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PHASE III PROPOSAL

SUPERSONIC TRANSPORT DIVISION

SEPTEMBER 6, 1966

SST

D6A10078-1

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6 *Supersonic Transport Development Program* , Phase III
Proposal,
BOEING MODEL 2707,

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STARTING SUBSYSTEM SPECIFICATION,

14 D6A10078-1

10 Grant W. Ort

September 6, 1966

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Prepared for

FEDERAL AVIATION AGENCY

Office of Supersonic Transport Development Program

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THE **BOEING** COMPANY
SUPERSONIC TRANSPORT DIVISION

FAA

ISSUE NO. A 105

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TABLES

1. SCOPE

This specification defines the objectives, criteria, and configuration, and establishes the requirements for performance, design, test and qualification of the starting subsystem (SS) for the prototype model supersonic transport airplane. Differences between the prototype and production airplanes are described in Supplement I. The SS provides for starting and windmill braking of the engine, drives the accessory drive subsystem (ADS) and its attached accessories in the engine disconnect mode, and supplies ground source or engine bleed air to the environmental control subsystem (ECS).

2. APPLICABLE DOCUMENTS

The following documents of the exact issue shown, form a part of this specification to the extent specified herein. In the event of conflict between documents listed herein and the requirements specified by this specification, the requirements of this specification shall take precedence.

2.1 Specifications.

Military

MIL-L-23699 (1)	10 June 1964	Lubricating Oil, Aircraft Turboprop and Turboshaft Engines, Synthetic Base.

The Boeing Company

D6A10089-1	6 September 1966	Accessory Drive Subsystem Specification
D6A10107-1	6 September 1966	Airframe Subsystem Specification
D6A10109-1	6 September 1966	Flight Deck Subsystem Specification
D6A10113-1	6 September 1966	Aircraft Engine Installation Subsystem Specification
D6A10119-1	6 September 1966	Electrical Power Subsystem Specification
D6A10120-1	6 September 1966	Flight Controls and Hydraulics Subsystem Specification
D6A10121-1	6 September 1966	Environmental Control Subsystem Specification

2.2 Standards.

Federal

FAR 25	14 November 1965	Airworthiness Standards, Transport Category Airplanes
FAR 25.1309 (tentative supplement)	1 November 1965	Tentative Airworthiness Objectives and Standards for Supersonic Transports

2.3 Other Publications.

The Boeing Company

D6-9458	17 June 1965	Maintenance Design Guide - Commercial Supersonic Transport
D6A10072-1	6 September 1966	Protective Finishes, Detailed Requirements for Supersonic Transport
D6-16328	28 June 1966	Electrical Requirements for Installed Equipment, Sec. 1, 2 and 3.
D6A10064-2	6 September 1966	Reliability Analysis Document - Accessory Drive and Engine Starting
D6A10236-1	5 August 1966	Electrical Bonding and Grounding Design Requirements for B-2707 Airplane
D6-17467	13 August 1966	Preliminary Vibration Test Requirements for Equipment Installed in Model B-2707 Airplane

3. SUBSYSTEM DESIGN OBJECTIVES

The design objectives of the SS are to:

a. Convert pneumatic energy from either a ground or engine bleed source into shaft power for accelerating the ADS accessories, and the engine rotor to accomplish an engine start.

b. Develop sufficient pneumatic power from engine bleed air to drive the accessories through the ADS in the event of inflight loss of engine power, and by using air from a ground source to drive the accessories through the ADS, independent of the engine, for ground checkout.

c. Provide the capability for driving the ADS with the accessories unloaded to permit coupling of the ADS to the engine at any speed up to engine idle on the ground.

d. Transfer engine bleed air for engine windmill braking.

e. Transfer engine bleed and ground cart air to the ECS.

4. SUBSYSTEM DESIGN CRITERIA

4.1 Operability. The allocation of the reliability and maintainability defined herein has been accomplished by analysis and experience and may be revised as long as the overall airplane requirements as specified in specification D6A10107-1 are satisfied. The operability requirements below are dependent, in part, upon the reliability and maintainability definitions listed in Pars. 6.1.1 and 6.1.2 of specification D6A10107-1.

4.1.1 Reliability. After 18 months of scheduled airline operation, flight turnbacks or deviations due to malfunction of the SS shall not exceed 1.0 per 1,000,000 scheduled flights. For reliability purposes, the term flight is interpreted to mean a nominal SST supersonic flight of 1.75-hr duration. Dispatch delays caused by malfunction of the SS shall not exceed 0.078 per 100 scheduled departures. Normal maintenance of the system is assumed.

4.1.2 Maintainability. The SS shall be so designed that after 18 months of scheduled airline operation, the direct maintenance manhours per 1,000 flt hr shall not exceed a mean value of 80 not including servicing of consumables, and the mean unscheduled maintenance task time at a transit or turnaround service shall be 35 minutes. These values are based on an average flight length of 1.75 hr with scheduled maintenance accomplished as planned.

