

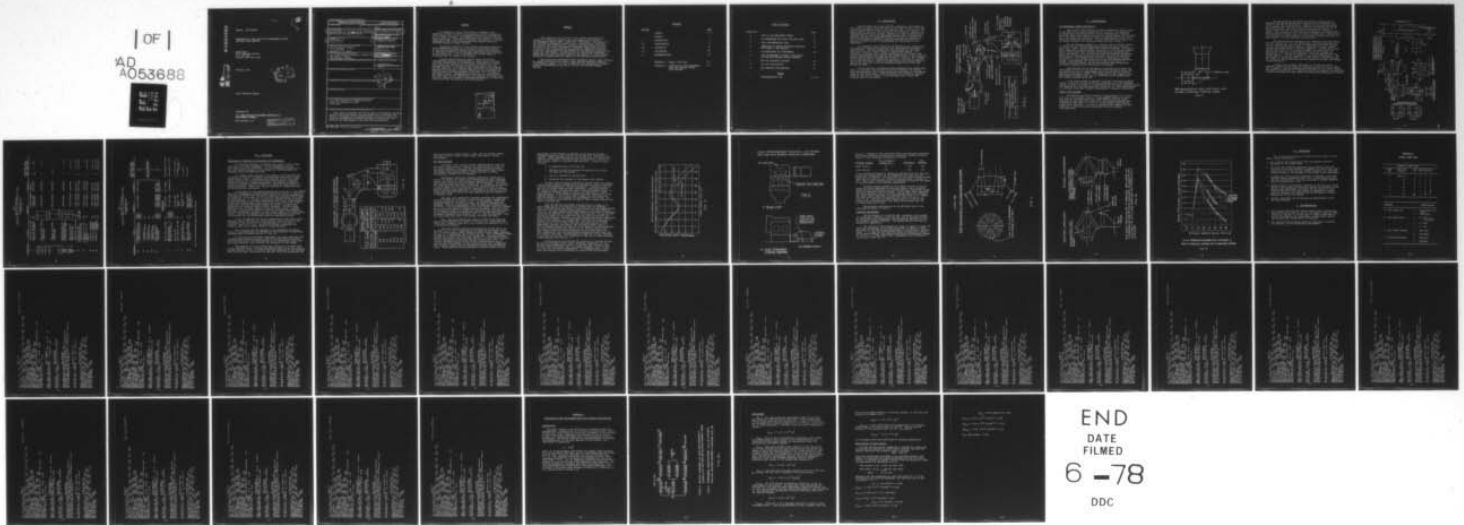
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PERFORMANCE OF THE LACV-20 AIR MANAGEMENT SYSTEM ORIGINAL CONFIDENTIAL (U)  
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PERFORMANCE OF THE LACV-30 AIR MANAGEMENT SYSTEM  
ORIGINAL CONFIGURATION

Frank Bond  
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P. O. Box One  
Buffalo, New York 14240

February 1978

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Final Technical Report

Prepared For

U.S. ARMY MOBILITY EQUIPMENT RESEARCH AND  
DEVELOPMENT COMMAND

Fort Belvoir, VA

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SUMMARY

In response to early indications of excessive sand ingestion through the LACV-30 main engines and low pressures at their inlets, the inlet Air Management System was instrumented for air flows, pressures and temperatures and tested at various power conditions. These tests confirmed the presence of negative pressures at the inlets and provided data showing where the principal pressure losses occurred.

Concurrent analysis of the original two-stage filtration system demonstrated that at its design filtration efficiency it would pass excessive amounts of particulates when operating in the high sand and dust environment experienced during testing at Fort Story, Va. It was concluded that a third stage of filtration must be added to the system.)

Various modifications to reduce losses and further increase AMS pressures to accommodate a third stage of filtration were investigated. A modified AMS configuration incorporating additional filtration, a diffuser at the fan exit, an enlarged entrance to the engine inlet compartment, and shifting the oil cooler air load from the AMS fan to the lift system was designed and analyzed. Analysis showed that this configuration would provide a positive pressure of from 4" to 7" of water at the engine inlets. Recommendations were made for installation and early tests of key components in the original AMS aboard LACV-30-2 and, upon verification of expected performance, to fabricate, install and test the modified AMS configuration.

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## PREFACE

This report is one of a set of two reports documenting the results of a program to improve the performance of the LACV-30 Air Management System (AMS). Report No. 7467-928007, "Performance of the LACV-30 Air Management System Initial Configuration" describes the original AMS configuration, presents test data showing the performance of its various components, recommends design modifications to provide higher pressures and incorporate an additional stage of filtration, and predicts the performance of the modified configuration. Report No. 7467-928008, "Performance of the LACV-30 Air Management System Modified Configuration" presents the results of a test program conducted to demonstrate the adequacy of the AMS after modification.

The program was performed by Bell Aerospace Textron under Contract No. DAAK02-75-C-0149 with the U.S. Army Mobility Equipment Research & Development Command. Mr. John Sargent was the Contracting Officer's Technical Representative and Mr. C. E. Burr was the BAT Program Manager.

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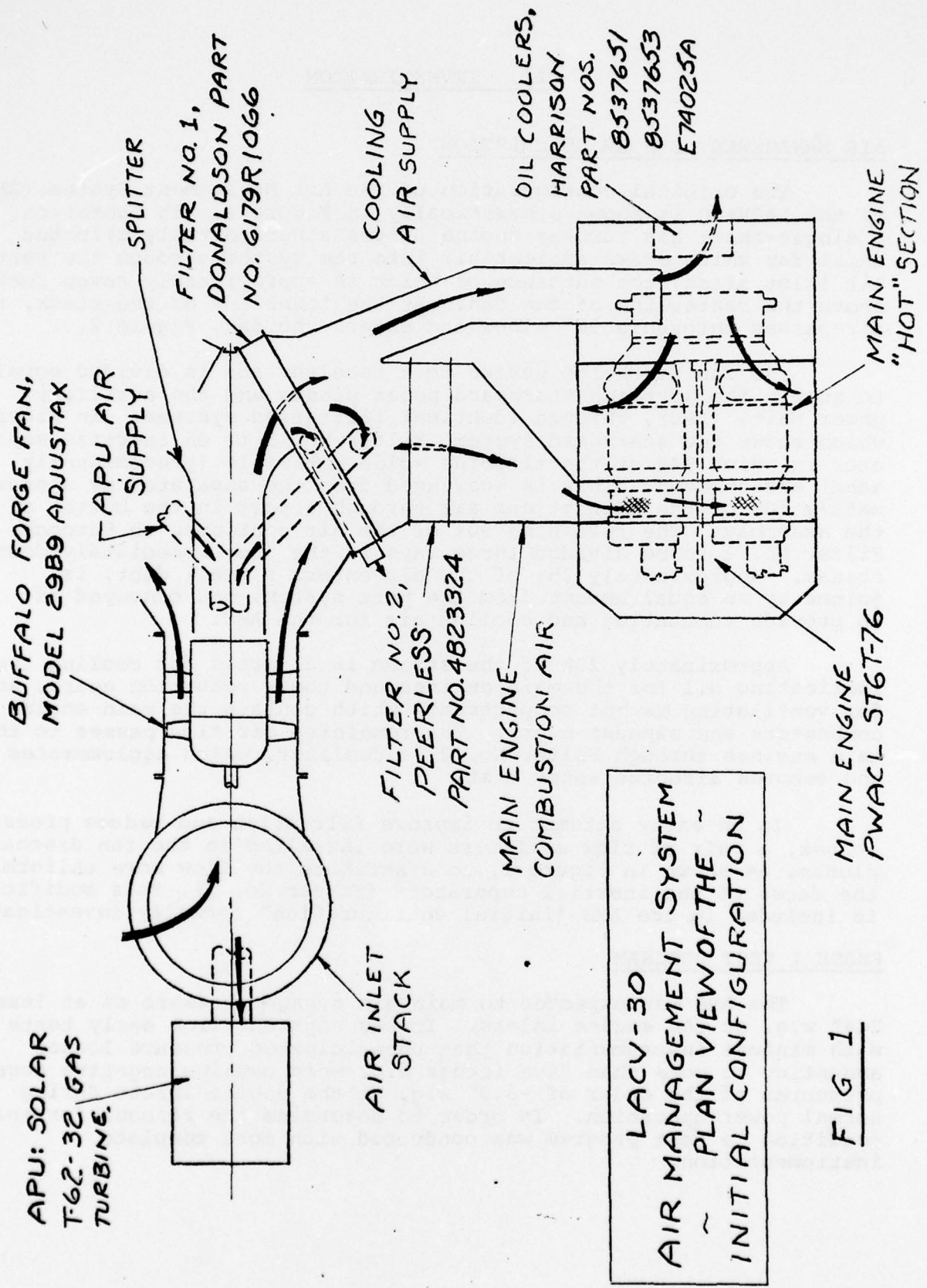
## I. INTRODUCTION

Initial operation of the LACV-30-1 vehicle on the beaches of Fort Story, Virginia, revealed that the main engine first stage compressor blades were wearing at an excessive rate. The nature of the wear, shown in Figure 1, was typical of that caused by ingestion of abrasive particles such as sand. However, the LACV-30 vehicles are equipped with an active Air Management System (AMS) incorporating moisture and particle separation devices to clean the incoming air, and a fan designed to maintain positive pressures throughout the system to prevent inflow of contaminated air downstream of the separators.

In response to the indications of excessive sand ingestion by the engines, a preliminary survey of key AMS pressures was made in February 1976. The data showed that the pressures at the engine inlet were actually several inches of water below ambient. In addition to allowing sand to enter downstream of the filters, the low system pressures also impaired the effectiveness of the engine oil cooler, which required pressurized cooling air from the AMS. Several minor modifications to increase AMS pressure, including an improved lip at the AMS intake, higher fan blade angles, and turning vanes in the intake elbow and in the fan discharge plenum were tried with minimal success.

In the meantime, calculations were performed which showed that even at the design value of AMS filtration efficiency the engines would see excessive inlet contamination when operating in the extreme sand and dust environment, often producing zero visibility, experienced at Fort Story. Hence, it was concluded that a major AMS redesign must be considered.





LACV-30  
 AIR MANAGEMENT SYSTEM  
 ~  
 PLAN VIEW OF THE  
 INITIAL CONFIGURATION

FIG 1

## II. INVESTIGATION

### AIR MANAGEMENT SYSTEM DESCRIPTION

The original configuration of the Air Management System (AMS) of the LACV-30 is shown schematically in Figure 1. In operation, a single-shaft gas turbine engine drives a horizontally oriented axial fan which draws ambient air into the system through the vertical air inlet stack, the entrance of which is approximately seven feet above the centerline of the fan. At the lower end of the stack, the air passes through a 90° elbow and enters the fan, Figure 2.

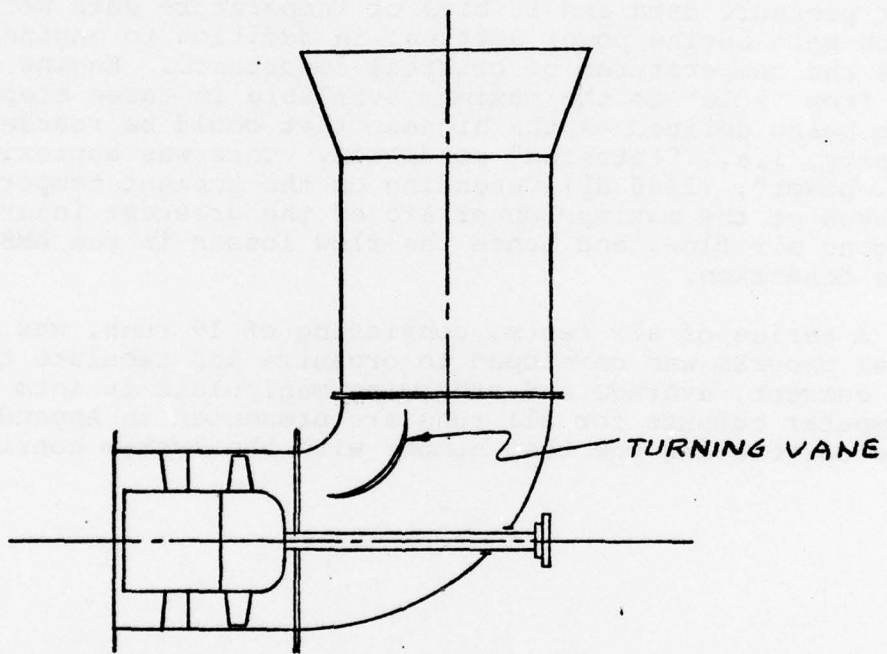
The fan discharge passes to a receiver and is divided equally to supply the port and starboard power plants and the auxiliary power unit, (APU), through identical filtration systems. In Figure 1, which shows the starboard system, Filter No. 1 is an inertial separator in which 94% of the airborne solid materials (predominantly sand) are removed. This is scavenged from the separator by approximately 10% of the main stream air through a port in the bottom of the assembly. The remaining 90% of the air continues on through Filter No. 1 to be divided three ways in the duct immediately downstream. Approximately 25% of the air enters a small duct, is joined by an equal amount from the port system, and conveyed aft to provide combustion and cooling air for the APU.

Approximately 20% of the stream is diverted for cooling the lubricating oil for the main engines and their reduction gears, and for ventilating the hot compartments which contain the main engine combustors and exhaust ducts. The remaining air flow passes to the main engines through Filter No. 2, a demister, which agglomerates and removes airborne water mist.

In an early attempt to improve filtration and reduce pressure losses, a pair of flow splitters were installed in the fan discharge plenum, as shown in Figure 1, to distribute the flow more uniformly across the faces of the inertial separators (Filter No. 1). This modification is included in the AMS "initial configuration" formally investigated.

### PHASE I TEST PROGRAM

The AMS was expected to maintain a gage pressure of at least 2.4" w.g. at the engine inlets. It was apparent from early tests with minimal instrumentation that unanticipated pressure losses amounting to more than five inches w.g. were causing negative gage pressures of the order of -3.0" w.g. at the engine inlets during normal power operation. In order to determine the reasons for this condition a test program was conducted with more complete instrumentation.



AIR MANAGEMENT FAN INLET DUCT AND  
ELBOW SHOWING TURNING VANE.

FIG 2

The test plan for this phase was directed specifically at assessing the AMS performance and identifying the components that failed to perform as anticipated. Figure 3 is the instrumentation plan, showing the locations of the pressure and temperature probes. The identification code associated with each sensor appears in Table I where the type of probe and its purpose are indicated. In general, the objective of the plan was to determine the temperatures, static pressure distributions, and velocity heads (where significant), to facilitate the determination of flow rates, pressure drop and, in some regions, the local pressure distributions.

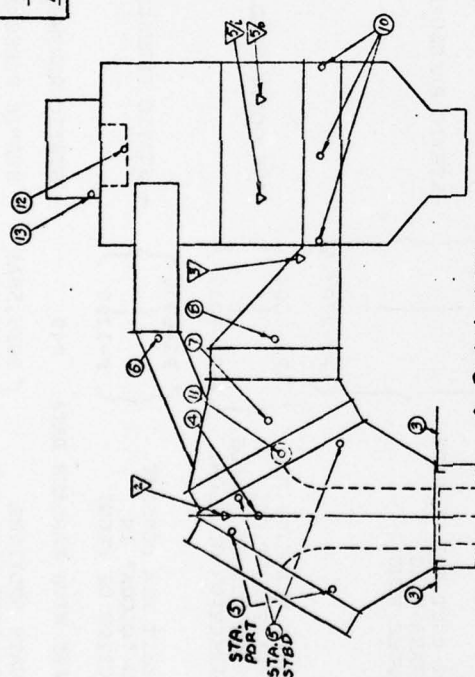
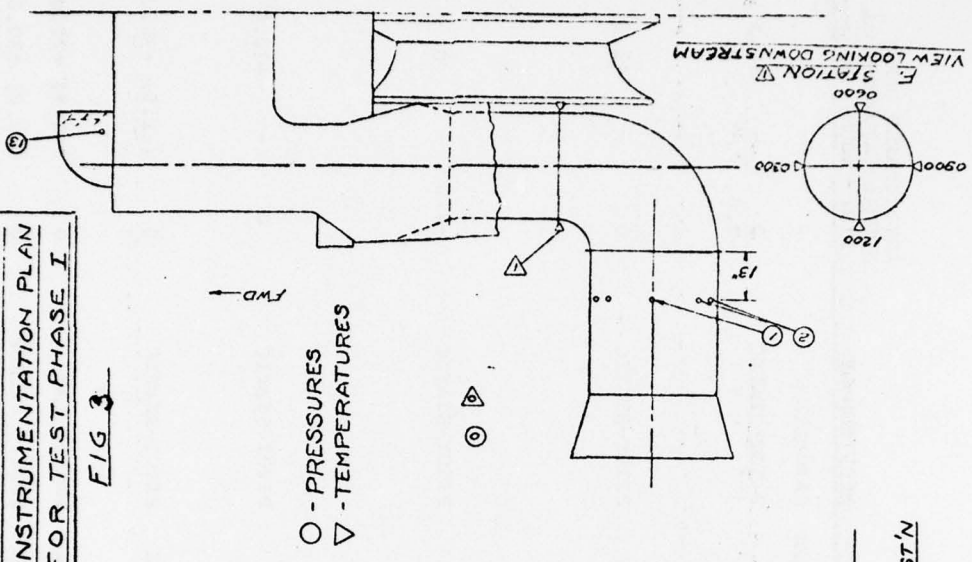
The test matrix was arranged to be compatible with the vehicle, the time schedule and the test objectives. Briefly summarized, 52 bits of pressure data and 10 bits of temperature data were recorded for each main engine power setting, in addition to engine speeds, torques and temperatures of critical importance. Engine powers were varied from "idle" to the maximum available in three steps, the maximum being defined as the highest that could be reached in a stationary, i.e., "tethered" condition. This was approximately the "normal power", (1440 HP) depending on the ambient temperature. The data taken at the maximum power are of the greatest interest because the engine air flow, and hence the flow losses in the AMS, are largest at this condition.

