ETS-1 TEST REPORT
FOR
ETC HELIUM PURGE SYSTEM DIFFUSOR CHECKOUT

MASTER

NTO-R-0131

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FIGURES 1.1, 1.2 and 5.1 through 5.51 ATTACHED

PORTION OF THIS DOCUMENT IS
 BASED ON THE FOLLOWING INFORMATION
 COPY OF THE FOLLOWING INFORMATION IS
 ATTACHED.

REFERENCES

1. Test Operations Procedure for ETC Diffusor Checkout, NTO-M-11494, from R. J. McConnell to C. K. Soppet, dated 14 November 1967
2. Analysis of Design Requirements and Recommendations for a Low Impedance Helium Diffusor in the ETC at ETS-1, 7710:M939, from K. Sato to W. L. Winegar, dated 26 October 1967
3. Requirements for He-1 Diffusor Integrity Test, NTO-M-11492, from S. N. Kemp to D. D. VanderMeer, dated 8 November 1967
4. ETS-1 Test Report for ETC Helium Purge System Checkout, NTO-R-0122, dated 5 October 1967

1.0 INTRODUCTION

1.1 PURPOSE

This report presents the results of an evaluation of the data acquired during the ETC Helium Purge System Diffusor Checkout Test conducted on 17 November 1967.

1.2 DIFFUSOR FUNCTION AND DESCRIPTION

The purpose of the ETC Helium Purge System diffusor is to minimize the interaction between the exiting purge gas and ETC enclosure/engine. This is accomplished by introducing the purge gas through a diffusor which distributes the gas through 68 2-inch-diameter holes. Interaction between purge flow and the ETC/engine is minimized by optimized hole locations. The diffusor was designed to handle helium flowrates up to 60 pps. Figure 1.1 is a drawing of the diffusor.

1.3 TEST DESCRIPTION

The test was conducted with the ETC open. PCV-449 was operated from the temporary NES control (TNC) console. Figure 1.2 is a schematic of the flow path used for the test. Tests 1, 2, 3 and 4 consisted of manual ramp openings of PCV-449 to achieve planned steady-state GN_2 flowrates equivalent to GHe flowrates of 15, 30, 45 and 60 pps. Test 5 consisted of a PCV-449 step opening to achieve a nominal steady-state GN_2 flowrate of 150 pps. Cross-correlation tests were conducted but the results are not considered in this report.

2.0 TEST OBJECTIVES

The primary test objective was to verify the structural integrity of the diffusor under conditions which are equivalent to GHe flowrates of 15, 30, 45 and 60 pps. A secondary objective was to perform various cross-correlation tests to checkout the NRO cross-correlation data analysis process.

NOTES

1. NO SCALE
2. REFERENCE AGC
DWS NO 1134677

FIGURE 1.1

DIFFUSER, PIPE - 68 HOLE - ETC AT ETS-1

FIGURE 1.2

3.0 SUMMARY TEST RESULTS

- 3.1 The maximum GN_2 flowrates achieved during the tests were: 45 pps, 77 pps, 122 pps and 230 pps. The capability of the diffuser to handle GN_2 flowrates in excess of 150 pps for 6.1 seconds without damage to the diffuser was demonstrated.
- 3.2 Evaluation of the strain gage data showed that significant zero shift occurred during each test and this shift made strain gage interpretation difficult; however, the total indicated strains (including the shift) were not excessive.
- 3.3 The delay time between the initial change in command and initial PCV-449 opening was 49 ms and delay time between the command change and the initial change in PT-906W pressure was 96.5 ms. These delay times were higher than the respective PCV-449 checkout test times of 42 and 86 ms, respectively. The delay time difference may be due to: 1) improved resolution of the high speed diffuser test data; 2) the influence of the diffuser and increased PCV-449 upstream volume and impedance, and 3) the differences between GN_2 and GHe characteristics
- 3.4 A diffuser resonance of 4.6 gs (peak-to-peak) occurred at 25 cps. This frequency was in good agreement with the low frequency component evidenced in the strain gage data. Another resonance peak of 3.26 gs (peak-to-peak) occurred at 150 cps.
- 3.5 Instrumentation leads were broken during the tests due to inadequate attachment techniques. Specifically, the electrical leads to accelerometers HT112A, 112 T and 112 R failed during Test No. 1. Also, the impact pressure tube sensing the total pressure (6 inches) from a bottom hole in the diffuser was bent during Test No. 2.
- 3.6 Higher than expected GN_2 flowrates were experienced during Test Numbers 4 and 5 due to a lower than predicted impedance between a single GN_2 vessel and GN_2 header and also due to a higher PCV-449 Cv versus position relationship at openings greater than 50%.