4.1.2.1 Maintenance and Repair Cycles. Time change items shall be kept to a minimum. Whenever possible, component replacement shall be on a failure or impending failure (on condition) basis, rather than on a scheduled or time controlled basis. The scheduled check intervals for the aircraft and the down times established for these checks are shown below. All scheduled maintenance, inspections, and servicing shall be fitted within one of these cycles.

Scheduled Check	Time Interval	Elapsed Time
Transit Service	Not applicable	30 min
Turnaround Service	Not applicable	90 min
Daily Check	50 flt hr	1 hr
Intermediate Check	300 flt hr	4 hr
Periodic Check	1,200 flt hr	16 hr
Basic Check	8,400 flt hr	5 days

4.1.2.2 Servicing and Access. The following features shall be provided in the subsystem:

a. Subsystem and component assemblies shall be easily accessible for the purpose of fault isolation, adjustment, servicing, and replacement.

b. Servicing functions shall be accomplished without removal of structural access doors or structural panels.

c. All servicing points shall be readily accessible.

d. Scheduled lubrication frequencies, if required, shall coincide with the accomplishment of scheduled maintenance checks.

e. Maintenance shall be accomplished by personnel with skill levels required to maintain subsonic jet aircraft.

4.1.3 Useful Life. The SS shall have a useful life commensurate with that of the airplane (50,000 hr) assuming normal maintenance of equipment. The Time Before Overhaul (TBO) of individual components shall be specified in the contractors procurement specifications when applicable.

4.1.4 Environmental. The SS shall operate satisfactorily when subjected to the environments defined in specification D6A10107-1, except as follows:

4.1.4.1 Ambient Temperature. The ambient temperature will be as follows:

a. Accessory drive bay . . . . . -50° to +300°F for normal operation; transient excursion to +375°F for 5 minutes for not more than 10 times in 10,000 airplane flt hr and one excursion from -50° to +450°F for a maximum of 2 hr with the air turbine inoperative.

b. Engine nacelle area . . . . . -50° to +750°F

c. Other airframe unpressurized areas . . . . -50° to +450°F

d. Cabin and flight deck . . . . -50° to +160°F

4.1.4.2 Pressure. Compartment pressures will be as follows:

a. Unpressurized . . . . from -1,000 to +73,000 ft equivalent pressure altitude.

b. Pressurized . . . . from -1,000 to 15,000 ft equivalent pressure altitude.

4.1.4.3 Ozone. Concentrations shall not exceed 0.2 ppm by volume in all pressurized compartments and the accessory drive bay for normal operations and 0.3 ppm by volume for short durations.

4.1.4.4 Vibration. The air turbine and control valve will be subjected to vibration levels not to exceed those shown in Fig. 1. Other equipment will be subjected to vibration levels not to exceed the appropriate maximums shown in specification D6-17467.

4.1.4.5 Attitude. The SS shall be capable of operation under the following aircraft flight attitudes:

Airplane attitude	Maximum continuous Angle (deg)	Maximum (short duration) Angle (deg)	Maximum (short duration) Time (sec)
Nose up	20	25	6
Nose down	20	25	6
Bank	60	90	3
Roll	--	90	3

4.1.4.6 Explosive Atmoshpere. The SS shall not cause ignition in an environment of any mixture of jet A kerosene and air.

4.1.4.7 Structural Loads. The SS shall be designed to meet the following ultimate load factors:

Down . . . . . 6 g

Up . . . . . . 4 g

Thrust . . . . ±3 g

Side . . . . . ±2.5 g

4.1.4.8 Negative Acceleration. The SS shall operate satisfactorily when subjected to a negative acceleration of 1 g for 10 sec and zero g for 5 sec.

4.1.5 Human Performance. SS controls and displays shall be located and meet the requirements of specification D6A10109-1.

4.1.6 Safety. The design shall meet the requirements of FAR 25.1309, "Tentative Airworthiness Standards - SST"; and shall assure that no single failure, as determined by a failure mode, effect and criticality analysis shall result in a condition of catastrophic hazard.