A series of six tests, consisting of 19 runs, was made. A computer program was developed to organize and tabulate the raw data, and to correct, average and otherwise manipulate it into useful forms. The computer outputs for all runs are presented in Appendix A, along with a table correlating the test number with the system configuration tested.

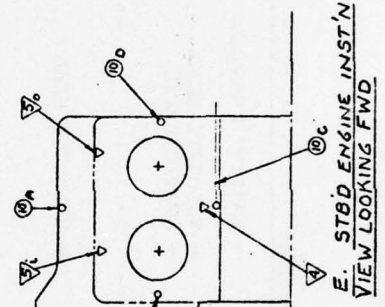
MODEL 7467, (LACV-30-2)  
 AIR MANAGEMENT SYSTEM  
 INSTRUMENTATION PLAN  
 FOR TEST PHASE I

FIG 3

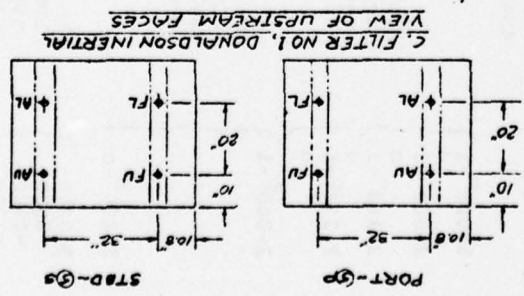
B. STBD ELEVATION



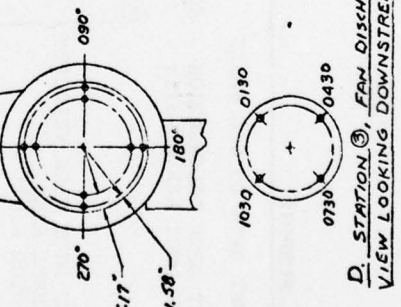
A. PLAN VIEW



E. STBD ENGINE INSTN VIEW LOOKING FWD



C. FILTER NO.1, DONALDSON INERTIAL VIEW OF UPSTREAM FACES



D. STATION ⑤, FAN DISCHARGE, VIEW LOOKING DOWNSTREAM

TABLE I  
 MODEL 6467 (LACV-30-2)  
 PERFORMANCE TESTS OF THE AIR MANAGEMENT SYSTEM  
 INSTRUMENTATION LIST  
 SHEET 1 PF 2

STATION NO.	PURPOSE	PARAMETER	ACQUIRED BY	ANTICIPATED RANGE	
				MIN.	MAX.
0	ADJUST DATA TO STD BASIS	PO	BAROMETER	-	-
1	INLET DUCT CALIBRATION	$\Delta P_1$	PITOT-STATIC	0	+1.5
	INLET DUCT AIR DENSITY	P1	"	-2.0	0
2-000 <sup>o</sup> -i	INLET DUCT FLOW VELOCITY (i=INNER RING, o=OUTER RING)	$\Delta P_{000}^o L$	PITOT-STATIC	0	+1.5
2-180 <sup>o</sup> -i					
2-270 <sup>o</sup> -i					
2-000 <sup>o</sup> -i					
2-270 <sup>o</sup> -o	INLET DUCT AIR DENSITY (i=INNER RING, o=OUTER RING)	$\Delta P_{270}^o L$	PITOT-STATIC	-2.0	0
3-0300	FAN EXIT VELOCITY AND FLOW DISTRIBUTION. (STATION "CLOCK" READS IN DIRECTION OF FLOW)	$\Delta P_{3-0300}$	PITOT-STATIC	0	+10.0
-0600					
-0900					
-1200					
3-0300	FAN EXIT AIR DENSITY (READ "CLOCK" IN DIRECTION OF FLOW)	$\Delta P_{3-0300}$	PITOT-STATIC	0	+20.0
-0600					
-0900					
-1200					
4	COMPARE WITH EARLIER DATA	P45	STATIC TAP	0	+20.0
5S	EVALUATE SPLITTER PERFORMANCE FLOW AND PRESSURE DISTRIBUTION	5SFU, 5SAU 5SFL, 5SAL	STATIC PICKUP	0	+20.0
6S	COOLING AIR DUCT FLOW VELOCITY COOLING AIR DUCT AIR DENSITY	$\Delta P_G$	PITOT-STATIC	0	+1.0
7S	FILTER #1, P. (DONALDSON INERTIAL)	P75	STATIC TAP	0	+20.0
8S	FILTERS #2, P. (FEERLESS DEMISTER)	P85	STATIC TAP	0	+18.0
9S	FILTERS #3, P. (DONALDSON BARRIER)	P95	STATIC TAP	0	+26.0

TABLE I  
 MODEL 7467 (LACV-30-2)  
 PERFORMANCE TESTS OF THE AIR MANAGEMENT SYSTEM  
 INSTRUMENTATION LIST  
 SHEET 2 OF 2

STATION NO.	PURPOSE	PARAMETER	ACQUIRED BY	ANTICIPATED RANGE NORMAL (APU) NORMAL MIN. (OUT) MAX.
5P	{ EVALUATE SPLITTER PERFORMANCE, FLOW AND PRESSURE DISTRIBUTION	{ P5PFU P5PEL P5PAU P5PAL	STATIC PICKUP	
7P	P FILTER NO. 1, (DONALDSON INERTIAL)	P7P		
8P	P FILTER NO. 2, (PEERLESS DEMISTER)	P8P		
9P*	P FILTER NO. 3, (DONALDSON BARRIER)	P9P		
10P	ENGINE INLET PLENUM STATIC PRESSURE DISTRIBUTION	{ P10PA P10PB P10PC P10PD	{ STATIC PRESSURE STATIC TAP STATIC TAP STATIC PROBE STATIC TAP	
← SAME AS CORRESPONDING STARBOARD STATIONS →				
<u>TEMPERATURES</u>				
1.	ADJUST DATA TO STD BASE FAN INLET MACH NO. EXHAUST INGESTION FAN INLET AIR DENSITY	{ T1-1200 T1-0300 T1-0600 T1-0900	LAB. THERMOM. CU CONSTATAN TC	LOCAL AMBIENT, 0°-110°F LOCAL AMBIENT, 0-110°F
2	FAN EFFICIENCY	T2	" "	T1 + (6° TO 20°) (F)
3	ADJUST POWER TO STD BASE	T3	" "	T2 (NORMAL), TO + 30° (APU OUT)
4	MONITOR FOR WARM AIR LEAKAGE AND COMP. BLEED AIR	T4	" "	T1 + 100° (F)
5I	MONITOR ENG. COMBUSTOR "HOT" SECTION COOLING EFFICACY	T5I	" "	T2 TO 400°F
5O		T5O	INBOARD COMBUSTOR SPACE TEMP. OUTBOARD COMBUSTOR SPACE TEMP.	

\*NO. 9 TO BE ACTIVATED WHEN BARRIER FILTER IS INSTALLED.

### III. DISCUSSION

#### COMPARISON OF PREDICTED AND MEASURED AMS PERFORMANCE

The expected pressures throughout the original AMS had been predicted for a 3200 horsepower, or 1600 horsepower per Twin Pac, engine operating condition. The high horsepower condition is the most critical because the high engine air flow maximizes the pressure losses throughout the AMS.

The highest power achieved in the Phase I tests was the 1385 horsepower of Test No. 6-C3b0616, performed with the LACV-30 under way at about 30 mph. Although partial recovery of the free stream dynamic pressure in the AMS inlet stack could present a slightly optimistic picture of system performance, the maximum theoretical value of recovered pressure is about 0.5 inches of water, which is deemed negligible. Thus, that run was selected for comparison with the predicted AMS performance.

A tabulation of key system pressures from Test No. 6, Run C3b0616 with the corresponding original design prediction appears in Figure 4. These data indicated that the static pressure, P5 at the upstream face of Filter No. 1 was lower by 2.9" w.g. than was predicted. This could be attributed to: 1) failure of the fan to produce its design value of pressure head, 2) fan inlet disturbances due to the close proximity of the inlet stack elbow to the front face of the fan, or 3) to the inability of the fan discharge receiver to convert a significant portion of the discharge head to static pressure. Of these three possibilities, the first appeared to be the least likely. Further, Test Nos. 3 and 4 showed there is little to be gained by resetting the fan blade angles. However, if the turning vane in the inlet elbow, Figure 2, failed to suppress sufficiently the formation of vortices in the elbow, the fan performance could be adversely effected.

It can be deduced from the fan manufacturer's data that at the designed rate of flow rate of 32,000 CFM the static pressure of the discharge of the fan annulus is approximately 6.1" w.g. with a velocity head of 7.9" w.g. The data in Figure 4 indicates that little if any of this kinetic head is being recovered.

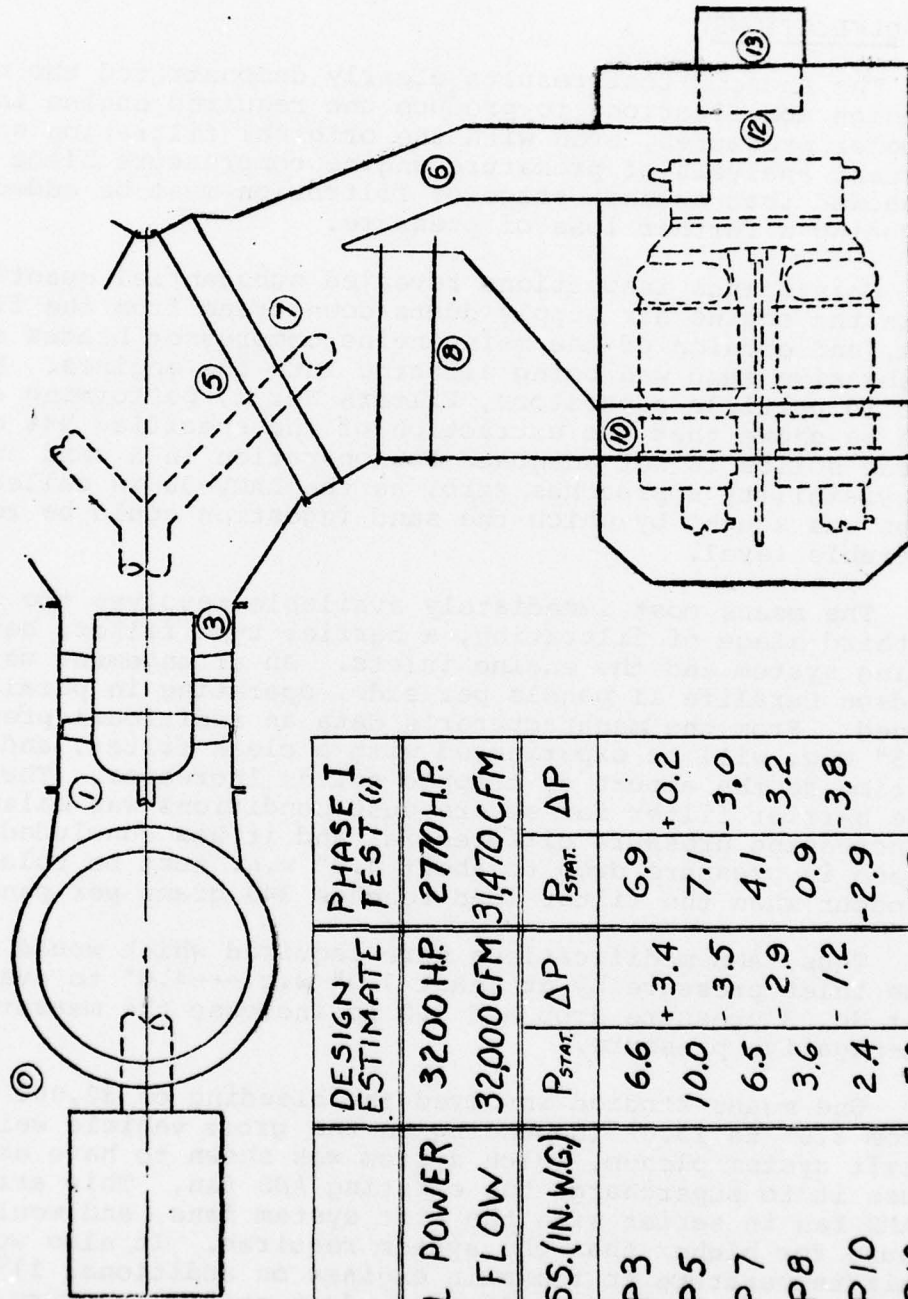
The filtration devices appeared to be performing reasonably close to the predictions, as indicated by the similarity of predicted and measured  $\Delta P$ 's between Stations 5-7 and 7-8.

At the inlet to the engine compartment, the data indicates that pressure losses between Stations 8 and 10 are more than three times the predicted values, due most probably to an insufficient inlet area producing excessive inlet velocity and turbulence in the chamber.

The pressure in the oil cooler bay, Station 12, is about half of the predicted value. Although the pressure drop across the coolers, between Stations 12 and 13 is about what was predicted, it was attained only with full-open louver doors at the exit, while the prediction was



COMPARISON OF DESIGN ESTIMATED PRESSURES WITH PHASE I TEST RESULTS



	DESIGN ESTIMATE		PHASE I TEST (1)	
	P <sub>STAT.</sub>	ΔP	P <sub>STAT.</sub>	ΔP
TOTAL POWER	3200 H.P.		2770 H.P.	
FAN FLOW	32000 CFM		31470 CFM	
P3	6.6	+ 3.4	6.9	+ 0.2
P5	10.0	- 3.5	7.1	- 3.0
P7	6.5	- 2.9	4.1	- 3.2
P8	3.6	- 1.2	0.9	- 3.8
P10	2.4		- 2.9	
P12	5.2	- 1.3	2.7	- 1.2
P13	3.9		1.5	

FIG 4

(1) TEST NO. 6-(C360616), UNDER WAY

based on partially closed louvers. Thus, the oil cooling system had nothing left in hand to meet higher than nominal cooling requirements.

#### AMS MODIFICATIONS

The Phase I test results clearly demonstrated the need for AMS design modifications to produce the required engine inlet and oil cooler pressures, even with the original filtration scheme. Concurrent analysis of premature engine compressor blade erosion also showed that another stage of filtration must be added, introducing a further loss of pressure.

Maintenance inspections revealed substantial quantities of sand in the engine air supply ducts downstream from the filtration system, and erosion of the main engine compressor blades confirmed that abrasive sand was being airborne into the engines. Even with the solid particle separators, Filters No. 1, performing as intended, it can be shown that the extraction of the specified 94% of the airborne solids is not adequate for operation in a sand environment where visibility approaches zero, as the LACV-30 is called on to do. A means was sought by which the sand ingestion could be reduced to a tolerable level.

The means most immediately available involves the installation of a third stage of filtration, a barrier type filter, between the existing system and the engine inlets. An arrangement using four Donaldson Duralife II panels per side, operating in parallel was designed. From the manufacturer's data an additional pressure loss of 1.5" w.g. will be experienced with a clean filter, and will increase with time as the amount of trapped solids increases. The cycle life of the barrier filter for severe dust conditions was balanced against the increasing pressure differential and it was concluded that an increase in pressure drop to about 4.0" w.g. must be tolerated. This will occur when the filter load reaches 340 grams per panel.

Thus, AMS modifications were required which would raise the engine inlet pressure by at least 7.0" w.g.--4.0" to overcome the filter No. 3 pressure drop and 3.0 to increase the measured -2.4" to a non-negative pressure.

One means studied involved the bleeding of 32,000 CFM of air at from 8.0" to 15.0" (depending on the gross vehicle weight) from the lift system plenum, which system was shown to have ample capacity, and use it to supercharge the existing AMS fan. This arrangement places the AMS fan in series with the lift system fans, and would provide pressure for higher than the system requires. It also would increase the air temperature to the main engines on additional 11<sup>o</sup>F. The increase of approximately 80 psf in duct system pressure would require some reinforcement of the existing ducts, and a substantial duct addition between the lift fan plenum and the existing AMS fan inlet. These additions were estimated to increase weight by about

600 pounds, at the expense of payload, and to have an adverse (rearward) effect on the location of the center of gravity of the vehicle. These considerations as well as the cost and elapsed time required for designs, fabrications and installations turned attention to other means of increasing AMS pressures. Potential means included:

1. An improved inlet to the AMS fan.
2. Reducing the AMS fan airload by supplying oil cooling air from the lift system.
3. Use of a diffuser at the fan exit.
4. Enlarging the entrance to the engine inlet plenum.

