proper data are available. One could even calculate a theoretical curve, which would provide this information, but, the current problem is sensitive enough in nature, that utilizing the actual data is more meaningful. In this case, forty-one (41) pressure readings were available from the record maintained while the instrument was in the PSE Laboratory. Each of these forty-one points were accompanied by a corresponding temperature reading traceable to a record from a calibrated instrument. Consequently, a pressure vs temperature curve was derived from this data, utilizing linear regression techniques described in ATM-920, because this data represented the largest single block of information which met the prerequisite accuracy for the intended application (See Exhibit C-S1, Table 1 for tabular summary). Limits were assigned to this curve at the 95% level of confidence for an expected value of pressure, taking into account the variance about the mean value of pressure and the variance about the regression coefficient (or slope in mv/ ^{o}F). The curve is shown in Figure 2-S1 (See Exhibit C-S1, Table 2

TABLE 2-S1

95% CONFIDENCE INTERVAL FOR Y = 150.2 - 0.0169 X

Line Item	(X - 29.7)	(Y - 149.7)	$(X - \overline{X})(Y - \overline{Y})$	$(X - \overline{X})^2$	$(Y - \overline{Y})^2$	
1	- 28.7	+ 0.3	- 8.61	823.69	0.09	
2	- 27.7	+ 0.2	- 5.54	767.29	0.04	
3	- 27.7	+ 0.3	- 8.31	767.29	0.09	
4	- 26.7	+ 0.2	- 5.34	712.89	0.04	
5	- 26.7	+ 0.3	- 8.01	712.89	0.09	
6	- 25.7	+ 0.2	- 5.14	660.49	0.04	
7	- 25.7	+ 0.3	- 7.71	660.49	0.09	
8	- 24.7	+ 0.4	- 9.88	610.09	0.16	
9	- 24.7	+ 0.5	- 12.35	610.09	0.25	
10	- 23.7	+ 0.3	- 7.11	561.69	0.09	
11	- 23.7	+ 0.4	- 9.48	561.69	0.16	
12	- 22.7	+ 0.5	- 11.35	515.29	0.25	
13	- 22.7	+ 0.6	- 13.62	515.29	0.36	
14	- 21.7	- 1.2	+ 26.04	470.89	1.44	From ATM-920
15	- 15.7	+ 0.3	- 4.71	246.49	0.09	Table 2
16	- 14.7	+ 0.6	- 8.82	216.09	0.36	
17	- 12.7	+ 0.3	- 3.81	161.29	0.09	
18	- 11.7	+ 0.3	- 3.51	136.89	0.09	
19	- 10.7	+ 0.4	- 4.28	114.49	0.16	
20	- 9.7	+ 0.5	- 4.85	94.09	0.25	
21	- 4.7	+ 0.5	- 2.35	22.09	0.25	
22	- 3.7	+ 0.3	- 1.11	13.69	0.09	
23	- 2.7	+ 0.4	- 1.08	7.29	0.16	
24	- 1.7	+ 0.4	- 0.68	2.89	0.16	
25	- 0.7	+ 0.3	- 0.21	0.49	0.09	
26	+ 3.3	+ 0.5	+ 1.65	10.89	0.25	
27	+ 4.3	+ 0.6	+ 2.58	18.49	0.36	
28	+ 5.3	+ 0.1	+ 0.53	28.09	0.01	
29	+ 6.3	- 0.3	- 1.89	39.69	0.09	
30	+ 20.3	- 0.1	- 2.03	412.09	0.01	
31	+ 21.3	+ 1.5	+ 31.95	453.69	2.25	
32	+ 23.3	- 0.5	- 11.65	542.89	0.25	
33	+ 24.3	- 1.0	- 24.30	590.49	1.00	
34	+ 25.3	- 2.0	- 50.60	640.09	4.00	
35	+ 26.3	- 1.0	- 26.30	691.69	1.00	From Supplemen
36	+ 27.3	- 2.0	- 54.60	745.29	4.00	1, ATM-920,
37	+ 30.3	+ 0.7	+ 21.21	918.09	0.49	Table 1-S1
38	+ 31.3	- 0.9	- 28.17	979.69	0.81	Line Items
39	+ 33.3	- 0.2	- 6.66	1108.89	0.04	1 thru 17
40	+ 34.3	- 0.5	- 17.15	1176.49	0.25	
41	+ 37.3	- 0.5	- 18.65	1391.29	0.25	
42	+ 40.3	- 1.0	- 40.30	1624.09	1.00	
43	+ 45.3	- 1.1	- 49.83	2052.09	1.21	
			Σ = - 396.03	Σ = 23,389.87	Σ = 22.25	

$\overline{X}$ = 29.7 days

$\overline{Y}$ = 149.7 millivolts

1. Correlation Coefficient $= r = \dfrac{\Sigma (X - \overline{X})(Y - \overline{Y})}{\sqrt{\Sigma (X - \overline{X})^2 \, \Sigma (Y - \overline{Y})^2}}$

2. Standard Error about Regression line $= \sigma_r = \sqrt{1 - r^2} \sqrt{\dfrac{\Sigma (Y - \overline{Y})^2}{N - 2}}$

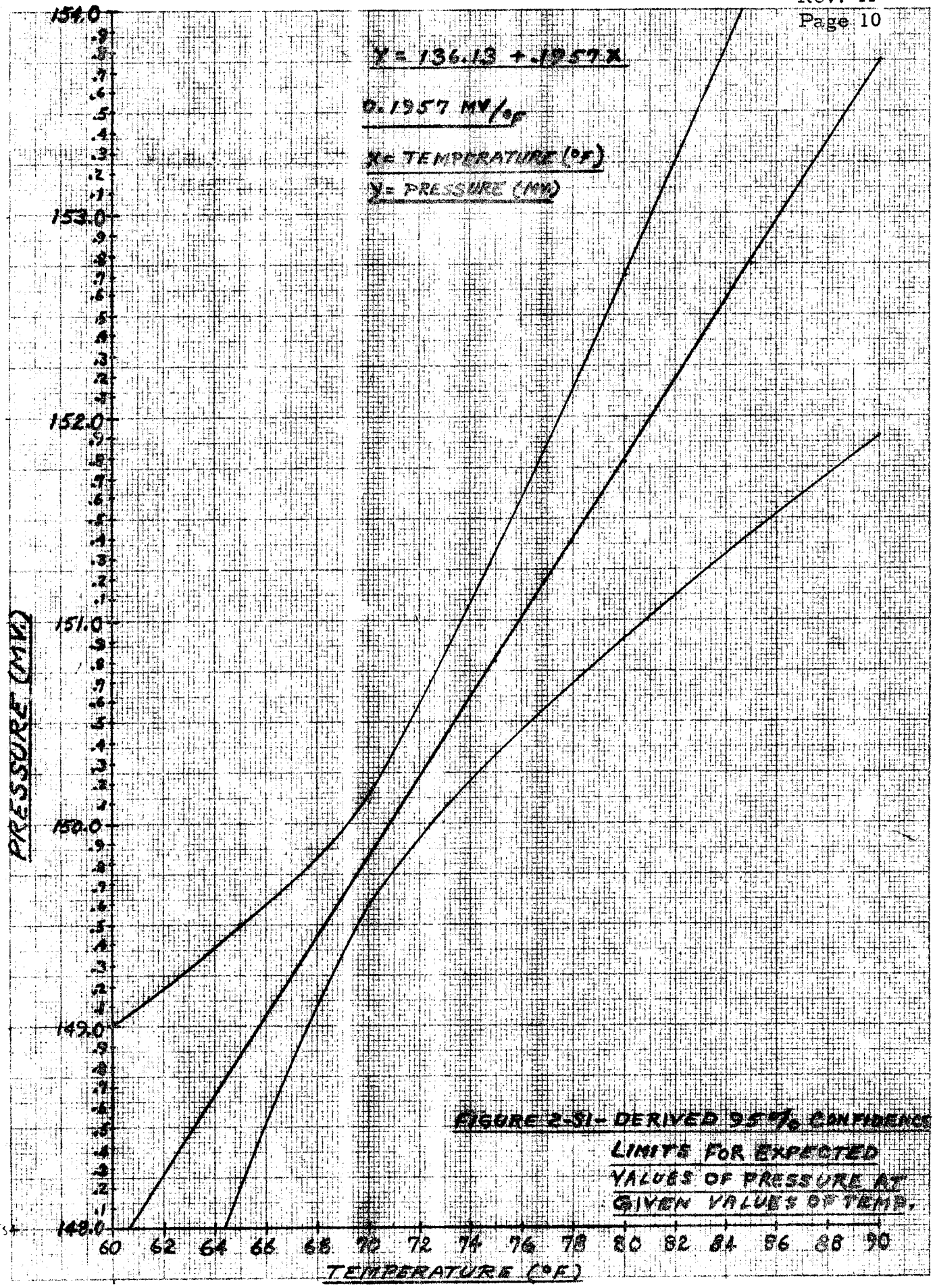

FIGURE 2-51 - DERIVED 95% CONFIDENCE LIMITS FOR EXPECTED VALUES OF PRESSURE AT GIVEN VALUES OF TEMP.

for tabular summary).

The second step involved in this procedure can be more readily described by referring to Table 3-S1. The ten "as-read" pressure values were extracted from Table 1-S1 (reference line items 27 through 36), and appear in Column 3 of Table 3-S1. The available corresponding temperatures are listed in Column 2 of the same table.

At this point a short digression is in order to clarify a particular "ground rule" which was used for evaluation purposes in the analytical method currently being described. The derived curve shown in Figure 2-S1 is based on pressure data in the 149 millivolt to 152 millivolt range. The tolerances on the expected values of pressure, at given temperatures, are going to be applied to pressure values in the 140 millivolt to 143 millivolt range. On the surface, this appears to be a gross violation of the rule against extrapolating beyond the limits of the data points used in deriving the curve. The point to remember is the second part of the rule "--unless it can be shown that the conditions under examination will not change." The rule, "not to extrapolate", was imposed on the analysis in ATM 920 because there was no guarantee that the conditions would remain the same. In view of the problem being considered at that time, the decision was correct. The rule is being imposed in the opposite sense in this case, because the derived curve in Figure 2-S1 represents a "no change" condition, i.e., normally expected values of pressure for given temperatures (following the direct variation relationship between pressure and temperature). For the temperatures listed in Table 3-S1, Column 2, expected pressure values should nominally range between 149.5 millivolts and 150.9 millivolts. Instead, they are ranging on the order of 8 to 9 millivolts (or 17.6 to 19.8 psi) below these values. The problem at this point is one of determining whether the ten pressure readings reveal that an abnormal leakage rate exists, or whether an acceptable leak rate exists. The problem of rationalizing the marked difference in pressure readings will be addressed at a later point.

It would be absurd to extend the curve theoretically into the range represented by the pressure readings in Table 3-S1, because the corresponding temperatures necessary to achieve these low levels of pressure (assuming no leaking) are in the 19°F to 36°F range. There are no Plant #2 temperature records that remotely suggest these ambient temperatures have ever been reached, at least for the time span under discussion. It is permissible to transform these pressure values to levels which are within the range of the curve in Figure 2-S1 by adding a constant value to each pressure. This does not change the validity of the regression analysis. One must only

TABLE 3-S1

ANALYSIS OF PRESSURE DATA RECORDED FROM
3/21/71 THROUGH 4/27/71
(REF TABLE 1-S1, LINE ITEMS 27 THROUGH 36)

≠ except as noted

1	2	3	4	5	6
Line Item	≠ Recorded (°F) Temperature	Recorded Pressure (MV)	Expected Pressure for Temp in Col 2	95% C. L. for Expected Pressures at Given Temp	95% C. L. + DVM Tol + DVM Calib Tol
27	As Read, 69	**141.0	141.8	141.6 to 142.0	141.4 to 142.2
28	Derived Temp, (74-76)	143.0	- - -		
29	Derived Temp, (74-74)	143.0	- - -		
30	Derived Temp, (71)	142.4	- - -		
31	Derived Temp, (74)	142.6	- - -		
32	As Read, 74	*140.0	142.8	142.6 to 143.0	142.4 to 143.2
33	As Read, 76	*139.6	143.2	142.9 to 143.5	142.7 to 143.7
34	As Read, 71	**141.9	142.2	142.0 to 142.4	141.8 to 142.6
35	As Read, 70	142.0	142.0	141.8 to 142.2	141.6 to 142.4
36	As Read, 70	142.0	142.0	141.8 to 142.2	141.6 to 142.2

NOTES

1. Column 4 Values = (Column 2 - 70°) x 0.1957 mv/°F + 142.0

2. Column 5 Values = C. L. $(\hat{Y}) = \bar{y} + b\,(X_i - \bar{X}) \pm t_{0.5}\, S_r^2 \sqrt{\frac{1}{n} + \frac{(X_i - \bar{X})^2}{\Sigma (X_i - \bar{X})^2}}$

   (a) $\bar{y}$ = 150.11 mv

   (b) $\bar{x}$ = 71.44°F

   (c) $t_{0.5}$ = 2.02 (Value of Students' "t" statistic at the 95% level of confidence

   (d) S_r^2 = 0.4473

   (e) n = 39 = Degrees of Freedom

   (f) b = 0.1957 mv/°F

   (g) $\Sigma(X - \bar{X})^2$ = 186.0976

* Questionable accuracy

** Acceptable for analysis purposes

remember that the constant must be mathematically taken out when actual pressures are desired. The values listed in Columns 4, 5 and 6 in Table 3-S1 represent the results of implementing this procedure. This completes the digression mentioned earlier and a description of the analysis is picked up again at this point.

It will be recalled that the ten (10) pressure values in Table 3-S1, Column 3 were being evaluated. Four of these pressures (line items 28 through 31) did not have temperatures recorded and two pressures (line items 32 and 33) appeared to be inconsistent for the corresponding temperatures recorded with them. Using the techniques described earlier, expected values of pressure were calculated for those temperatures of record listed in Column 2, Table 3-S1. The expected values of pressure are listed in Column 4, Table 3-S1. Confidence limits for the pressure values were selected from Figure 2-S1 for each temperature and assigned to the appropriate pressures (reference Column 5, Table 3-S1). The reading accuracy tolerance and calibration tolerance (reference Page 16, ATM 920) of the Digital Voltmeter used for monitoring pressure were added to the confidence limits for a total tolerance range (reference Column 6, Table 3-S1) associated with each expected pressure value.

Comparing column 4 with column 6, two values of pressure (line item 27 and line item 34) were found to be borderline for the recorded temperatures, but nevertheless, acceptable. The two pressures (line items 32 and 33) which were suspected of being inconsistent with the recorded temperatures were revealed to be so, in reality. The converse of this (assuming pressures to be correct), would require a temperature on the order of 64° to 65°F to achieve these pressures. Ambient temperatures of this magnitude were not to be found in any available temperature records for laboratory areas in Plant 2 during this time interval. Consequently, it was concluded the pressure record was in error.

The four pressure readings (reference line items 28 through 31, Table 3-S1) without corresponding temperatures were treated as follows: Since these pressures were relatively constant and represented pressure monitoring over a time interval of one week, it was assumed they were correct. Therefore, the reverse procedure was applied in these cases relative to the previous treatment of the pressure values. Temperature ranges were calculated between which the recorded pressures in Column 3, Table 3-S1 (line items 28 through 31) could be expected to occur. Since the Column 3 pressure values for line items 30 and 31 represented lower limits of acceptable tolerances (reference Column 6, Table 3-S1 line items 32 and 33) only one temperature value was defined. The desired temperatures are identified in Column 2, Table 3-S1.