4.1.6.1 Flight Safety. The following features shall be provided to enhance safety of flight:

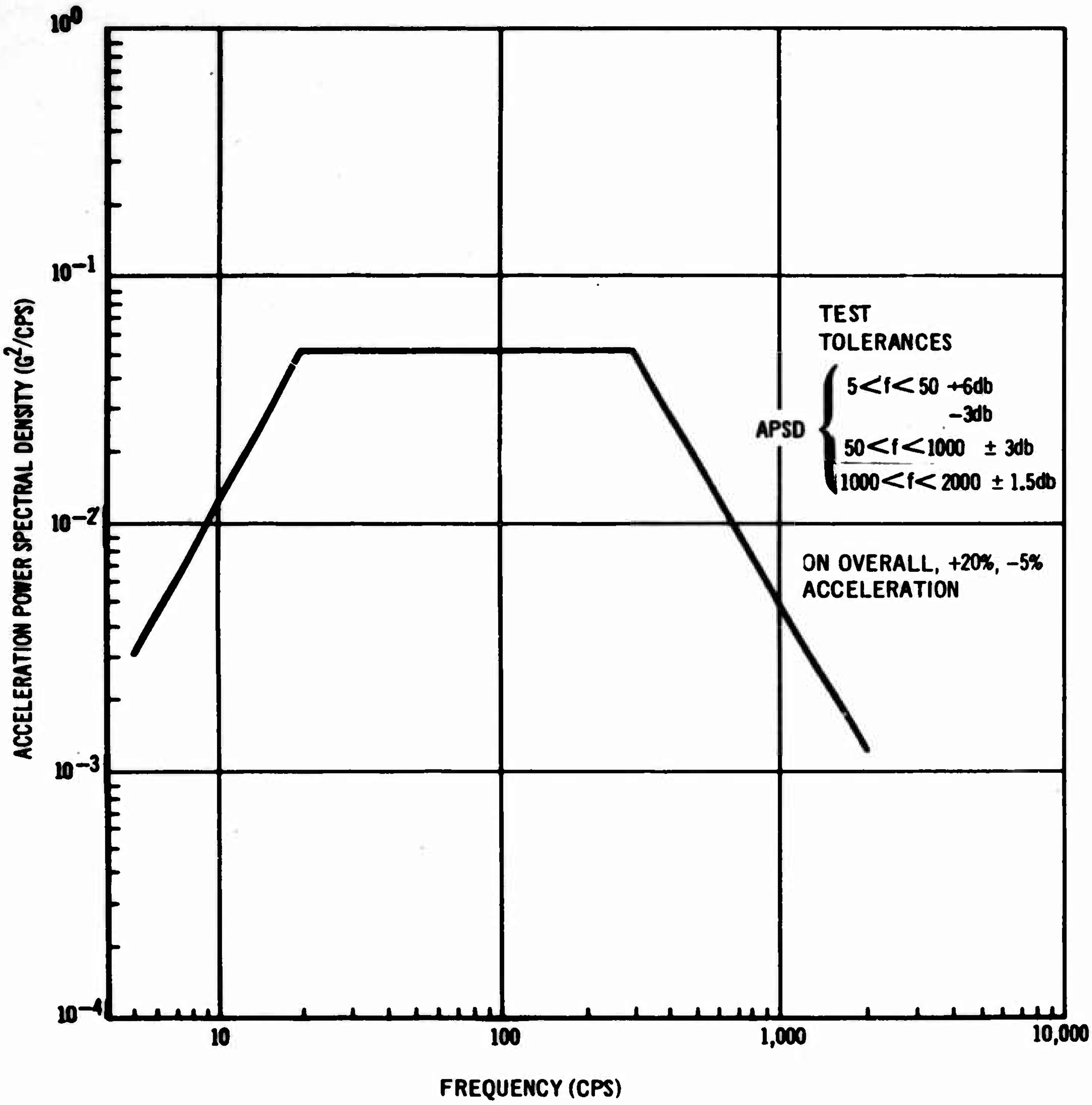


Figure 1. Vibration Test Envelope

D6A10078-1

a. The starter casing shall be designed to contain the turbine fragments in the event of failure.

b. Provisions shall be included to limit the speed of an unloaded starter turbine.

c. All SS components shall be electrically bonded in accordance with specification D6A10236-1.

d. Electrically operated valves shall be designed to fail-safe in the closed position.

e. Valving shall be included to prevent excessive loss of bleed air in the event of a duct failure.

f. Surface temperatures of ducts and equipment, located in areas where fuel vapors may exist, but which are outside designated fire zones, shall not exceed the autogenous temperature of the fuel, approximately +450°F.

4.1.6.2 Ground Safety. The ground penumatic connection shall not be located near the fueling station.

4.1.6.3 Personnel Safety. The SS design shall be such that when service and maintenance personnel are performing the tasks identified in the service and maintenance manuals, they shall not be placed in a hazardous environment.

4.2 Performance. The SS shall comply with FAR 25 and the tentative supplement -- "Airworthiness Objectives and Standards for Supersonic Transports."

5. SUBSYSTEM DESIGN REQUIREMENTS

5.1 Performance Requirements.

5.1.1 Starter Torque. The SS shall provide the output torque requirements of Fig. 2 for engine starting using an air supply with the characteristics specified in Fig. 3.

5.1.2 Accessory Motoring. The SS shall be capable of continuously supplying 175 shaft horsepower at a nominal 4,000 rpm for motoring the accessories during ground operation or during cruise condition using an air supply with characteristics as shown in Fig. 3 or Fig. 4 and 5 respectively.

5.1.3 ECS Air Requirements. The SS shall be capable of supplying the requirements of the ECS as contained in Table I when supplied with ground air from at least two ground carts, each having the characteristics shown in Fig. 6, or when supplied by engine bleed air as shown in Figs. 4, 5, 7, 8, 9, and 10.