- 3.7 Good correlation was evidenced between the on-line computed flowrate, FT-15 and the calculated flowrate, FE-15. The flowmeter ΔP transducer, PD-778, was under-ranged for the high flowrate tests since the bank pressure was lower than planned. Also, a "no-flow" PD-778 offset was evidenced during the tests.

4.0 CONCLUSIONS

The capability of the diffuser to handle GN_2 flowrates in excess of 150 pps for approximately 6 seconds without damage was demonstrated; therefore, satisfactory structural performance of the diffuser during NEP-He-1 is anticipated.

5.0 TECHNICAL DISCUSSION

5.1 PURGE SYSTEM STEADY-STATE CHARACTERISTICS

Since significant differences were not evidenced in the steady-state performance characteristics during all tests, only Test No. 2 will be discussed in detail. Table 1 is a summary of the data taken during steady-state GN_2 flow conditions. It is to be noted that significant GN_2 vessel and header pressure fluctuations occurred during the high flow periods; therefore, averaging techniques should be utilized for pressure drop analysis.

Figure 5.1 is a plot of PCV-449 demand (CP-449) and valve position (DP-449) versus range time. It is to be noted that large apparent changes occurred in the valve position trace during the test. Apparently, flow induced vibration caused oscillations in the valve position data potentiometer since no large changes in flow were observed as can be seen in Figure 5.2. Figure 5.2, which is a plot of the on-line computed GN_2 flowrate, FT-15 and the calculated flowrate, FE-15 versus range time, shows good agreement between the two flowrates. The on-line computed flow was calculated using the equation

$\dot{W} = 0.3299 \left[(PT-587)(PD-778) \right]^{1/2}$. The calculated flowrate, FE-15, was obtained by using the relationship;