At this point a regression analysis was then performed on six combinations of pressures and temperatures. The values used for these combinations are listed in Table 4-S1. Columns 2(a) through 2 (d) are temperatures, both recorded and derived. Column 2(a) represented recorded temperatures, the derived temperatures and the lower limit of the derived temperatures. Column 2(b) are the same with the exception that the high limit of the derived temperatures are used. Columns 2(c) and 2(d) correspond, respectively, to Columns 2(a) and 2(b) except line items 32 and 33 are omitted.

Columns 4(a) through 4(f) are the pressures from Column 3, Table 3-S1 corrected to 70°F. Column 4(a) includes pressures corrected to 70°F from the lower limit of the derived temperatures and column 4(b) includes pressures corrected to the upper limit of the derived temperatures. Columns 4(c) and 4(d) correspond, respectively, to Columns 4(a) and 4(b), except pressure line items 32 and 33 are omitted because of inconsistency. Columns 4(e) and 4(f) also correspond, respectively, to Columns 4(a) and 4(b), except pressure values for line items 32 and 33 were based on the corresponding expected values of pressure from Column 4, Table 3-S1, corrected to 70°F. Therefore, all combinations of temperatures and pressures are represented.

The analysis covered the following paired temperature-pressure combinations from Table 4-S1, with the independent variable being time (days) (reference Column 3, Table 4-S1.)

(1) Column 2(a) - Column 4(a) (2) Column 2(b) - Column 4(b)	Time averaged over 37 days.
(3) Column 2(c) - Column 4(c) (4) Column 2(d) - Column 4(d)	Time averaged over 37 days less line items 32 and 33.
(5) Column 2(a) - Column 4(e) (6) Column 2(b) - Column 4(f)	Time averaged over 37 days.

TABLE 4-S1

DATA USED FOR REGRESSION ANALYSIS ON SIX COMBINATIONS OF PRESSURES AND TEMPERATURES (REFERENCE TABLE 3-S1)

1	2				3	4					
Line Item	Temperatures used for Analysis Purposes (°F)				Day Number (X)	Pressures Used for Analysis Purposes (Mv.) (Y)					
	a	b	c	d		a	b	c	d	e	f
27	69	69	69	69	1	141.3	141.3	141.3	141.3	141.3	141.3
28	74*	76*	74*	76*	8	141.9*	141.4*	141.9*	141.4*	141.9*	141.4*
29	74*	76*	74*	76*	11	141.9*	141.4*	141.9*	141.4*	141.9*	141.4*
30	71*	71*	71*	71*	15	142.1*	142.1*	142.1*	142.1*	142.1*	142.1*
31	74*	74*	74*	74*	17	141.5*	141.5*	141.5*	141.5*	141.5*	141.5*
32	74	74			22	138.9	138.9			141.7**	141.7**
33	76	76			23	138.0	138.0			141.6**	141.6**
34	71	71	71	71	24	141.6	141.6	141.6	141.6	141.6	141.6
35	70	70	70	70	32	142.0	142.0	142.0	142.0	142.0	142.0
36	70	70	70	70	37	142.0	142.0	142.0	142.0	142.0	142.0

$\Sigma X_{a,b,e,f} = 190$ $\quad \Sigma y_a = 1411.2$ $\quad \bar{y}_a = 141.12$

$\bar{X}_{a,b,e,f} = 19.0$ $\quad \Sigma y_b = 1410.2$ $\quad \bar{y}_b = 141.02$

$\Sigma y_c = 1134.3$ $\quad \bar{y}_c = 141.79$

$\Sigma X_{c,d} = 145$ $\quad \Sigma y_d = 1133.3$ $\quad \bar{y}_d = 141.66$

$\bar{X}_{c,d} = 18.1$ $\quad \Sigma y_e = 1417.6$ $\quad \bar{y}_e = 141.76$

$\Sigma y_f = 1416.6$ $\quad \bar{y}_f = 141.66$

Reference Table 3-S1

*Derived temperatures and corresponding corrected pressures
**Corrected expected values of pressure for recorded temperatures

The following pressure change per day resulted from the above combinations:

	% of Max. Permissible Leak Rate
(a) Combination (1) = losing pressure at 0.0114 mv (0.0251 psi)/day.	61%
(b) Combination (2) = losing pressure at 0.0025 mv (0.0056 psi)/day.	14%
	Ref. Only
(c) Combination (3) = gaining pressure at 0.0101 mv (0.0224 psi)/day.	55%
(d) Combination (4) = gaining pressure at 0.0177 mv (0.0389 psi)/day.	95%
(e) Combination (5) = gaining pressure at 0.0089 mv (0.0197 psi)/day.	
(f) Combination (6) = gaining pressure at 0.0187 mv (0.0413 psi)/day.	101%

It should be recalled that the maximum permissible leakage rate is 0.04088 psi/day (reference Page 21, ATM-920). Furthermore, it is obvious that combinations (3) through (6) are not achievable in a practical sense, since these results represent an increase in pressure with time. Combinations (1) and (2) are representative of an achievable condition since these results represent a loss in pressure with time. It may be concluded from these results, that over the time period extending from 3-21-71 through 4-27-71 (37 days), the worst case that one could reasonably expect on the basis of the data(with a probability of being 95% correct, since it is being said that the true temperature parameters lies between the limits shown in Column 2, Table 3-S1, line items 28 through 31) is a leakage rate of 0.0251 psi/day, which is 61% of the maximum permissible. This is 36% less than the long term pressure data analyzed in ATM-920 and in the first part of this report. Any of the other combinations are less negative in pressure loss. The equation which represents the above condition is:

$$y' = 141.34 - 0.0114x \qquad (3)$$

The same definitions apply to equation (3) as those for equation (1). Table 5-S1 in Exhibit D-S1 summarizes the calculations used in developing equation (3). Figure 3-S1 contains a plot of equation (3); and, for comparison purposes, equation (1) was extrapolated to the same time interval under the assumption, that all conditions remaining normal, this would be the expected position of the curve. It is readily observed that the curve representing equation (3) is displaced from equation (1) on the order of 5.4 to 5.6 millivolts.

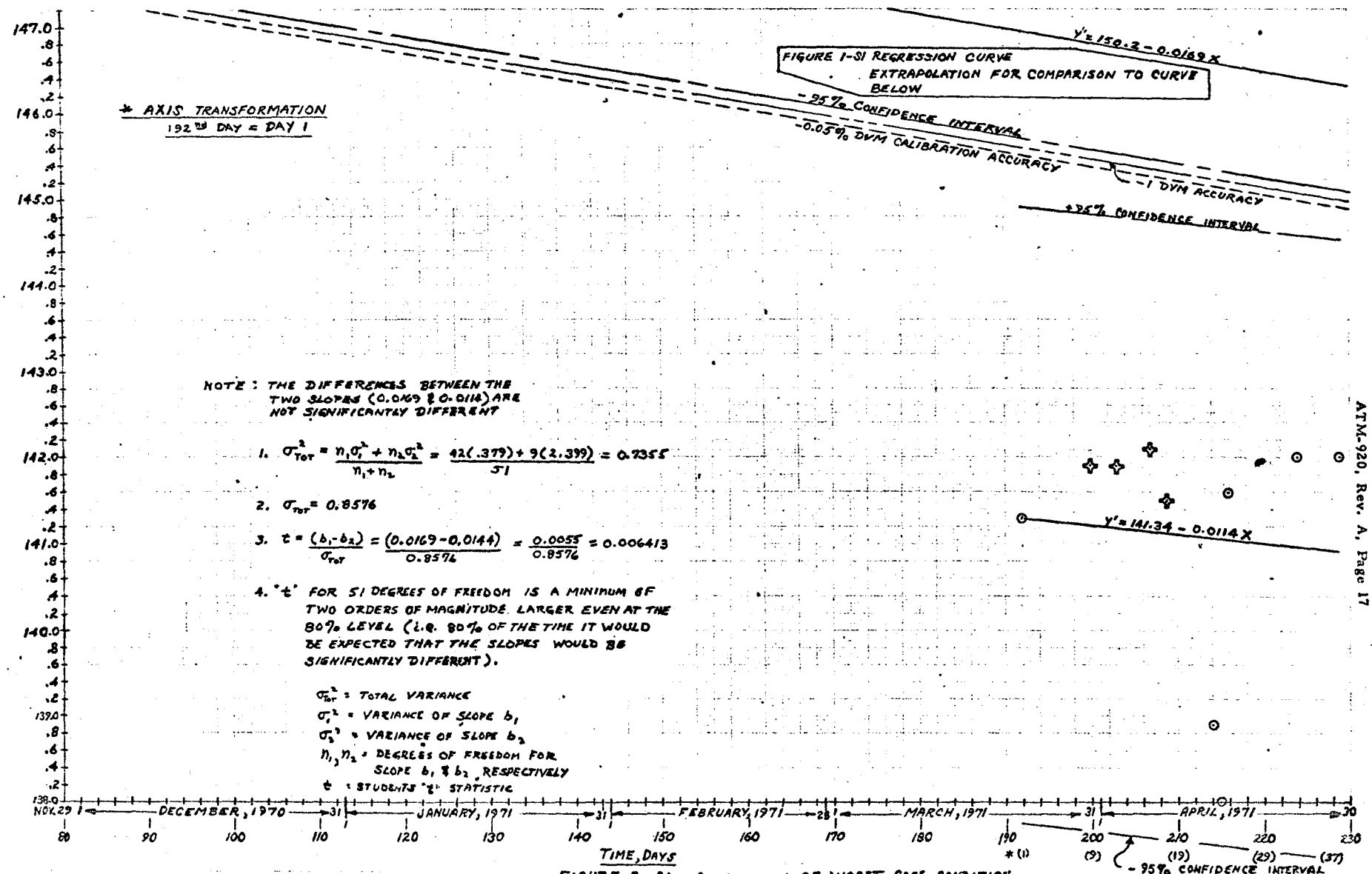

FIGURE 3-SI - COMPARISON OF WORST CASE CONDITION

It is also readily seen that the confidence intervals do not overlap, even though the confidence interval for equation (3) is quite broad (due in part to small sample size). Consequently, there is no doubt that a significant difference in displacement exists between the two curves. The slopes of the two curves were tested for significant differences as noted in the field of Figure 3-S1. There is no significant difference between the slopes, even when one considers an extreme case where it would be expected that 80% of the cases would exceed the critical value of "t", the statistical criterion used for acceptance or rejection, in this instance. Therefore, it can be concluded that both of the curves shown in Figure 3-S1 originate from data which result in the same rate change in pressure. The principle difference lies in the virtually constant displacement of the two curves.

Leakage rates have been discussed at considerable length in both ATM-920 and this supplement to ATM-920, but before dropping the subject entirely, the pressurized caging subsystem should be characterized from one other aspect. It can best be posed in the form of a question. "What is the relationship between system volume, system pressure, leakage in general, and time?" Leakage required to empty the system in time, t, may be calculated. In doing so, the parameters, identified in the question posed above, are elements of such a calculation. The velocity with which a fluid (under pressure) escapes from a closed system through an orifice can be related to the pressure and density of the fluid (gas or liquid). This relationship is given by Torricelli's Theorem and can be mathematically expressed as follows:

$$v = \sqrt{\frac{2gp}{\rho}} \qquad (4)$$

where: v = velocity (in./sec.)

g = acceleration due to gravity (386.4 in/sec^2)

p = instantaneous system pressure (psi)

ρ = density of fluid (lbs./in^3) (Nitrogen[1] = 45.18×10^{-6} lbs/in^3)

Substituting the constants for acceleration due to gravity and density, yields a specialized equation for the current discussion:

$$v = 4135.8 \sqrt{p} \qquad (5)$$

1 Reference Chemistry and Physics Handbook.

Equation (4), must be modified to account for frictional resistance as the gas passes through the orifice. The effect of frictional resistance is to decrease the rate of discharge to approximately 0.6 of that given by equations (4) and (5). Therefore, the final working equation is:

$$v = 2481.48 \sqrt{p} \qquad (6)$$

Ordinarily the amount of correction used in the above equation is not necessary because orifices are intentionally designed for streamline flow. In this instance it is assumed that the orifice shape (other than a circular cross section) is randomly irregular. Another equation is necessary at this point to integrate the volume and relate it to velocity. The rate of flow of fluid is usually measured as the volume that passes a reference cross section per unit time. This relation may be expressed as follows:

$$R = av \qquad (7)$$

where: R = volume per unit time (in^3/sec.)

a = cross sectional area of orifice (in^2)

v = velocity of fluid passing reference cross section per unit time (in/sec.).

$$\text{Cross section area} = \frac{\pi d^2}{4} = 0.785\, d^2 \qquad (8)$$

Substituting equation (8) into equation (7) yields the following expression for flow rate in cubic inches per second:

$$R = 0.785\, d^2 v \qquad (9)$$

Equation (9) may be further specialized to the PSE application by substituting the expression for velocity, [Equation (6)], into equation (9), which then becomes:

$$R = 1947.96\, d^2 \sqrt{p} \qquad (10)$$

where d = diameter of orifice through which leakage occurs.

The time necessary to exhaust the system is obtained by dividing the leakage rate (R) into the volume (V_s) of the caging pressure system. In this instance, the system volume is 1.895 in^3 (Ref. ATM-920, Exhibit G, page 1). Introducing this value into equation (10) yields a final specialized equation for the PSE caging

pressure system which contains the parameters of time, volume, pressure, orifice size and leakage rate as posed in the question postulated earlier. The resultant equation for time necessary to exhaust the system is shown for four elements of time, namely, seconds, hours, days and years, respectively. The need for this will become apparent later. The general equation for time is:

$$t = \frac{\text{Vol. } (V_s)}{R} \tag{11}$$

where t = time (units depend on volume and rate units)

The specialized forms are:

$$t \text{ (seconds)} = 9.728 \times 10^{-4} (d)^{-2} (p)^{-1/2} \tag{12}$$

$$t \text{ (hours)} = 2.702 \times 10^{-7} (d)^{-2} (p)^{-1/2} \tag{13}$$

$$t \text{ (days)} = 1.126 \times 10^{-8} (d)^{-2} (p)^{-1/2} \tag{14}$$

$$t \text{ (years)} = 3.085 \times 10^{-11} (d)^{-2} (p)^{-1/2} \tag{15}$$

Table 6-S1 represents a summary of instantaneous velocities (Column 4) which may be expected for various caging pressures from the application of equation (6). Table 7-S1 lists a series of assumed orifice diameters ranging from 1×10^{-4} through 1×10^{-7} inches in one order of magnitude increments. Tables 8-S1 (a) through (d) represent the results of applying equations (10) through (15) and are shown in Exhibit E-S1.