An inlet elbow designed to minimize turning losses and provide a more uniform velocity distribution to the AMS fan face is available from the fan manufacturer, and was considered. A modified inlet at the top of the AMS stack was also considered. This would replace the existing funnel configuration with a rounded bellmouth inlet, in an attempt to minimize losses in static and, especially, forward speed operation. A diversity of opinion existed, however, as to the probable benefit of this rather major change, and that additional data was needed on the potential for improvement in this area. To obtain this data, it was decided to test an ideal, though impractical, inlet to the AMS fan.

From the AMS fan performance characteristics, Figure 5, it can be shown that if the flow rate is reduced from the designed level of 32,000 cfm by the amount of the cooling air load (approximately 7,000 cfm) the fan discharge total pressure will rise approximately 4.0" w.g., an amount which would fully offset the increase in resistance caused by the addition of a third stage of filtration. To replace the cooling air supply it was noted that for the first alternative the lift system had ample capacity to provide 32,000 cfm with no significant effect on the vehicle. It follows that one-fifth that amount can be diverted for cooling without difficulty. For this it is proposed that plenum air will be taken from the side deck adjacent to and immediately outboard from each of the two power plants, Figure 6. This arrangement devotes the AMS fan to the supply of engine combustion air only, and reassigns the cooling load to the lift system fans. This scheme avoids the weight penalties and the higher engine air inlet temperatures with the corresponding penalty in power loss, and will require less time. Another positive effect of the 20% reduction in fan rate of flow will be a reduction of some 40% in system pressure losses upstream of Filter No. 2.

A high priority was accorded the recovery of a greater portion of the fan discharge kinetic head, estimated to approach 6.0" w.g. The test data summarized in Figure 4 indicates that virtually none of this head is recovered (the  $\Delta P$  between Stations 3 and 5 is only 0.2" w.g.) in the present arrangement. To accomplish this, a diffuser was designed for installation in place of the two splitters,

AIR MANAGEMENT FAN PERFORMANCE  
 BUFFALO FORGECO TYPE 29B9 ADUSTAX AT 3600 RPM

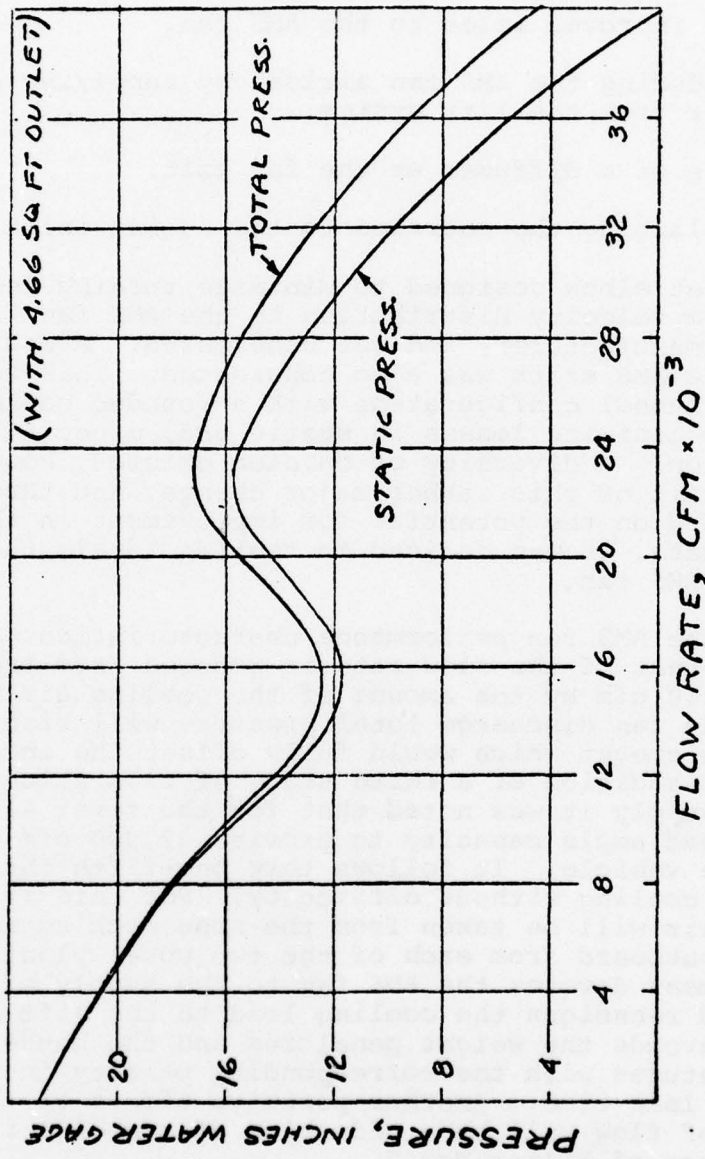


FIG. 5

DUCT ARRANGEMENT TO SUPPLY LIFT SYSTEM  
AIR FOR MAIN ENGINE COOLING PURPOSES.

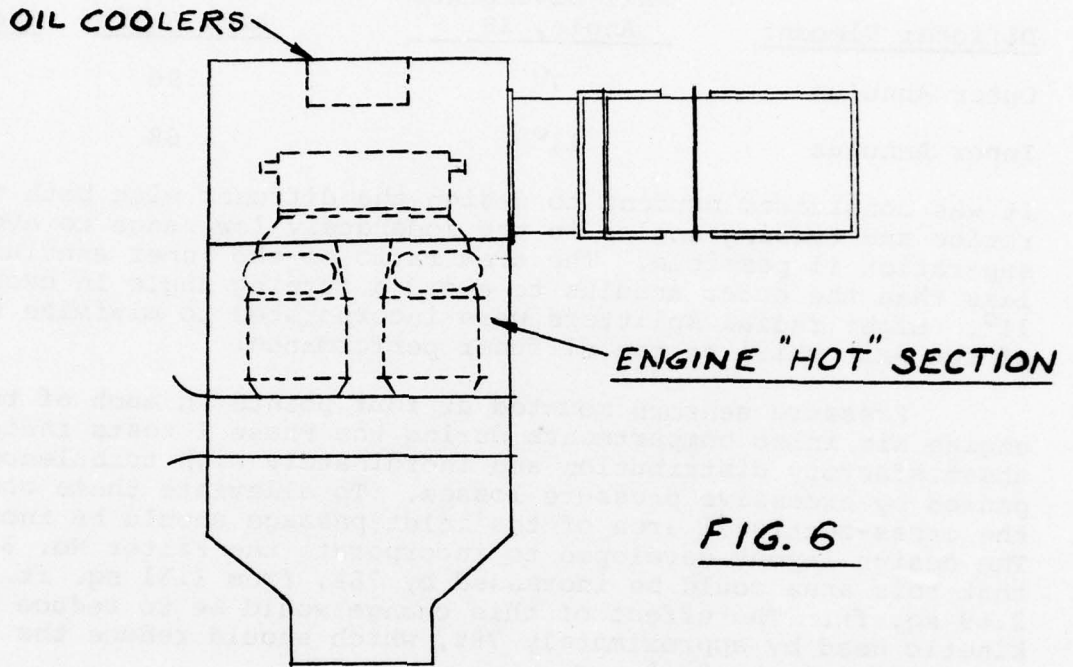
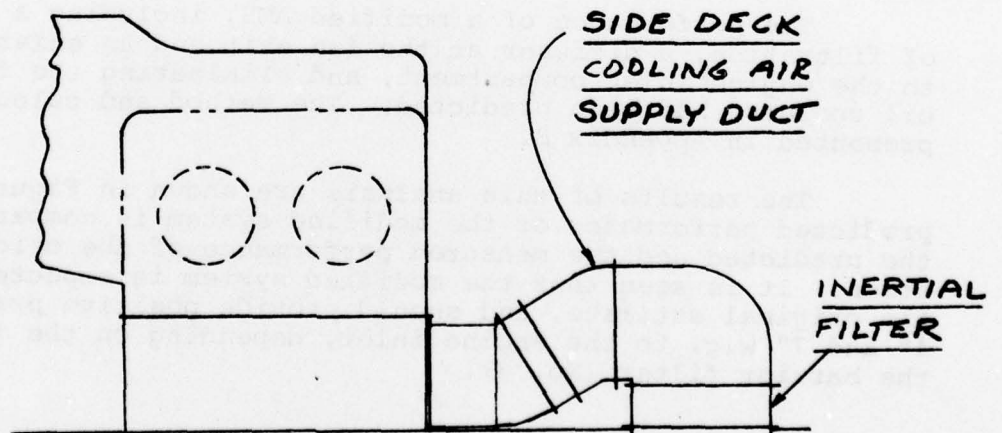


FIG. 6

a. PLAN VIEW.



LIFT SYSTEM PLENUM

b. VIEW - STB ENGINE  
LOOKING FORWARD.

Figure 1. Because of the relatively short axial distance available, the concept selected consists of two concentric annular diffusers, Figure 7, with principal parameters as follows:

<u>Diffuser Element</u>	<u>Wall Divergence Angle, <math>2\theta</math></u>	<u>Area Ratio</u>	<u>Est. Recovery</u>
Outer Annulus	$7^\circ$	1.96	59%
Inner Annulus	$11^\circ$	1.68	53%

It was considered prudent to design the diffuser with both the area ratios and turning angles in the moderately low range to avoid separation if possible. The area ratio of the inner annulus was made less than the outer annulus to avoid a turning angle in excess of  $11^\circ$ . Eight radial splitters were incorporated to minimize the effect of fan exit whirl on the diffuser performance.

Pressure sensors mounted at four points in each of the two engine air inlet compartments during the Phase I tests indicated unsatisfactory distribution and inordinately high turbulence, accompanied by excessive pressure losses. To alleviate these conditions the cross-sectional area of the inlet passage should be increased. The design layout developed to incorporate the Filter No. 3 showed that this area could be increased by 78%, from 1.51 sq. ft. to 2.69 sq. ft. The effect of this change would be to reduce the kinetic head by approximately 78%, which should reduce the 3.8" w.g inlet loss by 2.6" w.g.

The proposed modifications to the AMS would lead to the configuration shown in Figure 8.

#### PREDICTED PERFORMANCE

The performance of a modified AMS, including a third stage of filtration, a diffuser at the fan exit and an enlarged entrance to the engine inlet compartment, and eliminating the flow to the oil coolers, has been predicted. The method and calculations are presented in Appendix B.

The results of this analysis are shown in Figure 9, where the predicted performance of the modified system is compared to both the predicted and the measured performance of the original configuration. It is seen that the modified system is expected to exceed the original estimate, and should provide positive pressures between 4" and 7" w.g. to the engine inlet, depending on the freshness of the barrier filter (No. 3).

LACV-30

AIR MANAGEMENT FAN DISCHARGE DIFFUSER

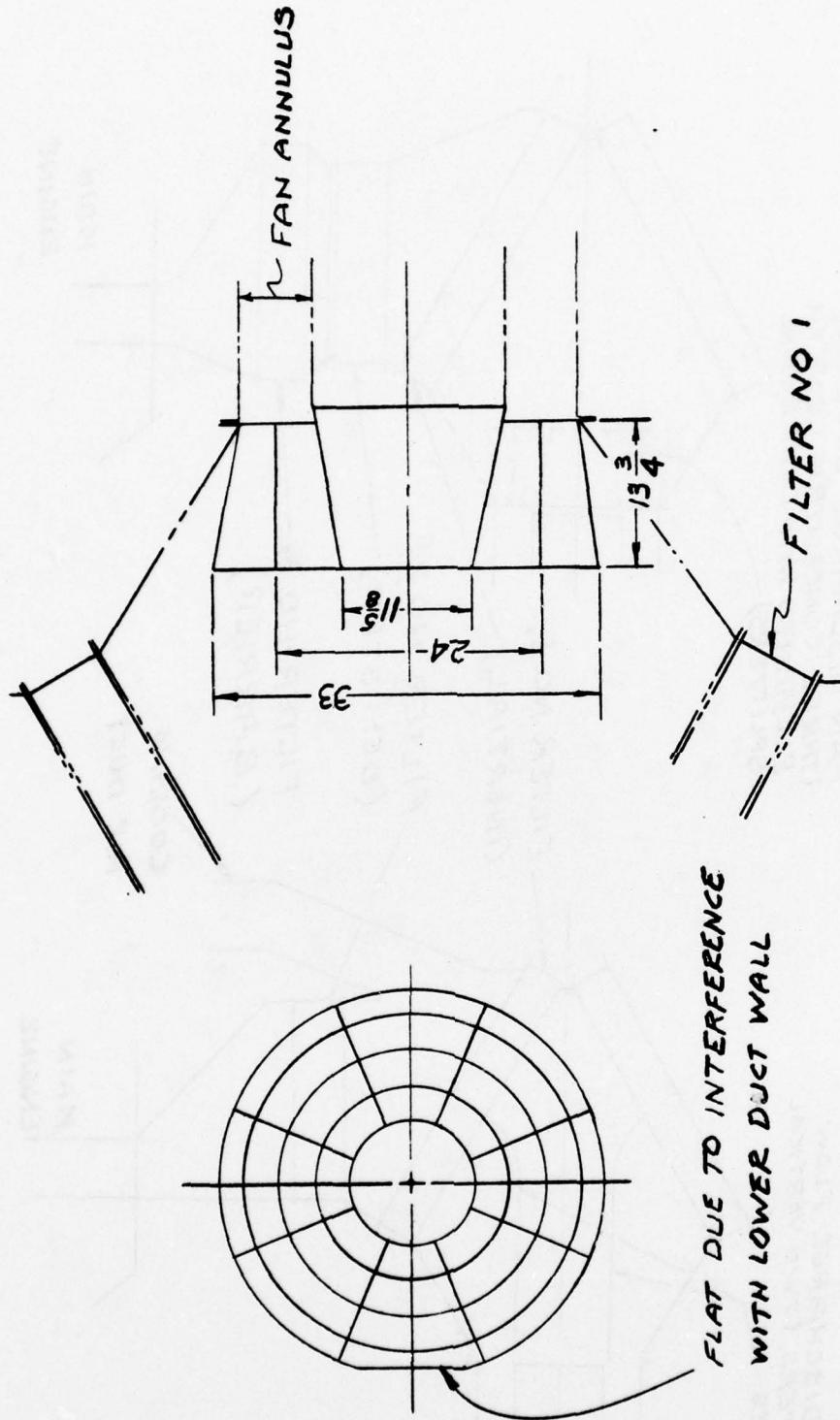
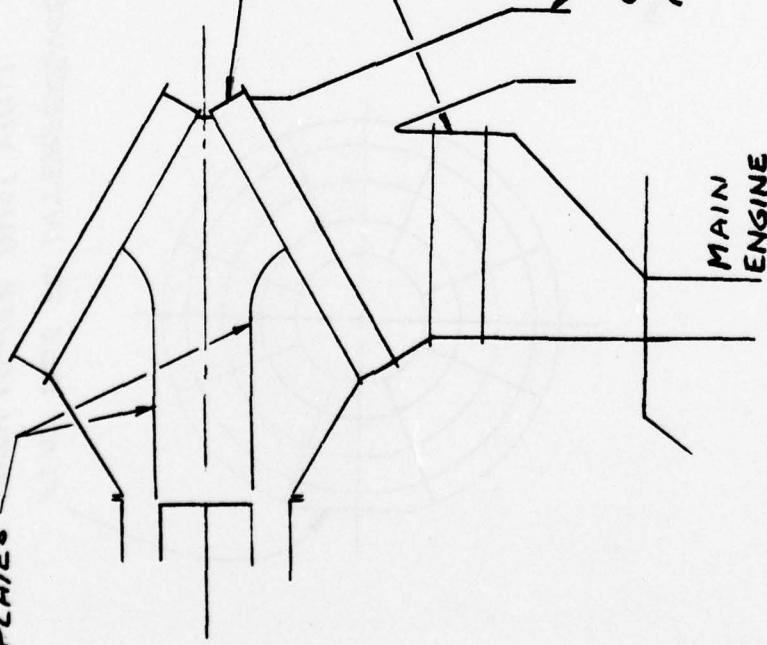


FIG 7

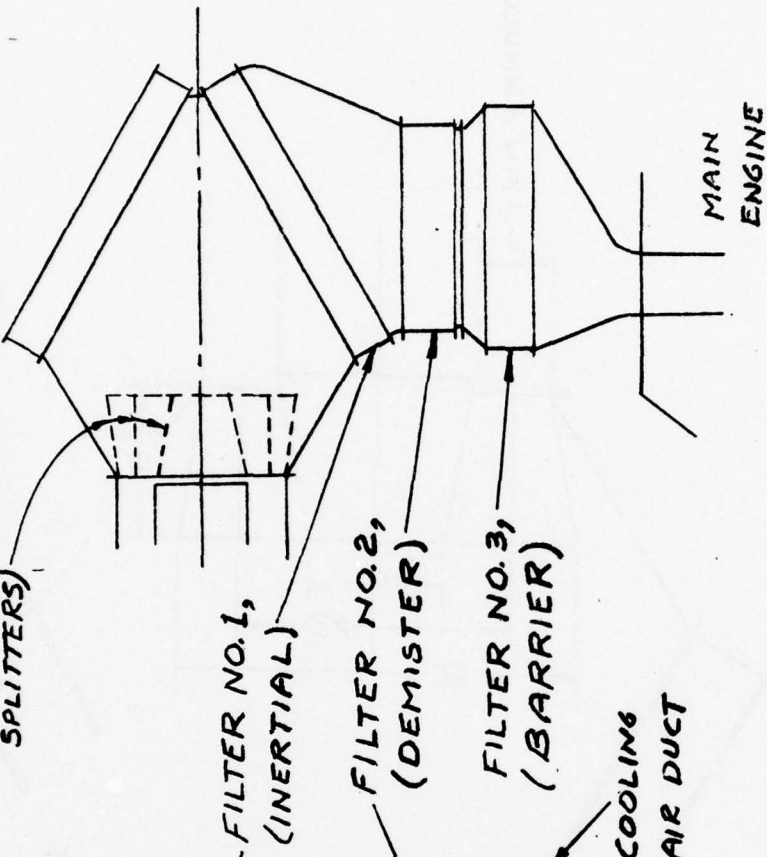
0) INITIAL ARRANGENT.

