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USAAVLABS TECHNICAL REPORT 69-22

SUGGESTED SPECIFICATION FOR A LIFT FAN PROPULSION SYSTEM

By

Walter B. Davis

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May 1969

U. S. ARMY AVIATION MATERIEL LABORATORIES
FORT EUSTIS, VIRGINIA

CONTRACT DA 44-177-AMC-345(T)
RYAN AERONAUTICAL COMPANY
SAN DIEGO, CALIFORNIA

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DEPARTMENT OF THE ARMY
HEADQUARTERS US ARMY AVIATION MATERIEL LABORATORIES
FORT EUSTIS, VIRGINIA 23604

This report has been reviewed by the US Army Aviation Materiel Laboratories and is considered to have a technically sound base.

The lift fan propulsion system component design requirements offered in this report reflect experience gained from the XV-5A lift fan aircraft program and would be useful to future designs of lift fan aircraft.

This report is published for the dissemination of information and stimulation of ideas.

Project 1F131201D161
Contract DA 44-177-AMC-345 (T)
USAAVLABS Technical Report 69-22
May 1969

SUGGESTED SPECIFICATION
FOR A
LIFT FAN PROPULSION SYSTEM

REPORT NO. 29469-3

By

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For

U.S. ARMY AVIATION MATERIEL LABORATORIES
FORT EUSTIS, VIRGINIA

SUMMARY

This report presents propulsion system component design requirements believed to be necessary for successful development of operational lift fan aircraft. The work was done under U. S. Army Aviation Materiel Laboratories (USAAVLABS) Contract DA 44-177-AMC-345(T) from 1 July 1965 to 1 March 1966 for the purpose of identifying lift fan airframe and propulsion system performance and installation interfaces. Military specification requirements are first examined for applicability; they are then expanded or modified.

The requirements presented in this report reflect experience gained from the XV-5A lift fan aircraft flight test program. Requirements in areas such as flight design loads, reliability and maintainability, and fan control rates are lacking in detail and authority and will need additional definition as new criteria develop.

FOREWORD

This report is submitted in partial compliance with Study Contract DA 44-177-AMC-345(T) with the U.S. Army Aviation Materiel Laboratories. It contains preliminary propulsion system component design requirements believed to be necessary for the successful development of an operational lift fan aircraft, based on the contractor's experience and the results of a Study of Airframe Requirements for Lift Fan Technology Advancement, USAAVLABS Report 69-21. Military specification requirements are first examined for applicability; then, they are expanded or modified in the same general order and format used in the presentation of airframe-propulsion system interfaces in the above-mentioned report. Some preliminary requirements (such as flight design loads, reliability and maintainability, and fan control response rates) are lacking in detail and authority. Work to develop authoritative requirements in these and other special requirement areas should be continued.

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LIST OF SYMBOLS AND ABBREVIATIONS

A_Z	Linear acceleration	
CTOL	Conventional takeoff and landing	
KEAS	Knots equivalent airspeed	knots
M	Mach number	
t_a	Cooling air temperature	^oF
t_{amb}	Ambient air temperature	^oF
T_{amb}	Absolute ambient air temperature	^oR
t_g	Leakage air temperature	^oF
V_{KEAS}	Equivalent air speed	knots
V_{KNOTS}	Aircraft speed	knots
V/STOL	Vertical or short takeoff and landing	
VTOL	Vertical takeoff and landing	
X	Ratio of leakage rate to cooling airflow rate	
β_v	Fan exit louver angle	degrees
$\dot{\theta}$	Pitch rate	rad/sec
$\ddot{\theta}$	Pitch acceleration	rad/sec^2
$\dot{\phi}$	Roll rate	rad/sec
$\ddot{\phi}$	Roll acceleration	rad/sec^2
$\dot{\psi}$	Yaw rate	rad/sec
$\ddot{\psi}$	Yaw acceleration	rad/sec^2

1.0 SCOPE

This report presents a draft outline of design requirements for the propulsion system and compatible propulsion system components for an advanced lift fan technology aircraft. This report is submitted in partial compliance with the requirements of Contract DA 44-177-AMC-345(T).

The preliminary design requirements are presented to reflect the special requirements established during the trade-off and interfacial problem area studies conducted as a part of the above contract. Also, they are presented as an exemplary aid to the preparation of procurement specifications and the procurement of such components. Compliance with the design requirements specified is believed to be possible within the current state of the art.

In an attempt to provide a comprehensive review of all factors affecting procurement practices, the preliminary requirements presented herein have been compared with the standard requirements of MIL-E-5007C. "Engines, Aircraft, Turbojet and Turbofan, General Specification For". The results of the comparison are summarized in Table I, which shows those sections of MIL-E-5007C which might be modified by the indicated sections of this report. Also shown are preliminary judgments regarding the applicability of certain requirements of MIL-E-5007C to the propulsion system components of this report. Where no modification is indicated in Table I, compliance with the requirements of MIL-E-5007C is required.

TABLE I

SUMMARY OF APPLICABLE MILITARY SPECIFICATION REQUIREMENTS - PRELIMINARY

NOTE: An x means MIL-E-5007C requirement modified.
No x means compliance with MIL-E-5007C required.
NA means not applicable.

MIL-E-5007C Section	Engine		LFX Wing Fan		LFX Nose Fan		Diverter Valve	
	Spec Mod	Section	Spec Mod	Section	Spec Mod	Section	Spec Mod	Section
1.	x	1.0	x	1.0	x	1.0	x	1.0
1.1	x	1.0	x	2.0	x	1.0	x	1.0
1.2								
2.	x	2.0	x	2.0	x	2.0	x	2.0
2.1	x	2.0	x	2.0	x	2.0	x	2.0
3.								
3.1								
3.2								
3.2.1								
3.2.2								
3.3								
3.3.1								
3.4	x	4.1	x	4.3	x	4.4	x	4.2
3.4.1								
3.4.1.1								
3.4.1.2								
3.4.1.3								
3.4.2	x	4.1	x	4.3	x	4.4	x	4.2
3.4.2.1	x	4.1	x	4.3	x	4.4	x	4.2
3.4.2.2	x	4.1	x	4.3	x	4.4	x	4.2
3.4.3								
3.4.4	x	6.4	x	6.4	x	6.4	x	6.4
3.4.5							NA	
3.4.6	x	6.2	x	6.2	x	6.2	x	6.2
3.4.6.1								
3.4.7	x	6.4	x	6.4	x	6.4	x	6.4
3.4.8	x	4.1.2	NA		NA		NA	
3.4.9	NA		NA		NA		NA	
3.4.10	?		?		?		NA	
3.4.11								
3.4.12	x	4.1.4						
3.4.13			NA		NA		NA	
3.4.14			NA		NA		NA	
3.4.14.1			NA		NA		NA	
3.4.15	x	4.1.2	x	4.3.4	x	4.4.4	NA	
3.4.15.1			NA		NA		NA	
3.4.15.2			NA		NA		NA	