If an average velocity is assumed to act over the range of 343 psi to 50 psi, then the following summary in Table 9-S1 illustrates the time to exhaust the system:

TABLE 6-S1

INSTANTANEOUS VELOCITIES FOR VARIOUS CAGING PRESSURES

1	2	3	4
Line Item	Pressure lbs/in^2	$\sqrt{\text{Column (2)}}$	Velocity = 2481.48x(3) in./sec.
1	343	18.52	45957
2	333	18.25	45287
3	323	18.00	44667
4	313	17.69	43897
5	300	17.32	42979
6	290	17.03	42260
7	260	16.12	40000
8	230	15.17	37644
9	200	14.14	35088
10	170	13.04	32358
11	140	11.83	29355
12	110	10.49	26031
13	80	8.94	22184
14	50	7.07	17544

TABLE 7-S1

ASSUMED ORIFICE DIAMETERS

1	2	3	4
LINE ITEM	ASSUMED ORIFICE DIAMETER (INCHES)	[COLUMN (2)]^2	AREA = 0.785 [COL. (3)] (INCHES)^2
1	1×10^{-4}	1×10^{-8}	785×10^{-11}
2	1×10^{-5}	1×10^{-10}	785×10^{-13}
3	1×10^{-6}	1×10^{-12}	785×10^{-15}
4	1×10^{-7}	1×10^{-14}	785×10^{-17}

1×10^{-4} inches = 2.54 microns = 25400 Å
1×10^{-5} inches = 0.254 microns = 2540 Å
1×10^{-6} inches = 0.0254 microns = 254 Å
1×10^{-7} inches = 0.00254 microns = 25.4 Å

1 micron = 10^{-4} cm = 3.937×10^{-5} inches

1 Å = 10^{-8} cm = 3.937×10^{-9} inches

Table 9-S1 Comparison of Orifice Diameter to Time to Exhaust Caging Pressure System

1	2	3	4	5
Approximate Visibility Range	Orifice Size (Inches)	Orifice Size (Microns)	Orifice Size (Ångstrom Units)	Time to Exhaust System
(Minimal) Naked Eye	1×10^{-2}			~0.75 seconds
Light Optics	1×10^{-3}			~1-1/4 minutes
	1×10^{-4}	2.54	25400 Å	~2 hours
Electron Optics	1×10^{-5}	0.254	2540 Å	~8 days
	1×10^{-6}	0.0254	254 Å	~2 years and up
	1×10^{-7}	0.00254	25.4 Å	~200 years and up

The results listed in Table 9-S1 are also shown graphically in Figure 4-S1. It is interesting to note that the following relationship between orifice size and time to exhaust the system emerges: When the orifice size increases by one order of magnitude, the time required to exhaust the system decreases by two orders of magnitude.

When the data in Tables 8-S1 (a) through (d) and 9-S1 are examined, it is not difficult to see that an orifice of any significant magnitude will empty the system completely in a matter of seconds. On the other hand, if the orifice size is in the range where magnification is necessary to identify the opening, within the resolving power of light optics, the time to exhaust the system can vary from a few minutes to several hours. When the orifice becomes small enough that electron optics are necessary for identification, then the time to exhaust the system can vary from several days upwards to years.

When the times in Column 5, Table 9-S1 are considered in terms of the PSE requirements, in order to be acceptable, a virtually perfect close-off solder joint is necessary (in addition to the internal joints) because one is within an order of magnitude of where the diffusion process becomes effective. When diffusion finally becomes the dominant process, the limit of the material to retain gas under pressure has been reached (reference Exhibit F-S1 for additional discussion).

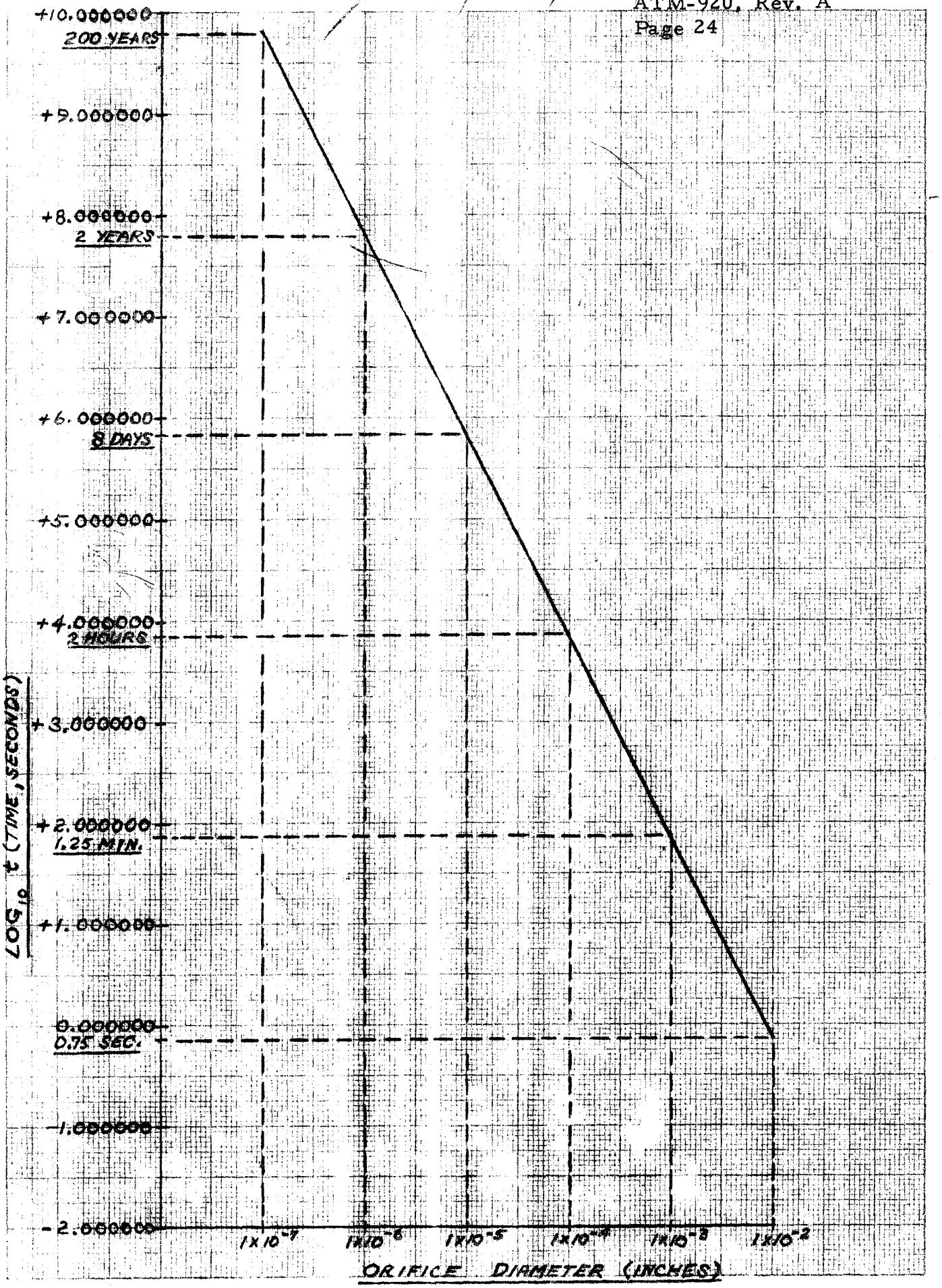

FIGURE 4-S1 — ORIFICE DIAMETER VS. TIME TO EXHAUST SYSTEM

Consider the converse situation, i.e., the conditions of initially obtaining an acceptable leak rate; then dislodging sufficient material only to the degree that the system remains within acceptable leakage limits. Such an event would require a number of fortuitous circumstances occurring, virtually, at the same time. The probability of this happening is rather small when one considers how the material would be dislodged. Some of the likely conditions are failure because of vibration from any number of extraneous sources, bumping, long-term creep or poor wetting (to name a few). Any, or all, of these can happen because of the inherent weaknesses in solder joints, particularly in this type of application. The probability of the opposite situation occurring is greater, i.e., dislodging sufficient material such that the system leaks at a rate greater than the acceptable limits. The likely modes of failure are such that the system would exhaust itself, in the worst case, in a matter of seconds and, at best, in a matter of a few weeks.

Based on the analysis of the recorded pressure data, and expected leak rates for various orifice sizes, the conclusion that the apparent abrupt changes in caging pressure cannot be attributed to leakage still remains intact. Furthermore, the following concluding statements also apply:

1. The pressurized caging subsystem is of such small volume that the system is very sensitive to changes in temperature.

2. The leak rate requirements are, by necessity, extremely tight because of the small capacity of the system.

3. It is not probable that an acceptable leak rate would change to an unacceptable leak rate; wherein, the unacceptable condition would extend over a long time period (more than a few weeks).

Accepting these remarks as valid, one must look elsewhere for the answer to the problem. One area which has not been examined is the pressure transducer. The construction of this component is such that one or several things could occur with time that would be symptomatic of the conditions currently being experienced by PSE SN03, for example, a shift in calibration, a zero shift, or a change in electrical characteristics.

When the entire pressurized caging system is examined, the pressure transducer represents the one link in the system wherein events could occur that would fit the current situation. Therefore, the principle recommendation

of this report is that a thorough examination of the pressure transducer currently installed in PSE SN03 be initiated. To check some of the points in question, will require that the system be depressurized. How far beyond this point it is desired to carry the investigation is not within the scope of this report, because this type of investigation is a step-wise procedure with each succeeding step being dependent on the results of the step immediately preceding it.

A further recommendation, not explicitly stated in ATM 920, is related to Engineering Procedures. Procedures which describe the handling of the instrument after the caging system is pressurized and closed-off should be modified to reflect pressure monitoring requirements. At a minimum, when to monitor, and recording of time and temperature with the corresponding pressure, should be included.

LIST OF EXHIBITS

A-S1 Operating Events Log, SN03, Pages 3 Through Page 18, (See ATM-920 for Pages 1 and 2).

B-S1 Hygro-Thermograph Charts from 10-30-70 Through 4-27-71, As Required (Only PSE Pressure Monitoring in PSE Lab Provides This Data).

C-S1 Tabulated Summary for Expected Values of Pressure at Given Temperatures (Curve Derivation and Calculation of 95% Confidence Limits).

D-S1 Tabulated Summary of Analysis for Pressure - Temperature Time Data From Table 4-S1 (Reference Page 16).

E-S1 Tabular Summary of Time to Exhaust System (Equations 10 Through 15, Pages 20 and 21).

F-S1 Existing PSE Leak Rate Requirements in Terms of the Current Analysis.

EXHIBIT A-S1

Operating Events Log, SN03, Pages 3 Through Page 18,
(See ATM-920 for Pages 1 and 2)

OPERATING [illegible]ENTS LOG

PROGRAM Ala.

ITEM	DATE	OPERATING OR EVENT DESCRIPTION	TEST ENG OR TECH	OPERATION TIME EVENT	OPERATION TIME TOTAL	Q.C. ACCEPTANCE
190	10/30/69	LOGBOOK REVIEWED BY Q.A & DCAS. FOUND WITH THE FOLLOWING OPEN ITEMS:				10-30-6[illegible]
		① O.E.L. LINE ITEM 186 - OPEN "D" STAMP - REF TO DR AB5324				
		② DR AB 5324 - REWORK TO REPLACE RADIATION SHEATH (W/O'S GENERATED & IN SSED LAB) UNACCOMPLISHED. (LIMITED HOLD UPTO BUT NOT INCLUDING T/V)				
					210.7 HRS.	
	12/16/69	POST DATED SUMMARY OF TOTAL RUN TIME —				
		1. TELEDYNE ORIGINAL ADP - 216.7 HRS.				
		2. TELEDYNE REWORK ADP - 162.6 "				
		3. BxA - "SSED" LOG BOOK - 429.07 "				
		4. BxA LOG BOOK - 210.7 "				
		SENSOR RUN TIME TOTAL: 1019.07 HRS.			1019.07 HRS.	
Since 2/9/70						
195	2/9/70	UNIT MOVED TO EXP LAB PER SHEET 4 OF DR 8457 FOR IST FOR A2	SLC			10/19/[illegible]
196	10/19/70	LOG BOOK REVIEWED BY QA & DCAS AND FOUND ACCEPTABLE FOR IST WITH FOLLOWING OPEN ITEMS				
		ITEM 190 OPEN ITEMS				
		DR AB 8457 USE THRU A2 ELECTRICAL TEST UP TO TN, DR 5324 APPLY LIMITED HOLD.	SLC		1019.07 HRS.	10/19/[illegible]

PART NUMBER 2334668/8460-5D S/N 03 REVIEWED BY [illegible]

PART NAME Passive Seismic Experiment Sensor

NEXT ASS'Y Sub-Pack I

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OPERATING NTS LOG

PROGRAM ACSC.

ITEM	DATE	OPERATING OR EVENT DESCRIPTION	TEST ENG OR TECH	OPERATION TIME EVENT	OPERATION TIME TOTAL	Q.C. ACCEPTANCE
197	10-23	PWR ON @ 00:12:32 hrs. TP 2346320				
	10/23	PWR OFF @ 07:32:00		7 HRS 20 MIN	326 HRS 24 MIN	
	10/23	~~PWR Stand by~~				
		PWR ON @ 09:13:35				
		OFF 10:11:03		54 MIN	1027 HRS 18 MIN	
		ON 11:15:00				10/23/70
		~~OFF~~ OFF 12:37:45 IST(TP2346320) COMPLETED		1 HR 22 MIN	1028 HRS 40 MIN	
						10/26/70
198	10-26	MOVED EM ET LAB TO SSED LAB 1115 HRS				
199	10/29	MOVED FROM SSED LAB TO EMI CHAMBER 2120				10/29/70
200	10/29	LOG BOOK REVIEWED BY QA & DCAS & FOUND ACCEPTABLE FOR THE EMI A2 TEST (NO CONSTRAINT) WITH THE FOLLOWING OPEN ITEMS				
		(1) OEL ITEM 186 - OPEN D STAMP. 11-19-70				
		(2) DR AB 5324 - LIMITED HOLD UP TO T/V closed 10-30-70				
		(3) DR AB 8457 - LIMITED HOLD THRU A-2 TESTING				ACCEPT 104 BxA
201	10-30	1715 HRS PSE CASING PRESSURE 149.9 mv @ 71°F				10-30-70
202	10/31	POWER ON @ 12:30:00 TP2333087				10-31-70
203	10/31	POWER ~~STDBY~~ OFF @ ET 11:34:30 TP2333087 COMPLETED		11 HRS 5 MIN	1039 HRS 45 MIN	

PART NUMBER 2334668/8-160-5D S/N 03 REVIEWED BY F. Sullivan 10-31-70

PART NAME P.S.E.