FAN DISCHARGE FLOW SPLITTERS, (TWO VERTICAL PLATES)



b) FINAL CONFIGURATION.

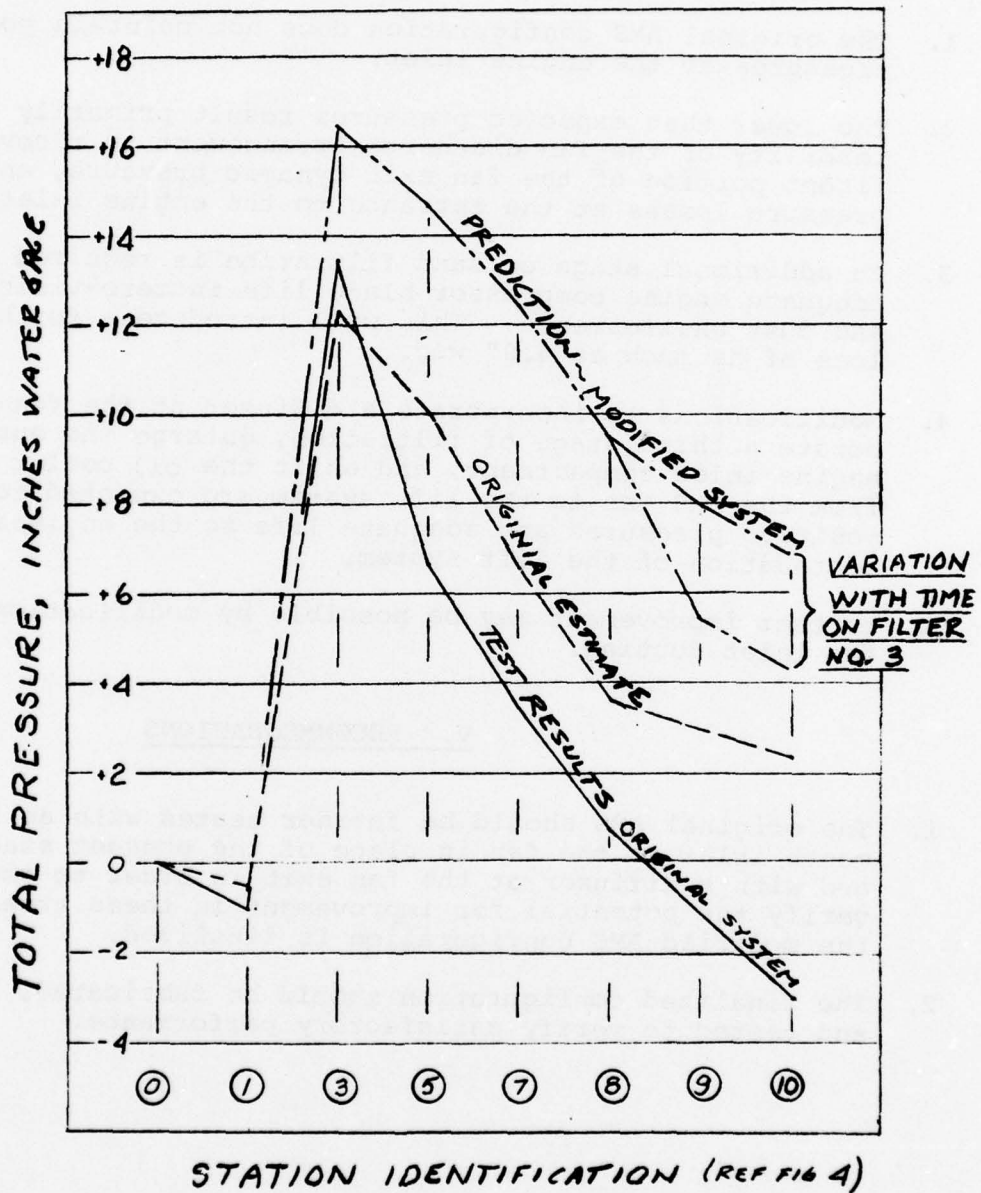
FAN DISCHARGE DIFFUSER, (THREE CONCENTRIC CONICAL ELEMENTS WITH EIGHT RADIAL SPLITTERS)



AIR DUCT MODIFICATION TO PROVIDE 3RD STAGE OF FILTRATION OF AIR TO MAIN ENGINES, ELIMINATE THE COOLING AIR DUCT, AND REPLACE SPLITTERS WITH A DIFFUSER.

FIG 8





AMS PRESSURE DISTRIBUTIONS. ESTIMATE & TEST OF ORIGINAL SYSTEM; EST. OF MODIFIED SYSTEM

FIG. 9

#### IV. CONCLUSIONS

The following conclusions are drawn from the results of the Phase I tests and analysis.

1. The original AMS configuration does not maintain positive pressures at the engine inlet.
2. The lower than expected pressures result primarily from the inability of the fan discharge arrangement to recover any significant portion of the fan exit dynamic pressure, and from high pressure losses at the entrance to the engine inlet compartment.
3. An additional stage of sand filtration is required to provide adequate engine compressor blade life in zero-visibility sand and dust environments. This will introduce a further pressure loss of as much as 4.0" w.g.
4. Modifications to incorporate a diffuser at the fan exit, incorporate a third stage of filtration, enlarge the entrance to the engine inlet compartment, and shift the oil cooler air load from the AMS fan to the lift system are expected to restore positive pressures and adequate life to the engines, without degradation of the lift system.
5. Further improvement may be possible by modifications to the fan inlet ducting.

#### V. RECOMMENDATIONS

1. The original AMS should be further tested with an ideal bell-mouth inlet to the fan in place of the present stack and elbow and with a diffuser at the fan exit in order to ascertain or verify the potential for improvement in these areas, before the modified AMS configuration is finalized.
2. The finalized configuration should be fabricated, installed and tested to verify satisfactory performance.

APPENDIX A  
PHASE I TEST DATA

SUMMARY OF AMS TESTS					
TEST NO.	TEST DATE (1976)	TEST CONFIGURATION			
		A	B	C	D
1	June 8, 9	1	1	1	1
2	10	↓	1	2	↓
3	11	↓	2	1	↓
4	15	↓	3	↓	↓
5	15	↓	1	↓	↓
6	16	↓	1	↓	2

VARIABLE		CONFIGURATION
A - Fan Inlet Duct	1	Inlet Stack and Elbow
	2	Inlet Bell
B - Fan Blade Angle	1	$\beta = 36^\circ$ (as delivered)
	2	$\beta = 38\frac{1}{2}^\circ$
	3	$\beta = 33^\circ$
C - Oil Cooler Louvres	1	Full Open
	2	Half Open
D - Vehicle Condition	1	Tethered
	2	Underway

INPUT DATA  
 N2= 0.0  
 TOP 0.0  
 STACK VEL. HD.= 0.65 0.70 0.65 0.75 0.73 0.75 0.75 0.40 0.40 0.35  
 STACK STATIC HD.= -0.80 -0.80 -0.80 -0.75 -0.90 -0.75 -0.80 -0.75 -0.80  
 FAN VEL. HD.= 5.900 2.200 4.900 4.700  
 FAN STATIC HEAD= 11.500 11.000 11.000 11.500  
 PRESS. AT DONALDSON-STBD 12.000 11.000 13.000 12.000  
 PRESS. AT DONALDSON-POR= 10.500 12.000 11.250 12.500  
 OIL COOLER VEL. HD.= 3.100  
 OIL COOLER STATIC= 7.000  
 PEERLESS PRESS-STBD=11.000 PORT=10.250  
 PRESS AFT OF PEERLESS-STBD=10.750 PORT=10.250  
 ENGINE PLENUM PRESS-STBD= 10.50 10.50 10.50 10.50  
 ENGINE PLENUM PRESS-POR= 10.00 9.75 10.40 10.00  
 SCAV. EXH. PRESS= 5.400 HOT SECT. PRESS.= 5.300 COOLER PRESS= 3.200  
 OUTSIDE AIR TEMP.= 98.000  
 STACK TEMPS.= 87.000 84.000 84.000 84.000  
 FAN DISCHARGE TEMP.= 93.000  
 ENGINE PLENUM AIR TEMP.= 94.00 95.00

ENGINE PERFORMANCE  
 TEMP= 94.00 ADJ. HP= 0.0 TEMP= 95.00 ADJ. HP= 0.0  
 AVERAGE HORSEPOWER--BOTH ENGINES-- 0.0 TAVG(3&4)= 94.500  
 ENGINE AIR(BOTH SIDES)-CFM= 0.0

STACK PERFORMANCE  
 AVG STACK TEMP= 84.75  
 STACK PRESSURES VEL= 0.611 STATIC=-0.787 TOTAL HEAD=-0.177  
 FLOW IN STACK-CFM= 0.2108E 05

FAN PERFORMANCE  
 PRESS. RECOVERY WITH DIFFUSER(56( OF VEL HD.)) = 13.73  
 FAN DISCHARGE PRESS. STATIC=11.250 VEL. HEAD= 4.425 TOTAL HEAD=15.675  
 STATIC PRESS. COR.= 11.809 TOTAL PRESS. COR.= 16.233  
 FAN PRESS INCREASE=15.852 FAN FLOW CFM= 0.2396E 05 FAN HORSEPOWER= 0.5984E 02  
 AVG. OF STACK AND FAN FLOW-CFM= 0.2252E 05

APU AND OIL COOLER FLOWS  
 APU AIR FLOW, CFM = 0.1608E 04  
 OIL COOLER FLOW CFM= 0.1298E 05 VEL. FT/SEC= 0.1202E 03

SYSTEM PRESSURE DROPS  
 PRESS. AT DONALDSON, STB= 12.00 PORT= 11.56 AVG= 11.78  
 DONALDSON PRESS. DROP, STB= 1.00 PORT= 1.31 AVG= 1.16  
 PEERLESS PRESS. DROP, STB= 0.25 PORT= 0.0 AVG= 0.13  
 PRESS DROP TO ENG., STB= 0.25 PORT= 0.21 AVG= 0.23  
 PLENUM PRESS., PORT= 10.500 STBD= 10.037 AVG= 10.269  
 SCAV. PRESS. DROP= 4.950  
 OIL COOLER DUCT DROP= 3.250  
 DUCT TO HOT COMP. DROP= 1.700  
 DUCT TO OIL COOLER DROP= 3.800

TEST No. 1 CIBD608

INPUT DATA

N2= 40.000 39.500 41.000 41.000  
 TOP 3.000 4.000 3.000 4.000  
 STACK VEL. HD.= 0.80 0.91 0.78 0.95 0.91 1.20 0.67 0.75 0.11  
 STACK STATIC HD.= -1.03 -1.10 -1.00 -0.80 -0.20 -0.90 -0.75 -1.00 -1.00  
 FAN VEL. HD.= 7.000 2.700 6.800 4.500  
 FAN STATIC HEAD= 10.000 10.500 9.800 9.900  
 PRESS. AT DONALDSON-STRO 11.000 9.500 12.250 9.500  
 PRESS. AT DONALDSON-PORT# 9.000 11.000 11.000 11.750  
 OIL COOLER VEL. HD.= 2.400 OIL COOLER STATIC= 6.000  
 PEERLESS PRESS-STRO= 9.000 PORT= 8.600  
 PRESS AFT OF PEERLESS-STRO= 8.300 PORT= 8.000  
 ENGINE PLENUM PRESS-STRO= 8.00 7.90 7.50 7.40  
 ENGINE PLENUM PRESS-PORT= 7.20 7.00 7.40 7.00  
 SCAV. EXH. PRESS= 4.400 HOT SECT. PRESS.= 4.400 COOLER PRESS= 2.800  
 OUTSIDE AIR TEMP.= 98.000  
 STACK TEMPS.= 84.000 87.000 93.000 85.000  
 FAN DISCHARGE TEMP.= 98.000  
 ENGINE PLENUM AIR TEMP.= 102.00 132.00

TEMP= 102.00 ADJ. HP= 0.4696 O2TEMP= 132.00 ADJ. HP= 0.4576E 02  
 AVERAGE HORSEPOWER--BOTH ENGINES-- 0.4887E 02  
 ENGINE AIR(BOTH SIDES)-CFM= 0.1235E 05 TAVG(3&4)= 117.000

AVG STACK TEMP= 87.25  
 STACK PRESSURES VEL= 0.789 STATIC=-0.896 TOTAL HEAD=-0.107  
 FLOW IN STACK-CFM= 0.2369E 05

FAN PERFORMANCE  
 PRESS. RECOVERY WITH DIFFUSER(56( OF VEL HD.)) = 12.99  
 FAN DISCHARGE PRESS. STATIC=10.050 VEL. HEAD= 5.250 TOTAL HEAD=15.300  
 STATIC PRESS. COR.= 10.597 TOTAL PRESS. COR.= 15.847  
 FAN PRESS INCREASE=15.407 FAN FLOW CFM= 0.2611E 05 FAN HORSEPOWER= 0.6338E 02  
 AVG. OF STACK AND FAN FLOW-CFM= 0.2490E 05

APU AIR FLOW, CFM = 0.1616E 04  
 OIL COOLER FLOW CFM= 0.1147E 05 VEL. FT/SEC= 0.1062E 03

SYSTEM PRESSURE DROPS  
 PRESS. AT DONALDSON, STB= 10.56 PORT= 10.69 AVG= 10.62  
 DONALDSON PRESS. DROP, STB= 1.56 PORT= 2.09 AVG= 1.83  
 PEERLESS PRESS. DROP, STB= 0.70 PORT= 0.60 AVG= 0.65  
 PRESS DROP TO ENG., STB= 0.60 PORT= 0.85 AVG= 0.72  
 PLENUM PRESS., PORT= 7.700 STBD= 7.150 AVG= 7.425  
 SCAV. PRESS. DROP= 4.200  
 OIL COOLER DUCT DROP= 2.600  
 DUCT TO HOT COMP. DROP= 1.600  
 DUCT TO OIL COOLER DROP= 3.200

TEST No. 1 C2A0608

INPUT DATA

N2= 94.500 94.200 94.200 95.500  
TOP 20.000 21.000 20.000 20.000  
STACK VEL. HD.= 1.00 1.24 0.90 1.12 0.90 1.40 0.90 0.40 4.20  
STACK STATIC HD.= -1.20 -1.40 -1.40 -1.20 -1.40 -1.20 -1.40 -1.10 -0.50 -1.00  
FAN VEL. HD.= 6.000 5.200 6.700 10.000  
FAN STATIC HEAD= 6.000 6.000 6.000 6.300  
PRESS. AT DONALDSON-STBD 7.600 5.800 3.500 5.400  
PRESS. AT DONALDSON-PORT= 4.800 7.800 7.200 8.500  
OIL COOLER VEL. HD.= 1.400  
OIL COOLER STATIC= 3.000  
PORT= 4.600  
PRESS AFT OF PEERLESS-STBD= 2.500 PORT= 2.200  
ENGINE PLENUM PRESS-STBD= 0.80 0.0 -0.70 -2.00  
ENGINE PLENUM PRESS-PORT= -1.30 0.0 -0.80 -1.70  
SCAV. EXH. PRESS= 2.000 HOT SECT. PRESS.= 2.500 COOLER PRESS= 3.000  
OUTSIDE AIR TEMP.= 90.000  
STACK TEMPS.= 122.000 118.000 117.000 105.000  
FAN DISCHARGE TEMP.= 110.000  
ENGINE PLENUM AIR TEMP.= 120.000 174.000

TEMP= 120.00 ADJ. HP= 0.6269E 03TEMP= 174.00 ADJ. HP= 0.5996E 03  
AVERAGE HORSEPOWER--BOTH ENGINES-- 0.6628E 03  
ENGINE AIR(BOTH SIDES)-CFM= 0.1756E 05 TAVG(3&4)= 147.000

ENGINE PERFORMANCE

AVG STACK TEMP= 115.50  
STACK PRESSURES VEL= 1.247 STATIC=-1.167 TOTAL HEAD= 0.080  
FLOW IN STACK-CFM= 0.2985E 05

STACK PERFORMANCE

TEMP RISE IN STACK 25.50

FAN PERFORMANCE

PRESS. RECOVERY WITH DIFFUSER(56( OF VEL HD.)) = 9.98  
FAN DISCHARGE PRESS. STATIC= 6.075 VEL. HEAD= 6.975 TOTAL HEAD=13.050  
STATIC PRESS. COR.= 6.737 TOTAL PRESS. COR.= 13.712  
FAN PRESS INCREASE=12.970 FAN FLOW CFM= 0.3111E 05 FAN HORSEPOWER= 0.6359E 02  
AVG. OF STACK AND FAN FLOW-CFM= 0.3048E 05