$$WF .15 = 0.3455 \left[\frac{(PT-587)(PD-778c)(530)}{TT-527} \right]^{1/2}$$

TABLE 1

SUMMARY OF STEADY-STATE DATA

	RANGE TIME IN SECONDS	PT001.. WD 157F PSIA	TT489.. WD 171F RANKINE	PT004.. WD 159F PSIA	TT490.. WD 172F RANKINE	PT007.. WD 160F PSIA	TT491.. WD 173F RANKINE	PT002.. WD 158F PSIA	PT587.. WD 161R PSIA	TT527.. WD 166R RANKINE	PD776-C WD 103 PSID	PT004.. WD 163F PSIA	FE156NC WD 102 PPS	F.015.. WD 167R PPS	CP449WM WD 169R XDOT	DP449W. WD 170R XDOT	PT002.. WD 162R PSIA	PT004.. WD 175F PSIA	TE834.. WD 168R RANKINE	PT906W. WD 164F PSIA
TEST #1	70226.4	1556.8	528.6	2404.3	531.0	1644.0	533.0	1560.7	1561.5	533.2	.0	1556.8	.00	8.13	-.6	-.6	12.6	12.719	523.3	12.70
	70226.5	1555.9	528.9	2405.5	531.2	1645.5	532.8	1560.7	1562.4	533.2	.0	1557.1	.00	8.06	-.6	-.7	12.8	12.721	523.2	12.68
	70250.4	1502.8	527.4	2385.7	530.8	1625.4	533.4	1487.5	1465.5	524.3	9.8	1445.2	41.64	41.77	7.3	2.4	27.1	13.760	457.8	22.97
	70250.5	1499.5	527.1	2409.4	531.0	1655.9	533.4	1484.5	1460.4	524.4	10.7	1445.5	43.48	41.73	7.3	2.1	27.2	13.644	457.8	22.91
	70250.6	1498.6	526.8	2401.0	531.3	1640.7	532.6	1483.9	1466.2	524.6	10.1	1446.1	42.30	42.13	7.4	2.5	27.2	13.880	456.2	22.71
	70250.7	1498.3	527.6	2403.7	530.7	1653.5	533.0	1485.7	1455.0	524.3	8.7	1436.2	39.15	42.03	7.4	2.2	27.6	13.635	457.4	22.81
	70250.8	1501.9	526.3	2407.9	531.2	1649.1	533.0	1483.0	1477.2	524.5	9.4	1438.3	40.83	40.83	7.4	2.4	27.4	13.567	455.3	23.14
TEST #2	71059.9	1448.8	526.1	2404.3	531.1	1641.9	533.0	1451.8	1449.2	527.9	.0	1445.5	.00	6.64	-.6	-.6	12.9	12.635	515.9	12.74
	71070.0	1448.8	526.1	2404.6	531.0	1641.9	533.0	1451.8	1446.9	528.0	.0	1444.3	.00	6.66	-.6	-.6	12.9	12.634	515.8	12.72
	71092.0	1280.5	518.6	2424.1	530.8	1653.5	532.6	1232.2	1127.3	516.5	37.0	1104.5	71.46	71.00	20.7	16.6	48.2	12.192	457.9	40.85
	71092.1	1304.8	518.3	2405.8	530.8	1641.6	533.0	1246.0	1139.9	516.3	37.0	1108.4	71.85	71.18	20.6	12.2	48.7	12.241	457.1	40.85
	71092.2	1314.4	518.3	2408.8	530.5	1641.0	532.8	1236.1	1134.5	516.8	36.9	1100.0	71.54	70.40	20.6	16.9	48.3	12.292	457.4	41.02
	71092.3	1305.4	518.9	2407.9	530.8	1651.2	534.0	1241.8	1142.3	516.8	36.7	1098.2	71.67	71.52	20.4	14.7	48.5	12.283	456.4	40.65
	71092.4	1289.8	518.8	2393.2	531.2	1637.1	532.8	1245.6	1124.3	516.5	36.5	1100.3	70.93	70.56	20.0	17.0	47.8	12.265	456.8	40.45
TEST #3	71676.1	1318.0	521.4	2404.6	531.0	1599.7	530.2	1606.9	1609.0	527.5	.2	1600.9	5.54	8.11	-.6	-.5	12.9	12.531	509.5	12.74
	71676.2	1317.4	521.4	2404.6	531.1	1600.0	530.0	1607.8	1608.4	527.6	.4	1602.7	8.61	8.04	-.7	-.6	12.9	12.532	509.4	12.69
	71692.3	1322.8	521.6	2409.7	531.8	1410.3	524.0	1293.7	1020.1	509.6	109.7	936.2	117.87	117.38	36.4	36.1	75.8	12.412	458.0	64.96
	71692.4	1316.8	521.7	2396.8	531.9	1416.5	522.8	1288.9	1031.0	509.6	107.2	936.2	117.15	117.42	36.8	32.9	76.7	12.585	456.6	64.77
	71692.5	1300.9	522.8	2378.8	531.0	1428.5	524.1	1301.5	1030.1	509.7	110.9	911.0	119.08	118.20	36.7	33.4	76.5	12.419	459.2	65.14
	71692.6	1308.7	521.3	2404.3	530.7	1418.0	523.9	1291.3	1014.8	510.0	113.5	910.4	119.28	118.71	36.7	32.1	77.2	12.416	456.5	65.39
	71692.7	1316.8	521.2	2406.7	530.7	1386.3	523.2	1282.6	1009.6	510.5	115.2	920.0	120.07	118.39	36.8	33.7	76.9	12.404	459.0	65.31
TEST #4	72535.3	1331.8	526.8	2080.9	522.4	1679.6	535.3	1689.7	1735.7	525.9	.0	1727.2	.00	4.33	-.6	-.7	12.7	12.540	507.1	12.68
	72535.4	1332.1	526.6	2081.5	522.4	1679.0	535.3	1689.7	1736.3	525.7	.0	1725.1	.00	4.33	-.7	-.6	12.9	12.540	506.9	12.76
	72557.0	1331.5	526.5	2089.3	523.6	1496.4	530.7	1313.8	803.8	496.1	245.3	479.1	158.26	180.70	58.0	50.7	112.3	11.099	460.4	93.67
	72557.1	1333.0	526.6	2086.6	522.6	1489.6	531.0	1300.9	787.5	497.6	245.3	466.5	156.73	179.71	58.4	50.3	109.8	11.187	460.5	91.74
	72557.2	1349.5	526.7	2083.9	522.7	1480.0	530.6	1295.8	794.2	497.7	245.3	453.0	157.38	179.35	58.1	50.6	107.3	11.093	462.5	90.73
	72557.3	1325.5	526.8	2081.5	522.0	1488.4	530.3	1303.3	784.8	498.6	245.3	468.0	156.30	178.01	58.6	56.4	107.4	11.142	463.6	89.50
	72557.4	1341.7	526.7	2089.9	522.5	1499.4	530.6	1294.9	791.2	497.5	245.3	445.8	157.40	177.61	58.7	55.5	105.2	11.153	462.3	88.20
TEST #5	73598.2	1332.7	526.0	1939.0	523.1	1594.6	533.8	1604.8	1609.6	524.5	.0	1598.2	.00	3.93	-.6	-.6	12.7	12.608	503.7	12.79
	73598.3	1335.4	528.1	1937.8	522.9	1596.1	533.7	1603.9	1608.4	524.4	.0	1599.1	.00	3.89	-.6	-.6	12.9	12.608	504.5	12.74
	73608.4	1325.5	526.3	1925.5	522.6	1465.3	532.8	1288.3	820.6	500.3	246.7	567.3	160.01	166.25	53.8	51.5	101.0	11.218	467.1	85.50
	73608.5	1312.6	528.3	1937.8	523.9	1472.2	531.6	1309.9	817.9	500.4	246.7	558.6	159.74	166.03	53.5	47.8	100.1	11.441	467.3	84.88
	73608.6	1342.6	529.1	1926.7	524.4	1458.4	532.5	1290.4	815.2	500.9	246.7	553.5	159.39	166.90	53.3	51.6	100.1	11.335	466.9	84.08
	73608.7	1308.1	528.3	1916.8	522.8	1453.3	532.6	1313.5	812.2	499.8	246.7	557.4	159.27	164.87	53.7	52.5	99.1	11.223	466.3	83.73
	73608.8	1339.3	527.7	1924.9	523.2	1465.0	531.6	1319.8	810.4	501.0	246.7	554.4	158.90	164.03	53.5	51.3	98.3	11.342	467.7	83.03