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OPERATING EVENTS LOG

PROGRAM ALSA

ITEM	DATE	OPERATING OR EVENT DESCRIPTION	TEST ENG OR TECH	OPERATION TIME EVENT	OPERATION TIME TOTAL	Q.C. ACCEPTANCE
203	10/31	1400 HRS PSE CASING PRESSURE 152.3 mv @ 74°F	[illegible]	11-10-70	1086 HRS 039 HRS 45 MIN	10-31-70
205	11/2	PSE MOVED FROM EMI CHAMBER TO SE LAB				
206	11/2	Pressure 150 mv At @ 73°F 1330	[illegible]			11-2
207	11/3	Pressure 149 mv At @ 71°F 1400	[illegible]			11-3
208	11/4	Pressure 148 mv At @ 71°F 1430	[illegible]			11-4
209	11/5	Pressure 149 mV At @ 71°F 1500	[illegible]			11-5
210	11/6	" 148 mV At @ 71°F 1415	[illegible]			11-6
211	11/6	PSE MOVED FROM SSED LAB TO COMPONENTS LAB FOR INSTALLATION ON SUB PACK I PER ITEM 5 OF TP 2333049	WK			11-6-70
212	11/06	PSE INSTALLATION ON SUB PACK-I (2344986 SN16) COMPLETE PER ITEM 5 OF TP 2333049	WK			11-6-70
213	11/06	Moved From CT LAB To EMI CHAMBER AREA IN PREP FOR MAG PROPS TP2333049 1635 HRS	[illegible]			11-06-70
214	11/07	MOVED FROM E.M.I. CHAMBER TO COMPONENTS LAB. (TP 2333049 Comp.)	WK			11-7-70
215	11/09/70	REMOVED SN3 PSE FROM S/P I A-2 2344986 SN16 + RETURNED TO SSED LAB	WK			11-9-70

PART NUMBER 2338460-5D S/N 3 REVIEWED BY [illegible]

PART NAME PSE - SENSOR

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OPERATING [illegible]NTS LOG

PROGRAM ALSO

ITEM	DATE	OPERATING OR EVENT DESCRIPTION	TEST ENG OR TECH	OPERATION TIME EVENT	OPERATION TIME TOTAL	Q.C. ACCEPTANCE
216	11/9/70	MOVED PSE FROM COMPONENTS LAB TO SSED LAB	JCK		1026 HRS ~~10 MIN~~ 1239 HRS 45 MIN	
217	11/9/70	PSE PRESSURE TEMP °F 72°F mv 151.0	AJ	11-9-70		11-9
218	11/10/70	Pressure 149.1 Temp 71° F	LJB			11-10
219	11/10/70	UNIT MOVED FROM SSED LAB TO EXP. LAB FOR A-2 MIST PER TP 2338600	JB			11-10-70
220	11/10	PRESSURE CHECK PER MIST TP 2338600 -150.0 MV = 325 PSI	JR			11-10-70
221	11/11	POWER ON @ 0135 HRS TP 2338600 POWER OFF @ 0214 HRS TP 2338600 COMPLETED (A-2 MIST)	JR	11-11-70 39 min	1040 1027 HRS ~~19~~ MIN 24	11-11-70
222	11/11/70	PSE MOVED FROM EXP LAB TO SSED LAB	WN			11-11-70
223	11/12/70	Pressure 149.8 MV TEMP 71°	LJB			11-12-70
224	11/13/70	Pressure 149.2 MV Temp 70°	LJB			11-13-70
225	11/14/70	PRESSURE 149.2 MV TEMP. 70°	JJ			11-14
226	11/17/70	Pressure 149.3 temp 72°	LJB			11-17

PART NUMBER 2338460-50 S/N 3 REVIEWED BY [illegible]

PART NAME PSE - SENSOR

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OPERATING EVENTS LOG

PROGRAM ALS

ITEM	DATE	OPERATING OR EVENT DESCRIPTION	TEST ENG OR TECH	OPERATION TIME EVENT	OPERATION TIME TOTAL	Q.C. ACCEPTANCE
227	11/19/70	Performed 6.1.3 OP 2333043 (Released enclosure Pressure)	[illegible]		2646 Hrs 244 Min	11-19-70
228	11/19/70	LOG BOOK REVIEWED BY QA + DCAS. FOUND ACCEPTABLE FOR ATA/N TESTING. NO CONSTRAINT WITH THE FOLLOWING OPEN ITEM: ① DR AB 8457 - LIMITED HOLD THEN A-2 TESTING	[illegible]			11-19-70
229	11/19/70	PSE MOVED FROM PSE LAB TO COMP. TEST AREA.	WK	—	—	11-19
230	11/20/70	SHROUD ASSY SN10, RADIATION BARRIER & MTG HDWR INSTALLED ON SN3 P.S.E. to BECOME 2338460-5 SN1. PER WODS IN THIS LOG. SYSTEM ACESS PORT TUBE CUT PER ABOVE WODS [redacted]	[illegible]			11-20
231	11-20	Moved From CT LAB To T/V 20'X27' CHAMBER AREA	WK			11-20-70
232	11-20	Deployed on Lunar Surface in 20'X27' CHAMBER PER TP 2345115 1900 HRS	WK			11-20-70
233	[illegible]					
234	11-20-70	[redacted] PSE THERMAL SHROUD GIRDLE REMOVED FROM T/V LAB AND STORED IN COMP. LAB.	WK			11-20-70

PART NUMBER 2338460-50 S/N 3 REVIEWED BY [illegible]

PART NAME PSE- SENSOR

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OPERATING NTS LOG

PROGRAM ALSC

ITEM	DATE	OPERATING OR EVENT DESCRIPTION	TEST ENG OR TECH	OPERATION TIME EVENT	OPERATION TIME TOTAL	Q.C. ACCEPTANCE
234	11-20	UNIT MOVED FROM C.T. TO ENV AREA	WK		.040 HRS 24 MIN	
235	11-20	UNIT INSTALLED DEPLOYED ON T/V CHAMBER LUNAR SURFACE	WK			11-20-70
236	11-21	PSE PRESSURE CHECK 148.3 MV 2240 HRS	WK			11-21-70
237	11/22	EXP #1 PWR ON @ 326 02:47:55	WK			11-22-70
238	11/23	PSE PRESSURE CHECK 152.8 1320	WK			11-23-70
239	11/23	EXP #1 PWR OFF @ 15:39:47	WK	36 HRS 52 MIN	.077 HRS 16 MIN	
240	11/23	EXP #1 PWR ON @ 16:39:10				
		OFF @ 18:49:12		2 HRS 10 MIN	.074 HR 26 MIN	
		ON @ 19:21:32				11-23-70
		OFF @ 20:42:43	JB	1 HR 21 MIN	.080 HR 17 MIN	116 BX4
241	11/24	PSE PRESSURE CHECK @ 1105 HRS — 148.0 MV, 68°F	WK			
242	11/1/70	PSE PRESSURE CHECK @ 15:27 — 151.6 mV 332 psi	SEK			
243	12-01	POWER ON @ 1723 HRS - LUNAR MORN T/P 345115 PSI = 1016	HK			12-01-
244	12-02	PSE PRESSURE CHECK @ 22:06 — 165.1 mV 357 psi	[illegible]			

PART NUMBER 2338460-50 S/N 3 REVIEWED BY L. Sullivan

PART NAME PSE - SENSOR

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OPERATING [illegible]NTS LOG

PROGRAM ALSEP

ITEM	DATE	OPERATING OR EVENT DESCRIPTION	TEST ENG OR TECH	OPERATION TIME EVENT	OPERATION TIME TOTAL	Q.C. ACCEPTANCE
245	12/02	POWER OFF @ 23:15:10	RRK	29 HR 32 MIN	1010 HRS 39 MIN	
						12-02-70
246	12-02	PWR. ON @ 23:48:17	RRK			
						12-02-70
247	12-03	PWR OFF @ 19:18:40	RRK	19 HR 30 MIN	1130 HRS 09 MIN	
						12-03-70
248	12-4	PWR ON @ 10:16:	RRK			
249	12-5	PWR OFF @ 18:57	RRK	32 HRS 31 MIN	1152 HRS 40 MIN	
						12-05-70
250	12-5	PWR ON @ 19:17	RRK	33 HRS 02 MIN		
						12-05-70
251	12-07	PRESSURE CHECK @ 1220 HRS = 165.1 mv	LL			12-07-70
252	12-08	POWER OFF @ 19:41 HRS	RRK	72 HRS 21 MIN	1235 HRS 04 MIN	12-08-70
						12-08-70
253	12-08	POWER ON @ 20:01 HRS	RRK			
254	12-09	PRESSURE CHECK @ 1200 HRS = 165.2 mv	LL			12-08-7[illegible]
255	12-09	PRESSURE CHECK @ 1400 HRS = 165.7 mv	LL			12-08-7[illegible]
256	12-10	PRESSURE CHECK @ 1015 HRS = 163.8 mv	LL			12-08-7[illegible]

PART NUMBER 2338460-50 S/N 3 REVIEWED BY W. Karns

PART NAME PSE - SENSOR

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OPERATIN[illegible]NTS LOG

PROGRAM ALSEP

ITEM	DATE	OPERATING OR EVENT DESCRIPTION	TEST ENG OR TECH	OPERATION TIME EVENT	OPERATION TIME TOTAL	Q.C. ACCEPTANCE
257	12-11	PRESSURE CHECK @ 1230 HRS — 164.7 MV	LL			12-11-70
258	12-11	POWER OFF @ 2203 HRS	LL	74 HRS 02 MIN	1304 HRS 06 MIN	12-12-70
259	12-12	POWER ON @ 0845 HRS	LL			12-12-70
260	12-12	PRESSURE CHECK @ 1230 HRS — 151.4 MV	LL			12-12-70
261	12-13	POWER OFF @ 0412 HRS T.P. 2345115 Comp.	LL	19 HRS 27 MIN	1328 HRS 33 MIN	12-13-70
262	12-17	POWER ON @ 1611 HRS TROUBLESHOOTING PER DR AB9249	LL			
		OFF @ ~~1635 HRS~~ LL 1714 HRS		1 HRS 03 MIN	1329 HRS 36 MIN	
		ON @ ~~1850 HRS~~ LL 1801 HRS				
		OFF @ 1832 HRS		31 MIN	1330 HRS 07 MIN	
		ON @ 1850 HRS				
		OFF @ 1912 HRS		22 MIN	1330 HRS 29 MIN	12-17-70
263	12-21	POWER ON @ 1331 HRS TROUBLESHOOTING PER DR AB9249	LL			
		OFF @ 1502 HRS		1 HR 31 MIN	1332 HRS 00 MIN	
		ON @ 1732 HRS				
		OFF @ 1745 HRS		13 MIN	1332 HRS 13 MIN	
		ON @ 2007 HRS				
		OFF @ 2129 HRS		1 HR 22 MIN	1333 HRS 35 MIN	12-21-70

PART NUMBER 2338460-50 S/N 03 REVIEWED BY L. [illegible]

PART NAME PSE SENSOR

NEXT ASS'Y SP I

PAGE 10 OF

BxA 218B

OPERATIN ENTS LOG

PROGRAM ALSEP

ITEM	DATE	OPERATING OR EVENT DESCRIPTION	TEST ENG OR TECH	OPERATION TIME EVENT	OPERATION TIME TOTAL	Q.C. ACCEPTANCE
~~250~~ 264	12/22	PSE REMOVED FROM TV CHAMBER & MOVED TO PSE LAB	WK			
		SHROUD REMOVED FROM SENSOR AND RETURNED TO OMT. LAB.				
265	1/6/71	LOG BOOK REVIEWED BY QA AND DCAS. FOUND				
		ACCEPTABLE FOR PIA TEST PER MEMO 978-10-3553				
		DTD 12/21/70 FROM D BRESEKE. NO CONSTRAINT TO				
		TEST WITH THE FOLLOWING OPEN ITEMS:				
		W003 2338016-501 OPER 220 & 230.				1/6/70
		DR 8743 - L.H USE THRU FINAL MIST				
		DR 8457 - L.H. THRU A-2 TESTING	WK			
266	1/12/71	Started PIA 2333019 Per DR 9402 & Completed			1333 / 35M	1-12-71 ACCEPT 107 BxA
		Thru Page 8 PARA 6.3.6 with 1 VARIATION.	WK			
267	1/13/71	Cont'd PIA 2333019. Power on 07:45				1/13/71 ACCEPT 107 BxA
		Power off 13:30	WK	5 HR 15M	1337 / 20	
268	1/13/71	Test Completed with TDR 0693 written but	WK			1/13/71 ACCEPT 107 BxA
		Not Cleared satisfactory to DCAS.				
269	1/13/71	TDR 0693 Cleared off with DCAS T.P. 2333019 Comp.	WK			1/13/71 ACCEPT 107 BxA
270	1/13/71	Log Book Reviewed by QA & DCAS AFTER PIA TESTING				

PART NUMBER 2338460-SD S/N 3 REVIEWED BY E. Clark

PART NAME PSE SENSOR

NEXT ASS'Y SP I

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1-13-71

BxA 218B

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OPERATING [illegible]NTS LOG

PROGRAM ALSEP

ITEM	DATE	OPERATING OR EVENT DESCRIPTION	TEST ENG OR TECH	OPERATION TIME EVENT	OPERATION TIME TOTAL	Q.C. ACCEPTANCE
270 (CONT)	1/13/71	And The Following Items ARE OPEN				1-13-71
		1. DR 8703 L.H. use thru Final mist				ACCEPT 107 BXA
		2. DR 8457 L.H. Thru D ARRAY Testing	WP			
		2LC				
271	01/13/71	Moved From PSE LAB To E.T. LAB @ 1910 HRS For INTEGRATION To "D" ARRAY C.S.E. PER TP 2346331				01-13-71
272	01/14	EXP. PWR ON @ 1800 HRS	EK			1/14/71
273	01/14/71	GENERATED DR AB 9230-DECREASE IN RESERVE POWER O.T.	EK			1/14/71
274	01/14	EXP PWR off @ 2052 HRS		2 HRS 52 MIN	1342 HRS 12 MIN	01-14-71
275	01/15	EXP PWR ON @ 1054 HRS TP2346331				
		off @ 1109 HRS		15 MIN	1342 HRS 27 MIN	
		ON @ 1339 HRS				
		off @ 1623 HRS		2 HRS 44 MIN	1345 HRS 11 MIN	
		ON @ 1637 HRS				
		off @ 2359 HRS		7 HRS 22 MIN	1352 HRS 33 MIN	01-15-71
276	01/16	EXP POWER ON @ 0035 HRS				JAN 16 1971
		off @ 0323 HRS TP2346331 COMPLETE		2 HRS 48 MIN	1355 HRS 21 MIN	

PART NUMBER 2338460-50 S/N 03 REVIEWED BY E. Clark

PART NAME PSE SENSOR

NEXT ASS'Y SP I PAGE 12 OF

XA 218B

ATM-920 Rev. A Page 38

OPERATING [illegible]ENTS LOG

PROGRAM ALSEP

ITEM	DATE	OPERATING OR EVENT DESCRIPTION	TEST ENG OR TECH	OPERATION TIME EVENT	OPERATION TIME TOTAL	Q.C. ACCEPTANCE
277	1/18/71	Thermal Shroud SN-10 Unstowed For Re-inspection Ref. DR AB 8743				1-18-71
278	1/20/71	Exp. Power ON @ 1903 Hrs. Troubleshooting Per DR AB 9249				
		off @ 2040 Hrs.		1 HR. 37 min	1356 HRS 58 min	01-20-71
		ON @ 2116 Hrs.				
		off @ 2305 Hrs.		1 HR. 49 min.	1358 HRS 47 min.	01-20-71
279	1/21/71	Exp. Power ON @ 1330 Hrs Trouble shooting Re DR AB 9249				
		OFF @ 1735		4 HRS 5 min	1362 HRS 52 min	01-21-71
280	1/22/71	Exp Power ON @ 1648 Hrs. Trouble shooting Per DR AB 9249				
		OFF @ 1812 Hrs.		1 HR. 24 min	1364 HRS 6 min.	01-22-71
281	1/23/71	Exp. Power ON @ 2136 Hrs. Per DR AB 9249				
		OFF @ 2142 Hrs.		6 min	1364 HRS. 12 min.	01-23-71
282	1/23/71	DR AB 9322 PSE Pattern 11100 caused M.F. Loss	ECK			1/23/71
283	1/23/71	Exp Power ON @ 2151 Hrs. Per DR AB 9322 & 9249	ECK			1/23/71
		OFF @ 1114 Hrs ON 01-25-71		37 HRS 23 min	1401 HRS. 29 min.	
284	1/25/71	Exp. Power ON @ 1348 Hrs. Per DR AB 9249				
		OFF 1620 Hrs.		2 HRS. 32 min	1406 HRS 1 min	1/25/71