APU AND OIL COOLER FLOWS

APU AIR FLOW, CFM = 0.1650E 04  
OIL COOLER FLOW CFM= 0.8857E 04 VEL. FT/SEC= 0.8201E 02

SYSTEM PRESSURE DROPS

PRESS. AT DONALDSON, STB= 5.57 PORT= 7.07 AVG= 6.32  
DONALDSON PRESS. DROP, STB= 0.97 PORT= 2.47 AVG= 1.72  
PEERLESS PRESS. DROP, STB= 2.10 PORT= 2.40 AVG= 2.25  
PRESS DROP TO ENG., STB= 2.97 PORT= 3.15 AVG= 3.06  
PLENUM PRESS., PORT= -0.475 STBD= -0.950 AVG= -0.712  
SCAV. PRESS. DROP= 2.600  
OIL COOLER DUCT DROP= 1.600  
DUCT TO HOT COMP. DROP= 0.500  
DUCT TO OIL COOLER DROP= 0.0

TEST No. 1 C2B0608

INPUT DATA

N2= 92.500 92.500 93.000 94.000  
TOP 34.000 34.000 34.000 34.000  
STACK VEL. HD.= 1.15 0.85 0.80 0.45 1.00 0.90 1.10 1.10  
STACK STATIC HD.= -1.80 -2.00 -1.50 -1.50 -1.50 -1.50 -1.50 -1.50  
FAN VEL. HD.= 8.100 4.500 6.200 5.400  
FAN STATIC HEAD= 1.900 1.500 5.000 5.000  
PRESS. AT DONALDSON-STBD 6.500 4.700 8.500 4.300  
PRESS. AT DONALDSON-PORT= 3.500 7.000 6.600 8.500  
OIL COOLER VEL. HD.= 0.850  
PEERLESS PRESS-STBD= 3.600 PORT= 3.600  
PRESS AFT OF PEERLESS-STBD= 0.900 PORT= 0.800  
ENGINE PLENUM PRESS-STBD= -1.40 -2.10 -2.80 -4.20  
ENGINE PLENUM PRESS-PORT= -3.80 -1.90 -2.80 -3.40  
SCAV. EXH. PRESS= 1.500 HOT SECT. PRESS.= 2.000 COOLER PRESS= 2.000  
OUTSIDE AIR TEMP.= 75.000  
STACK TEMPS.= 100.090 93.000 93.000 100.000  
FAN DISCHARGE TEMP.= 104.000  
ENGINE PLENUM AIR TEMP.= 103.00 125.00

TEMP= 103.00 ADJ. HP= 0.1050E 04  
AVERAGE HORSEPOWER--BOTH ENGINES-- 0.1094E 04  
ENGINE AIR (BOTH SIDES)-CFM= 0.1891E 05 TAVG(3&4)= 114.000

AVG STACK TEMP= 96.50  
STACK PRESSURES VEL= 0.996 STATIC=-1.642 TOTAL HEAD=-0.646  
FLOW IN STACK-CFM= 0.2722E 05

FAN PERFORMANCE  
PRESS. RECOVERY WITH DIFFUSER(56( OF VEL HD.)) = 6.51  
FAN DISCHARGE PRESS. STATIC= 3.125 VEL. HEAD= 6.050 TOTAL HEAD= 9.175  
STATIC PRESS. COR.= 3.351 TOTAL PRESS. COR.= 9.401  
FAN PRESS INCREASE= 9.821 FAN FLOW CFM= 0.2855E 05 FAN HORSEPOWER= 0.4419E 02  
AVG. OF STACK AND FAN FLOW-CFM= 0.2789E 05

APU AIR FLOW, CFM = 0.1678E 04  
OIL COOLER FLOW CFM = 0.6865E 04 VEL. FT/SEC= 0.6356E 02

APU AND OIL COOLER FLOWS  
SYSTEM PRESSURE DROPS  
PRESS. AT DONALDSON, STB= 6.00 PORT= 6.40 AVG= 6.20  
DONALDSON PRESS. DROP, STB= 2.40 PORT= 2.80 AVG= 2.60  
PEERLESS PRESS. DROP, STB= 2.70 PORT= 2.80 AVG= 2.75  
PRESS DROP TO ENG., STB= 3.52 PORT= 3.77 AVG= 3.65  
PLENUM PRESS., PORT= -2.625 STBD= -2.975 AVG= -2.800  
SCAV. PRESS. DROP= 2.100  
OIL COOLER DUCT DROP= 1.100  
DUCT TO HOT COMP. DROP= 0.500  
DUCT TO OIL COOLER DROP= 0.500

TEST No. 1 C2C0608

INPUT DATA

N2= 91.750 92.000 91.000 92.000  
TOP 42.000 42.000 44.000 43.000  
STACK VEL. HD.= 1.20 1.35 1.00 0.90 0.80 1.20 1.20 1.20 0.90  
STACK STATIC HD.= -2.00 -1.80 -1.60 -1.70 -1.50 -1.60 -1.50 -1.50  
FAN VEL. HD.= 10.000 9.100 6.800 4.000  
FAN STATIC HEAD= 3.000 1.700 4.500 5.000  
PRESS. AT DONALDSON-STBD 6.400 4.700 8.000 4.200  
PRESS. AT DONALDSON-PORT# 3.500 6.400 6.200 8.000  
OIL COOLER VEL. HD.= 0.800  
OIL COOLER STATIC= 2.000  
PEERLESS PRESS-STBD= 3.000  
PRESS. AFT OF PEERLESS-STBD= 0.0 PORT= 0.500  
ENGINE PLENUM PRESS-STBD= -0.50 -2.00 -3.50 -4.50  
ENGINE PLENUM PRESS-PORT# -4.00 -2.00 -2.00 -4.50  
SCAV. EXH. PRESS= 1.500 HOT SECT. PRESS.= 1.500 COOLER PRESS= 1.600  
OUTSIDE AIR TEMP.= 78.000  
STACK TEMPS. = 87.000 85.000 84.000 83.000  
FAN DISCHARGE TEMP.= 91.000  
ENGINE PLENUM AIR TEMP.= 95.00 112.00

ENGINE PERFORMANCE

TEMP= 95.00 ADJ. HP= 0.1311E 04TEMP= 112.00 ADJ. HP= 0.1292E 04  
AVERAGE HORSEPOWER--BOTH ENGINES-- 0.1356E 04  
ENGINE AIR(ROTH SIDES)-CFM= 0.1978E 05 TAVG(3&4)= 103.500

STACK PERFORMANCE

AVG STACK TEMP= 84.75  
STACK PRESSURES VEL= 1.117 STATIC=-1.733 TOTAL HEAD=-0.617  
FLOW IN STACK-CFM= 0.2862E 05

FAN PERFORMANCE

PRESS. RECOVERY WITH DIFFUSER(56( OF VEL HD.)) = 7.74  
FAN DISCHARGE PRESS. STATIC= 3.550 VEL. HEAD= 7.475 TOTAL HEAD=11.025  
STATIC PRESS. COR.= 3.726 TOTAL PRESS. COR.= 11.201  
FAN PRESS INCREASE=11.642 FAN FLOW CFM= 0.3116E 05 FAN HORSEPOWER= 0.5715E 02  
AVG. OF STACK AND FAN FLOW-CFM= 0.2989E 05

APU AND OIL COOLER FLOWS

APU AIR FLOW, CFM = 0.1608E 04  
OIL COOLER FLOW CFM= 0.6582E 04 VEL. FT/SEC= 0.6095E 02

SYSTEM PRESSURE DROPS

PRESS. AT DONALDSON, STB= 5.82 PORT= 6.02 AVG= 5.92  
DONALDSON PRESS. DROP, ST9= 2.82 PORT= 3.02 AVG= 2.92  
PEERLESS PRESS. DROP, STB= 3.00 PORT= 2.50 AVG= 2.75  
PRESS DROP TO ENG., STB= 2.62 PORT= 3.62 AVG= 3.13  
PLENUM PRESS., PORT= -2.625 STBD= -3.125 AVG= -2.875  
SCAV. PRESS. DROP= 1.500  
OIL COOLER DUCT DROP= 1.000  
DUCT TO HOT COMP. DROP= 0.500  
DUCT TO OIL COOLER DRDP= 0.400



TEST No. 2 CIA 0610

INPUT DATA  
N2= 42.750 42.500 42.500 43.000  
TOP 2.000 4.000 3.000 3.000  
STACK VEL. HD.= 0.60 0.50 0.30 0.60 0.50 0.48 0.60 0.60 0.58  
STACK STATIC HD.= -0.80 -0.80 -0.80 -0.60 -0.70 -0.60 -0.50 -0.80 -0.50  
FAN VEL. HD.= 3.200 3.200 3.700 2.600  
FAN STATIC HEAD= 10.000 10.500 10.500 11.000  
PRESS. AT DONALDSON-STBD 12.000 11.000 12.200 10.000  
PRESS. AT DONALDSON-PORT= 10.000 11.300 10.800 11.500  
OIL COOLER VEL. HD.= 2.900 OIL COOLER STATIC= 5.000  
PEERLESS PRESS-STBD=10.000 PORT= 9.800  
PRESS AFT OF PEERLESS-STBD=10.000 PORT= 9.800  
ENGINE PLENUM PRESS-STBD= 10.00 10.00 10.00 10.10  
ENGINE PLENUM PRESS-PORT= 9.80 9.50 9.00 9.50  
SCAV. EXH. PRESS= 5.200 HDT SECT. PRESS.= 5.000 COOLER PRESS= 4.400  
OUTSIDE AIR TEMP.= 87.800  
STACK TEMPS. = 89.000 89.000 90.000 91.000  
FAN DISCHARGE TEMP.= 100.000  
ENGINE PLENUM AIR TEMP.= 99.00 100.00

ENGINE PERFORMANCE  
TEMP= 99.00 ADJ. HP= 0.4267E 02TEMP= 100.00 ADJ. HP= 0.4263E 02  
AVERAGE HORSEPOWER--BOTH ENGINES-- 0.4429E 02  
ENGINE AIR (BOTH SIDES)-CFM= 0.1211E 05 TAVG(3&4)= 99.500

STACK PERFORMANCE  
AVG STACK TEMP= 89.75 TEMP RISE IN STACK 1.95  
STACK PRESSURES VEL= 0.547 STATIC=-0.708 TOTAL HEAD=-0.162  
FLOW IN STACK-CFM= 0.2010E 05

FAN PERFORMANCE  
PRESS. RECOVERY WITH DIFFUSER(56( OF VEL HD.)) = 12.28  
FAN DISCHARGE PRESS. STATIC=10.500 VEL. HEAD= 3.175 TOTAL HEAD=13.675  
STATIC PRESS. COR.= 11.122 TOTAL PRESS. COR.= 14.297  
FAN PRESS INCREASE=13.837 FAN FLOW CFM= 0.2064E 05 FAN HORSEPOWER= 0.4500E 02  
AVG. OF STACK AND FAN FLOW-CFM= 0.2037E 05

APU AND OIL COOLER FLOWS  
APU AIR FLOW, CFM = 0.1664E 04  
OIL COOLER FLOW CFM= 0.1263E 05 VEL. FT/SEC= 0.1170E 03

SYSTEM PRESSURE DROPS  
PRESS. AT DONALDSON, STB= 11.30 PORT= 10.90 AVG= 11.10  
DONALDSON PRESS. DROP, STB= 1.30 PORT= 1.10 AVG= 1.20  
PEERLESS PRESS. DROP, STB= 0.0 PORT= 0.0 AVG= 0.0  
PRESS DROP TO FNG., STB= -0.02 PORT= 0.35 AVG= 0.16  
PLENUM PRESS., PORT= 10.025 STBD= 9.450 AVG= 9.737  
SCAV. PRESS. DROP= 4.600  
OIL COOLER DUCT DROP= 4.800  
DUCT TO HOT COMP. DROP= 9.0  
DUCT TO OIL COOLER DROP= 0.600

TEST No. 2 C1B0610

INPUT DATA

N2= 42.750 42.500 42.500 43.000  
 TOP 2.000 4.000 3.000 3.000  
 STACK VEL. HD.= 0.80 0.60 0.50 0.82 0.78 0.72 0.78 0.82 0.79  
 STACK STATIC HD.= -0.90 -1.10 -1.00 -0.80 -1.00 -0.90 -0.70 -1.00 -0.90  
 FAN VEL. HD.= 3.100 4.580 6.100 3.100  
 FAN STATIC HEAD= 9.000 10.000 10.000 10.000  
 PRESS. AT DONALDSON-STBD 11.000 9.200 12.000 9.000  
 PRESS. AT DONALDSON-PORTR 9.500 11.000 10.000 11.500  
 OIL COOLER VEL. HD.= 2.500  
 OIL COOLER STATIC= 4.000  
 PEERLESS PRESS-STBD= 8.700 PORT= 9.000  
 PRESS AFT OF PEERLESS-STBD= 9.000 PORT= 7.800  
 ENGINE PLENUM PRESS-STBD= 8.00 7.80 7.50 7.40  
 ENGINE PLENUM PRESS-PORTR= 7.00 7.40 7.40 7.10  
 SCAV. EXH. PRESS= 4.600 HOT SECT. PRESS.= 4.500 COOLER PRESS= 4.200  
 OUTSIDE AIR TEMP.= 87.800  
 STACK TEMPS.= 91.000 91.000 91.000 91.000  
 FAN DISCHARGE TEMP.= 99.000  
 ENGINE PLENUM AIR TEMP.= 99.00 128.00

TEMP= 99.00 ADJ. HP= 0.4267E 02TEMP= 128.00 ADJ. HP= 0.4161E 02  
 AVERAGE HORSEPOWER--BOTH ENGINES-- 0.4429E 02  
 ENGINE AIR(BOTH SIDES)-CFM= 0.1226E 05 TAVG(13&4)= 113.500

AVG STACK TEMP= 90.25 STACK PERFORMANCE  
 STACK PRESSURES VEL= 0.751 TEMP RISE IN STACK 2.45  
 FLOW IN STACK-CFM= 0.2360E 05 STATIC=-0.917 TOTAL HEAD=-0.166

FAN PERFORMANCE  
 PRESS. RECOVERY WITH DIFFUSER(56( OF VEL HD.)) = 11.86  
 FAN DISCHARGE PRESS. STATIC= 9.500 VEL. HEAD= 4.220 TOTAL HEAD=13.720  
 STATIC PRESS. COR.= 10.072 TOTAL PRESS. COR.= 14.292  
 FAN PRESS INCREASE=13.886 FAN FLOW CFM= 0.2360E 05 FAN HORSEPOWER= 0.5165E 02  
 AVG. OF STACK AND FAN FLOW-CFM= 0.2360E 05

APU AND OIL COOLER FLOWS  
 APU ATR FLOW, CFM = 0.1644E 04  
 OIL COOLER FLOW CFM= 0.1172E 05 VEL. FT/SEC= 0.1085E 03

SYSTEM PRESSURE DROPS  
 PRESS. AT DONALDSON, STB= 10.30 PORT= 10.50 AVG= 10.40  
 DONALDSON PRESS. DROP, STB= 1.60 PORT= 1.50 AVG= 1.55  
 PEERLESS PRESS. DROP, STB= 0.70 PORT= 1.20 AVG= 0.95  
 PRESS DROP TO ENG., STB= 0.33 PORT= 0.58 AVG= 0.45  
 PLENUM PRESS., PORT= 7.675 STBD= 7.225 AVG= 7.450  
 SCAV. PRESS. DROP= 4.400  
 OIL COOLER DUCT DROP= 5.000  
 DUCT TO HOT COMP. DROP= -0.500  
 DUCT TO OIL COOLER DROP= -0.200

TEST No. 2 CZA0610

INPUT DATA

N2= 95.300 95.000 94.500 95.500  
 TOP 19.000 20.000 19.000 19.000  
 STACK VEL. HD.= 1.20 1.00 0.80 1.00 1.00 1.00 0.90 0.95  
 STACK STATIC HD.= -1.10 -1.30 -1.20 -1.00 -1.10 -1.00 -0.80 -1.00  
 FAN VEL. HD.= 3.200 5.100 6.150 4.100  
 FAN STATIC HEAD= 5.800 6.000 7.000 7.000  
 PRESS. AT DONALDSON-STBD 8.200 6.200 8.300 6.000  
 PRESS. AT DONALDSON-PORT= 5.600 8.000 7.200 9.000  
 OIL COOLER VEL. HD.= 1.150 OIL COOLER STATIC= 3.000  
 PEERLESS PRESS-STBD= 5.000 PORT= 4.800  
 PRESS AFT OF PEERLESS-STBD= 3.000 PORT= 2.700  
 ENGINE PLENUM PRESS-STBD= 1.40 0.50 -0.40 -1.00  
 ENGINE PLENUM PRESS-PORT= -0.80 0.60 -0.20 -1.00  
 SCAV. EXH. PRESS= 2.300 HOT SECT. PRESS.= 2.800 COOLER PRESS= 2.700  
 OUTSIDE AIR TEMP.= 95.000  
 STACK TEMPS.= 87.000 88.000 88.000 89.000  
 FAN DISCHARGE TEMP.= 95.000  
 ENGINE PLENUM AIR TEMP.= 95.00 140.00