TABLE I (Continued)								
	Engine		LFX Wing Fan		LFX Nose Fan		Diverter Valve	
MIL-E-5007C Section	Spec Mod	Section	Spec Mod	Section	Spec Mod	Section	Spec Mod	Section
3.4.15.3			NA		NA		NA	
3.4.16	x	5.1.3	x	5.3.8	x	5.4.8	x	5.2.6
3.4.17	x	6.1	x	6.1	x	6.1	x	6.1
3.5								
3.6								
3.6.1								
3.6.1.1								
3.6.2								
3.6.3								
3.7								
3.8								
3.8.1								
3.8.1.1								
3.8.2								
3.8.2.1								
3.8.3								
3.8.4								
3.9								
3.9.1								
3.9.2								
3.10	x	7.2	x	7.2	x	7.2	x	7.2
3.11			NA		NA		NA	
3.11.1			NA		NA		NA	
3.11.1.1			NA		NA		NA	
3.11.2			NA		NA		NA	
3.11.2.1			NA		NA		NA	
3.11.3			NA		NA		NA	
3.11.4			NA		NA		NA	
3.12	x	5.1.4	x	5.3.9	x	5.4.9	x	5.2.7
3.12.1	x	5.1.4	x	5.3.9	x	5.4.9	x	5.2.7
3.12.2			NA		NA		NA	
3.13	x	5.1.1	x	5.3.1	x	5.4.1	x	5.2.1
3.14	x	6.2	x	6.2	x	6.2	x	6.2
3.14.1								
3.14.2			x	6.2	x	6.2	NA	
3.15								
3.16								
3.16.1							NA	
3.16.2	x	6.1	x	6.1	x	6.1	x	6.1
3.16.2.1								
3.16.3							NA	
3.16.3.1							NA	
3.16.3.2			x		x		NA	

TABLE I (Continued)								
	Engine		LFX Wing Fan		LFX Nose Fan		Diverter Valve	
MIL-E-5007C Section	Spec Mod	Section	Spec Mod	Section	Spec Mod	Section	Spec Mod	Section
3.16.4			x	7.1	x	7.1	x	7.1
3.16.5			x	7.1	x	7.1	x	7.1
3.17			x	6.1	x	6.1	x	6.1
3.18	x	4.1.5	NA		NA		NA	
3.18.1	x	4.1.5	NA		NA		NA	
3.18.2			x	4.3.5	x	4.4.5	x	4.2.2
3.19								
3.19.1	x	4.1.3	x	4.3.6	x	4.4.6	x	4.2.3
3.19.2	x	4.1.3	x	4.3.6	x	4.4.6	x	4.2.3
3.19.3			NA		NA		NA	
3.20								
3.21								
3.21.1	x	5.1.2	x	5.3.3	x	5.4.3	x	5.2.5
3.21.2	x	4.1.4	x	4.3.1	x	4.4.1	x	4.2.1
3.21.3								
3.22							NA	
3.22.1							NA	
3.22.1.1			x	6.4	x	6.4	NA	
3.23							NA	
3.24								
3.25								
3.26								
3.27								
3.27.1								
3.27.2								
3.28								
3.29								
3.29.1	x	5.1.1	x	5.3.5	x	5.4.5	x	5.2.1
3.29.2							NA	
3.29.3	x	5.1.2	x	5.3.5	x	5.4.5	x	5.2.5
3.30								
3.30.1			NA		NA		NA	
3.30.2			NA		NA		NA	
3.30.3			NA		NA		NA	
3.30.4			NA		NA		NA	
3.30.5			NA		NA		NA	
3.30.5.1			NA		NA		NA	
3.30.5.1.1			NA		NA		NA	
3.30.5.1.2			NA		NA		NA	
3.30.6			NA		NA		NA	
3.31			NA		NA		NA	
3.31.1			NA		NA		NA	
3.31.1.1			NA		NA		NA	

TABLE I (Continued)								
	Engine		LFX Wing Fan		LFX Nose Fan		Diverter Valve	
MIL-E-5007C Section	Spec Mod	Section	Spec Mod	Section	Spec Mod	Section	Spec Mod	Section
3.31.1.2			NA		NA		NA	
3.31.1.3			NA		NA		NA	
3.31.1.4			NA		NA		NA	
3.31.2			NA		NA		NA	
3.31.3			NA		NA		NA	
3.31.4			NA		NA		NA	
3.31.5			NA		NA		NA	
3.31.6			NA		NA		NA	
3.31.7								
3.31.8			NA		NA		NA	
3.31.9			NA		NA		NA	
3.32			x	5.3.7	x	5.4.7	x	5.2.2
3.32.1			x	4.3.4	x	4.4.4	x	4.2.4
3.32.1.1	x	4.1.2	x	4.3.4	x	4.4.4	NA	
3.32.2			x	4.3.4	x	4.4.4	x	4.2.4
3.32.3			x	5.3.7	x	5.4.7	x	5.2.4
3.32.3.1			x	5.3.7	x	5.4.7	x	5.2.4
3.32.4								
3.32.4.1			NA		NA		NA	
3.32.4.2			x	4.3.4	x	4.4.4	NA	
3.32.4.3			NA		NA		NA	
3.32.4.4			NA		NA		NA	
3.32.5	x	7.2	x	7.2	x	7.2	x	7.2
3.32.6	x	7.1	x	7.1	x	7.1	x	7.1
3.32.6.1								
3.33			NA		NA		NA	
3.33.1			NA		NA		NA	
3.33.2			NA		NA		NA	
3.34	x	4.1.1	NA		NA		NA	
3.35								
3.36								
3.36.1								
3.36.2								
3.37								
3.37.1								
3.37.2								
3.38								
3.39								
3.39.1	x	7.1	x	7.1	x	7.1	NA	
3.40	x	7.2	x	7.2	x	7.2	x	7.2
3.41	x	7.2	x	7.2	x	7.2	x	7.2
3.42	x	7.1	x	7.1	x	7.1	x	7.1

TABLE I (Continued)								
	Engine		LFX Wing Fan		LFX Nose Fan		Diverter Valve	
MIL-E-5007C Section	Spec Mod	Section	Spec Mod	Section	Spec Mod	Section	Spec Mod	Section
4.								
4.1								
4.2								
4.3	x	8.0	x	8.0	x	8.0	x	8.0
4.4	x	8.0	x	8.0	x	8.0	x	8.0
4.5			x	8.0	x	8.0	x	8.0
4.6								
4.6.1								
4.6.2								
4.6.3								
4.6.4								
4.6.4.1								
4.6.5								
4.7			NA		NA		NA	
5.								
5.1								
6.								
6.1								
6.2								
6.2.1								
6.2.1.1								
6.2.1.2								
6.2.1.3								
6.2.1.4								
6.2.1.5								
6.2.1.6								
6.2.1.7								
6.2.1.8								
6.2.1.9								
6.2.1.10			x	4.3.4	x	4.4.4	x	4.2.4
6.2.1.11								
6.2.1.12								
6.2.1.13								
6.2.1.14	NA		NA		NA		NA	
6.2.1.15	NA		NA		NA		NA	
6.2.1.16	NA		NA		NA		NA	
6.2.1.17							NA	
6.2.1.18							NA	
6.2.1.19							NA	
6.2.1.20							NA	
6.2.1.21							NA	
6.2.1.22							NA	
6.2.1.23								

TABLE I (Continued)								
	Engine		LFX Wing Fan		LFX Nose Fan		Diverter Valve	
MIL-E-5007C Section	Spec Mod	Section	Spec Mod	Section	Spec Mod	Section	Spec Mod	Section
6.2.1.24								
6.2.1.25								
6.2.1.26								
6.2.1.27								
6.2.1.28							NA	
6.2.1.29								
6.2.1.30								
6.2.1.31								
6.2.1.32							NA	
6.2.2								
6.2.2.1								
6.2.2.2								
6.2.2.3								
6.3								
6.4								

2.0 APPLICABLE DOCUMENTS

2.1 The following specifications, standards, drawings, and publications shall be applicable to this preliminary specification. In the event of conflicting requirements, or exceptions, the requirements of this preliminary specification shall supersede the conflicting requirements.