Since a no-flow PD-778 offset was observed during the tests, a corrected flowmeter ΔP value (PD-778C) was calculated and used in the calculated flowrate equation. This offset is shown in Figure 5.3.

Figure 5.4 is a plot of the GN_2 system pressures upstream of PCV-449. It is to be noted that flow induced vibration caused pressure oscillations; however, the maximum oscillation represents only 2% of the full scale transducer range.

Figure 5.5 is a plot of various system temperatures during Test No. 2. A significant temperature change occurs across the valve due to the throttling process. Also, the storage vessel gas temperature decreases due to the near-isentropic blowdown process.

Figure 5.6 shows the PCV-449 downstream pressure (PT-882), diffuser inlet pressure, (PT-906W) and the diffuser exit gas impact pressure. The impact pressure tube was located 6" away from the bottom hole in the diffuser. The maximum recorded impact pressure of 15.3 psia occurred during Test No. 2 at 76 pps. As noted on Figures 5.6 and 5.6A the impact pressure tube failed during the test.

Figures 5.7 thru 5.30 are plots of the aforementioned parameters for Tests 1, 3, 4 and 5. The GN_2 system steady-state behavior was generally consistent with Test No. 2. It is to be noted in Figures 5.21 and 5.27 that the pressure drop exceeded the PD-778 full scale value of 250 psia.

Figure 5.31 is a plot of PT-882 pressure versus the FE-15 calculated flowrate. Based on the maximum recorded PT-882 pressure of 151 psia, the maximum GN_2 transient flowrate attained was 230 pps during Test No. 5.

Figure 5.32 is a plot of PT-906W pressure versus FE-15 flowrate. Also plotted is the PT-906W versus flow based on the PCV-449 checkout tests. No significant increase in pressure resulted from the addition of the diffuser.

Figure 5.33 is a plot of the pressure drop between the GN₂ header (PT-002) and the FE-15 inlet (PT-587) versus FE-15 flowrate. Also plotted are several data points corrected to a bank pressure of 1500 psia. These points are in good agreement with the uncorrected data. Agreement with the average pressure drop curve based on corrected data is also evident.

Figure 5.34 is a plot of the pressure drop between the FE-15 inlet (PT-587) and PCV-449 inlet (PT-904). Using the general isothermal equation;

$$W^2 = \frac{19.9 \text{ dp}^4 (P_1^2 - P_2^2)}{ZRT (k + 2 \ln P_1/P_2)}$$

the impedance, K, of the various

line segments was computed and the results are given in Table 5.2.

TABLE 5.2
SUMMARY TABLE OF IMPEDANCES

<u>Line Segment</u>	<u>K(^d_p = 5.189")</u>
PT-001 to PT-002	11.0
PT-007 to PT-002	11.9
PT-002 to PT-587	23.1
PT-587 to PT-904	8.6
PT-882 to PT-906W	.07

Figure 5.35 is a plot of the on-line computed flowrate (FT-15) and the calculated flowrate FE-15. Some disagreement at the higher flowrates is evidenced; however, during Tests 4 and 5 the ΔP across the flowmeter exceeded the maximum range of PD-589, which is the input into the on-line flow computer and PD-778, which was used to calculate the FE-15 flowrate. Therefore, the flowmeter correlation at the high flowrates is questionable.

Figure 5.36 is a plot of Cv versus valve position. Cv was calculated using the relationship; $C_v = (70.33 \sqrt{TT527}) \text{ FE-15/PT-904}$. It is to be noted that good agreement exists between this curve based on NEPN-1 data and the diffusor test data for valve openings less than 35%; however, the

calculated Cv is higher than the NEPN-1 curve at openings greater than 35%. This disagreement may be due to the inaccuracy of the NEPN-1 Cv calculations since flow was based on the simulated primary nozzle flowrates.