ENGINE PERFORMANCE

TEMP= 95.00 ADJ. HP= 0.6123E 03TEMP= 140.00 ADJ. HP= 0.5889E 03  
 AVERAGE HORSEPOWER--BOTH ENGINES-- 0.6332E 03  
 ENGINE AIR(BOTH SIDES)-CFM= 0.1707E 05 TAVG(3&4)= 117.500

STACK PERFORMANCE

AVG STACK TEMP= 88.00 TEMP RISE IN STACK -7.00  
 STACK PRESSURES VEL= 1.029 STATIC=-1.067 TOTAL HEAD=-0.037  
 FLOW IN STACK-CFM= 0.2758E 05

FAN PERFORMANCE

PRESS. RECOVERY WITH DIFFUSER(56( OF VEL HD.)) = 9.05  
 FAN DISCHARGE PRESS. STATIC= 6.450 VEL. HEAD= 4.637 TOTAL HEAD=11.087  
 STATIC PRESS. COR.= 6.811 TOTAL PRESS. COR.= 11.448  
 FAN PRESS INCREASE=11.125 FAN FLOW CFM= 0.2477E 05 FAN HORSEPOWER= 0.4343E 02  
 AVG. OF STACK AND FAN FLOW-CFM= 0.2618E 05

APU AND OIL COOLER FLOWS

APU AIR FLOW, CFM = 0.1654E 04  
 OIL COOLER FLOW CFM= 0.7921E 04 VEL. FT/SEC= 0.7334E 02

SYSTEM PRESSURE DROPS

PRESS. AT DONALDSON, STB= 7.17 PORT= 7.45 AVG= 7.31  
 DONALDSON PRESS. DROP, STB= 2.17 PORT= 2.65 AVG= 2.41  
 PEERLESS PRESS. DROP, STB= 2.00 PORT= 2.10 AVG= 2.05  
 PRESS DROP TO ENG., STB= 2.87 PORT= 3.05 AVG= 2.96  
 PLENUM PRESS., PORT= 0.125 STBD= -0.350 AVG= -0.113  
 SCAV. PRESS. DROP= 2.500  
 OIL COOLER DUCT DROP= 1.800  
 DUCT TO HOT COMP. DROP= 0.200  
 DUCT TO OIL COOLER DROP= 0.300

INPUT DATA  
 N2= 0.0 0.0 0.0 0.0 0.0 0.0  
 TDP 0.0 0.0 0.0 0.0 0.0  
 STACK VEL. HD.= 0.55 0.60 0.40 0.05 0.25 0.24 0.45 0.55 0.58  
 STACK STATIC HD.= -0.80 -0.80 -0.70 -0.70 -0.80 -0.60 -0.50 -0.50  
 FAN VEL. HD.= 5.000 2.800 3.600 3.400  
 FAN STATIC HEAD= 9.500 10.000 10.000 10.300  
 PRESS. AT DONALDSON-STBD 11.200 10.200 11.000 10.000  
 PRESS. AT DONALDSON-PORT= 9.500 10.700 10.200 11.200  
 OIL COOLER VEL. HD.= 2.700 OIL COOLER STATIC= 6.000  
 PEERLESS PRESS-STBD= 9.900 PORT= 9.500  
 PRESS AFT OF PEERLESS-STBD= 9.500 PORT= 9.200  
 ENGINE PLENUM PRESS-STBD= 9.50 9.50 9.50 9.40  
 ENGINE PLENUM PRESS-PORT= 9.20 8.60 9.00 9.10  
 SCAV. EXH. PRESS= 4.800 HOT SECT. PRESS.= 4.800 COOLER PRESS= 0.0  
 OUTSIDE AIR TEMP.= 92.000  
 STACK TEMPS.= 85.000 86.000 87.000  
 FAN DISCHARGE TEMP.= 95.000  
 ENGINE PLENUM AIR TEMP.= 92.00 93.00

ENGINE PERFORMANCE  
 TEMP= 92.00 ADJ. HP= 0.0 TEMP= 93.00 ADJ. HP= 0.0  
 AVERAGE HORSEPOWER--BOTH ENGINES-- 0.0 TAVG(13&4)= 92.500  
 ENGINE AIR(BOTH SIDES)-CFM= 0.0

STACK PERFORMANCE  
 AVG STACK TEMP= 85.75 TEMP RISE IN STACK -6.25  
 STACK PRESSURES VEL= 0.443 STATIC=-0.692 TOTAL HEAD=-0.248  
 FLOW IN STACK-CFM= 0.1758E 05

FAN PERFORMANCE  
 PRESS. RECOVERY WITH DIFFUSER(561 OF VEL HD.1) = 12.02  
 FAN DISCHARGE PRESS. STATIC= 9.950 VEL. HEAD= 3.700 TOTAL HEAD=13.650  
 STATIC PRESS. COR.= 10.463 TOTAL PRESS. COR.= 14.163  
 FAN PRESS INCREASE=13.898 FAN FLOW CFM= 0.2212E 05 FAN HORSEPOWER= 0.4844E 02  
 AVG. OF STACK AND FAN FLOW-CFM= 0.1985E 05

APU AND OIL COOLER FLOWS  
 APU AIR FLOW, CFM = 0.1640E 04  
 OIL COOLER FLOW CFM= 0.1214E 05 VEL. FT/SEC= 0.1124E 03

SYSTEM PRESSURE DROPS  
 PRESS. AT DONALDSON, STB= 10.60 PORT= 10.40 AVG= 10.50  
 DONALDSON PRESS. DROP, STB= 0.70 PORT= 0.90 AVG= 0.80  
 PEERLESS PRESS. DROP, STB= 0.40 PORT= 0.30 AVG= 0.35  
 PRESS DROP TO ENG., STB= 0.03 PORT= 0.23 AVG= 0.13  
 PLENUM PRESS., PORT= 9.475 STBD= 8.975 AVG= 9.225  
 SCAV. PRESS. DROP= 4.700  
 OIL COOLER DUCT DROP= 3.500  
 DUCT TO HOT COMP. DROP= 1.200  
 DUCT TO OIL COOLER DROP= 6.000

TEST No. 3 CIB0611

10

INPUT DATA

N2= 42.000 41.500 42.000 42.500  
 TOP 2.000 4.000 3.000 4.000  
 STACK VEL. HD.= 0.80 0.90 0.65 0.30 0.15 0.10 0.60 0.70 0.80  
 STACK STATIC HD.= -1.00 -1.20 -1.00 -1.00 -1.10 -0.90 -0.80 -0.90 -0.90  
 FAN VEL. HD.= 7.400 3.800 5.800 4.400  
 FAN STATIC HEAD= 10.000 10.500 10.500 10.500 9.500  
 PRESS. AT DONALDSON-STBD 11.500 9.500 12.500 10.500 9.500  
 OIL COOLER VEL. HD.= 3.600 9.500 11.000 10.500 12.000  
 OIL COOLER STATIC= 6.000  
 PEERLESS PRESS-STBD= 9.000 PORT= 9.000  
 PRESS AFT OF PEERLESS-STBD= 8.500 PORT= 8.300  
 ENGINE PLENUM PRESS-STBD= 8.50 8.00 7.70 7.50  
 ENGINE PLENUM PRESS-PORT= 7.40 7.20 7.20 7.20  
 SCAV. EXH. PRESS= 4.600 HOT SECT. PRESS.= 4.600 COOLER PRESS= 0.0  
 OUTSIDE AIR TEMP.= 92.000  
 STACK TEMPS. = 110.000 90.000 85.000 94.000  
 FAN DISCHARGE TEMP.= 93.000  
 ENGINE PLENUM AIR TEMP.= 94.00 123.00

ENGINE PERFORMANCE

TEMP= 94.00 ADJ. HP= 0.4571E 02TEMP= 123.00 ADJ. HP= 0.4456E 02  
 AVERAGE HORSEPOWER--BOTH ENGINES-- 0.4723E 02  
 ENGINE AIR(BOTH SIDES)-CFM= 0.1224E 05 TAVG(13&4)= 108.500

STACK PERFORMANCE

AVG STACK TEMP= 92.25 TEMP RISE IN STACK 0.25  
 STACK PRESSURES VEL= 0.617 STATIC=-0.983 TOTAL HEAD=-0.367  
 FLOW IN STACK-CFM= 0.2072E 05

FAN PERFORMANCE

PRESS. RECOVERY WITH DIFFUSER(561 OF VEL HD.1 = 13.37  
 FAN DISCHARGE PRESS. STATIC=10.375 VEL. HEAD= 5.350 TOTAL HEAD=15.725  
 STATIC PRESS. COR.= 11.040 TOTAL PRESS. COR.= 16.390  
 FAN PRESS INCREASE=16.092 FAN FLOW CFM= 0.2668E 05 FAN HORSEPOWER= 0.6766E 02  
 AVG. OF STACK AND FAN FLOW-CFM= 0.2370E 05

APU AND OIL COOLER FLOWS

APU AIR FLOW, CFM = 0.1594E 04 VEL. FT/SEC= 0.1295E 03  
 OIL COOLER FLOW CFM= 0.1399E 05

SYSTEM PRESSURE DROPS

PRESS. AT DONALDSON, STB= 10.75 PORT= 10.75 AVG= 10.75  
 DONALDSON PRESS. DROP, STB= 1.75 PORT= 1.75 AVG= 1.75  
 PEERLESS PRESS. DROP, STB= 0.50 PORT= 0.70 AVG= 0.60  
 PRESS DROP TO ENG., STB= 0.58 PORT= 1.05 AVG= 0.81  
 PLENUM PRESS., PORT= 7.925 STBD= 7.250 AVG= 7.587  
 SCAV. PRESS. DROP= 4.400  
 OIL COOLER DUCT DROP= 3.000  
 DUCT TO HOT COMP. DROP= 1.400  
 DUCT TO OIL COOLER DROP= 6.000

TEST No. 3 C2A0611

INPUT DATA

N2= 94.500 94.500 94.500 95.500  
 TOP 18.000 20.000 19.000 19.000  
 STACK VEL. HD.= 1.00 1.10 0.90  
 STACK STATIC HD.= -1.10 -1.30 -1.10 0.60 0.70 0.80 0.90 0.90  
 FAN VEL. HD.= 7.400 4.900 6.100 5.400 -1.10 -1.10 -1.00 -1.00  
 FAN STATIC HEAD= 7.700 7.300 7.400 7.000  
 PRESS. AT DONALDSON-STBD 8.500 6.300 10.000 6.000  
 PRESS. AT DONALDSON-PORT= 5.700 8.000 7.900 9.500  
 OIL COOLER VEL. HD.= 1.300  
 OIL COOLER STATIC= 3.600  
 PEERLESS PRESS-STBD= 5.500 PORT= 5.400  
 PRESS AFT OF PEERLESS-STBD= 3.400 PORT= 3.000  
 ENGINE PLENUM PRESS-STBD= 1.60 0.80 0.0 -1.00  
 ENGINE PLENUM PRESS-PORT= -0.60 1.00 0.20 -0.80  
 SCAV. EXH. PRESS= 2.600 HOT SECT. PRESS.= 3.000 COOLER PRESS= 0.0  
 OUTSIDE AIR TEMP.= 92.000  
 STACK TEMPS. = 87.000 86.000 95.000  
 FAN DISCHARGE TEMP.= 92.000  
 ENGINE PLENUM AIR TEMP.= 93.00 132.00

ENGINE PERFORMANCE

TEMP= 93.00 ADJ. HP= 0.6034E 03TEMP= 132.00 ADJ. HP= 0.5832E 03  
 AVERAGE HORSEPOWER--BOTH ENGINES-- 0.6229E 03  
 ENGINE AIR(BOTH SIDES)-CFM= 0.1695E 05 TAVG(3&4)= 112.500

STACK PERFORMANCE

AVG STACK TEMP= 88.75  
 TEMP RISE IN STACK -3.25  
 STACK PRESSURES VEL= 0.892 STATIC=-1.075 TOTAL HEAD=-0.183  
 FLOW IN STACK-CFM= 0.2566E 05

FAN PERFORMANCE

PRESS. RECOVERY WITH DIFFUSER (561 OF VEL HD.) = 10.68  
 FAN DISCHARGE PRESS. STATIC= 7.350 VEL. HEAD= 5.950 TOTAL HEAD=13.300  
 STATIC PRESS. COR.= 7.772 TOTAL PRESS. COR.= 13.722  
 FAN PRESS INCREASE=13.483 FAN FLOW CFM= 0.2820E 05 FAN HORSEPOWER= 0.5991E 02  
 AVG. OF STACK AND FAN FLOW-CFM= 0.2693E 05

APU AND OIL COOLER FLOWS

APU AIR FLOW, CFM = 0.1605E 04  
 OIL COOLER FLOW CFM= 0.8399E 04 VEL. FT/SEC= 0.7776F 02

SYSTEM PRESSURE DROPS

PRESS. AT DONALDSON, STB= 7.70 PORT= 7.77 AVG= 7.74  
 DONALDSON PRESS. DROP, STB= 2.20 PORT= 2.37 AVG= 2.29  
 PEERLESS PRESS. DROP, STB= 2.10 PORT= 2.40 AVG = 2.25  
 PRESS DROP TO ENG., STB= 3.05 PORT= 3.05 AVG= 3.05  
 PLENUM PRESS., PORT= 0.350 STBD= -0.050 AVG= 0.150  
 SCAV. PRESS. DROP= 2.800  
 OIL COOLER DUCT DROP= 1.800  
 DUCT TO HOT COMP. DROP= 0.600  
 DUCT TO OIL COOLER DROP= 3.600

TEST No. 3 C2B0611

INPUT DATA

N2= 89.000 RR-500 91.500 92.500  
 TOP 30.000 31.000 38.000 38.000  
 STACK VEL. HD.= 1.20 1.10 1.00 1.00 1.50 1.40 1.00  
 STACK STATIC HD.= -2.00 -2.00 -1.60 -1.60 -1.50 -2.00 -1.50  
 FAN VEL. HD.= 7.000 7.000 6.200 5.200  
 FAN STATIC HEAD= 4.300 5.500 5.200  
 PRESS. AT DONALDSON-STBD 7.000 4.600 7.500 4.600  
 PRESS. AT DONALDSON-PORT= 4.000 6.500 6.000 8.000  
 OIL COOLER VEL. HD.= 1.700  
 OIL COOLER STATIC= 2.000  
 PEERLESS PRESS-STBD= 3.500 PORT= 3.500  
 PRESS AFT OF PEERLESS-STBD= 0.600 PORT= 1.500  
 ENGINE PLENUM PRESS-STBD= -2.00 -3.50 -3.50 -4.00  
 ENGINE PLENUM PRESS-PORT= -3.00 -2.00 -2.50 -3.50  
 SCAV. EXH. PRESS= 1.400 HOT SECT. PRESS.= 1.500 COOLER PRESS= 0.0  
 OUTSIDE AIR TEMP.= 92.000  
 STACK TEMPS.= 120.000 110.000 110.000 125.000  
 FAN DISCHARGE TEMP.= 116.000  
 ENGINE PLENUM AIR TEMP.= 118.00 137.00

ENGINE PERFORMANCE

TEMP= 118.00 ADJ. HP= 0.1017E 04TEMP= 137.00 ADJ. HP= 0.1000E 04  
 AVERAGE HORSEPOWER--BOTH ENGINES-- 0.1073E 04  
 ENGINE AIR(BOTH SIDES)-CFM= 0.1900E 05 TAVG(3&4)= 127.500

STACK PERFORMANCE

AVG STACK TEMP= 116.25 TEMP RISE IN STACK 24.25  
 STACK PRESSURES VEL= 1.192 STATIC=-1.808 TOTAL HEAD=-0.617  
 FLOW IN STACK-CFM= 0.3043E 05

FAN PERFORMANCE

PRESS. RECOVERY WITH DIFFUSER(561 OF VEL HD.) = 8.56  
 FAN DISCHARGE PRESS. STATIC= 5.000 VEL. HEAD= 6.350 TOTAL HEAD=11.350  
 STATIC PRESS. COR.= 5.552 TOTAL PRESS. COR.= 11.902  
 FAN PRESS INCREASE=11.967 FAN FLOW CFM= 0.2989E 05 FAN HORSEPOWER= 0.5636E 02  
 AVG. OF STACK AND FAN FLOW-CFM= 0.3016E 05

APU AND OIL COOLER FLOWS

APU AIR FLOW, CFM = 0.1683E 04  
 OIL COOLER FLOW CFM= 0.9811E 04 VEL. FT/SEC= 0.9084E 02

SYSTEM PRESSURE DROPS

PRESS. AT DONALDSON, STB= 5.92 PORT= 6.12 AVG= 6.02  
 DONALDSON PRESS. DROP, STB= 2.42 PORT= 2.62 AVG= 2.52  
 PEERLESS PRESS. DROP, STB= 2.90 PORT= 2.00 AVG= 2.45  
 PRESS DROP TO ENG., STB= 3.85 PORT= 4.25 AVG= 4.05  
 PLENUM PRESS., PORT= -3.250 STBD= -2.750 AVG= -3.000  
 SCAV. PRESS. DROP= 2.100  
 OIL COOLER DUCT DROP= 1.500  
 DUCT TO HOT COMP. DROP= 0.500  
 DUCT TO OIL COOLER DROP= 2.000