2.1.1 Specifications

Military

Item 1 - MIL-E-5007C; Engines, Aircraft, Turbojet and Turbofan General Specifications For.

Item 2 - MIL-E-5008C; Engines, Aircraft, Turbojet and Turbofan Model Specification For (Outline and Instructions for Preparation).

Item 3 - MIL-E-5009C; Engines, Aircraft, Turbojet and Turbofan, Tests For.

3.0 DEFINITIONS

3.1 ENGINE AND ACCESSORIES

The turbojet engine shall include all normally furnished components such as overspeed control; self-contained lubrication system, including oil tank and cooler; filtered fuel system; tachometer generator; inlet bullet nose; gearbox for aircraft accessory power takeoff; oil pressure and temperature controls; fuel flow rate and exhaust gas temperature transmitters; insulation blanket; ignition system; exhaust gas thermocouple harness; and shall meet the design requirements of this specification.

3.2 DIVERTER VALVE

The diverter valve shall include all normally furnished components such as integral mounts; valve actuating linkages but not including the actuator; valve mode signal; leads and connectors to the periphery of the gas generator envelope.

3.3 WING LIFT FAN AND CONTROLS

The wing lift fan and controls shall meet the design requirements of this specification. It shall include all normally furnished components such as the rotor; front frame, including integral mounts; inlet guide vanes, and inlet closure mounting hard points or fittings; scroll, including variable area control and linkages but not including the actuator; rear frame, including stators, exit louver system and linkage but not including actuators; insulation; fan instrumentation, including fan rpm and overspeed sensing system, fan cavity and fan bearing temperature signals, fan vibration signal, and exit louver position signals, with leads and connectors to the inboard periphery of the system envelope.

3.4 NOSE LIFT FAN AND CONTROLS

The nose lift fan and controls shall meet the design requirements of this specification. It shall include all normally furnished components such as the rotor; front frame, including integral mounts, inlet guide vanes, and inlet closure mounting hard points or fittings; scroll, including variable area control and linkages but not including the actuators; rear frame, including stators, exit louver system and linkage if required but not including actuators; insulation; fan instrumentation including fan rpm and overspeed sensing system, fan cavity and bearing temperature signals, and fan vibration signal and exit louver position signals, with leads and connectors to the aft periphery of the system envelope.

4.0 PERFORMANCE

4.1 ENGINE

Item 1 - The engine shall operate without malfunction under the following conditions:

a. At any continuous or transient power setting,

b. In either fan or turbojet mode condition,

c. Over the speed-altitude range of the V/STOL aircraft,

d. Under the environmental conditions of Section 6.0, particularly those of Section 6.4 Item 3,

e. When the diverter valve is actuated from one mode position to the other in either direction,

f. At idle power while randomly ingesting hot gases as specified in Section 4.1.4.

Item 2 - No internal surfaces exposed to engine airflow shall require special coatings to prevent corrosion.

4.1.1 Engine Controls (Response)

Item 1 - Engine response rates for either fan mode or turbojet mode operation to step inputs, accomplished in one second or less, shall comply with the requirements of MIL-E-5007C, except as they may be modified by Item 2 below in this section.

Item 2 - Engine response rates for fan mode operation, with power extraction and a customer bleed, to step inputs between 95% rpm and takeoff power settings together with the lift fan response rates shall permit a combined "engine-lift fan" lift response rate such that 63 percent of the commanded value is obtained in no greater than 0.3 second.

Item 3 - The engine shall not malfunction or exceed allowable operating limits during any transient operation resulting from Items 1 and 2 of this section and/or the conditions of Section 4.1.4.

Item 4 - Data shall be furnished to the airframe manufacturer showing incremental effects resulting from providing the engine response rates of Item 2 in this section on engine weight, dimensions, performance, stall margin, life, reliability and other parameters significantly affected.

4.1.2 Heat Rejection

Item 1 - No engine case materials or engine mounted components shall exceed their allowable temperature limits when surrounded by still air under the following conditions:

a. The conditions specified in Section 3.19 of MIL-E-5007C.

b. Continuous operation with ambient air maintained at MIL-STD-210A hot day sea level conditions plus 90°F (50°C) when surrounded by a reflective enclosure, the engine facing walls of which are maintained at the above ambient air temperature and have a reflectivity greater than 80%.

Item 2 - A nonwicking, pressure-vented, foil covered insulation blanket may be used on the burner section of the engine.

Item 3 - Total heat rejection data shall be provided for all engine operating conditions within the speed-altitude envelope of the V/STOL aircraft.

4.1.3 Stall Margin Parameter Limits

Item 1 - In addition to the conditions of MIL-E-5007C, Section 3.4.12, compressor stall shall not occur under any conditions due to temperature and pressure fluctuations resulting from hot gas ingestion under the following conditions:

a. The range of increase in average inlet air temperature due to hot gas ingestion shall be from 0°F to 115°F with local hot streaks corresponding to 10 percent of the total inflow to 250°F above ambient temperature.

b. The range of temperature fluctuation shall occur within a range of time intervals varying from 0.1 to 5.0 seconds.

c. The duration of randomly fluctuating hot gas ingestion conditions shall not be less than 2.0 minutes.

Item 2 - No compressor stall shall be experienced when the engine is operating under the combined conditions of Item 1 of this section and the requirements of Section 4.1.2, Item 1.

Item 3 - Special engine requirements that require a modification of the inlet internal airflow shall not be permitted.

Item 4 - Compressor stall shall not occur under any operating condition with the engine inlet airflow distortions defined below:

a. No compressor stall shall be experienced under any combination of pressure distribution corresponding to a total pressure distortion index of 15% and a static pressure distortion index of 8%.

b. The total pressure distortion index is defined as the difference between the maximum and minimum total pressures divided by the average total pressure over the compressor face.

c. The static pressure distortion index is defined as the difference between the maximum and minimum static pressures divided by the average total pressure across the compressor face.

d. The requirements of this item shall apply over the entire compressor face except for the annular areas in contact with the inner hub and the outer wall surfaces and which extend radially from the surfaces, a distance of 3 percent of the inlet radius.

Item 5 - Complete substantiating analytical and test data shall be required to show compliance with the requirements of this section.

4.1.4 Installed Performance Computer Routine

Item 1 - An estimated installed performance deck shall be provided together with complete operating instructions for its use in accordance with the following items.

Item 2 - The deck shall permit investigation of the effect of the following variables on installed performance: altitude, ambient temperature, power setting, inlet pressure recovery, compressor bleed air and power extraction, changes in interstage bleed air schedule, exhaust gas ducting pressure loss from station to station, and thrust nozzle area and flow coefficient.

Item 3 - The deck output shall include conventional output parameters plus ideal gas horsepower, gas flow rate, and total pressure at various stations along the exhaust gas ducting system.

4.2 DIVERTER VALVE

Item 1 - The diverter valve shall operate without malfunction under the following conditions:

a. At any continuous or transient engine power setting,

b. In either fan or turbojet mode position, and during changes from either position to the other,

c. Over the speed-altitude range of the V/STOL aircraft,

d. Under the environmental conditions of Section 6.0, particularly those of Section 6.4, Item 3.

4.2.1 Pressure Losses

Item 1 - The pressure loss of the diverter valve in the turbojet mode position shall not exceed 2.5 percent of the inlet total pressure; however a pressure loss of 1.0 percent shall be a design objective.