5.2 PCV-449 RESPONSE CHARACTERISTICS

Test No. 5 was evaluated to determine the system response characteristics and compare the results with the PCV-449 checkout test data. Table 5.3 summarizes the results.

TABLE 5.3

	Valve Position	Delay Time Between Command and Initial PCV-449 Open (ms)	Delay Time Between Command and Initial PT-906W Change (ms)	Maximum Valve Opening Rate %/sec
PCV-449 C/O	10%	42	86	264
DIFFUSOR C/O	51.1%	49	96.5	300

Figure 5.37 is an oscillograph trace of the valve command (CP-449) valve position (DP-449), valve outlet pressure (PT-882) and diffuser inlet pressure (PT-906W). The plot reflects a lag in the command, which may be the result of the temporary control system characteristics. This lag is discussed in detail in Reference 4.

5.3 STRAIN GAGE DATA ANALYSIS

Strain gage data interpretation was difficult since significant zero shifts occurred during each test. This zero shift is clearly shown in Figure 5.38, which shows the pre-calibration and post-calibration 0, 25%, 50% and 100% levels.

Figures 5.39 thru 5.43 are plots of the no-flow and maximum steady-state flow strain gage outputs for 26L, 26T, 27L and 27T. The locations of the various strain gages are shown in Figures 5.45 thru 5.51. Strain gage 26T exhibited an erratic and noisy behavior as shown in Figure 5.39; therefore, the data was considered invalid.

Pre-test predictions indicated that a strain of 1000 microinches/inch represented 85% of the diffusor material yield strength. Based on strain gages 26L and 27L, the maximum compressive or tensile strain did not exceed 100 μ inches/in. Also, the maximum unidirectional strain based on the difference between the pre-test zero and the value at maximum flow period was -220 μ inches/in. It appears that the diffusor was not overstressed during the test since the strain gage data, which was evaluated, did not evidence strains in excess of 500 μ inches/in; however, due to zero shifts and defective strain gages a complete strain analysis was not attempted.

A low frequency vibration mode is evidenced in various strain gage data. For example, a low frequency oscillation, which varied from 20.2 to 25 cps, is shown in the 27L trace. This frequency range is in good agreement with the first resonant peak frequency of 25 cps determined from accelerometer data.

5.4 ACCELEROMETER DATA ANALYSIS

Figure 5.44 is an oscillograph record of the output from accelerometers HT111-R, 111-T, 112-T, 112-R and 112-A during Test No. 1. Figure 5.45 shows the locations of the various accelerometers. Interpretation of the oscillograph data is difficult since many frequencies are present; however, a low frequency component is evident in the HT111-T, 112-T and 112-R data. Only one acceleration vs. frequency plot was generated since local data facilities were engaged in NRX-A6 test support activities. NRO has been requested to provide power spectral density plots for analysis and the evaluation of those plots will be considered

in the future. Figures 5.46 and 5.47 are acceleration vs. frequency plots based on HT111-R during the maximum flow period during Test No. 1. The plots show one resonant peak of 4.6 g's at 25 cps and another 3.26 g peak at approximately 150 cps. The most critical is the low frequency resonance.

Figure 5.46 is an oscillograph trace of the same accelerometer outputs during Test No. 5. It is to be noted that HT112 is inactive; however, HT111-R remains active and evidences a low frequency component somewhat higher than Test No. 1. Also, the amplitude appears greater but quantitative interpretation will be made from the forthcoming PSD plots.

Figures 5.48, 5.49, 5.50, and 5.51 are photographs of the diffuser and instrumentation taken after the test was completed. It is to be noted that the HT112 wires are broken and the PT-884 impact pressure tube is bent in the post-test photos.

The equations used to make various computations are included in the Appendix.

5.5 POST-TEST EXAMINATION

A post-test examination revealed that the diffuser had not been damaged during tests. The following observations were made:

1. Dye penetrant inspection of the diffuser welds did not reveal any defective welds.
2. None of the 207-HE-12 support bracket bolts nor the diffuser flange bolts were found to be loose.
3. The diffuser may have been slightly repositioned during the test, since some offset was noticed in the bellows which connect the 207-HE-12 pipe to the top shield. Also, the gap between the 207-HE-12 line and the thrust ring below the top shield had increased during the test.