PART NUMBER 2338460-5D S/N 03 REVIEWED BY E. Clark

PART NAME PSE Sensor

NEXT ASS'Y SP I PAGE 13 OF

BxA 218B

OPERATING NTS LOG

PROGRAM ALSEP

ITEM	DATE	OPERATING OR EVENT DESCRIPTION	TEST ENG OR TECH	OPERATION TIME EVENT	OPERATION TIME TOTAL	Q.C. ACCEPTANCE
285	1-25-71	EXP. POWER ON @ 16:36 HRS. PER. DR AB 9249			1404 HRS. 1 MIN.	
		OFF @ 19:21 HRS.	WK	2 HRS. 45 MIN.	1406 HRS. 46 MIN.	1-27-71
286	1-27-71	EXP. POWER ON @ 23:27 HRS			3-1-71	
287	1-28-71	EXP POWER OFF @ 02:59 HRS.	WK	3 HRS. 32 MIN.	1410 ~~1409~~ HRS 18 MIN	1-28-71
		ON @ 03:25 HRS.			1410	
		OFF @ 03:58 HRS.		0 HRS. 33 MIN.	~~1409~~ HRS 51 MIN	1-28-71
288	1-29-71	MOVED EXP. FROM EXP. TEST LAB. TO P.S.E. LAB.	RRR			1-29-71 ACCEPT 9
289	2-3-71	GENERATED D/R AB 9616. THERMAL PAINT CRACKED AND CHIPPED AT GNOMON HINGE AND DECALS PEELING FROM GIRDLE. REF. D/R ONLY.	WK		2-3-71	ACCEPT 21 DWA
290	2-4-71	THERMAL SHROUD HAS BEEN STOWED PER PROCEDURE 2337084-G PARA 6.4 TO 6.4.22	D.E.P.			2-4-71 ACCEPT 19 EXA
291	2-5-71	MOVED PSE SENSOR FROM PSE LAB TO COMPONENTS LAB FOR INSTALLATION ON SUB PACK I S/N 16	LoB		2-5-71	ACCEPT 32 ED 21
292	2/16/71	Thermal Shroud moved From PSE LAB TO Components LAB S/N 10 Per DR 2847	WK		3-1-71 1410 ~~1409~~ HRS 51 MIN	2-16-71 ACCEPT 107 BM

PART NUMBER 2338460-5D S/N 03 REVIEWED BY W. Kane

PART NAME PSE SENSOR

NEXT ASS'Y SPI

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3xA 218B

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OPERATING EVENTS LOG

PROGRAM _____

ITEM	DATE	OPERATING OR EVENT DESCRIPTION	TEST ENG OR TECH	OPERATION TIME EVENT	OPERATION TIME TOTAL	Q.C. ACCEPTANCE
293	2/22/71	POST ENTRY FOR 2/09/71: UNIT MOVED FROM C.T TO EXP LAB FOR CF2	WK	4-1971	109 HRS 4 MIN 1410 HRS 51 MIN	2/22/71
294	2/22/71	POST ENTRY FOR 2/09/71: UNIT REMOVED FROM SP I PER CF2	WK			2/22/71
295	2/22/71	LOG BOOK REVIEWED BY QA & DCAS - FOUND ACCEPTABLE FOR MIST. NO CONSTRAINT TO TEST WITH THE FOLLOWING OPEN ITEMS: WOOS 2338016-501 OPER 220 & 230 WOOS 2338460-5 OPER 40 & 50 WOOS 2338794-3 OPER 33-50 & 60 DR AB 8457 - DISPO - L.H. THRU A2 & D ARRAY TESTING DR AG 9616 - DISPO - L.H UP TO SHIPMENT	WK			2-22-71
296	2/23/71	POWER ON @ 0718 HRS PER TP 2338600 OFF @ 0758 HRS TP 2338600 Comp.	MS MS	40 MIN.	1418 HRS 31 MIN.	2-23-71 2-23-71
297	2-25-71	LOG REVIEWED BY QA & DCAS AND FOUND ACCEPTABLE FOR "D" ARRAY TROUBLESHOOTING PER DR AB 9330 WITH THE FOLLOWING OPEN ITEMS: WOOS 2338016-501 OPER 220 & 230 WOOS 2338460-5 OPS 30, 40 & 50				

PART NUMBER 2338460-5D S/N 03 REVIEWED BY [signature]

PART NAME PSE SENSOR

NEXT ASS'Y SP I PAGE 15 OF 41

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OPERATING EVENTS LOG

PROGRAM AL-EP

ITEM	DATE	OPERATING OR EVENT DESCRIPTION	TEST ENG OR TECH	OPERATION TIME EVENT	OPERATION TIME TOTAL	Q.C. ACCEPTANCE
297	CONTINUED.	closed 9-2-70				
		WOOS 2338794-3 OPS ~~35~~, 50, 60			3-15-71	
		WOOS QC #23903 OPS 210			1411	
		DR AB8457 - L.H. THRU A2+D TESTING			~~1416~~ HRS	
		AB9616 - L.H. UP TO SHIPMENT	SLC		31 MIN	3-25-71
298	3-03-71	MOVED UNIT FROM ALSEP TEST LAB TO P.S.E. LAB.	RRK			ACCEPT 3-03-71
299	03-12-71	CONNECT PSE SN03 TO CSE SN01 FOR TROUBLE SHOOTING PER DRAB9831				3/12/71
		SHEET'S 15 & 16 POWER ON 2300 POWER OFF 24:30	WK	1 hr 30 MIN	1413 HRS 01 MIN	05
300	3/3/71	S/N 03 SENSAR DISCONNECTED & RETURNED TO				3/13/71
		STORAGE AREA IN CLEAN ROOM	WK			05
301	3/15/71	LOG BOOK REVIEWED BY QA: DCAS FOUND with following:				
		1) WOOS 2338794-3, QC 22623				
		a) OPS 50:60 OPEN.				
		2) WOOS 2338460-5, QC 24734				
		a) MB ITEMS 4/15 17, 18, 19, 20 OPEN: NO QUANTITY ISSUE				
		b) OP 20 OPEN D STAMP				
		c) OPS 30, 40: 50 OPEN				
		(CONTINUED)				

PART NUMBER 2338460-5D S/N 03 REVIEWED BY W. Karns

PART NAME PSE SENSOR 3-15-71

NEXT ASS'Y SP#1 PAGE 16 OF

BxA 218B

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OPERATING [illegible]NTS LOG

PROGRAM AL-P

ITEM	DATE	OPERATING OR EVENT DESCRIPTION	TEST ENG OR TECH	OPERATION TIME EVENT	OPERATION TIME TOTAL	Q.C. ACCEPTANCE
					1413 HRS 01 MIN	
301 CONT	3/15/71	3) WOOS 2338460-5, QC 23998				
		~~a) MB ITEM 10 OPEN~~ 04-05-71				
		b) OPS ~~10~~ 20 : 40 OPEN 06-05-71				
		~~4) WOOS 2338016-501, QC 23903~~				
		~~a) OPS 210, 220 : 230 OPEN~~ 3-30-71				
		5) OPEN DR's:				
		a) AB 8457 - L.H. THRU D TESTING.				
		b) AB 9616 - L.H. ~~THRU~~ UP TO SHIPMENT 3-15-71				
		THE ABOVE OPEN ITEMS ARE NO CONSTRAINT TO NEXT SCHEDULED TESTING.	WK		1413 HRS 01 MIN	3-15-71
302	3/21/71	Pressure Monitored 141 MV = 308 PSIG	[illegible]			3/21/71
303	3/21/71	UNIT MOVED FROM PSE LAB TO EMI CHAMBER PER DR AB 9257	WK			3/21/71
304	3/24/71	UNIT MOVED FROM EMI CHAMBER TO PSE LAB PER DR AB 9257	MS			3-24-71
305	3-27-71	UNIT MOVED FROM PSE LAB. TO EMI. CHAMBER FOR TROUBLESHOOTING PER DR AB 9257.	RRK			3-27-71
306	3-27-71	UNIT MOVED TO TEST LAB FROM EMI CHAMBER PER DR AB 9257	MS		1413 HRS 01 MIN	3-27-71

PART NUMBER 2338460-5D S/N 03 REVIEWED BY [illegible]

PART NAME PSE SENSOR

NEXT ASS'Y SP #1

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3xA 218B

OPERATING NTS LOG

PROGRAM ALS.

ITEM	DATE	OPERATING OR EVENT DESCRIPTION	TEST ENG OR TECH	OPERATION TIME EVENT	OPERATION TIME TOTAL	Q.C. ACCEPTANCE
307	3-29-71	PRESSURE MONITORED -143 MV = 311 P.S.I.G.	RRK		1413 HRS 01 MIN	ACCEPT 69 BXA 3-29-71
308	4-01-71	PRESSURE MONITORED -143 MV = 311 P.S.I.G.	RRK			ACCEPT 59 BXA 4-01-71
309	4/3/71	MOVED FROM EXP LAB TO EMI CHAMBER	JEK			4-3-71
310	4/5/71	PRESSURE MONITORED -142.4 mV = 310 P.S.I.G.	[illegible]			04-05-71
311	4-6-71	PWR ON @ 23:15:15 PER DRAB9257 OFF @ 23:23:50	OJT	9 MIN	1413 HRS 10 MIN	04-06
312	04/07	PRESSURE MONITORED - 142.6 mV = 310 PSIG	LL			ACCEPT 97 BXA
313	04/12/71	PRESSURE MONITORED -140.0 mV = 305 PSIG 74°F	JEK			4-12-71
314	04/13/71	PRESSURE MONITORED -139.6 mV = 303 PSIG 76°F	[illegible]			04-13-71
315	04/14/71	PRESSURE MONITORED -142.2 mV = 310 P.S.I.G. 71°F	[illegible]			04-14-71
316	04/14/71	MOVED FROM EMI CHAMBER TO PSE LAB. 0855 HRS	[illegible]			04-14-71
					1413 HRS 00 MIN	

PART NUMBER 2338460-5D S/N 03 REVIEWED BY A M Christ

PART NAME PSE SENSOR

NEXT ASS'Y SP #1

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3xA 218B

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EXHIBIT B-S1

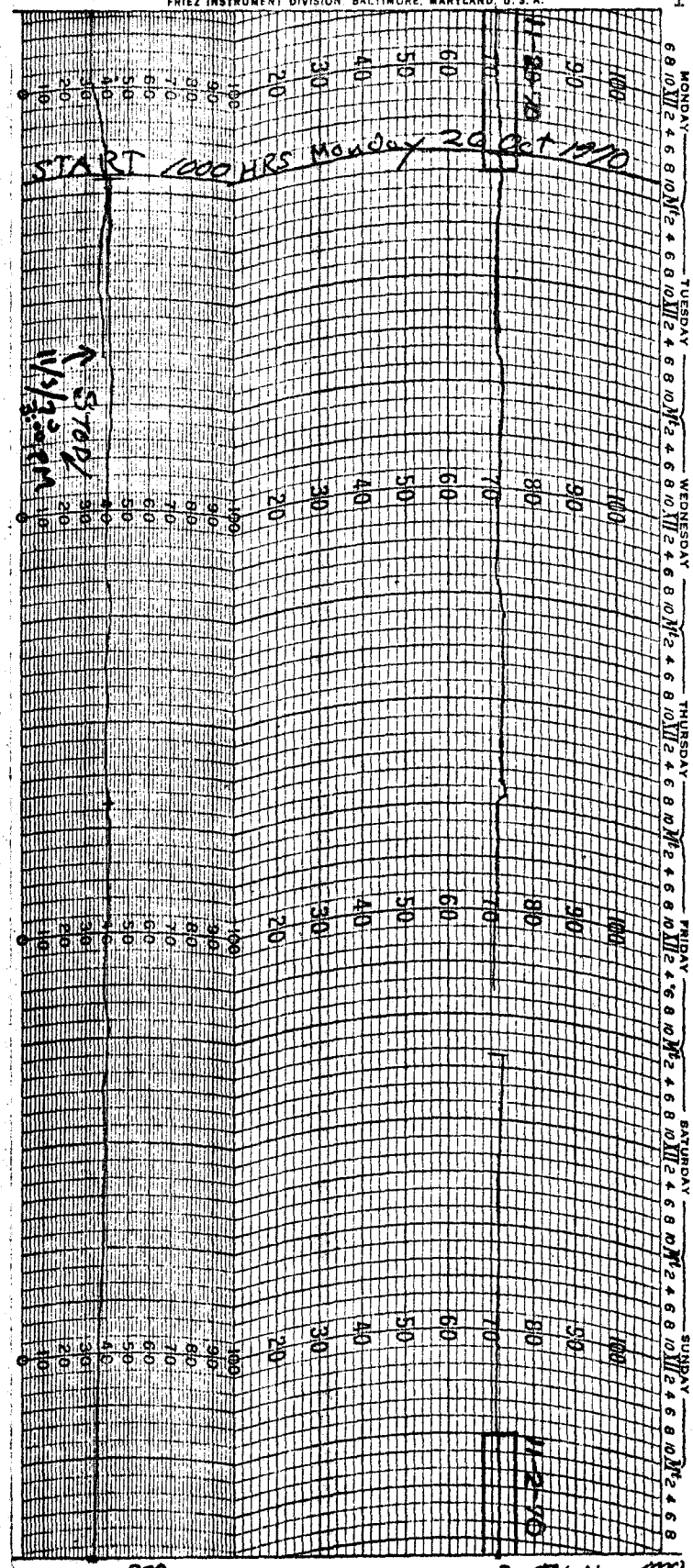
Hygro-Thermograph Charts from 10-30-70 Through 4-27-71, As Required (Only PSE Pressure Monitoring in PSE Lab Provides this Data).

WHEN ORDERING BINDER FOR THIS CHART SPECIFY PART NO. 502392

HYGRO-THERMOGRAPH
CHART NO. 207-W8

PART NO. 502495 PRINTED IN U.S.A.