Item 2 - The pressure loss of the diverter valve in the fan mode position shall not exceed 3.5 percent of the inlet total pressure; however, a pressure loss less than 2.5 percent of the inlet total pressure shall be a design objective.

Item 3 - Substantiating analytical and test data shall be furnished showing compliance with the requirements and objectives of Items 1 and 2 of this section.

4.2.2 Leakage

Item 1 - Diverter valve leakage in the turbojet mode position shall not exceed 1.0 percent by weight of the inlet gas flow. A leakage rate of less than 0.25 percent shall be a design objective.

Item 2 - Diverter valve leakage in the fan mode position shall not exceed 0.5 percent by weight of the inlet gas flow. A leakage rate of less than 0.25 percent shall be a design objective.

Item 3 - There shall be no measurable leakage from the diverter valve through the actuation mechanisms.

Item 4 - There shall be no measurable leakage from the end flanges of the diverter valve.

Item 5 - Substantiating analytical and test data shall be furnished showing compliance with the requirements and objectives of items of this section.

..2.3 Heat Rejection

Item 1 - No diverter valve materials or diverter valve mounted components shall exceed their allowable temperature limits when surrounded by still air under the following conditions:

a. The conditions specified in MIL-E-5007C, Section 3.19.

b. Continuous operation with ambient air maintained at MIL-STD-210A hot day sea level conditions plus 135°F (75°C) when surrounded by a reflective enclosure, the engine facing walls of which are maintained at the above ambient temperature and have a reflectivity greater than 80%.

Item 2 - A nonwicking, pressure vented, foil covered insulation blanket shall be installed on the external diverter valve surface. The insulation blanket shall not interfere in any way with the actuation of the diverter valve.

Item 3 - Total heat rejection data shall be provided for all engine operating conditions within the speed-altitude envelope of the V/STOL aircraft.

4.2.4 Door Actuation

Item 1 - The diverter valve doors shall be capable of being actuated from one mode position to the other in either direction within 0.2 second, and complete travel shall be accomplished within the specified time interval, at all conditions specified in Section 4.2, Item 1a.

Item 2 - The diverter valve door shall not depart from its design mode position after actuation under any operating conditions.

Item 3 - Substantiating analytical and test data shall be supplied showing compliance with the requirements of this section.

4.3 WING LIFT FAN

Item 1 - The wing lift fan performance shall not be less than that presented in the Wing Fan Model Specification or the special requirements of the following subsections, whichever are greater.

Item 2 - The wing lift fan shall operate without malfunction under the following conditions:

a. At any continuous or transient engine power setting,

b. Over the fan mode speed-altitude envelope of the V/STOL aircraft and during conversions from VTOL to CTOL and CTOL to VTOL configurations,

c. Under the environmental conditions of Section 6.0, particularly those of Section 6.4, Item 3,

d. During transients immediately following diverter valve position actuation at any power setting,

e. Over the full range of scroll area adjustment to the properly specified values,

f. One engine nonoperating with no affect on the performance of the remaining engine.

4.3.1 Hover Lift

Item 1 - The wing fan lift for AFDC standard day sea level conditions shall not be less than _____ pounds at heights above the ground plane equivalent to one fan diameter and above, when the wing fan, the wing fan bellmouth, and the exit closure and louver system are designed for the following conditions:

a. Wing Fan

(1) Pressure ratio = ___

(2) Fan tip diameter = ____ inches

(3) Power transfer = ±___%

b. Wing Fan Bellmouth

(1) Bellmouth radius = ___%

(2) No inlet guide vanes

(3) Inlet pressure loss = ___%

c. Wing Fan Exit Louvers and Closure System

(1) Loss of lift = ___% when

(2) Vectored fan stream angle = ___°

d. Engine Operating Conditions

(1) Inlet pressure recovery = ___%

(2) Takeoff power setting

(3) Bleed air extraction = ___%

(4) Power extraction = ___ horsepower

(5) Exhaust gas flow minus _% leakage = _____ pounds per second

e. Scroll Inlet Conditions

(1) Inlet gas flow in percent of total gas flow from one engine in Item 1d(5) of this section = ____%

(2) Inlet total pressure equal to the engine exhaust gas pressure minus pressure losses of ___% for the diverter valve and ___% for the interconnecting ducting. Scroll pressure losses equal ___%

Item 2 - The wing fan inlet bellmouth radius shall not exceed ___% of the fan tip diameter. Equivalent bellmouth contours may be selected from NACA Series 1 inlet coordinates and shall not exceed a height above the rotor corresponding to the above requirement.

Item 3 - Inlet guide vanes shall be permissible if necessary to meet the requirements of Item 1 of this section; however, they shall not extend above 1.5 inches below the bellmouth inlet envelope as established in Item 2 of this section, they shall be capable of operation under all fan flight conditions, and they shall not produce adverse effects during lateral and aft translation velocities to 50 knots.

Item 4 - Provisions shall be made for the wing fan to pump from the scroll compartment, cooling air at ambient atmospheric pressures at a rate equivalent to 0.5% of the fan inlet airflow rate when operating at 100% fan speed. The incremental weight and dimensional changes for providing this capability shall be presented to the airframe manufacturer and the procuring service in the wing fan model specification.

Item 5

a. The power transfer scroll area control system shall provide a linear variation of lift with respect to area control input displacement and the design shall consider the following factors:

   (1) Increasing or decreasing the inactive turbine admission arc by closing or opening individually and sequentially only those scroll nozzle ports necessary to achieve the required area change.

   (2) Increasing or decreasing the inactive turbine admission arc by partially closing or opening arc segments, with the arc segments operating sequentially following complete closing or opening as necessary to achieve the required area change.

   (3) A nozzle area control device that shall not interfere with the gas flow when the nozzle is completely open.

   (4) A nozzle area control device that is located in the gas flow stream.

b. Analytical and test data shall be presented, showing incremental performance, weight, dimensions, and actuating loads for the factors of this section, to the airframe manufacturer and procuring service in the model specification.

Item 6

a. No wing fan materials or components or wing fan mounted components shall exceed their allowable temperature limits when the wing fan is mounted in a simulated fan mode aircraft wing structure surrounded by still air at an ambient air temperature of 320°F (160°C) and operated under any combination of power transfer conditions specified in Item 1a(3) of this section, engine power settings, and the conditions of Section 4.1.2, Items 1 and 2.

b. No wing fan materials or components or wing fan mounted components shall exceed their allowable temperature limits when completely enclosed in a simulated turbojet mode aircraft wing structure and closure structure which is surrounded by still air when

   (1) subjected to the diverter valve leakage specified in Section 4.2.2, Item 1,

(2) the outside ambient air temperature is equal to MIL-STD-210A hot day sea level conditions, and either

(3) no cooling air is provided, or

(4) a specified amount of cooling air is provided by a cooling system which is integral with the wing fan.

c. Analytical and test data shall be provided to the airframe manufacturer and to the procuring service with the model specification, showing incremental performance, weight, and dimensional and operating penalties for the conditions of this section.

Item 7 - The wing fan exit louver system shall be capable of efficiently vectoring the fan efflux statically over a range from 25 degrees forward ($\beta_v = -25^\circ$) to 45 degrees aft ($\beta_v = 45^\circ$).

4.3.2 Transition Performance and Power Absorption

The wing fan shall be capable of absorbing the maximum gas horsepower supplied to the wing fan scroll without encountering overspeed limits when operating under the conditions of Figure 1, and any combination of power transfer conditions, engine power settings, and engine control response rates.