TEST No. 4 C1B0615

INPUT DATA  
 N2= 40.000 40.000 39.000 39.500  
 TOP 4.000 4.000 4.000 4.000  
 STACK VEL. HD.= 0.80 0.90 0.70 0.60 0.40 0.80 0.70 0.80 0.80 0.90  
 STACK STATIC HD.= -1.00 -1.10 -1.00 -1.00 -1.10 -1.00 -0.90 -1.00 -0.90 -0.90  
 FAN VEL. HD.= 7.100 2.200 6.300 4.300  
 FAN STATIC HEAD= 9.500 10.000 9.500 9.500  
 PRESS. AT DONALDSON-STBD 10.500 8.900 10.700 9.900  
 PRESS. AT DONALDSON-PORT= 9.000 10.200 9.500 11.500  
 OIL COOLER VEL. HD.= 2.500 OIL COOLER STATIC= 5.500  
 PEERLESS PRESS-STBD= 8.900 PORT= 8.500  
 PRESS AFT OF PEERLESS-STBD= 8.000 PORT= 8.000  
 ENGINE PLENUM PRESS-STBD= 8.00 7.70 7.40 7.50  
 ENGINE PLENUM PRESS-PORT= 7.20 7.40 7.30 7.00  
 SCAV. EXH. PRESS= 4.600 HOT SECT. PRESS.= 5.500 COOLER PRESS= 0.200  
 OUTSIDE AIR TEMP.= 72.500  
 STACK TEMPS. = 110.000 110.000 93.000 95.000  
 FAN DISCHARGE TEMP.= 104.000  
 ENGINE PLENUM AIR TEMP.= 105.00 134.00

ENGINE PERFORMANCE  
 TEMP= 105.00 ADJ. HP± 0.5256E 02TEMP= 134.00 ADJ. HP= 0.5126E 02  
 AVERAGE HORSEPOWER--BOTH ENGINES-- 0.5484E 02  
 ENGINE AIR(BOTH SIDES)-CFM= 0.1245E 05 TAVG(364)= 119.500

STACK PERFORMANCE  
 AVG STACK TEMP= 102.00 TEMP RISE IN STACK 29.50  
 STACK PRESSURES VEL= 0.750 STATIC=-1.000 TOTAL HEAD=-0.250  
 FLOW IN STACK-CFM= 0.2378E 05

FAN PERFORMANCE  
 PRESS. RECOVERY WITH DIFFUSER(561 OF VEL HD.1) = 12.41  
 FAN DISCHARGE PRESS. STATIC= 9.625 VEL. HEAD= 4.975 TOTAL HEAD=14.600  
 STATIC PRESS. COR.= 10.423 TOTAL PRESS. COR.= 15.398  
 FAN PRESS INCREASE=14.850 FAN FLOW CFM= 0.2562E 05 FAN HORSEPOWER= 0.5994E 02  
 AVG. OF STACK AND FAN FLOW-CFM= 0.2470E 05

APU AND OIL COOLER FLOWS  
 APU AIR FLOW, CFM = 0.1640E 04  
 OIL COOLER FLOW CFM= 0.1177E 05 VEL. FT/SEC= 0.1090E 03

SYSTEM PRESSURE DROPS  
 PRESS. AT DONALDSON, STB= 9.75 PORT= 10.05 AVG= 9.90  
 DONALDSON PRESS. DROP, STB= 0.85 PORT= 1.55 AVG= 1.20  
 PEERLESS PRESS. DROP, STB= 0.90 PORT= 0.50 AVG = 0.70  
 PRESS DROP TO ENG., STB= 0.35 PORT= 0.78 AVG= 0.56  
 PLENUM PRESS., PORT= 7.650 STBD= 7.225 AVG= 7.437  
 SCAV. PRESS. DROP= 3.900  
 OIL COOLER DUCT DROP= 3.000  
 DUCT TO HOT COMP. DROP= 0.0  
 DUCT TO OIL COOLER DROP= 5.300



TEST No. 4 C2A061S

INPUT DATA  
 N2= 95.000 94.500 94.200 95.000  
 TOP 20.000 22.000 19.000 20.000  
 STACK VEL. HD.= 1.00 1.00 0.80 1.00 1.00 0.90 0.95 1.10 1.00  
 STACK STATIC HD.= -1.10 -1.50 -1.20 -1.00 -1.10 -1.00 -0.90 -1.00 -1.00  
 FAN VEL. HD.= 7.900 5.000 6.300 10.000  
 FAN STATIC HEAD= 8.500 7.000 7.000  
 PRESS. AT DONALDSON-STBD= 8.200 7.000 9.500 6.200  
 PRESS. AT DONALDSON-PORT= 5.500 8.500 7.700 9.000  
 OIL COOLER VEL. HD.= 4.800 OIL COOLER STATIC= 3.500  
 PEERLESS PRESS-STBD= 5.200 PORT= 5.000  
 PRESS. AFT OF PEERLESS-STBD= 3.200 PORT= 3.500  
 ENGINE PLENUM PRESS-STBD= 1.20 0.40 0.50 1.40  
 ENGINE PLENUM PRESS-PORT= -1.00 -0.50 -0.50 -1.00  
 SCAV. EXH. PRESS= 2.000 HOT SECT. PRESS.= 2.500 COOLER PRESS= 0.200  
 OUTSIDE AIR TEMP.= 72.500  
 STACK TEMPS. = 76.000 77.000 79.000 79.000  
 FAN DISCHARGE TEMP.= 83.000  
 ENGINE PLENUM AIR TEMP.= 85.00 129.00

ENGINE PERFORMANCE  
 TEMP= 85.00 ADJ. HP= 0.6473E 03TEMP= 129.00 ADJ. HP= 0.6227E 03  
 AVERAGE HORSEPOWER--BOTH ENGINES-- 0.6634E 03  
 ENGINE AIR(BOTH SIDES)-CFM= 0.1708E 05 TAVG(3&4)= 107.000

STACK PERFORMANCE  
 AVG STACK TEMP= 77.75 TEMP RISE IN STACK 5.25  
 STACK PRESSURES VEL= 0.979 STATIC=-1.092 TOTAL HEAD=-0.112  
 FLOW IN STACK-CFM= 0.2669E 05

FAN PERFORMANCE  
 PRESS. RECOVERY WITH DIFFUSER(561 OF VEL HD.) = 11.34  
 FAN DISCHARGE PRESS. STATIC= 7.250 VEL. HEAD= 7.300 TOTAL HEAD=14.550  
 STATIC PRESS. COR.= 7.512 TOTAL PRESS. COR.= 14.812  
 FAN PRESS INCREASE=14.662 FAN FLOW CFM= 0.3076E 05 FAN HORSEPOWER= 0.7107E 02  
 AVG. OF STACK AND FAN FLOW-CFM= 0.2872E 05

APU AND OIL COOLER FLOWS  
 APU AIR FLOW, CFM = 0.1559E 04 VEL. FT/SEC= 0.1482E 03  
 OIL COOLER FLOW CFM= 0.1601E 05

SYSTEM PRESSURE DROPS  
 PRESS. AT DONALDSON, STR= 7.72 PORT= 7.67 AVG= 7.70  
 DONALDSON PRESS. DROP, STR= 2.52 PORT= 2.67 AVG= 2.60  
 PEERLESS PRESS. DROP, STR= 2.00 PORT= 1.50 AVG= 1.75  
 PRESS DROP TO ENG., STR= 2.32 PORT= 4.25 AVG= 3.29  
 PLENUM PRESS., PORT= 0.875 STBD= -0.750 AVG= 0.062  
 SCAV. PRESS. DROP= 3.000  
 OIL COOLER DUCT DROP= 1.500  
 DUCT TO HOT COMP. DROP= 1.000  
 DUCT TO OIL COOLER DROP= 3.300

TEST No. 5 C2A0615-1

INPUT DATA

N2= 70.000 69.900 69.900 70.200  
 TOP 8.000 12.000 10.000 10.000  
 STACK VEL. HD.= 1.00 0.80 0.78 1.10 1.00 1.15 1.00 1.05 1.00 1.00  
 STACK STATIC HD.= -1.50 -1.60 -1.50 -1.00 -1.30 -1.20 -1.00 -1.20 -1.00  
 FAN VEL. HD.= 8.000 3.800 6.900 10.000  
 FAN STATIC HEAD= 8.000 8.500 8.500 8.500  
 PRESS. AT DONALDSON-STBD 10.000 7.500 11.300 7.500  
 PRESS. AT DONALDSON-PORT= 7.800 9.700 9.100 10.300  
 OIL COOLER VEL. HD.= 1.500  
 OIL COOLER STATIC= 4.500  
 PORT= 6.800  
 PEERLESS PRESS-STBD= 7.100  
 PORT= 5.500  
 PRESS AFT OF PEERLESS-STBD= 5.800  
 PORT= 3.00  
 ENGINE PLENUM PRESS-STBD= 5.00 4.20 3.60 3.00  
 ENGINE PLENUM PRESS-PORT= 3.20 4.00 3.60 3.00  
 SCAV. EXH. PRESS= 3.300  
 HOT SECT. PRESS.= 3.600  
 COOLER PRESS= 0.200  
 OUTSIDE AIR TEMP.= 84.000  
 STACK TEMPS.= 87.000 84.000 86.000 87.000  
 FAN DISCHARGE TEMP.= 95.000  
 ENGINE PLENUM AIR TEMP.= 94.00 137.00

ENGINE PERFORMANCE

TEMP= 94.00 ADJ. HP= 0.2344E 03 TEMP= 137.00 ADJ. HP= 0.2258E 03  
 AVERAGE HORSEPOWER--BOTH ENGINES-- 0.2422E 03  
 ENGINE AIR(BOTH SIDES)-CFM= 0.1445E 05 TAVG(3&4)= 115.500

STACK PERFORMANCE

AVG STACK TEMP= 86.00  
 TEMP RISE IN STACK 2.00  
 STACK PRESSURES VEL= 0.990  
 STATIC=-1.317 TOTAL HEAD=-0.327  
 FLOW IN STACK-CFM= 0.2702E 05

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FAN PERFORMANCE

PRESS. RECOVERY WITH DIFFUSER(561 OF VEL HD.) = 12.52  
 FAN DISCHARGE PRESS. STATIC= 8.500 VEL. HEAD= 7.175 TOTAL HEAD=15.675  
 STATIC PRESS. COR.= 8.942 TOTAL PRESS. COR.= 16.117  
 FAN PRESS INCREASE=16.002 FAN FLOW CFM= 0.3056E 05 FAN HORSEPOWER= 0.7705E 02  
 AVG. OF STACK AND FAN FLOW-CFM= 0.2879E 05

APU AND OIL COOLER FLOWS

APU AIR FLOW, CFM = 0.1584E 04  
 OIL COOLER FLOW CFM= 0.9046E 04 VEL. FT/SEC= 0.8376E 02

SYSTEM PRESSURE DROPS

PRESS. AT DONALDSON, STB= 9.07 PORT= 9.22 AVG= 9.15  
 DONALDSON PRESS. DROP, STB= 1.97 PORT= 2.42 AVG= 2.20  
 PEERLESS PRESS. DROP, STB= 1.30 PORT= 1.30 AVG= 1.30  
 PRESS DROP TO ENG., STB= 1.85 PORT= 2.05 AVG= 1.95  
 PLENUM PRESS., PORT= 3.950 STBD= 3.450 AVG= 3.700  
 SCAV. PRESS. DROP= 3.500  
 OIL COOLER DUCT DROP= 2.300  
 DUCT TO HOT COMP. DROP= 0.900  
 DUCT TO OIL COOLER DROP= 4.300

TEST No. 5 C2A0615-2

INPUT DATA  
 NZ= 85.100 85.000 84.500 85.200  
 TOP 15.000 17.000 14.000 15.000  
 STACK VEL. HD.= 1.10 0.95 0.80  
 STACK STATIC HD.= -1.30 -1.50 -1.30 -1.20 1.05 1.10 1.05 1.10 1.05 1.10 1.10 0.80  
 FAN VEL. HD.= 8.400 4.400 7.100 5.200  
 FAN STATIC HEAD= 8.500 7.500 7.500 7.500  
 PRESS. AT DONALDSON-STBD 9.000 7.000 10.500 7.000  
 PRESS. AT DONALDSON-PORT= 6.000 9.200 8.500 10.000  
 OIL COOLER VEL. HD.= 1.600  
 OIL COOLER STATIC= 4.000  
 PEERLESS PRESS-STBD= 6.100 PORT= 5.800  
 PRESS AFT OF PEERLESS-STBD= 4.400 PORT= 7.800  
 ENGINE PLENUM PRESS-STBD= 3.10 2.30 1.70 0.70  
 ENGINE PLENUM PRESS-PORT= 1.00 2.00 1.90 0.50  
 SCAV. EXH. PRESS= 2.900 HOT SECT. PRESS.= 3.200 COOLER PRESS= 0.200  
 OUTSIDE AIR TEMP.= 84.000  
 STACK TEMPS.= 83.000 83.000 85.000 88.000  
 FAN DISCHARGE TEMP.= 91.000  
 ENGINE PLENUM AIR TEMP.= 93.00 130.00

ENGINE PERFORMANCE  
 TEMP= 93.00 ADJ. HP= 0.4343E 03TEMP= 130.00 ADJ. HP= 0.4204E 03  
 AVERAGE HORSEPOWER--ROTH ENGINES-- 0.4483E 03  
 ENGINE AIR(BOTH SIDES)-CFM= 0.1597E 05 TAVG(3&4)= 111.500

STACK PERFORMANCE  
 AVG STACK TEMP= 84.75 TEMP RISE IN STACK 0.75  
 STACK PRESSURES VEL= 1.033 STATIC=-1.217 TOTAL HEAD=-0.183  
 FLOW IN STACK-CFM= 0.2757E 05

FAN PERFORMANCE  
 PRESS. RECOVERY WITH DIFFUSER(561 OF VEL HD.) = 11.39  
 FAN DISCHARGE PRESS. STATIC= 7.875 VEL. HEAD= 6.275 TOTAL HEAD=14.150  
 STATIC PRESS. COR.= 8.266 TOTAL PRESS. COR.= 14.541  
 FAN PRESS INCREASE=14.333 FAN FLOW CFM= 0.2871E 05 FAN HORSEPOWER= 0.6485E 02  
 AVG. OF STACK AND FAN FLOW-CFM= 0.2814E 05

APU AND OIL COOLER FLOWS  
 APU AIR FLOW, CFM = 0.1593E 04  
 OIL COOLER FLOW CFM= 0.9309E 04 VEL. FT/SEC= 0.8619E 02

SYSTEM PRESSURE DROPS  
 PRESS. AT DONALDSON, STB= 8.37 PORT= 8.42 AVG= 9.40  
 DONALDSON PRESS. DROP, STB= 2.28 PORT= 2.62 AVG= 2.45  
 PEERLESS PRESS. DROP, STB= 1.70 PORT= -2.00 AVG = -0.15  
 PRESS DROP TO ENG., STB= 2.45 PORT= 6.45 AVG= 4.45  
 PLENUM PRESS., PORT= 1.950 STBD= 1.350 AVG= 1.650  
 SCAV. PRESS. DROP= 2.900  
 OIL COOLER DUCT DROP= 1.900  
 DUCT TO HOT COMP. DROP= 0.800  
 DUCT TO OIL COOLER DROP= 3.800

TEST No. 5 CZA0615-3

INPUT DATA  
 N2= 96.200 95.000 94.700 95.300  
 TOP 20.000 22.000 19.000 19.000  
 STACK VEL. HD.= 1.10 0.95 0.82 1.10 1.05 1.00 1.05 1.20 1.05  
 STACK STATIC HD.= -1.30 -1.50 -1.30 -1.20 -1.30 -1.00 -1.00 -1.10 -1.00  
 FAN VEL. HD.= 8.500 4.600 7.100 5.200  
 FAN STATIC HEAD= 6.800 8.000 7.000 7.000  
 PRESS. AT DONALDSON-ST80 8.500 6.400 10.000 6.200  
 PRESS. AT DONALDSON-P0RT= 6.000 8.600 8.000 9.200  
 OIL COOLER VEL. HD.= 1.400  
 OIL COOLER STATIC= 3.500  
 PEERLESS PRESS-ST80= 5.200 PORT= 5.200  
 PRESS AFT OF PEERLESS-ST80= 3.100 PORT= 3.000  
 ENGINE PLENUM PRESS-ST80= 1.60 0.40 0.0 -1.20  
 ENGINE PLENUM PRESS-P0RT= -0.80 0.80 -0.20 -1.00  
 SCAV. EXH. PRESS= 2.000 HOT SECT. PRESS.= 3.000 COOLER PRESS= 0.100  
 OUTSIDE AIR TEMP.= 84.000  
 STACK TEMPS. = 83.000 84.000 84.000  
 FAN DISCHARGE TEMP.= 90.000  
 ENGINE PLENUM AIR TEMP.= 92.00 135.00

ENGINE PERFORMANCE  
 TEMP= 92.00 ADJ. HP= 0.6315E 03TEMP= 135.00 ADJ. HP= 0.6082E 03  
 AVERAGE HORSEPOWER--80TH ENGINES-- 0.6513E 03  
 ENGINE AIR(BOTH SIDES)-CFM= 0.1710E 05 TAVG(13&4)= 113.500