ETC DIFFUSOR C/O
TEST NO. 2

11-17-67

1	-*-	CP449WM	-*-	↓POT
2	-*-	DP449W.	-*-	↓OPEN

FIGURE 3.1

ETC DIFFUSOR C/O
TEST NO. 2

11-17-67

1	-*-	F.015..	-*-	PPS
2	-*-	FE15GNC	-*-	PPS

FIGURE 3.2

ETC DIFFUSOR C/O TEST NO. 2

11-17-67

1 -*- PD778.. -*- PSID
2 -*- PD778-C -*- PSID

ETC DIFFUSOR C/O
TEST NO. 2

11-17-67

ETC DIFFUSOR C/O TEST NO. 2

11-17-67

ETC DIFFUSOR C/O
TEST NO. 2

11-17-67

1	-*- PT906W.	-*- PSIA
2	-*- PT882..	-*- PSIA
3	-*- PT884..	-*- PSIA

ETC DIFFUSOR C/O
TEST 2.

11-17-67

1 -*- PT884.. -*- PSIA

ETC DIFFUSOR C/O
TEST NO. 1

11-17-67

1	-*-	CP449WM	-*-	ΔPOT
2	-*-	DP449W.	-*-	ΔOPEN

FIGURE

ETC DIFFUSOR C/O
TEST NO. 1

11-17-67

1 -*- F.015.. -*- PPS
2 -*- FE15GNC -*- PPS

FLOWRATE

200.0

180.0

160.0

40.0

70244.0

70252.0

70260.0

70268.0

RANGE TIME-SECS.

FIGURE 5.8

2

ETC DIFFUSOR C/O
TEST NO. 1

11-17-67

1 -*- PD778.. -*- PSID
2 -*- PD778-C -*- PSID

ETC DIFFUSOR C/O TEST NO. 1

11-17-67

FIGURE 5.10

ETC DIFFUSOR C/O
TEST NO. 1

11-17-67

FIGURE 5.11

FIGURE

ETC DIFFUSOR C/O
TEST NO. 1

11-17-67

1	-*-	PT906W.	-*-	PSIA
2	-*-	PT882..	-*-	PSIA
3	-*-	PT884..	-*-	PSIA

FIGURE 5.12

ETC DIFFUSOR C/O
TEST 1.

11-17-67

1 -*- PT884.. -*- PSIA

FIGURE 5.12A

FIGURE

ETC DIFFUSOR C/O
TEST NO. 3

11-17-67

1 -*- CP449WM -*- ΔPOT
2 -*- DP449W. -*- ΔOPEN

ETC DIFFUSOR C/O
TEST NO. 3

11-17-67

1	-*-	F.015..	-*-	PPS
2	-*-	FE15GNC	-*-	PPS

FIGURE 5.14

ETC DIFFUSOR C/O
TEST NO. 3

11-17-67

1	-*-	PD778..	-*-	PSID
2	-*-	PD778-C	-*-	PSID

ETC DIFFUSOR C/O TEST NO. 3

11-17-67

FIGURE 5.16

ETC DIFFUSOR C/O TEST NO. 3

11-17-67

FIGURE

ETC DIFFUSOR C/O
TEST NO. 3

11-17-67

1	-*-	PT906W.	-*-	PSIA
2	-*-	PT882..	-*-	PSIA
3	-*-	PT884..	-*-	PSIA

PRESSURE

80.0

40.0

160.0

120.0

200.0

1 2 3 3 3 3 3 2 3 1 2

FIGURE 5.18

71680.0

71688.0

71696.0

71704.0

RANGE TIME-SECS.

ETC DIFFUSOR C/O
TEST NO. 4

11-17-67

1	-*-	CP449WM	-*-	1POT
2	-*-	DP449W.	-*-	1OPEN

ETC DIFFUSOR C/O
TEST NO. 4

11-17-67

11-17-67

ETC DIFFUSOR C/O
TEST NO. 4

1 - * - PD778 . - * - PSID
2 - * - PD778 - C - * - PSID

ETC DIFFUSOR C/O
TEST NO. 4

11-17-67

ETC DIFFUSOR C/O
TEST NO. 4

11-17-67

FIGURE

ETC DIFFUSOR C/O
TEST NO. 4

11-17-67

1	-*-	PT906W.	-*-	PSIA
2	-*-	PT882..	-*-	PSIA
3	-*-	PT884..	-*-	PSIA

ETC DIFFUSOR C/O
TEST NO. 5

11-17-67

1	-*-	CP449WM	-*-	ΔPOT
2	-*-	DP449W.	-*-	ΔOPEN

11-17-67

11-17-67

FIGURE

11-17-67

ETC DIFFUSOR C/O
TEST NO. 5

1 -*- PD778.. -*- PSID
2 -*- PD778-C -*- PSID

250.0

200.0

150.0

PSID
100.0

50.0

FIGURE 5.27

73605.0

RANGE TIME-SECS.