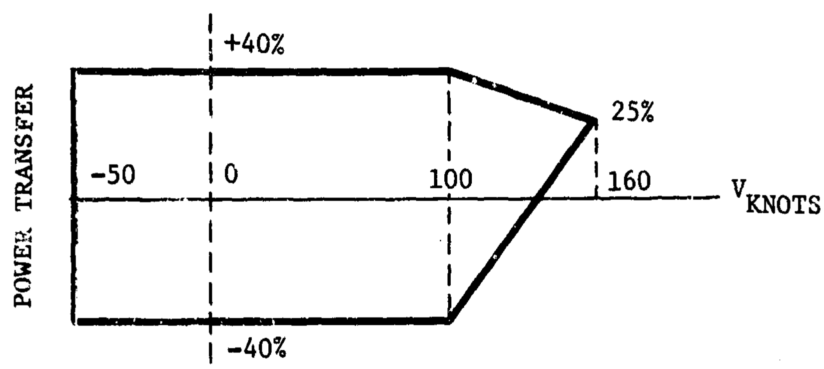

Figure 1. Wing Fan Power Transfer - Aircraft Speed Envelope

4.3.3 Wing Fan Control Response

Item 1 - The thrust response of the wing fan power transfer system shall have a time constant not greater than 0.35 second for a full roll control input, and not greater than 0.25 second for roll control inputs equal to, or less than, one-half of the maximum available.

Item 2 - The force response time constant for differential vector control shall be not greater than 0.1 second.

Item 3 - The time constants of Items 1 and 2 of this section shall apply throughout the range of 95 percent to 100 percent engine rpm.

4.3.4 Leakage

Item 1 - The internal wing fan leakage capable of entering the wing fan scroll cavity shall not exceed 0.2 percent of the design gas flow rate of Section 4.3.1, Item 1d(5), under any fan mode operating condition.

Item 2 - No external hot gas leakage into the wing fan scroll cavity shall be permitted under any fan mode operating condition as a result of spillage or deflection from the wing fan louver or closure system.

4.3.5 Heat Rejection

Item 1 - The heat rejection from the wing fan system, including hot gas leakage which shall be specified separately, when operating in the fan mode shall be in accordance with the wing fan model specification, when the wing fan is installed in a simulated wing structure and surrounded by ambient air at ARDC standard day sea level temperature flowing at a velocity of 30 feet/second.

Item 2 - Use of pressure vented foil covered insulation blanket is recommended.

Item 3 - Analytical and test data shall be presented to the airframe manufacturer and to the procuring service in the model specification, showing incremental changes in weight, dimensions, and lift performance, and heat rejected by the wing fan system and cooling air outlet temperature as a function of cooling airflow rate.

4.3.6 Installed Performance Computer Routine

Item 1 - An estimated installed wing fan performance deck for static conditions shall be provided, together with complete operating instructions for its use.

Item 2 - The deck of Item 1 of this section shall permit investigation of the effect on lift fan performance during hovering of the following variables:

a. Scroll inlet conditions, including gas flow rate, total temperature and total pressure,

b. Fan turbine admission scroll arc with either one or two inactive arcs covering the power transfer range required by Section 4.3.1, Item 1a(3), and for the recommended scroll area control system resulting from Section 4.3.1, Item 5,

c. Fan inlet pressure losses,

d. Fan exit louver angle over the range of ±25 degrees ($\beta_v = \pm 25^o$),

e. Fan height above the ground level for a range of height to fan diameter ratios from 0.5 to 4.0,

f. Ambient conditions of temperature and pressure for ARDC standard day and MIL-STD-210A hot and cold days with provisions for temperature increments to 30^oF due to hot gas ingestion,

g. Altitudes from sea level to 10,000 feet.

Item 3 - The deck of Item 1 of this section shall provide the following output data:

a. Input data of Item 2 of this section,

b. Identifying case number,

c. Gas horsepower supplied to the scroll inlet,

d. Wing fan lift and disk loading,

e. Velocities and dynamic pressures of the fan and turbine exhaust gas streams,

f. Weight flow rate of the fan stream,

g. Effective area of the scroll area,

h. Secondary cooling airflow rate provided for in Section 4.3.1, Item 4.

Item 4 - Provisions shall be included in the deck of Item 1 of this section to estimate the effects of cross-flow on fan performance parameters based on experimentally developed correlations.

4.4 NOSE LIFT FAN

Item 1 - The nose lift fan performance shall not be less than that presented in the nose fan model specification or the special requirements of the following subsections, whichever are greater.

Item 2 - The nose lift fan shall operate without malfunction for the conditions of Section 4.3, Item 2.

4.4.1 Hover Lift

Item 1 - The nose fan lift for ARDC standard day sea level conditions shall not be less than _____ pounds at 0 percent power transfer and at heights above a ground plane equivalent to one diameter and above when the nose fan, nose fan bellmouth, and the exit closure and louver systems are designed for the following conditions:

a. Nose fan

(1) Pressure Ratio = ____

(2) Fan Tip Diameter = __ inches

(3) Power Transfer = +___ percent to ___ percent

b. Nose Fan Bellmouth

Same as Section 4.3.1, Item 1b,

c. Nose Fan Exit Louvers and Closure System

Same as Section 4.3.1, Item 1c,

d. Engine Operating Condition

Same as Section 4.3.1, Item 1d,

e. Scroll Inlet Conditions

(1) Inlet gas flow in percent of total gas flow from one engine in Section 4.3.1, Item 1d(5) = _____ percent

(2) Inlet total pressure same as Section 4.3.1, Item 1e(2)

Item 2 - The nose fan inlet bellmouth requirements shall be the same as Section 4.3.1, Item 2.

Item 3 - Nose fan inlet guide vanes requirements and condition shall be the same as Section 4.3.1, Item 3.

Item 4 - Nose fan cooling air pumping requirements shall be the same as Section 4.3.1, Item 4.

Item 5 - Nose fan power transfer scroll area requirements shall be the same as Section 4.3.1, Item 5, plus the following:

a. Continuous modulation of the nose fan scroll area to zero flow area (0% of the gas flow of Section 4.3.1, Item 1d(5), and

b. Hot gas leakage through the scroll area control system shall not exceed 0.5% of the design flow rate to the nose fan specified in Item 1e(1) of this section when the nose fan is in the zero flow area position.

Item 6 - Operating temperature requirements of Section 4.3.1, Item 6, shall apply to the nose fan plus the leakage condition of Item 5b of this section.

4.4.2 Transition Performance and Power Absorption

Item 1 - The nose fan shall be capable of absorbing the maximum gas horsepower supplied to the nose fan scroll without encountering overspeed limits when operating under the conditions of Figure 2, and any combination of power transfer conditions, engine power settings, and engine control response rates.

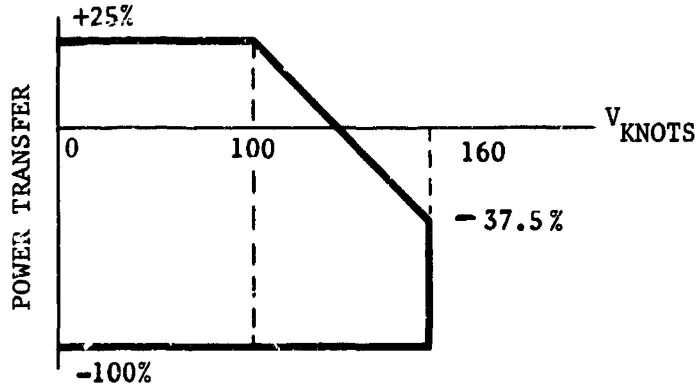

Figure 2. Nose Fan Power Transfer - Aircraft Speed Envelope

4.4.3 Nose Fan Control Response

The thrust response of the nose fan power transfer system shall have a time constant of not greater than 0.3 second. This time constant shall apply to 50 percent of the available thrust change at engine power settings from 95 percent rpm to takeoff power.