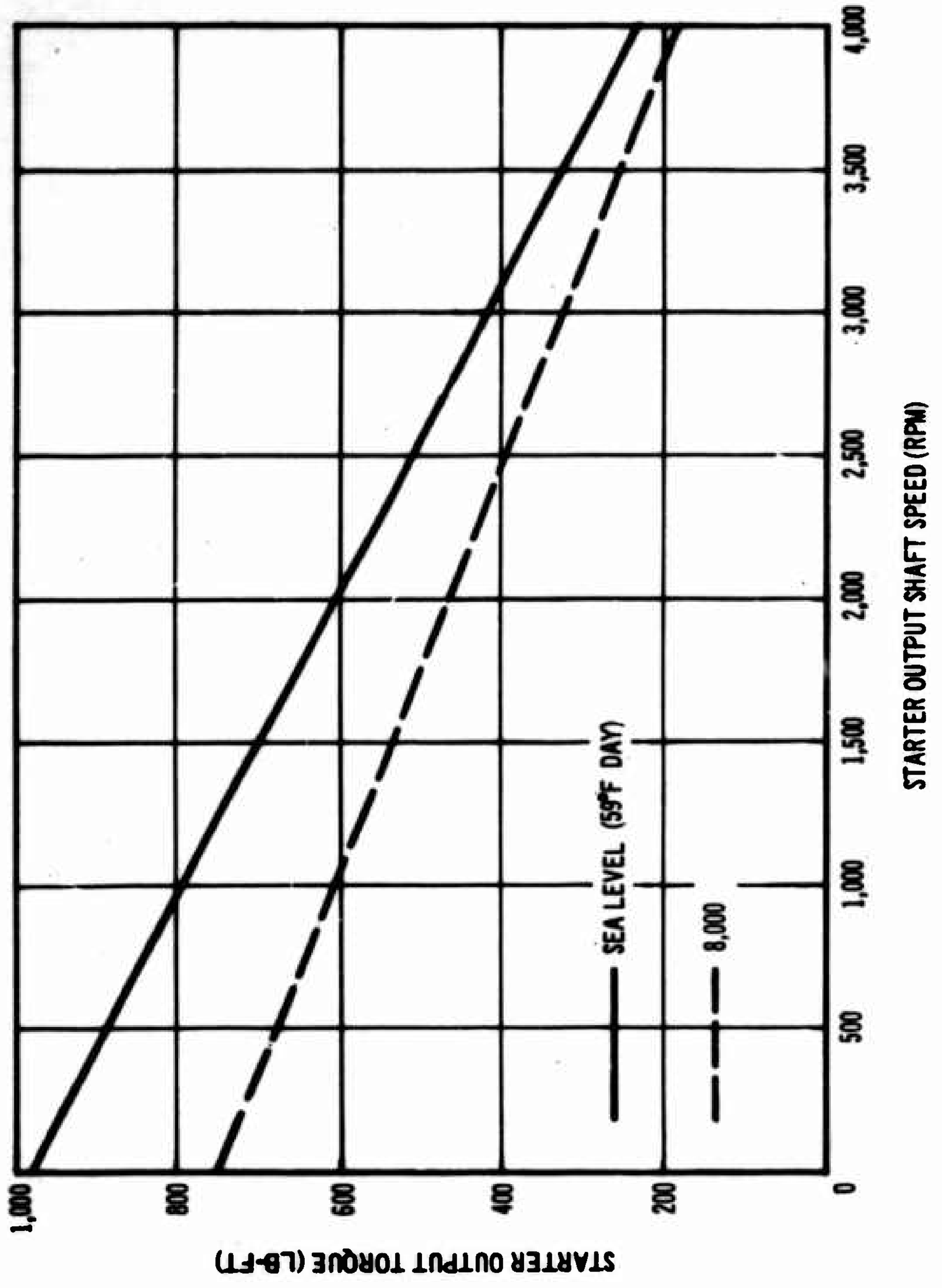


Figure 2. Starter Output Torque Requirements

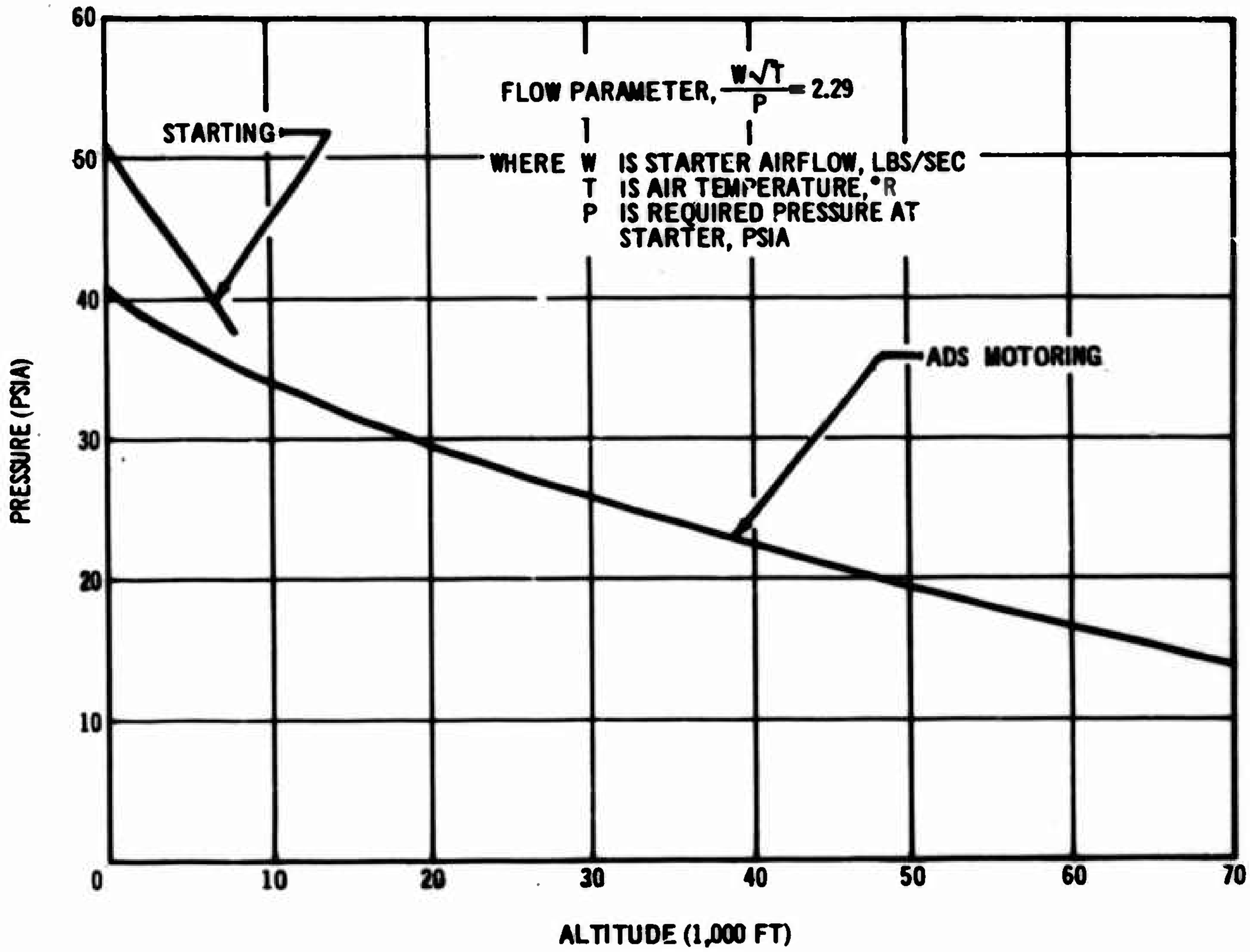


Figure 3. Starter Supply Air Characteristics

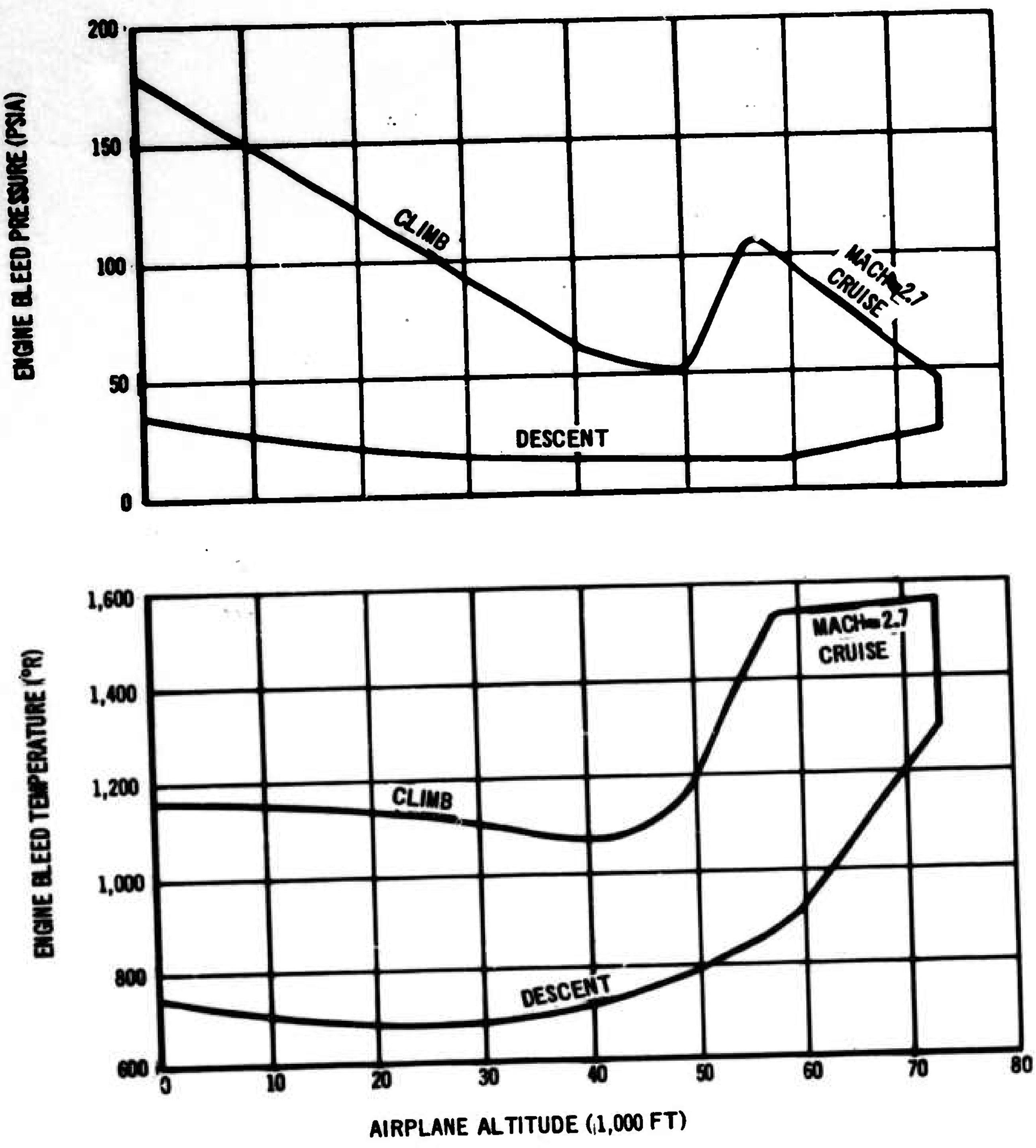


Figure 4. Engine Bleed Data, Supersonic Cruise, B-2707 (GE)

Table I. ECS Airflow Requirements

Flight Condition	Mach	Altitude (ft)	Requirements: Flow (lb/sec)[a]	Pressure (psia)	Temperature (deg F)
Ground and climb	0-.4	SL	2.10	43.5	1100 (Max)[b]
	.4-1.0	30,000	2.10	44.5	
Climb and cruise	1.08	40,000	1.95	41.5	
	1.35	50,000	1.80	39.5	
	2.5	60,000	1.75	39.5	
	2.5	70,000	1.65	39.5	
	2.5	73,000	1.60	39.5	
Descent	2.5	73,000	1.60	9.5	
	2.5	70,000	1.65	9.5	
	1.55	60,000	1.75	9.5	
	1.15	50,000	1.80	9.5	
	.95	40,000	1.95	9.5	
Descent and ground	0.8-0	30,000-SL	2.10	14.5-19.5	

[a] Airflow per ECS cooling unit. There are four cooling units per airplane.