174 HOURS
USE NO. 1-B-T PEN
THE BENDIX CORPORATION
FRIEZ INSTRUMENT DIVISION, BALTIMORE, MARYLAND, U.S.A.



INSTRUMENT NO. BSD 51457 STATION SSE Clean Rm #1 DATE 20 Oct 70 Mon 1000

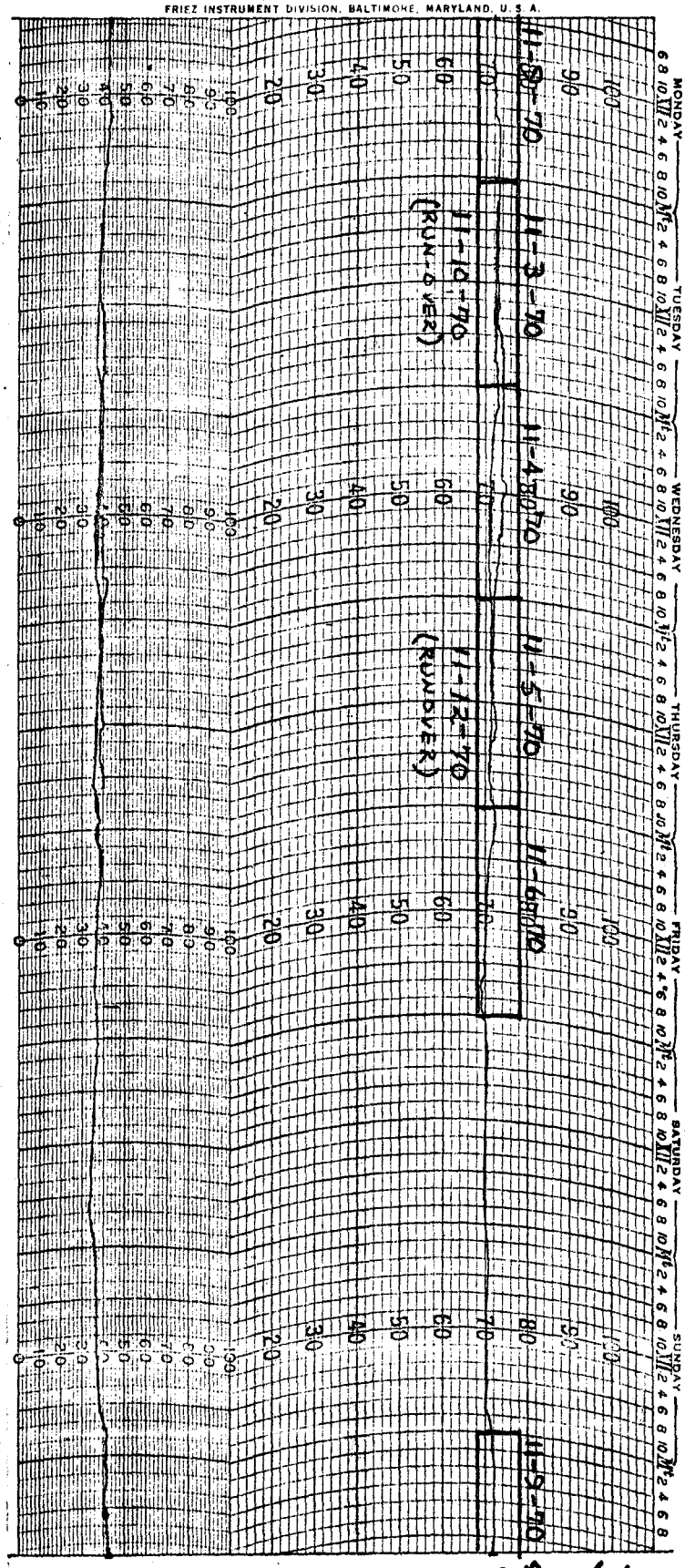
REMARKS ONE WEEK

WHEN ORDERING BINDER FOR THIS CHART SPECIFY PART NO. 502392

HYGRO-THERMOGRAPH
CHART NO. 207-WB

PART NO 502408 PRINTED IN U.S.A.

176 HOURS
USE NO 1 BT PEN
THE BENDIX CORPORATION
FRIEZ INSTRUMENT DIVISION, BALTIMORE, MARYLAND, U.S.A.



INSTRUMENT NO. 51457 STATION PSE Clean Room DATE 11/3/70

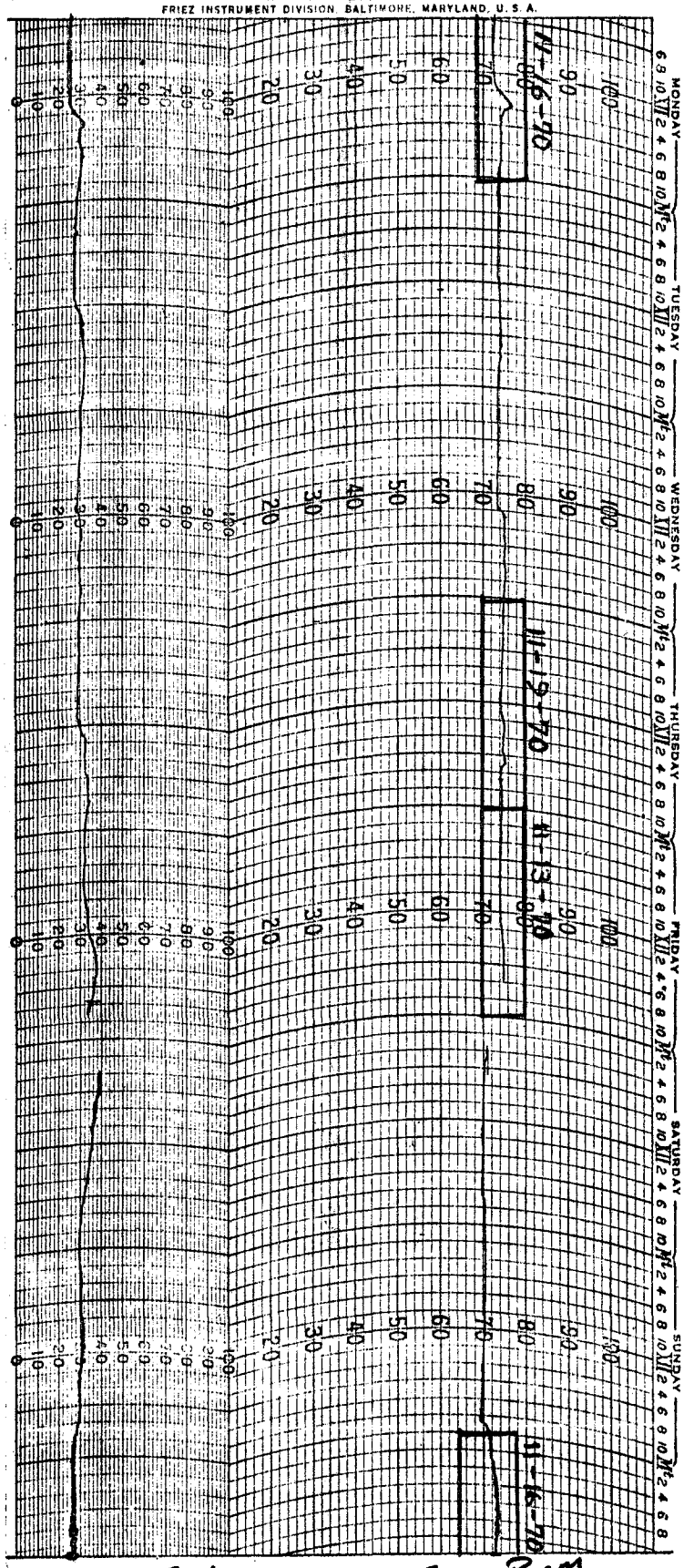
REMARKS

WHEN ORDERING BINDER FOR THIS CHART SPECIFY PART NO. 502392

HYGRO-THERMOGRAPH
CHART NO. 207-WB

176 HOURS
USE NO. 1-B-T PEN
THE BENDIX CORPORATION
FRIEZ INSTRUMENT DIVISION, BALTIMORE, MARYLAND, U.S.A.

PART NO. 502495 PRINTED IN U.S.A.



INSTRUMENT NO. 51457 STATION PSE Clean Room DATE 11-13-70

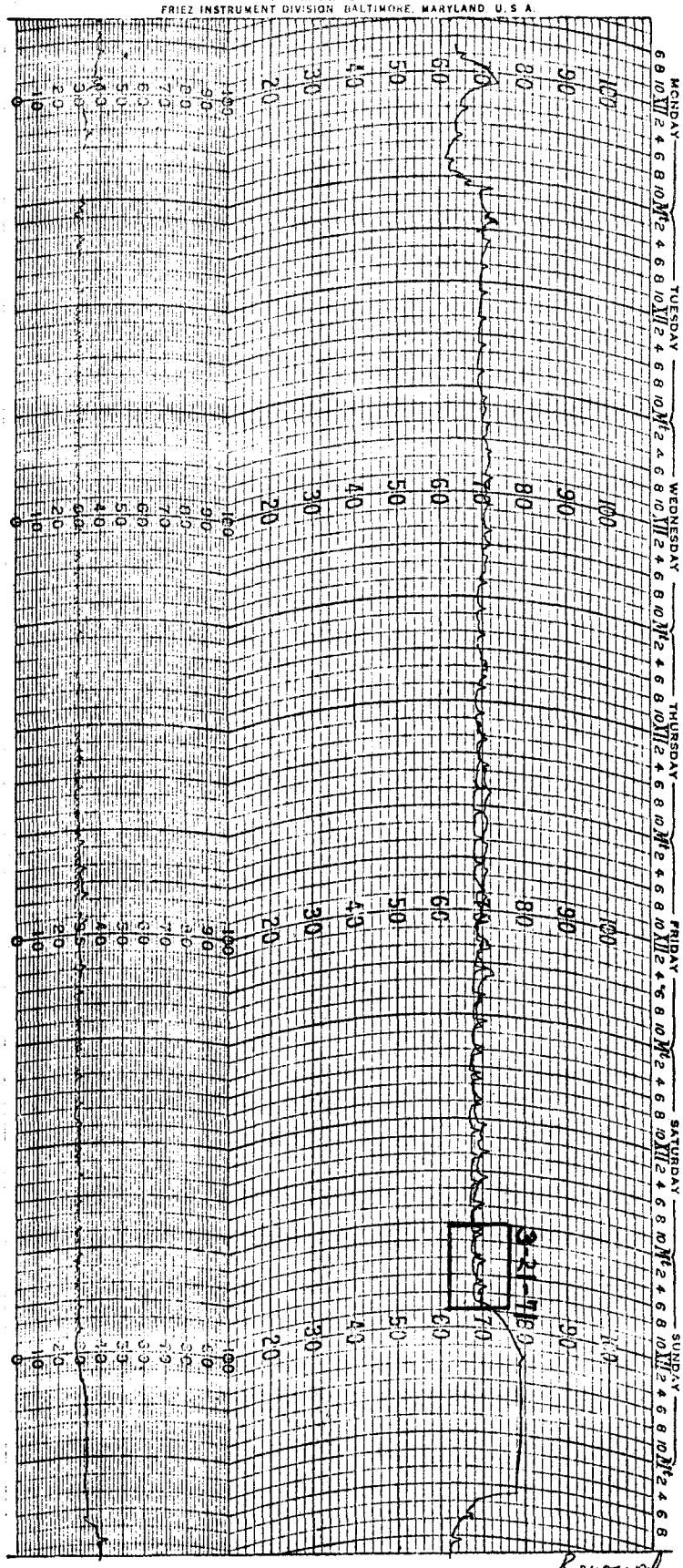
REMARKS

WHEN ORDERING BINDER FOR THIS CHART SPECIFY PART NO. 502392

HYGRO-THERMOGRAPH
CHART NO. 207-WB

PART NO. 502495 PRINTED IN U.S.A.

176 HOURS
USE NO. 1-R-T PEN
THE BENDIX CORPORATION
FRIEZ INSTRUMENT DIVISION BALTIMORE, MARYLAND U.S.A.



INSTRUMENT NO. ..... STATION SSED Clean Room DATE 3-21-71 Removed

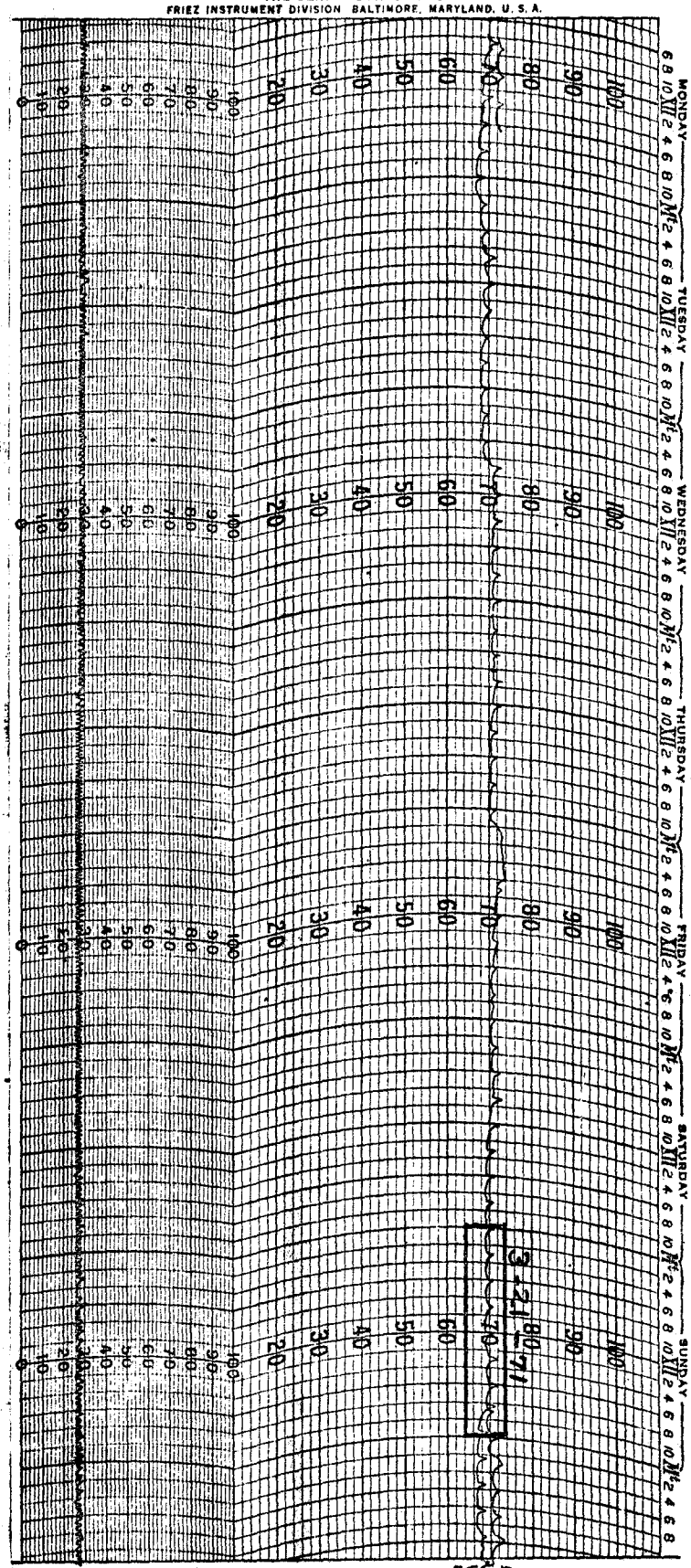
REMARKS .....

WHEN ORDERING BINDER FOR THIS CHART SPECIFY PART NO. 502382

HYGRO-THERMOGRAPH
CHART NO. 207-WB

PART NO 502495 PRINTED IN U.S.A.