4.4.5 Leakage

The leakage requirements for the nose fan shall be the same as those of Section 4.3.5 plus the requirements of Section 4.4.1, Item 5b.

4.4.6 Heat Rejection

The nose fan heat rejection requirements shall be in accordance with the nose fan model specification.

4.4.7 Installed Performance Computer Routine

The requirements for an estimated installed nose fan performance deck shall be the same as those of Section 4.3.6 except that the referenced wing fan report sections shall be replaced by equivalent referenced nose fan sections.

5.0 INSTALLATION FEATURES

5.1 ENGINE

5.1.1 Mounting

Item 1 - The engine shall have a mount point on either side, either mount to be used individually for vertical loads only. Fitting shall accept a uniball rod end in double shear.

Item 2 - Rear engine flange will attach to diverter valve on which shall be incorporated the additional mounting points required by Section 5.2.1.

5.1.2 Mating With Diverter Valve and Accessories

5.1.2.1 Engine and Diverter Valve Interconnect - The rear engine flange shall be bolted to the diverter valve front flange. The machined flange shall be of tapered cross section, spotfaced, indexed, and interchangeable.

5.1.2.2 Engine Air Inlet - The engine air inlet flange on the engine shall provide for such alignment as is required by the engine.

5.1.2.3 Fuel - Only one fuel connection shall be required. It shall be easily removable with standard tools. The engine fuel inlet shall be capable of accepting fuel containing contamination up to 200 microns per MIL-E-5007C.

5.1.2.4 Temperature and Pressure Sensing - Except by special permission, temperature and/or pressure sensors shall be engine mounted so that there shall be no requirement for airframe-engine interconnects to provide temperature or pressure signals to the engine. Permission for deviation from this requirement may be granted by the airframe manufacturer.

5.1.2.5 Accessory Provisions

Item 1 - A standard AND pad capable of accepting a flexible shaft for power takeoff and/or starter, shall be provided. Clearance for shaft and proper access shall be provided. It shall be capable of transmitting not less than ___HP at not more than _____ rpm.

5.2 DIVERTER VALVE

5.2.1 Mounting

Item 1 - The diverter valve shall provide a spherical mount fitting which shall be capable of accepting such loads as may be imposed by the engine and diverter valve assembly. This mount point will accept loads in all directions.

Item 2 - A second clevis fitting capable of accepting a uniball bearing bolted in double shear shall accept horizontal loads perpendicular to the line between the other two engine and diverter valve mounts.

5.2.2 Door Adjustment

Positive adjustment of the fan duct closure doors within ±2 inches of the fan mode design position in 0.5-inch increments and a position indexing device shall be provided.

5.2.3 Actuation

The time required for the diverter valve to move from one mode position to the other in either direction shall not exceed 0.2 second.

5.2.5 Mating to Engine and Ducting

Item 1 - For diverter valve to engine mating requirements, refer to Section 5.1.2.1.

Item 2 - The diverter valve connections to the ducting and the tailpipe shall be accomplished by means of V-band couplings and sheet metal flexible flanges.

Item 3 - Hot gas leakage at the mating flanges shall not exceed 0.0003% of the inlet gas flow rate.

5.2.6 Instrumentation

Item 1 - A diverter valve mode position sensor shall be provided.

5.2.7 Weight

The weight of the diverter valve shall be provided in the model specification.

5.3 WING LIFT FAN

5.3.1 Mounting

Item 1 - The wing fan mounting shall be in accordance with the wing fan model specification.

Item 2 - The wing fan mounting design shall consider the following factors:

a. The wheel and bearings mounted on an aircraft-supplied spindle shaft.

b. The scroll suspended by three mounting links from which the supporting beams will permit it to move to a position of proper alignment after expansion.

c. The fan rear frame halves suspended from the scrolls at the frame periphery and hinged from the chordwise louver support beam.

Item 4 - Analytical and test data shall be presented in the model specification showing incremental performance, weights, maintenance, reliability, response, and dimensional data for the factors of this section compared to the selected mounting system.

5.3.2 Envelope

Item 1 - The wing fan envelope shall be in accordance with the wing fan model specification.

Item 2 - The wing fan envelope design shall consider the following factors:

a. A tradeoff study to determine the effects of critical components and design decisions on the wing fan envelope dimensions with particular emphasis being focused on factors affecting fan thickness and radial dimensions and their effect on fan performance.

b. The tradeoff study shall include consideration of the following: offset bearings, the design division of gas power between the fan turbine and the turbine exhaust, scroll inlet gas conditions, scroll pressure losses, partial admission end losses, fan turbine blade characteristics, and the requirements of Section 5.3.6.

Item 2 - Analytical and test data shall be presented in the model specification showing incremental effects resulting from the factors considered in the tradeoff study of this section compared to the specification envelope.

5.3.3 Scroll Mating with Ducting

Item 1 - The wing fan scroll connection to ducting shall be accomplished by means of V-band couplings and sheet metal flexible flanges.

5.3.4 Inlet and Structure

The inlet bellmouth and structure shall be supplied by the airframe manufacturer. It shall contain provisions required for fan component attachments--i.e., seals, scrolls, etc., which are to be coordinated with the fan manufacturer.

5.3.5 Exit Louver

The exit louver assembly shall provide fan stream vectoring from -25 degrees to 45 degrees ($-25^\circ \leq \theta_V \leq 45^\circ$), shall consider the requirements of Section 4.3.1, Item 6, Section 4.3.4, and Section 5.3.6, and shall provide the wing fan exit closure system.

5.3.6 Cooling Air Outlet

A means of exhausting air from all four quadrants of the wing cavity shall be provided for rates of airflow to the value of Section 4.3.1, Item 4.

5.3.7 Controls Actuation

Item 1 - Controls actuation requirements shall include the requirements of Section 4.1.1; Section 4.3.1, Item 5; and Section 4.3.3. Actuation force requirements to meet the specified response rates shall be provided by the wing fan manufacturer.

5.3.8 Instrumentation

Fan instrumentation shall be provided at the inboard periphery of the wing fan envelope for both cockpit display and in-flight recording on a noninterference basis as follows:

Item 1 - Fan speed from 0 percent to maximum percent rpm with a signal accuracy meeting MIL-E-5007C qualification requirements for cockpit display.

Item 2 - Instrumentation shall include sensors for fan bearing and fan cavity temperatures, fan vibration, and the fan speed of Item 1 in this section.

5.3.9 Weight

A complete weight breakdown of the wing fan shall be submitted to the airframe manufacturer for use in evaluating wing fan to aircraft features.

5.4 NOSE LIFT FAN

5.4.1 Mounting

Item 1 - The nose fan mounting system shall be in accordance with the nose fan model specification.

5.4.2 Envelope

The envelope for the nose lift fan shall be in accordance with the model specification control drawing.

5.4.3 Scroll Mating with Ducting

The scroll shall be connected to the ducting by means of V-band couplings and sheet metal flanges. The location of the outlets shall be in accordance with the model specification control drawing. The scroll inlet loads will depend upon the ducting system concept; therefore, they will be specified by the specification control drawing.