[b] 100°F Minimum

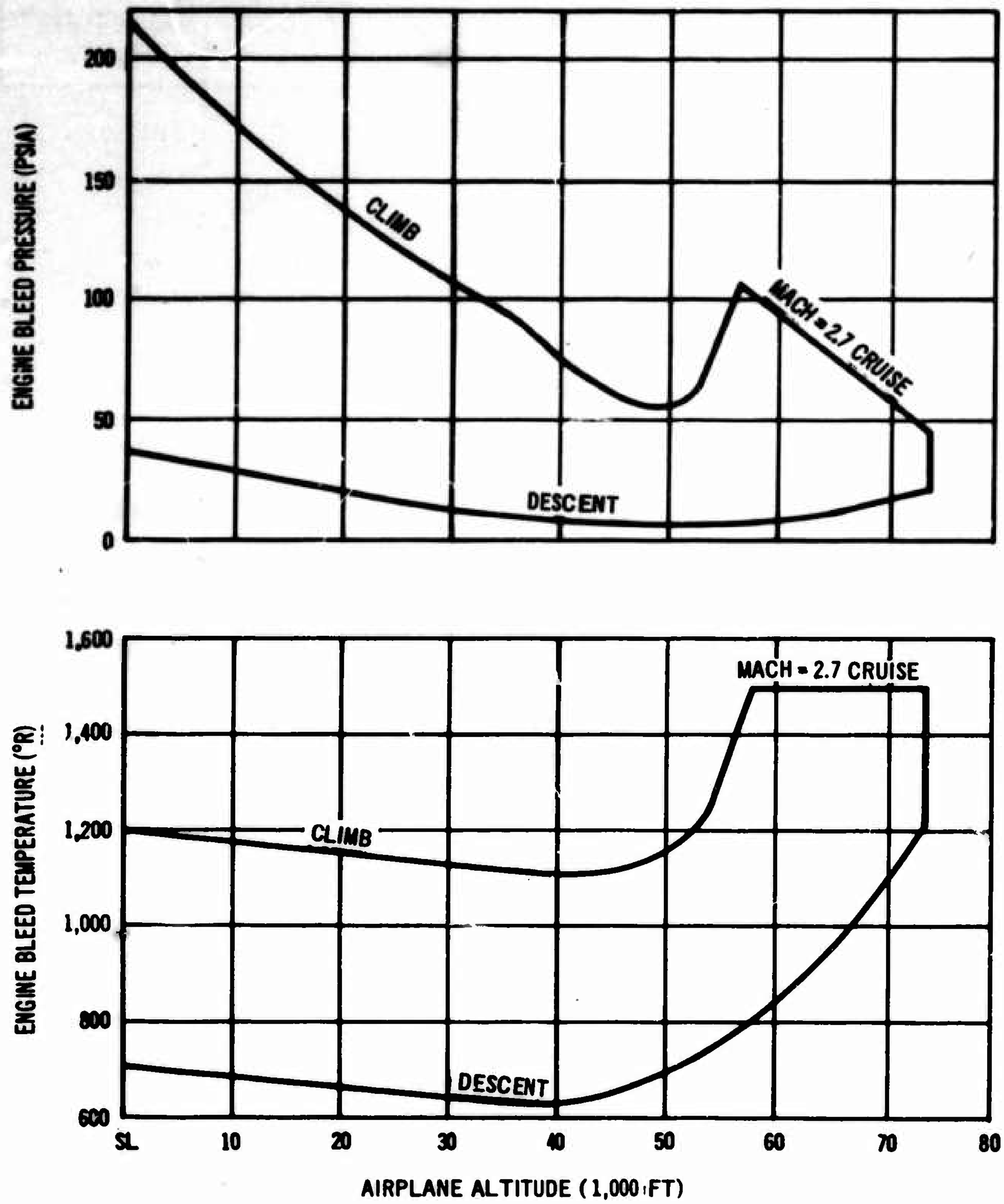


Figure 5. Engine Bleed Data, Supersonic Cruise, B–2707 (P&WA)