73609.0

73613.0

73617.0

ETC DIFFUSOR C/O TEST NO. 5

11-17-67

FIGURE 5.28

ETC DIFFUSOR C/O TEST NO. 5

11-17-67

FIGURE 5.29

ETC DIFFUSOR C/O
TEST NO. 5

11-17-67

1	-*- PT906W.	-*- PSIA
2	-*- PT882..	-*- PSIA
3	-*- PT884..	-*- PSIA

FIGURE 5.30

DIFFUSER PRESSURE VS GN2 FLOW RATE FIGURE

ETC DIFFUSOR C/O 11-17-67

UNIT 2 PLOT 1

1 --*-- PT882.. --*-- PSIA

PRESSURE - PSIA

PLOT TIME 70247.0 73609.0

PRESSURE - PSIA

200.0
160.0
120.0
80.0
40.0

40.0

80.0
GN2 FLOW - PPS

120.0

160.0

200.0

FIGURE 5.31

DIFFUSER PRESSURE VS GN2 FLOW RATE FIGURE ETC DIFFUSOR C/O 11-17-67

UNIT 3 PLOT 1

1 -*- PT906W. -*- PSIA

PRESSURE - PSIA

PLOT TIME 70247.0 73609.0

PRESSURE - PSIA

200.0
160.0
120.0
80.0
40.0

40.0

80.0

120.0

160.0

200.0

GN2 FLOW - PPS

FIGURE 5.32

PT-906W VS FLOW BASED ON
PCV-449 C/O TEST

1

1

1

PRESSURE - PSIA

DELTA PRESSURE VS GN2 FLOW RATE
ETC DIFFUSOR C/O. 11-17-67

UNIT 3
PLOT 1

PT002 - PT587

1 -*- DELTAP2 -*- PSID

DELTA PRESSURE VS GN2 FLOW RATE

FIGURE

ETC DIFFUSOR C/O

11-17-67

UNIT 4
PLOT 1

1 -*- DELTAP4 -*- PSID

DIFFUSER PRESSURE VS C/N2 FLOW RATE

ETC DIFFUSOR C/O 11-17-67

UNIT 1 PLOT 1

ON-LINE COMPUTED FLOWRATE
FT-015 - PPS
VS
FE-15 FLOWRATE

PLOT TIME 70247.0 73609.0
ON-LINE COMPUTED FLOWRATE, FT-015 - PPS

CV VS VALVE POSITION
ETC DIFFUSOR C/O

11-17-67

FIGURE

UNIT 1 PLOT 2

1 -*- CV -*- FACTOR

PLOT TIME 70247.0 73609.0

CV

FIGURE 5.36

20 ms

PT-882, PCV-449 POSITION (CP-449), PCV-449 COMMAND (CP-449)
and PT-906W Vs. TIME DURING TEST NO. 5

FIGURE 5.37

PRE-TEST
CALIBRATION OF
STRAIN GAGES

POST-TEST
CALIBRATION OF
STRAIN GAGES

← 70253.1 = Range Time (secs)

Time Scale: 1" = 25 ms

PRE-TEST
ZERO

MAXIMUM FLOW PERIOD

26L

26T

BAD CHANNEL

27L

OSCILLOGRAPH TRACE OF STRAIN GAGES 26L, 26T, 27L, 27T DURING TEST NO. 1

FIGURE 5.39

27T

←71091.1 = Range Time (secs)

Time Scale: 1" = 25 ms

PRE-TEST
ZERO

26L

MAXIMUM FLOW PERIOD

26T

27L

25 CPS

OSCILLOGRAPH TRACE OF STRAIN GAGES 26L, 26T, 27L, 27T DURING TEST NO. 2

FIGURE 5.40

27T

71693.6 = Range Time

Time Scale: 1" = 25 ms

PRE-TEST
ZERO

MAXIMUM FLOW PERIOD

26L

26T

BAD CHANNEL

27L

25 CPS

OSCILLOGRAPH TRACE OF STRAIN GAGES 26L, 26T, 27L, 27T DURING TEST NO. 3

FIGURE 5.41

27T

$\leq 72557.8 = \text{Range Time}$

Time Scale: 1" = 25 ms

PRE-TEST
ZERO

MAXIMUM FLOW PERIOD

26L

26T

← 22 CPS →

27L

OSCILLOGRAPH TRACE OF STRAIN GAGES 26L, 26T, 27L, 27T DURING TEST NO. 4

FIGURE 5.42

27T

$\leq 73607.4 = \text{Range Time}$

Time Scale: 1" = 25 ms

MAXIMUM FLOW PERIOD

PRE-TEST
ZERO

26L

BAD CHANNEL

26T

27L

OSCILLOGRAPH TRACE OF STRAIN GAGES 26L, 26T, 27L, 27T DURING TEST NO. 5

FIGURE 5.43

27T

70051 0.000

1 inch = 25 ms

111-R

111-T

112-T

112-R

ACCELEROMETER OUTPUTS DURING TEST NO 1

FIGURE 5.44

112-A

DIFFUSOR INSTRUMENTATION
(Pre-Test)