5.4.4 Inlet System Accommodation

The inlet ducting shall be supplied by the airframe manufacturer. The fan manufacturer shall supply such seals as he deems necessary; the airframe manufacturer shall provide for attachment and adjustment as required.

5.4.5 Exit Ducting and/or Closure Accommodation

The exit duct and closure shall be supplied by the airframe manufacturer. Type and location of seal between lift fan components and the outlet ducting shall be specified on the specification control drawing.

5.4.6 Cooling Air Inlets

A means of exhausting air from all four quadrants of the nose fan cavity shall be provided for rates of airflow to the value of Section 4.4.1, Item 4.

5.4.7 Controls Actuation

The scroll area modulation controls shall be supplied by the airframe manufacturer. Actuator force requirements shall be provided by the nose fan manufacturer.

5.4.8 Instrumentation

The nose fan instrumentation requirement shall be the same as those of Section 5.3.8.

5.4.9 Weight

The fan manufacturer shall supply a complete weight breakdown to the airframe manufacturer.

6.0 ENVIRONMENT

This section specifies the environmental conditions for the propulsion system and its components.

6.1 SHOCK, VIBRATION, NOISE

Shock, vibration and noise requirements shall be in accordance with amended currently applicable issues of the following documents:

1. MIL-E-5272 (ASG) Environmental Testing, Aeronautical and Associated Equipment, General Specification For.

2. MIL-STD-810A (USAF) Environmental Test Methods for Aerospace and Ground Equipment.

6.2 ANGULAR RATES, ACCELERATION

The angular rates and accelerations in fan mode operation shall be in accordance with the aircraft model specification. An example of maximum values expected is presented in Table II, including allowance for landings at 17 feet per second.

TABLE II

ANGULAR RATES AND ACCELERATIONS - FAN MODE OPERATION

Linear Acceleration $0 \leq$ Velocity ≤ 160 KEAS $A_Z = 3$ g's		
Angular Accelerations and Rates	Hover	Transition
Pitch $\ddot{\theta}$ rad/sec^2	±1.0	±2.75
Roll $\ddot{\phi}$ rad/sec^2	2.0	2.38
Yaw $\ddot{\psi}$ rad/sec^2	0.4	1.00
Pitch $\dot{\theta}$ rad/sec	±1.0	±1.0
Roll $\dot{\phi}$ rad/sec	2.0	2.0
Yaw $\dot{\psi}$ rad/sec	3.0	1.0

The structural design conditions for turbojet mode operation are:

a. Load factor of ___ acting in combination with pitch accelerations of 0 to ___ radians per second squared.

b. Load factor of ___ acting in combination with pitch accelerations of 0 to ___ radians per second squared.

c. Load factor of ___ to ___ acting in combination with a roll acceleration of ___ radians per second squared.

6.3 INSTALLED ENVIRONMENT

For hot day operation, the maximum operating environmental temperatures for the propulsion system components shall be as defined in Table III.

TABLE III
ENVIRONMENTAL TEMPERATURES - HOT DAY OPERATION

Component	Mode	Day[1*]	Mach	Temperature °F
Engine				
Compressor	Fan	Hot	0	t_{amb} + ingestion[2]
	Turbojet	Hot	All	t_{amb} + ram[3]
Turbine	Fan	Hot	0	t_{amb} + ingestion[2] + heat pickup[4]
	Turbojet	Hot	All	t_{amb} + ram[3]
Diverter Valve	Fan	Hot	0	t_{amb} + ingestion[2] + heat pickup[5]
	Turbojet	Hot	All	t_{amb} + ram[3] + heat pickup[5]
Wing Fan	Fan	Hot	0	t_{amb} + ingestion[2]
	Turbojet	Hot	All	t_{amb} + ram[3] + leakage[6] + heat pickup[7]

TABLE III (Continued)
ENVIRONMENTAL TEMPERATURES - HOT DAY OPERATION

Component	Mode	Day[1]*	Mach	Temperature °F
Nose Fan	Fan	Hot	0	t_{amb} + ingestion[2]
	Turbojet	Hot	All	t_{amb} + ram[3] + leakage[6] + heat pickup[7]

*The superscripts refer to the notes below.

Notes:

1. MIL-STD-210(A) HOT DAY; For cold day operation the minimum temperature shall be as defined for the conditions above by substituting cold day ambient conditions for hot day conditions.
2. temperature rise from ingestion (to 50°F)
3. temperature rise from ram = $.2M^2T_{amb}$ where M = Mach number and $T_{amb} = t_{amb} + 460$.
4. temperature rise from heat pickup over engine (to 70°F)
5. temperature rise from heat pickup over engine and diverter valve (to 110°F)
6. temperature rise from hot gas leakage = $[X\ (t_g - t_a)]\ /\ (1+X)$ where X = ratio of leakage to cooling airflow rates, t_g = hot gas temperature, t_a = cooling air temperature.
7. temperature rise from heat pickup from aircraft and fan cooling (to 100°F).

6.4 EXTERNAL ENVIRONMENT

Item 1 - The external environment shall include the climatic extremes of MIL-STD-210A and the induced environment around the aircraft.

Item 2 - Induced environmental conditions around the Model 215 which affect propulsion system components shall be as follows:

a. Temperature

(1) Engine inlet air = Section 4.1.3, Item 1,

(2) Wing fan inlet air = $t_{amb} + 10^{o}F$,

(3) Nose fan inlet air = $t_{amb} + 30^{o}F$;

b. Vertical velocities during hovering in ground effect

(1) Engine inlet to 100 feet per second,

(2) Wing fan to 75 feet per second,

(3) Nose fan to 75 feet per second;

c. It shall be assumed that the aircraft will be exposed to sand and dust conditions of the concentrations and durations in Table IV. The sand shall comply with that specified in MIL-E-5007C, Section 3.25.

TABLE IV
AIRCRAFT DUST ENVIRONMENT AND EXPOSURE TIME

Condition	Concentration (lbs sand/lb air)	Duration (minutes)
a	4.4×10^{-3}	17
b	4.4×10^{-4}	17
c	4.4×10^{-5}	66

d. It shall be assumed that the lower fuselage surfaces and landing gear of the aircraft will be exposed to particle impingement for the conditions of Table V.

TABLE V
AIRCRAFT PARTICLE IMPINGEMENT EXPOSURE CONDITIONS

Diameter (inches)	Velocity (feet/second)	Concentration (lbs sand/lb air)	Duration (minutes)
.05	225	Table IV	Table IV
.25	130	To Be Defined	To Be Defined
.50	110	To Be Defined	To Be Defined

7.0 RELIABILITY AND MAINTAINABILITY

Quantitative reliability and maintainability requirements shall equal or exceed the applicable requirements of the military specifications of Section 2.1.1 except as they may be modified by future studies.

8.0 QUALIFICATION TESTS

8.1 STATIC OPERATION

Item 1 - The engine shall demonstrate satisfactory compliance with the following:

a. Special requirements of this report.

b. Requirements of MIL-E-5009C except for the requirement of Item 4 of this section.

Item 2 - The diverter valve shall demonstrate satisfactory compliance with the following:

a. Special requirements of this report.

b. Applicable requirements of MIL-E-5009C except for the requirement of Item 4 of this section.

Item 3 - The nose fan and wing fans shall demonstrate satisfactory compliance with the following:

a. Special requirements of this report.

b. Applicable requirements of MIL-E-5009C except for the requirement of Item 4 of this section.