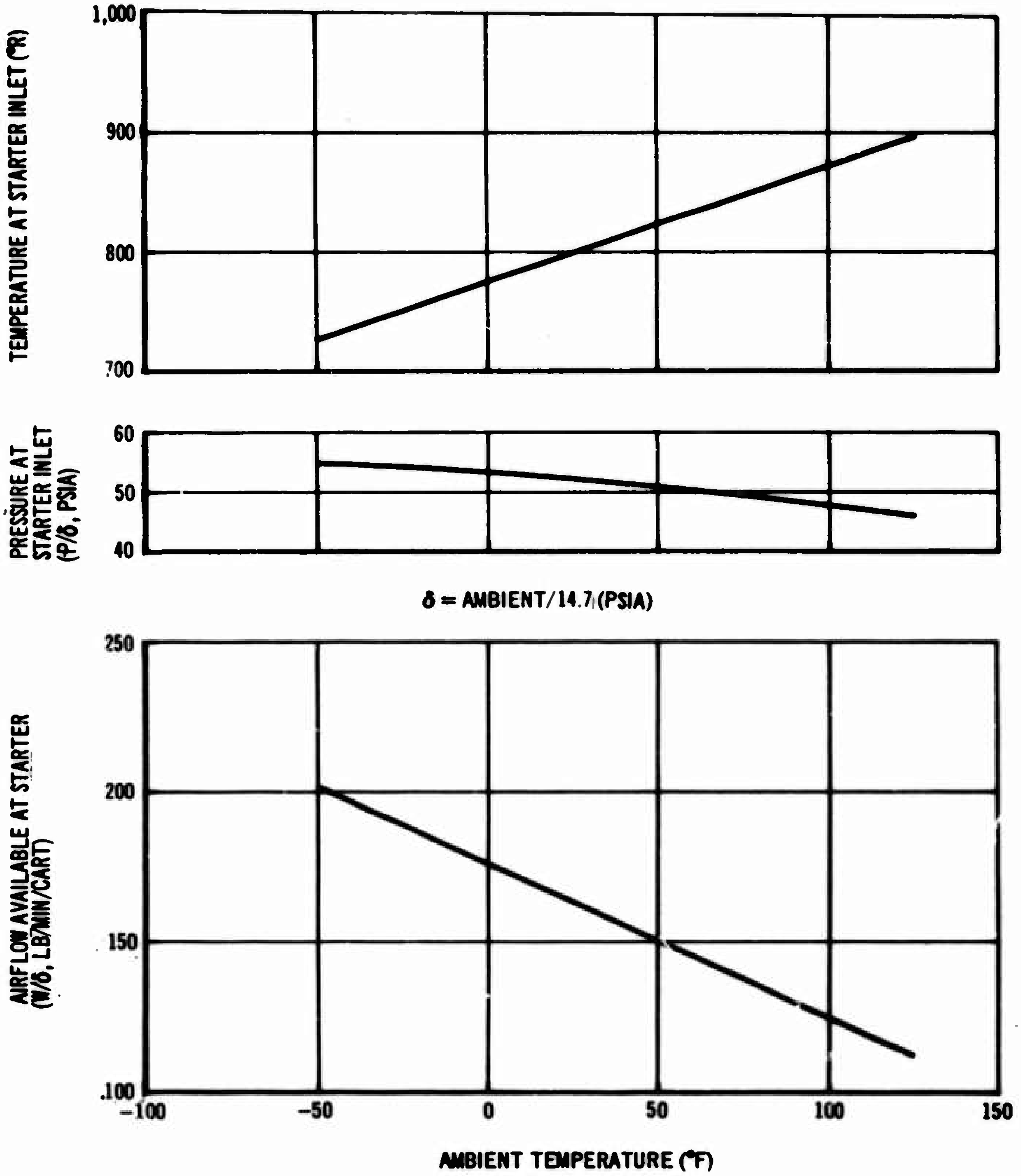


Figure 6. Typical Performance, Low Pressure Ground Cart