FIGURE 5.45

10R

70252 → 70254

FIGURE 5.46

HT118R

70252 → 70254

ACCELERATION vs. FREQUENCY

3.26 g's @ 150 cps

Frequency - cps

FIGURE 5.47

ACCELEROMETER - g's (Peak-to-Peak) X

20g

750

2000

5000

10000

15000

20000

FIGURE 5.48

FIGURE 5.49

FIGURE 5.50

LOCATIONS OF STRAIN
GAGES ABOVE TOP
SHIELD GG024A and T
IN LINE WITH GG026A
and T BELOW TOP
SHIELD

FOR OFFICIAL USE ONLY - UNCLASSIFIED

FIGURE 5.51

APPENDIX

CALCULATIONS FOR NEP-HE-1 DIFFUSER INTEGRITY TESTSorted WordCalculationFE015 Computed Flow Rate

100

$$FE15 \text{ GN}_2 = 0.3455 \sqrt{\frac{(PT587)(PD778)(530)}{(TT527)}}$$

102

$$FE15GNC = FE15GN_2 \sqrt{(PD778 - \text{offset})/PD778}$$

103

$$(PD778 - \text{offset})/PD778$$

For Range time 70230.0 to 70270.0, offset = 33.5

For Range time 71065.0 to 71100.0, offset = 7.2

For Range time 71660.0 to 71710.0, offset = 6.6

For Range time 72540.0 to 72580.0, offset = 4.8

For Range time 73600.0 to 73620.0, offset = 3.4

Nitrogen Compressibility Factors

For PT(X) Greater than or equal to 1600 psia:

$$ZN(X) = 2.6 \times 10^{-5} (PT(X)) + 0.962$$

For PT(X) Greater than or equal to 700 psia and less than 1600 psia:

$$ZN(X) = 3.091 \times 10^{-11} (PT(X))^2 + 1.104 \times 10^{-5} (PT(X)) + 1.0$$

For PT(X) Greater than 0 psia and less than 700 psia:

$$ZN(X) = 1.84 \times 10^{-11} (PT(X))^2 - 8.58 \times 10^{-6} (PT(X)) + 1.0$$

111

ZN(1) = Function of PT001

112

ZN(2) = Function of PT004

113

ZN(3) = Function of PT007

Sorted Word

Calculation

114

ZN(4) = Function of PT002

Weight of GN₂ in the Bottles and Line

101

$$\text{LBS-GN}_2 = 2.6105 (1763((\text{PT001}/(\text{ZN1})\text{TT489}) + (\text{PT004}/(\text{ZN2})\text{TT490}) + (\text{PT007}/(\text{ZN3})\text{TT491})) + (100)\text{PT002}/(\text{ZN4})\text{TT489})$$

"K" Factors

$$H = (19.9)(5.189)^4/55.16$$

121

$$K1 = ((H)(\text{PT001}^2 - \text{PT002}^2)/\text{TT489} - 2 \ln (\text{PT001}/\text{PT002}))/(\text{FE15GNC})^2$$

122

$$K2 = ((H)(\text{PT004}^2 - \text{PT002}^2)/\text{TT490} - 2 \ln (\text{PT004}/\text{PT002}))/(\text{FE15GNC})^2$$

123

$$K3 = ((H)(\text{PT007}^2 - \text{PT002}^2)/\text{TT491} - 2 \ln (\text{PT007}/\text{PT002}))/(\text{FE15GNC})^2$$

124

$$K4 = ((H)(\text{PT002}^2 - \text{PT587}^2)/\text{TT527} - 2 \ln (\text{PT002}/\text{PT587}))/(\text{FE15GNC})^2$$

125

$$K5 = ((H)(\text{PT587}^2 - \text{PT904}^2)/\text{TT527} - 2 \ln (\text{PT587}/\text{PT904}))/(\text{FE15GNC})^2$$

126

$$K6 = ((H)(\text{PT882}^2 - \text{PT906W}^2)/\text{TE834} - 2 \ln (\text{PT882}/\text{PT906W}))/(\text{FE15GNC})^2$$

127

$$\text{CV} = \frac{\text{FE15GNC}}{(0.0088)(12)\text{PT904}} \sqrt{(55.16)\text{TT527}}$$

Pressure Differences

104

$$\text{DELTAP1} = \text{PT007} - \text{PT002}$$

105

$$\text{DELTAP2} = \text{PT002} - \text{PT587}$$

106

$$\text{DELTAP3} = \text{PT001} - \text{PT002}$$

107

$$\text{DELTAP4} = \text{PT587} - \text{PT904}$$