Item 4 - A propulsion system including engines, diverter valves, nose fan, and wing fans shall be installed in a simulated aircraft structure on a variable height instrumented test fixture and subjected to a test program equivalent to a MIL-E-5009C Preliminary Flight Rating Test (PFRT).

a. Concurrent with the test program of Item 4a, the near and far field flow pattern characteristics, including temperature and velocity vectors, shall be established.

b. The propulsion system test program shall include test conditions covering actual or simulated winds and their orientation, the complete range of operating controls, and any combination thereof including steady-state and transient operation.

c. Sufficient instrumentation shall be provided that complete steady-state and transient propulsion system performance and the induced near and far field flow characteristics can be determined for each test condition.

d. A complete test report covering propulsion system performance, and the near and far field flow characteristics for all test conditions shall be furnished to the airframe manufacturer for approval.

Item 5 - In addition to the distribution requirements of MIL-E-5009C, test reports shall be furnished to the contracting agency demonstrating propulsion system component compliance with the following:

a. Special requirements of this report, and

b. Requirements of MIL-E-5009C.

8.2 WIND TUNNEL

Item 1 - Test Installation

Qualification of the lift fan propulsion system for fan mode forward flight will require testing of the system in a suitable wind tunnel or simulated crossflow conditions. While it would be desirable to qualify the system by testing it in a full-scale wind tunnel model, the minimum installation will require simulation of the fan inlets and closure doors and the correct orientation of fan and engine inlets.

Item 2 - Forward Velocity

The lift fan propulsion system shall be qualified for fan mode flight up to the maximum fan mode flight speed of ___ KEAS. Minimum test speeds need not be lower than 40 KEAS.

Item 3 - The effects of angle of attack shall be established for the fan mode flight envelope, an example of which is shown in Figure 3.

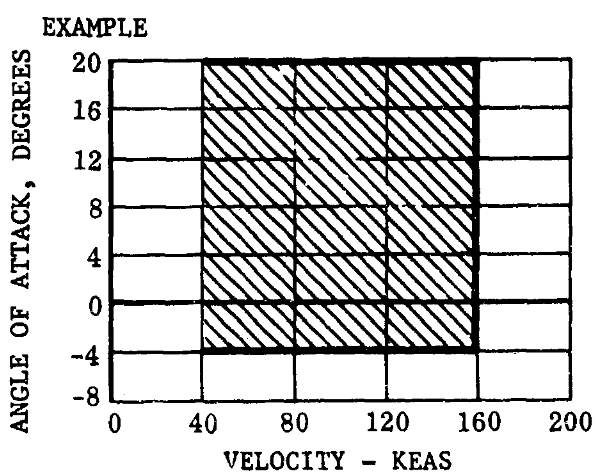

Figure 3. Aircraft Angle of Attack - Velocity Envelope

Item 4 - Vector Angle

The fan exit louvers shall be tested for the conditions established for fan mode flight, an example of which is shown in Figure 4.

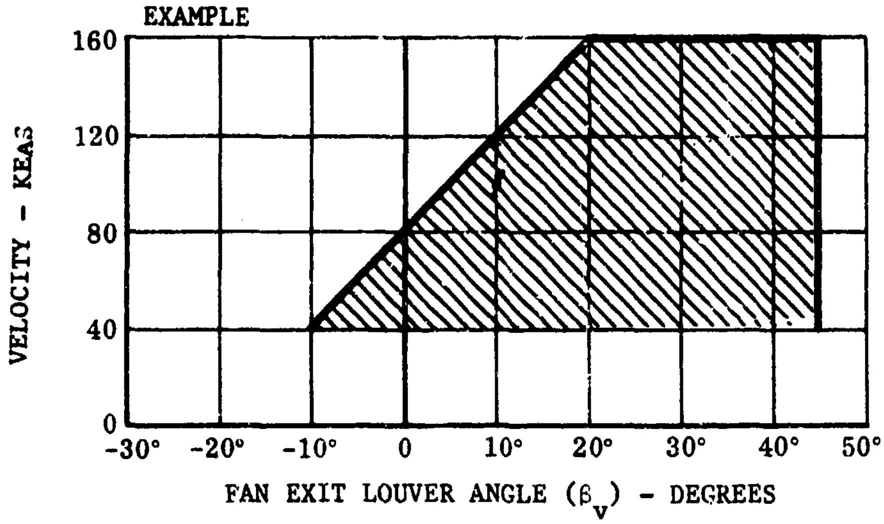

Figure 4. Aircraft Fan Exit Louver Angle - Velocity Envelope

Item 5 - Fan Speed

The lift fan propulsion system shall be qualified at takeoff power for the speed/vector angle envelope defined in the aircraft model specification, an example of which is shown in Figure 4.

Item 6 - Fan Stall

If fan stall is found to occur within the angle of attack and the vector angle envelopes, for example, Figures 3 and 4, the fan stall boundary shall be established.

Item 7 - Control Cycling

The power transfer roll control shall be cycled to full throw in each direction at 40 KEAS, 70 KEAS, and 100 KEAS. The power transfer pitch control shall be cycled to full throw in each direction at 40 KEAS and 70 KEAS. Differential vector for yaw control shall be cycled at all test velocities to the full extent of the system authority at the corresponding vector angle.

Roll, pitch, and yaw controls shall be cycled at maximum takeoff power. Conversions shall be made from fan mode to jet mode and from jet mode to fan mode at ___ KEAS and ___ KEAS. Power settings for conversions shall be maximum takeoff power and 85% engine rpm.

Item 8 - Maintenance and Inspection

Critical areas for maintenance and inspection shall be determined during these tests.

Item 9 - Endurance

Wind tunnel tests, in conjunction with the static tests, shall be of sufficient duration and shall entail sufficient cycling of all components to qualify the system for an initial 50-hour service life.

9.0 ACCEPTANCL TESTS

9.1 STATIC OPERATION

Item 1 - The propulsion system components including the engine, diverter valve, nose fan, and wing fans shall demonstrate compliance with the acceptance test requirements of MIL-E-5009C.

Item 2 - Test data corrected to ARDC standard day demonstrating component performance over the complete operating range of all control settings and all combinations thereof shall be furnished to the airframe manufacturer for each article accepted and delivered.

10.0 DATA

10.1 COMPONENT SPECIFICATIONS

A component model specification which complies with all applicable requirements of MIL-E-5008C shall be furnished to the airframe manufacturer for each component including the engine, diverter valve, nose fan, and wing fans.

10.2 COMPONENT DATA

Item 1 - Analytical and test data substantiating compliance with the requirements of this report shall be furnished to the airframe manufacturer.

Item 2 - Upon request, propulsion system component test reports covering PFRT, Qualification and Acceptance tests shall be furnished to the airframe manufacturer.

10.3 PROPULSION SYSTEM DATA

Analytical and test data and test reports covering propulsion system performance tests shall be furnished to the airframe manufacturer.

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13. ABSTRACT

This report presents propulsion system component design requirements believed to be necessary for successful development of operational lift fan aircraft. The work was done under U. S. Army Aviation Materiel Laboratories (USAAVLABS) Contract DA 44-177-AMC-345(T) from 1 July 1965 to 1 March 1966 for the purpose of identifying lift fan airframe and propulsion system performance and installation interfaces. Military specification requirements are first examined for applicability; they are then expanded or modified.

The requirements presented in this report reflect experience gained from the XV-5A lift fan aircraft flight test program. Requirements in areas such as flight design loads, reliability and maintainability, and fan control rates are lacking in detail and authority and will need additional definition as new criteria develop.

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