176 HOURS
USE NO. 1-B-T PEN
THE BENDIX CORPORATION
FRIEZ INSTRUMENT DIVISION BALTIMORE, MARYLAND, U. S. A.



INSTRUMENT NO. 5/4157 STATION Pat Run #1 55 E.B. DATE 22 Mar 71

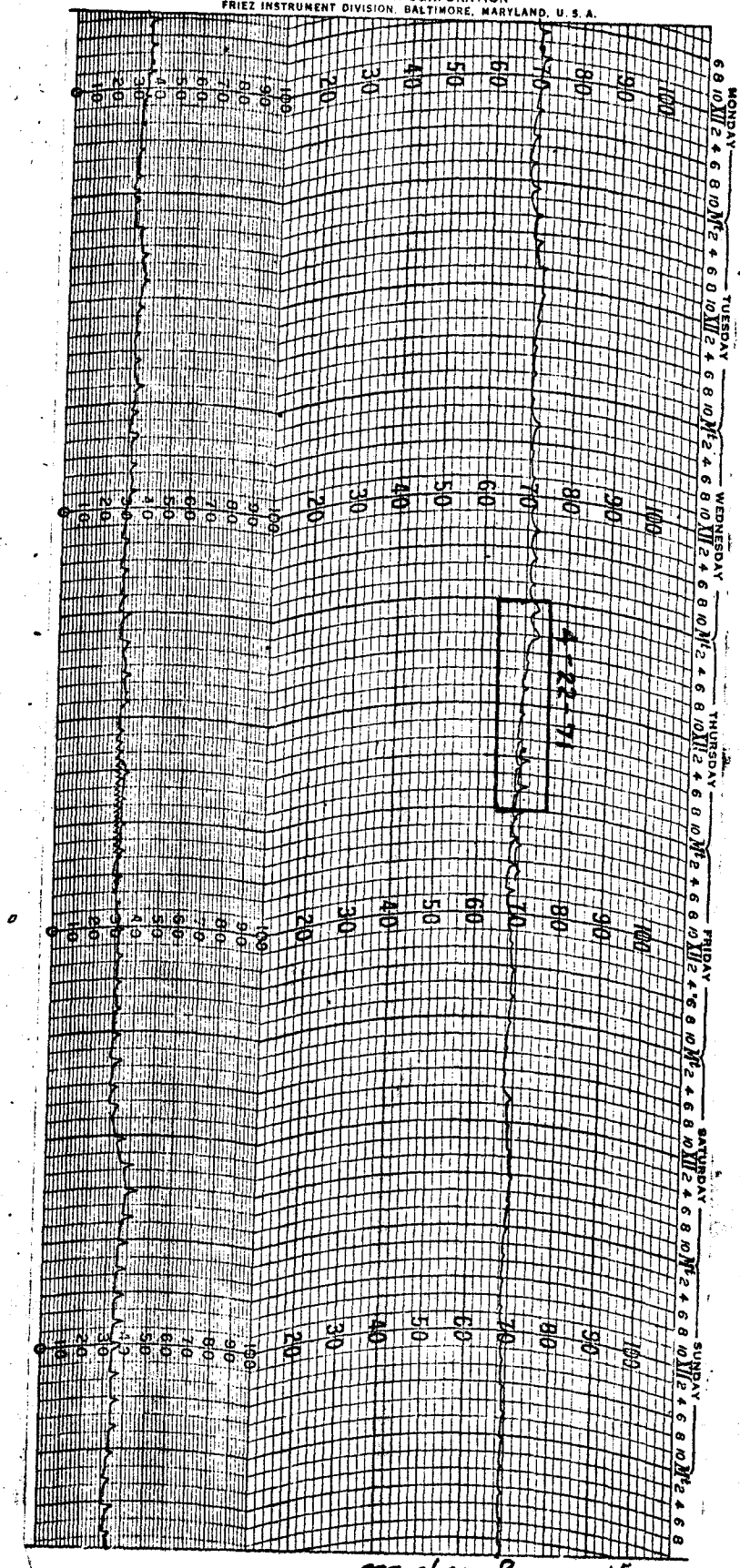
REMARKS one week

WHEN ORDERING BINDER FOR THIS CHART SPECIFY PART NO. 502392

HYGRO-THERMOGRAPH
CHART NO. 207-WB

PART NO 502495 PRINTED IN U.S.A.

174 HOURS
USE NO 1-B-7 PEN
THE BENDIX CORPORATION
FRIEZ INSTRUMENT DIVISION, BALTIMORE, MARYLAND, U.S.A.



INSTRUMENT NO. 51457 STATION SSE clean Rm Pt Rm # 1 DATE 4-15-71

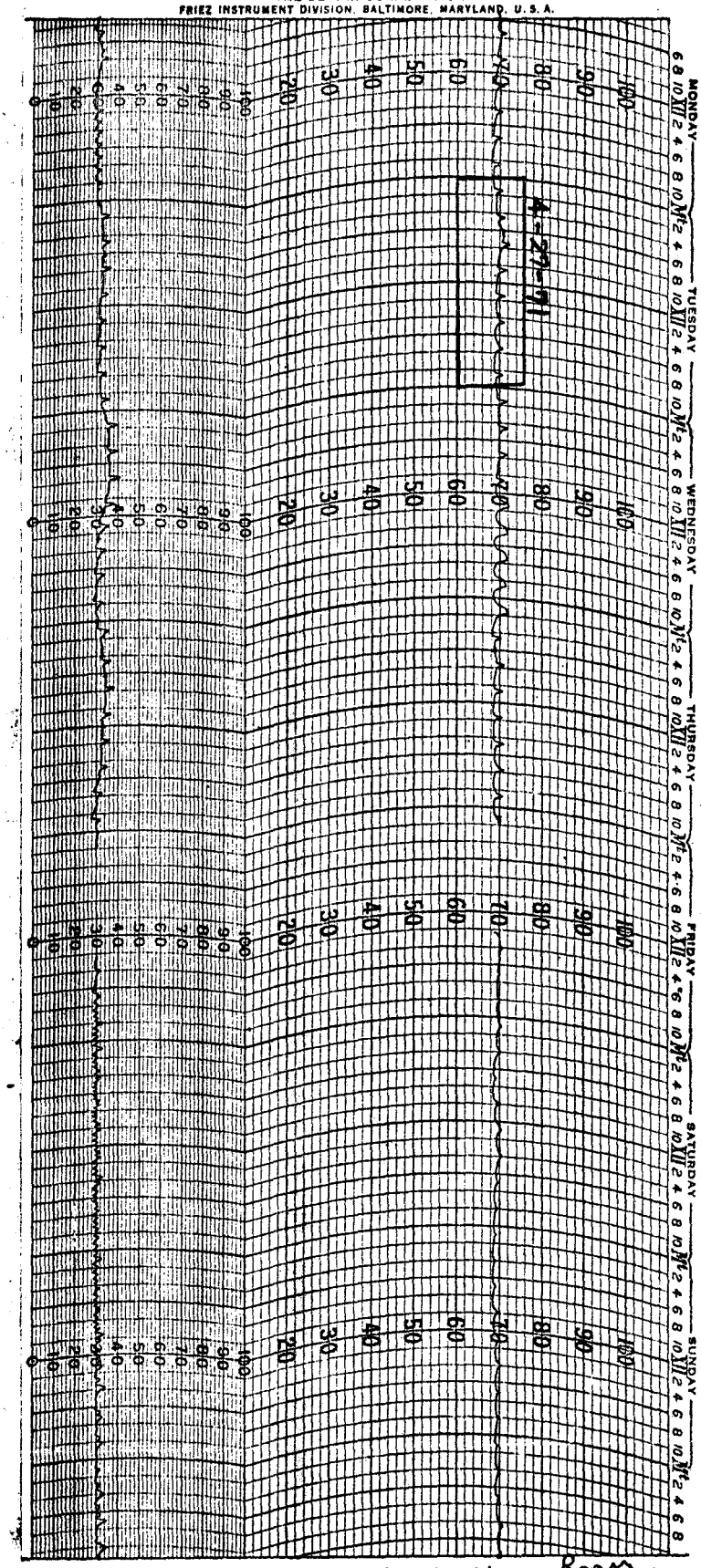
REMARKS ONE WEEK

WHEN ORDERING BINDER FOR THIS CHART SPECIFY PART NO. 502392

HYGRO-THERMOGRAPH
CHART NO. 207-WB

PART NO 502498 PRINTED IN U.S.A.

174 HOURS
USE NO 1-B-T PEN
THE BENDIX CORPORATION
FRIEZ INSTRUMENT DIVISION, BALTIMORE, MARYLAND, U.S.A.



INSTRUMENT NO. 51757 STATION P.S.E. Clean Room DATE 4/23/71

REMARKS One week

EXHIBIT C-S1

Tabulated Summary for Expected Values of Pressure at Given Temperatures (Curve Derivation and Calculation of 95% Confidence Limits).

TABLE C-51-1

DERIVATION OF CURVE FOR EXPECTED VALUES OF PRESSURE AT GIVEN TEMPERATURES (REF. FIGURE 2-S1)

1 Line Item	2 Temperature (X) (°F)	3 Pressure (Y) (MV)	4 $(x - \bar{x})$ $(x-71.44)$	5 $(y - \bar{y})$ $(y-150.11)$	6 $(x-\bar{x})(y-\bar{y})$ (4) x (5)	7 $(x - \bar{x})^2$ $(4)^2$	8 $(y - \bar{y})^2$ $(5)^2$	9 Remarks
1	72	150.6	+0.56	+0.49	+0.2744	0.3136	0.2401	Column 2 and
2		150.5		+0.39	+0.2184		0.1521	Column 3 of
3		150.6		+0.49	+0.2744		0.2401	this table are
4		150.5		+0.39	+0.2184		0.1521	extracted from
5		150.6		+0.49	+0.2744		0.2401	Column 4 and
6		150.5		+0.39	+0.2184		0.1521	Column 5 of
7	72	150.6	+0.56	+0.49	+0.2744	0.3136	0.2401	Table 1, line
8	71	150.4	-0.44	+0.29	-0.1276	0.1936	0.0841	items 1 through
9		150.5		+0.39	-0.1716		0.1521	14, ATM-920
10		150.3		+0.19	-0.0836		0.0361	
11		150.4		+0.29	-0.1276		0.0841	
12		150.5		+0.39	-0.1716		0.1521	
13	71	150.6	-0.44	+0.49	-0.2156	0.1936	0.2401	
14	81	151.6	+9.56	+1.49	+14.2444	91.3936	2.2201	
15	71	150.3	-0.44	+0.19	-0.0836	0.1936	0.0361	
16	68	149.7	-3.44	-0.41	+1.4104	11.8336	0.1681	
17	71	150.3	-0.44	+0.19	-0.0836	0.1936	0.0361	
18	72	150.6	+0.56	+0.49	+0.2744	0.3136	0.2401	
19	72	150.7	+0.56	+0.59	+0.3304	0.3136	0.3481	
20	69	149.9	-2.44	-0.21	+0.5124	5.9536	0.0441	Same as
21	68	149.6	-3.44	-0.51	+1.7544	11.8336	0.2601	above, except
22	70	150.0	-1.44	-0.11	+0.1584	2.0736	0.0121	this block
23	70	150.1	-1.44	-0.01	+0.0144	2.0736	0.0001	represents
24	70	150.1	-1.44	-0.01	+0.0144	2.0736	0.0001	line items 18
25	72	150.6	+0.56	+0.49	+0.2744	0.3136	0.2401	through 33
26	70	150.2	-1.44	+0.09	-0.1296	2.0736	0.0081	
27	72	150.9	+0.56	+0.79	+0.4424	0.3136	0.6241	
28	71	150.1	-0.44	-0.01	+0.0044	0.1936	0.0001	
29	78	151.7	+6.56	+1.59	+10.4304	43.0336	2.5281	
30	71	149.9	-0.44	-0.21	+0.0924	0.1936	0.0441	
31	73	150.0	+1.56	-0.11	-0.1716	2.4336	0.0121	
32	71	149.0	-0.44	-1.11	+0.4884	0.1936	1.2321	Column 2 and
33	71	148.0	-0.44	-2.11	+0.9284	0.1936	4.4521	Column 3 of
34	71	149.0	-0.44	-1.11	+0.4884	0.1936	1.2321	this table are
35	71	148.0	-0.44	-2.11	+0.9284	0.1936	4.4521	extracted from
36	72	151.0	+0.56	+0.89	+0.4984	0.3136	0.7921	Column 4 and
37	71	149.1	-0.44	-1.01	+0.4444	0.1936	1.0201	Column 5 of
38	71	149.8	-0.44	-0.31	+0.1364	0.1936	0.0961	Table 1-S1,
39	70	149.2	-1.44	-0.91	+1.3104	2.0736	0.8281	line items 1,
40	70	149.2	-1.44	-0.91	+1.3104	2.0736	0.8281	3-9, and 11-14.
41	72	149.3	+0.56	-0.81	-0.4536	0.3136	0.6561	
	Σ=2929	Σ=6154.5			Σ=+36.4244	Σ=186.0976	Σ=24.5761	

$$\bar{x} = \frac{2929}{41} = 71.44$$

$$\bar{y} = \frac{6154.5}{41} = 150.11$$

$$y' = \bar{y} + b(x - \bar{x})$$

$$y' = 150.11 + 0.1957\ (x - 71.44)$$

$$y' = 136.13 + 0.1957\ x$$

$$\text{Slope} = b = \frac{\Sigma(x - \bar{x})(y - \bar{y})}{\Sigma(x - \bar{x})^2}$$

$$b = \frac{+36.4244}{186.0976} = +0.1957$$

TABLE C-S1-2

95% CONFIDENCE LIMITS FOR PRESSURE VS. TEMPERATURE CURVE (REF. FIGURE 2-S1)

*Assumed Values Over Range of Curve

1	2	3	4	5	6	7	8	9	10
Line Item	σ_r^2/N	$\sigma_R^2 = \frac{\sigma_r^2}{\Sigma(X-\bar{X})^2}$	Temperature* (X) (°F)	$(X - \bar{X})$ (4) - 71.44	$(X - \bar{X})^2$ [5]^2	(3) x (6)	$\sqrt{(2) + (7)}$	$t_{.05}$ 39 D. F.	(9) x (8)
1	0.01147	0.002403	65	-6.44	41.4736	0.099661	0.333	2.02	± 0.673
2	↓	↓	70	-1.44	2.0736	0.004983	0.1283	↓	± 0.259
3			80	+8.56	73.2736	0.176076	0.4331		± 0.875
4			90	+18.56	344.4736	0.827770	0.9161		± 1.851

1. $\sigma_r = \sqrt{1 - r^2}\sqrt{\frac{\Sigma(Y - \bar{Y})^2}{n - 2}}$

   (a) σ_r = Standard Error About Regression Line Measured In Units of "Y", Parallel to Y-Axis = 0.6688

   (b) r = Regression Coefficient = $\frac{\Sigma(X - \bar{X})(Y - \bar{Y})}{\sqrt{\Sigma(X - \bar{X})^2\,\Sigma(Y - \bar{Y})^2}} = \frac{\Sigma \text{ Column (6), Table C-S1-1}}{\sqrt{[\Sigma \text{ Column (7)}]\,[\Sigma \text{ Column (8)}]}} = 0.5386$