STACK PERFORMANCE  
 AVG STACK TEMP= 83.50  
 TEMP RISE IN STACK -0.50  
 STACK PRESSURES VEL= 1.052 STATIC=-1.217 TOTAL HEAD=-0.165  
 FLOW IN STACK-CFM= 0.2780E 05

FAN PERFORMANCE  
 PRESS. RECOVERY WITH DIFFUSER(56( OF VEL HD.)) = 10.76  
 FAN DISCHARGE PRESS. STATIC= 7.200 VEL. HEAD= 6.350 TOTAL HEAD=13.550  
 STATIC PRESS. COR.= 7.540 TOTAL PRESS. COR.= 13.890  
 FAN PRESS INCREASE=13.715 FAN FLOW CFM= 0.2887E 05 FAN HORSEPOWER= 0.6238E 02  
 AVG. OF STACK AND FAN FLOW-CFM= 0.2833E 05

APU AND OIL COOLER FLOWS  
 APU AIR FLOW, CFM = 0.1595E 04 VEL. FT/SEC= 0.8055E 02  
 OIL COOLER FLOW CFM= 0.8700E 04

SYSTEM PRESSURE DROPS  
 PRESS. AT DONALDSON, ST8= 7.77 PORT= 7.95 AVG= 7.86  
 DONALDSON PRESS. DROP, ST8= 2.57 PORT= 2.75 AVG= 2.66  
 PEERLESS PRESS. DROP, ST8= 2.10 PORT= 2.20 AVG= 2.15  
 PRESS' DROP TO ENG., ST8= 2.90 PORT= 3.30 AVG= 3.10  
 PLENUM PRESS., PORT= 0.200 ST8D= -0.300 AVG= -0.050  
 SCAV. PRESS. DROP= 3.200  
 OIL COOLER DUCT DROP= 1.700  
 DUCT TO HOT COMP. DROP= 0.500  
 DUCT TO OIL COOLER DROP= 3.400

TEST No. 6 C3A0616

INPUT DATA  
 N2= 95.200 95.000 94.300 95.200  
 TNP 20.000 22.000 19.000 20.000  
 STACK VEL. HD.= 1.10 1.00 0.83 1.20 1.30 1.05 0.95 0.95 0.95  
 STACK STATIC HD.= -1.50 -1.60 -1.00 -1.00 -1.00 -0.80 -0.80 -1.30 -1.20  
 FAN VEL. HD.= 8.200 5.000 6.900 5.300  
 FAN STATIC HEAD= 7.000 8.400 7.500 7.500  
 PRESS. AT DONALDSON-STBD 9.000 6.700 10.200 7.600  
 PRESS. AT DONALDSON-PORT= 6.000 9.000 7.900 9.500  
 OIL COOLER VEL. HD.= 1.300 OIL COOLER STATIC= 4.000  
 PEERLESS PRESS-STBD= 5.590 PORT= 5.300  
 PRESS AFT OF PEERLESS-STBD= 3.300 PORT= 2.000  
 ENGINE PLENUM PRESS-STBD= 3.00 0.80 0.20 -1.10  
 ENGINE PLENUM PRESS-PORT= -0.50 1.00 -0.20 -0.80  
 SCAV. FXH. PRESS= 8.500 HOT SECT. PRESS.= 3.000 COOLER PRESS= 0.200  
 OUTSIDE AIR TEMP.= 81.000  
 STACK TEMPS. = 74.000 73.000 77.000 78.300  
 FAN DISCHARGE TEMP.= 84.000  
 ENGINE PLENUM AIR TEMP.= 83.00 118.00

TEMP= 83.00 ADJ. HP= ENGINE PERFORMANCE  
 0.6503E 03TEMP= 118.00 ADJ. HP= 0.6303E 03  
 AVERAGE HORSEPOWER--BOTH ENGINES-- 0.6652E 03  
 ENGINE AIR(BOTH SIDES)-CFM= 0.1701E 05 TAVG(364)= 100.500

AVG STACK TEMP= 75.50 TEMP RISE IN STACK -5.50  
 STACK PRESSURES VEL= 1.052 STATIC=-1.242 TOTAL HEAD=-0.189  
 FLOW IN STACK-CFM= 0.2758E 05

FAN PERFORMANCE  
 PRESS. RECOVERY WITH DIFFUSER(56( OF VEL HD.)) = 11.16  
 FAN DISCHARGE PRESS. STATIC= 7.600 VEL. HEAD= 6.350 TOTAL HEAD=13.950  
 STATIC PRESS. COR.= 7.842 TOTAL PRESS. COR.= 14.192  
 FAN PRESS INCREASE=14.139 FAN FLOW CFM= 0.2872E 05 FAN HORSEPOWER= 0.6399E 02  
 AVG. OF STACK AND FAN FLOW-CFM= 0.2815E 05

APU AIR FLOW, CFM = 0.1574E 04 VEL. FT/SEC= 0.7720E 02  
 OIL COOLER FLOW CFM= 0.8337E 04 VEL. FT/SEC= 0.7720E 02

SYSTEM PRESSURE DROPS  
 PRESS. AT DONALDSON, STR= 8.37 PORT= 8.10 AVG= 8.24  
 DONALDSON PRESS. DROP, STR= 2.87 PORT= 2.80 AVG= 2.84  
 PEERLESS PRESS. DROP, STR= 2.20 PORT= 3.30 AVG= 2.75  
 PRESS DROP TO ENG., STR= 2.57 PORT= 2.12 AVG= 2.35  
 PLENUM PRESS., PORT= 0.725 STBD= -0.125 AVG= 0.300  
 SCAV. PRESS. DROP= -3.200  
 OIL COOLER DUCT DROP= 1.300  
 DUCT TO HOT COMP. DROP= 1.000  
 DUCT TO CIL COOLER DROP= 3.800

TEST No. 6 C3B0616

INPUT DATA

N2= 92.500 92.300 93.700 94.000  
 TOP 42.000 43.000 44.000 46.000  
 STACK VEL. HD.= 1.50 0.80 0.50  
 STACK STATIC HD.= -0.20 -0.80 -0.60 1.40 1.65 1.60 1.65 1.60 1.60 1.50  
 FAN VEL. HD.= 8.800 6.700 7.200 5.000  
 FAN STATIC HEAD= 6.000 7.500 7.000 7.000 5.500  
 PRESS. AT DONALDSON-STBD 8.500 5.400 9.000 5.500  
 PRESS. AT DONALDSON-PORT= 5.000 8.000 7.500 8.000  
 OIL COOLER VEL. HD.= 1.000 OIL COOLER STATIC= 3.500  
 PEERLESS PRESS-STBD= 4.200 PORT= 4.000  
 PRESS AFT OF PEERLESS-STBD= 1.000 PORT= 0.800  
 ENGINE PLENUM PRESS-STBD= -4.00 -3.00 -2.20 -4.00  
 ENGINE PLENUM PRESS-PORT= -2.00 -2.60 -2.60 -3.00  
 SCAV. EXH. PRESS= 1.500 HOT SECT. PRESS.= 2.700 COOLER PRESS= 1.500  
 OUTSIDE AIR TEMP.= 81.000  
 STACK TEMPS. = 74.000 72.000 80.000 80.000  
 FAN DISCHARGE TEMP.= 85.000  
 ENGINE PLENUM AIR TEMP.= 84.00 78.00

ENGINE PERFORMANCE

TEMP= 84.00 ADJ. HP= 0.1377E 04TEMP= 78.00 ADJ. HP= 0.1385E 04  
 AVERAGE HORSEPOWER--BOTH ENGINES-- 0.1410E 04  
 ENGINE AIR(BOTH SIDES)-CFM= 0.1970E 05 TAVG(3&4)= 81.000

STACK PERFORMANCE

AVG STACK TEMP= 76.50 TEMP RISE IN STACK -4.50  
 STACK PRESSURES VEL= 1.392 STATIC=-0.375 TOTAL HEAD= 1.017  
 FLOW IN STACK-CFM= 0.3147E 05

FAN PERFORMANCE

PRESS. RECOVERY WITH DIFFUSER(56( OF VEL HD.)) = 10.75  
 FAN DISCHARGE PRESS. STATIC= 6.875 VEL. HEAD= 6.925 TOTAL HEAD=13.800  
 STATIC PRESS. COR.= 7.107 TOTAL PRESS. COR.= 14.032  
 FAN PRESS INCREASE=12.783 FAN FLOW CFM= 0.3002E 05 FAN HORSEPOWER= 0.6048E 02  
 AVG. OF STACK AND FAN FLOW-CFM= 0.3074E 05

APU AND OIL COOLER FLOWS

APU AIR FLOW, CFM = 0.1584E 04  
 OIL COOLER FLOW CFM= 0.7319E 04 VEL. FT/SEC= 0.6777E 02

SYSTEM PRESSURE DROPS

PRESS. AT DONALDSON, STB= 7.10 PORT= 7.12 AVG= 7.11  
 DONALDSON PRESS. DROP, STB= 2.90 PORT= 3.13 AVG= 3.01  
 PEERLESS PRESS. DROP, STB= 3.20 PORT= 3.20 AVG= 3.20  
 PRESS DROP TO ENG., STB= 4.30 PORT= 3.35 AVG= 3.82  
 PLENUM PRESS., PORT= -3.300 STBD= -2.550 AVG= -2.925  
 SCAV. PRESS. DROP= 2.500  
 OIL COOLER DUCT DROP= 0.500  
 DUCT TO HOT COMP. DROP= 0.800  
 DUCT TO OIL COOLER DROP= 2.000

## APPENDIX B

### PREDICTION OF AMS PERFORMANCE WITH THE PROPOSED MODIFICATIONS

#### INTRODUCTION

Four major changes in the LACV-30 Air Management System are contemplated: incorporation of a diffuser at the fan exit, incorporation of a third stage of filtration, enlargement of the entrance to the engine inlet compartment, and removal of the oil cooler airload. An estimate has been made of the performance which can be expected. The method involves the determinations of a pressure loss coefficient,  $k$ , for each component of the system. The coefficient is defined by:

$$k = \Delta P / Q^n$$

where  $\Delta P$  is the pressure drop across the element under scrutiny,  $Q$  is the volumetric flow rate, and  $n$  is an exponent defined by the mode of flow. In nearly all cases the flow is turbulent and  $n = 2.0$ . One exception occurs with the proposed barrier filter (Donaldson Duralife II), for which the manufacturer's data indicates that  $n = 1.4$ . For all components installed during the test program the loss coefficient  $k$  was determined from test data. For untested components, estimates were made from design data. The loss coefficients are identified by a two-digit subscript which is keyed to the system block diagram in Figure B-1. Flows are in CFM, pressure drop in inches, w.g.

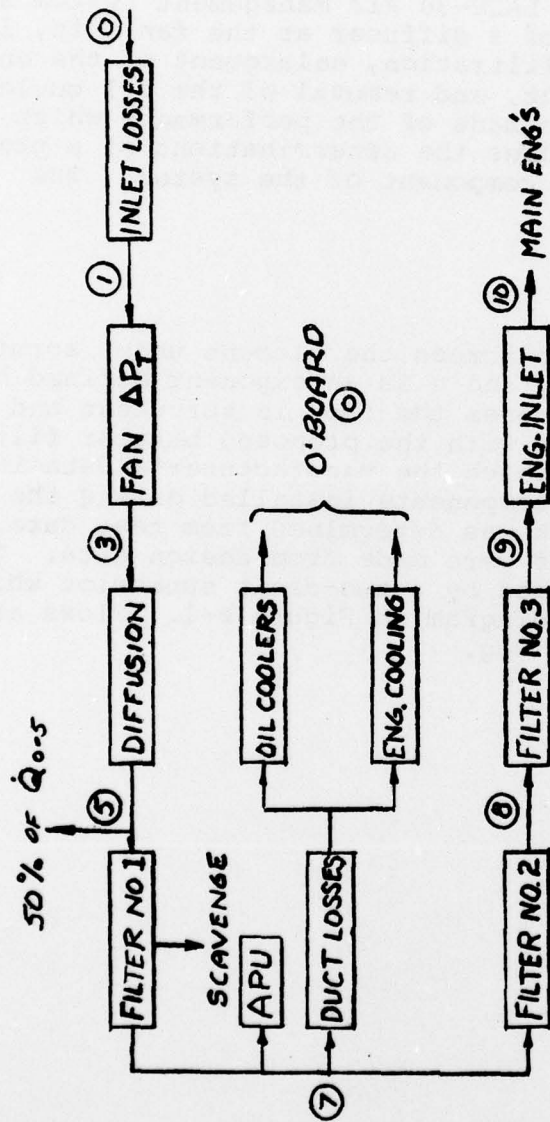


FIG B-1. BLOCK DIAGRAM OF AIR MANAGEMENT SYSTEM OF THE LACV-30 DURING PHASE I TESTS

NOTE: PROPOSED MODIFICATION WILL ELIMINATE COOLING SYSTEM BETWEEN STATIONS ⑦ & ⑩

FIG. B-1



## DEVELOPMENT

$\Delta P_{0-1}$ . The nine pitostatic measurements made in the inlet stack defined a coefficient for the inlet. Direct measurements for the inlet elbow were not provided for, so that a loss factor was developed for a Reynolds number of  $1.5 \times 10^6$  and a radius ratio of 0.7 using Reference 1. The sum of the two inlet coefficients yields:

$$\Delta P_{0-1} = -1.83 \times 10^{-9} Q_F^2$$

$\Delta P_{1-3}$ . This is the fan performance capability, and is taken from manufacturer's data, Figure 6, with corrections for the installation differences between the manufacturer basis for quotation and the LACV-30 system.

$\Delta P_{3-5}$ . The losses between these stations is the sum of the loss in the diffuser and the loss involved due to the abrupt discharge of the flow from the diffuser exit to the receiver. From diffuser design data from Reference 2, the recovery for the two concentric parts of the diffuser will be 56% of the inlet kinetic head, and for the uncontrolled turbulent diffusion downstream a recovery of 25% of the diffuser discharge head is assumed. Combining these results in an overall loss equation of:

$$\Delta P_{3-5} = -0.292 \times 10^{-8} Q_F^2$$

$\Delta P_{5-7}$ . From test data and using one-half of the fan flow rate,  $Q_F$  (because the fan flow is divided at this point), gives:

$$\Delta P_{5-7} = -1.452 \times 10^{-8} [Q_F/2]^2$$

$\Delta P_{7-8}$ . The flow through the demister, Filter No. 2,  $Q_E$ , is established by the engines. No direct mass rate measurement was provided for, but from the power measurement (speed and torque) the air rate can be deduced from the engine manufacturer's data, Reference 3, With appropriate corrections for engine operating conditions, the equation becomes:

$$\Delta P_{7-8} = -2.93 \times 10^{-8} Q_E^2$$

$\Delta P_{8-9}$ . Filter No. 3 is a Donaldson Duralife II Barrier filter untested by Bell. From the manufacturer's data it appears that the

flow through these elements is partially laminar, so that the loss equation is deduced to be:

$$\Delta P_{8-9} = -3.78 \times 10^{-6} Q_E^{1.4}$$

$\Delta P_{9-10}$ . A loss coefficient was determined for the existing engine inlet, the area of which is 218 in<sup>2</sup>. This is applied directly to the enlarged inlet 387 in<sup>2</sup>, now planned:

$$\Delta P_{9-10} = -1.25 \times 10^{-8} Q_E^2$$

It is probable that this coefficient is slightly pessimistic.

#### Applications of Loss Factors

For the modified system, supplying no cooling air, assume the engines are operated at normal power, 1440 HP, and that the ambient conditions are standard,  $P_{amb} = 2116$  PSFA  
 $T_{amb} = 518.7^\circ R$

Using the coefficients developed in the preceding section, the method for predicting the system performance and the end result follow: To develop the system airflow, first the engine air rates are determined from References 3 and 4:

$$\text{Main Engines} = Q_E = 9,930 \text{ cfm (per side)}$$

$$\text{APU Engine } 1/2 Q_S = \underline{840} \text{ cfm (per side)}$$

$$\text{Total} \quad 10,770 \text{ cfm}$$

Assuming that the scavenging air rate from Filter No. 1 is the 10% required for effective operation, the flow into both of the filters No. 1 is:

$$Q_F = 2 (10,770)/0.9 = 23,930$$

$$\Delta P_{0-1} = -1.183 \times 10^{-9} (23,930)^2 = 23,930$$

$$\Delta P_{1-3} @ 23,930 \text{ cfm} = +17.1 \text{ (fan data)}$$

$$\Delta P_{3-5} = 0.292 \times 10^{-8} (23,930)^2 = -1.67$$

$$Q_{5-7} = 0.5 (23,930) = 11,965$$

$$\Delta P_{5-7} = 1.452 \times 10^{-8} (11,965)^2 = -2.08$$

$$Q_{7-8} = 9,930 \text{ (engine air rate)}$$

$$\Delta P_{7-8} = -2.93 \times 10^{-8} (9,930)^2 = -2.89$$

$$\Delta P_{8-9} = -3.78 \times 10^{-6} (9,930)^{1.4} = -1.47$$

$$\Delta P_{9-10} = -1.25 \times 10^{-8} (9,930)^2 = -1.23$$

$$\Delta P_{10} \text{ (Eng Inlet)} = +7.06$$