   (c) $\Sigma(Y - \bar{Y})^2$ = Σ Column (8), Table C-S1-1

   (d) N = Number of Observations

2. σ_R = Standard Error of the Regression Coefficient

3. Confidence Limits $(Y') = \bar{Y} + b(X - \bar{X}) \pm t_{.05}\sqrt{\sigma_r^2 + \sigma_R^2 (X_i - \bar{X})^2}$

   (a) $\bar{Y}$ = 150.11

   (b) $\bar{X}$ = 71.44 — Ref. Table C-S1-2

   (c) b = 0.1957

TABLE 5-S1 - REGRESSION ANALYSIS FOR SIX COMBINATIONS OR PRESSURE AND TEMPERATURE (REF. TABLE 4-S1 FOR INITIAL DATA)

(A)

1	2						3					
	a	b	c	d	e	f	a	b	c	d	e	f
Line Item	$(X_a - \bar{X}_a)$ $(X_a - 19)$	$(X_b - \bar{X}_b)$ $(X_b - 19)$	$(X_c - \bar{X}_c)$ $(X_c - 18.1)$	$(X_d - \bar{X}_d)$ $(X_d - 18.1)$	$(X_e - \bar{X}_e)$ $(X_e - 19)$	$(X_f - \bar{X}_f)$ $X_f - 19$	$(Y_a - \bar{Y}_a)$ $Y_a - 141.12$	$(Y_b - \bar{Y}_b)$ $Y_b - 141.02$	$(Y_c - \bar{Y}_c)$ $Y_c - 141.79$	$(Y_d - \bar{Y}_d)$ $Y_d - 141.66$	$(Y_e - \bar{Y}_e)$ $Y_e - 141.76$	$(Y_f - \bar{Y}_f)$ $Y_f - 141.66$
27	- 18.0	S	- 17.1	S	S	S	+ 0.18	+ 0.28	- 0.49	- 0.36	- 0.46	- 0.36
28	- 11.0	A	- 10.1	A	A	A	+ 0.78	+ 0.38	+ 0.11	- 0.26	+ 0.14	- 0.26
29	- 8.0	M	- 7.1	M	M	M	+ 0.78	+ 0.38	+ 0.11	- 0.26	+ 0.14	- 0.26
30	- 4.0	E	- 3.1	E	E	E	+ 0.98	+ 1.08	+ 0.31	+ 0.44	+ 0.34	+ 0.44
31	- 2.0		- 1.1				+ 0.38	+ 0.48	- 0.29	- 0.16	- 0.26	- 0.16
32	+ 3.0	A	——	A	A	A	- 2.22	- 2.12	——	——	- 0.06	+ 0.04
33	+ 4.0	S	——	S	S	S	- 3.12	- 3.02	——	——	- 0.16	- 0.06
34	+ 5.0		+ 5.9				+ 0.48	+ 0.58	- 0.19	- 0.06	- 0.16	- 0.06
35	+ 13.0	(A)	+ 13.9	(C)	(A) & (B)	(A) & (B)	+ 0.88	+ 0.98	+ 0.21	+ 0.34	+ 0.24	+ 0.34
36	+ 18.0		+ 18.9				+ 0.88	+ 0.98	+ 0.21	+ 0.34	+ 0.24	+ 0.34

(B)

1	2	3	4	5	6	7	8	9
Line Item	$(X_a - \bar{X}_a)^2$	$(X_c - \bar{X}_c)^2$	$(Y_a - \bar{Y}_a)^2$	$(Y_b - \bar{Y}_b)^2$	$(Y_c - \bar{Y}_c)^2$	$(Y_d - \bar{Y}_d)^2$	$(Y_e - \bar{Y}_e)^2$	$(Y_f - \bar{Y}_f)^2$
27	324.00	292.41	0.0324	0.0784	0.2401	0.1296	0.2116	0.1296
28	121.00	102.01	0.6084	0.1444	0.0121	0.0676	0.0196	0.0676
29	64.00	50.41	0.6084	0.1444	0.0121	0.0676	0.0196	0.0676
30	16.00	9.61	0.9604	1.1664	0.0961	0.1936	0.1156	0.1936
31	4.00	1.21	0.1444	0.2304	0.0841	0.0256	0.0676	0.0256
32	9.00	——	4.9284	4.4944	——	——	0.0036	0.0016
33	16.00	——	9.7344	9.1204	——	——	0.0256	0.0036
34	25.00	34.81	0.2304	0.3364	0.0361	0.0036	0.0256	0.0036
35	169.00	193.21	0.7744	0.9604	0.0441	0.1156	0.0576	0.1156
36	324.00	357.21	0.7744	0.9604	0.0441	0.1156	0.0576	0.1156
	Σ= 1072.00	Σ= 1040.88	Σ= 18.7960	Σ= 17.6360	Σ= 0.5688	Σ= 0.7188	Σ= 0.6040	Σ= 0.7240

EXHIBIT D-S1

Tabulated Summary of Analysis for Pressure - Temperature Time Data From Table 4-S1 (Reference page 16).

TABLE 5-S (CONT'D)

(C)

1	2	3	4	5	6	7
Line Item	$(X_a - \overline{X}_a) \times (Y_a - \overline{Y}_a)$	$(X_b - \overline{X}_b) \times (Y_b - \overline{Y}_b)$	$(X_c - \overline{X}_c) \times (Y_c - \overline{Y}_c)$	$(X_d - \overline{X}_d) \times (Y_d - \overline{Y}_d)$	$(X_e - \overline{X}_e) \times (Y_e - \overline{Y}_e)$	$(X_f - \overline{X}_f) \times (Y_f - \overline{Y}_f)$
27	- 3.240	- 5.040	+ 8.379	+ 6.156	+ 8.280	+ 6.480
28	- 8.580	- 4.180	- 1.111	+ 2.626	- 1.540	+ 2.860
29	- 6.240	- 3.040	- 0.781	+ 1.846	- 1.120	+ 2.080
30	- 3.920	- 4.320	- 1.240	- 1.760	- 1.360	- 1.760
31	- 0.760	- 0.960	+ 0.580	+ 0.320	+ 0.520	+ 0.320
32	- 6.660	- 6.360			- 0.180	+ 0.120
33	-12.480	-12.080			- 0.640	- 0.240
34	+ 2.400	+ 2.900	- 0.950	- 0.300	- 0.800	- 0.300
35	+11.440	+12.740	+ 2.730	+ 4.420	+ 3.120	+ 4.420
36	+15.840	+17.640	+ 3.780	+ 6.120	+ 4.320	+ 6.120
	$\Sigma = -12.200$	$\Sigma = -2.700$	$\Sigma = +11.387$	$\Sigma = +19.428$	$\Sigma = +10.600$	$\Sigma = +20.100$

$$\text{slope} = b = \frac{\Sigma (X - \overline{X})(Y - \overline{Y})}{\Sigma (X - \overline{X})^2}$$

$$b_a = \frac{-12.200}{1072.00} = -0.0114 \text{ mv/day}$$

$$b_b = \frac{-2.700}{1072.00} = -0.0025 \text{ mv/day}$$

$$b_c = \frac{+11.387}{1040.88} = +0.0109 \text{ mv/day}$$

$$b_d = \frac{+19.428}{1040.88} = +0.0187 \text{ mv/day}$$

$$b_e = \frac{+10.600}{1072.00} = +0.0099 \text{ mv/day}$$

$$b_f = \frac{+20.100}{1072.00} = +0.0187 \text{ mv/day}$$

EXHIBIT E-S1

Tabular Summary of Time to Exhaust System (Equations 10 Through 15, Pages 20 and 21).

TABLE 8-S1

SUMMARY OF TIME TO EXHAUST SYSTEM
(EQUATIONS 10 THROUGH 15)

(a) *[Ref. Col. 4, Line 1, Table 7-S1]

1	2	3	4
Line Item	Leak Rate 785×10^{-11}* x (Col. 4, Table 6-S1) (in.^{3}/sec.)	Time to Exhaust System (Seconds) $\left[\frac{\text{Vol}}{\text{Rate}} = \frac{1.895}{\text{Col. 2}}\right]$	Time to Exhaust System (Hours) (Col. 3/3600)
1	3.61×10^{-4}	5249.31	1.4581
2	3.56×10^{-4}	5323.03	1.4786
3	3.51×10^{-4}	5398.86	1.4997
4	3.45×10^{-4}	5492.75	1.5258
5	3.37×10^{-4}	5623.14	1.5620
6	3.32×10^{-4}	5707.83	1.5855
7	3.14×10^{-4}	6035.03	1.6764
8	2.96×10^{-4}	6402.02	1.7783
9	2.75×10^{-4}	6890.90	1.9141
10	2.54×10^{-4}	7460.62	2.0724
11	2.30×10^{-4}	8239.13	2.2886
12	2.04×10^{-4}	9289.21	2.5803
13	1.74×10^{-4}	10890.80	3.0252
14	1.38×10^{-4}	13731.88	3.8144

TABLE 8-S1 (CONT'D)

(b) *[Ref. Col. 4, Line 2, Table 7-S1]

1	2	3	4	5
Line Item	Leak Rate 785×10^{-13} * x (Col. 4, Table 6-S1) (in.^{3}/sec.)	Time to Exhaust System (Seconds) $\boxed{\frac{\text{Vol.}}{\text{Rate}} = \frac{1.895}{\text{Col. 2}}}$	Time to Exhaust System (Hours) (Col. 3/3600)	Time to Exhaust System (Days) [Col. 4/24]
1	3.61×10^{-6}	524931	145.81	6.07
2	3.56×10^{-6}	532303	147.86	6.16
3	3.51×10^{-6}	539886	149.97	6.25
4	3.45×10^{-6}	549275	152.58	6.36
5	3.37×10^{-6}	562314	156.20	6.51
6	3.32×10^{-6}	570783	158.55	6.61
7	3.14×10^{-6}	603503	167.64	6.98
8	2.96×10^{-6}	640202	177.83	7.41
9	2.75×10^{-6}	689090	191.41	7.95
10	2.54×10^{-6}	746062	207.24	8.63
11	2.30×10^{-6}	823913	228.86	9.54
12	2.04×10^{-6}	928921	258.03	10.75
13	1.74×10^{-6}	1089080	302.52	12.60
14	1.38×10^{-6}	1373188	381.44	15.89

TABLE 8-S1 (CONT'D)

(c) *[Ref. Col. 4, Line 3, Table 7-S1]

1	2	3	4	5	6
Line Item	Leak Rate 785×10^{-15} * x (Col. 4, Table 6-S1) (in.^{3}/sec)	Time to Exhaust System (Seconds) $\boxed{\frac{\text{Vol.}}{\text{Rate}} = \frac{1.895}{\text{Col. 2}}}$	Time to Exhaust System (Hours) Col. 3/3600	Time to Exhaust System (Days) Col. 4/2A	Time to Exhaust System (Years) (Col. 5/365
1	3.61×10^{-8}	52,493,100	14581.	607	1.66
2	3.56×10^{-8}	53,230,300	14786.	616	1.69
3	3.51×10^{-8}	53,988,600	14997.	625	1.71
4	3.45×10^{-8}	54,927,500	15258.	636	1.74
5	3.37×10^{-8}	56,231,400	15620.	651	1.78
6	3.32×10^{-8}	57,078,300	15855.	661	1.81
7	3.14×10^{-8}	60,350,300	16764.	698	1.91
8	2.96×10^{-8}	64,020,200	17783.	741	2.03
9	2.75×10^{-8}	68,909,000	19141.	795	2.18
10	2.54×10^{-8}	74,606,200	20724.	863	2.36
11	2.30×10^{-8}	82,391,300	22886.	954	2.61
12	2.04×10^{-8}	92,892,100	25803.	1075	2.94
13	1.74×10^{-8}	108,908,000	30252.	1260	3.45
14	1.38×10^{-8}	137,318,800	38144.	1589	4.35

TABLE 8-S1 (CONCL'D)

(d) *[Ref. Col. 4, Line 4, Table 7-S1]

1	2	3	4	5	6
Line Item	Leak Rate 785×10^{-17} * x (Col. 4, Table 6-S1) (in.^{3}/sec)	Time to Exhaust System (Seconds) $\boxed{\frac{\text{Vol.}}{\text{Rate}} = \frac{1.895}{\text{Col. 2}}}$	Time to Exhaust System (Hours) Col. 3/3600	Time to Exhaust System (Days) Col. 4/24	Time to Exhaust System (Years) (Col. 5/365)
1	3.61×10^{-10}	5,249,310,000	1,458,100	60754	166
2	3.56×10^{-10}	5,323,030,000	1,478,600	61600	169
3	3.51×10^{-10}	5,398,860,000	1,499,700	62500	171
4	3.45×10^{-10}	5,492,750,000	1,525,800	63600	174
5	3.37×10^{-10}	5,623,140,000	1,562,000	65100	178
6	3.32×10^{-10}	5,707,830,000	1,585,500	66100	181
7	3.14×10^{-10}	6,035,030,000	1,676,400	69800	191
8	2.96×10^{-10}	6,402,020,000	1,778,300	74100	203
9	2.75×10^{-10}	6,890,900,000	1,914,100	79500	218
10	2.54×10^{-10}	7,460,620,000	2,072,400	86300	236
11	2.30×10^{-10}	8,239,130,000	2,288,600	95400	261
12	2.04×10^{-10}	9,289,210,000	2,580,300	107500	294
13	1.74×10^{-10}	10,890,800,000	3,025,200	126000	345
14	1.38×10^{-10}	13,731,880,000	3,814,400	158900	435

EXHIBIT F-S1

Existing PSE Leak Rate Requirements in Terms of the Current Analysis.

EXHIBIT F-S1

Existing PSE Leak Rate Requirements in Terms of the Current Analysis

If the currently existent pressurization and leak rate requirements for the PSE (343 psi $\pm$10 psi and 1 x10^{-6} $\frac{\text{ATM-CC}}{\text{Sec.}}$) are considered in terms of the analysis relating orifice size to volume and velocity, a quantitative value for the maximum permissable orifice diameter that may exist, and still allow specification requirements to be maintained, can be calculated. Equation 10, Page 20 of this supplement, is used for such a determination and is summarized in Table F-S1-1, below.

Table F-S1-1 - Permissable Orifice Diameter for Current Specification Requirements

1	2	3	4	5	
Pressure Requirements (Close-Off Psi)	$\sqrt{P}$ ($\sqrt{\text{Col. 1}}$)	R (in^3/sec)	Permissable Orifice Diameter (Inches)	Permissable Orifice Diameter (Microns)	Permissable Orifice Diameter (Angstroms)
353 (Max.)	18.78	7.513 x10^{-9}	4.53 x10^{-7}	0.01151	115.1
343 (Nom.)	18.51	↓	4.55 x10^{-7}	0.01156	115.6
333 (Min.)	18.25	↓	4.59 x10^{-7}	0.01166	116.6

$R = 1947.96\ d^2 \sqrt{P}$ (Equation 10 from Page 20)

The rate (R) in (in.^{3}/sec) equivalent to 1 x10^{-6} $\frac{\text{ATM-CC}}{\text{Sec.}}$ = 7.513 x10^{-9} in.^{3}/sec.

It can readily be seen that these results correlate well with the predictions in Table 9-S1, Page 24.