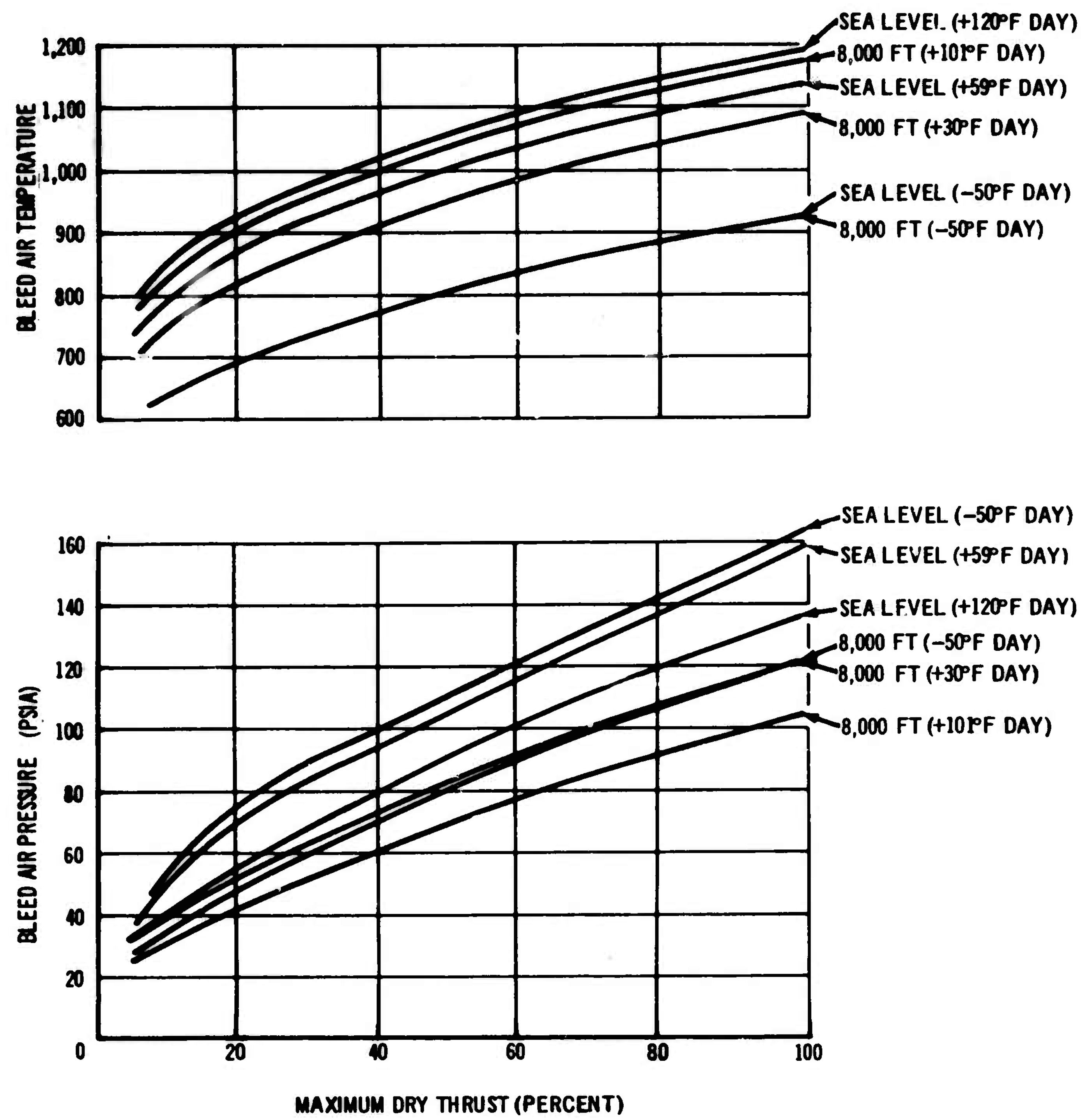


Figure 7. Engine Bleed Data, Ground Operation, B-2707 (GE)

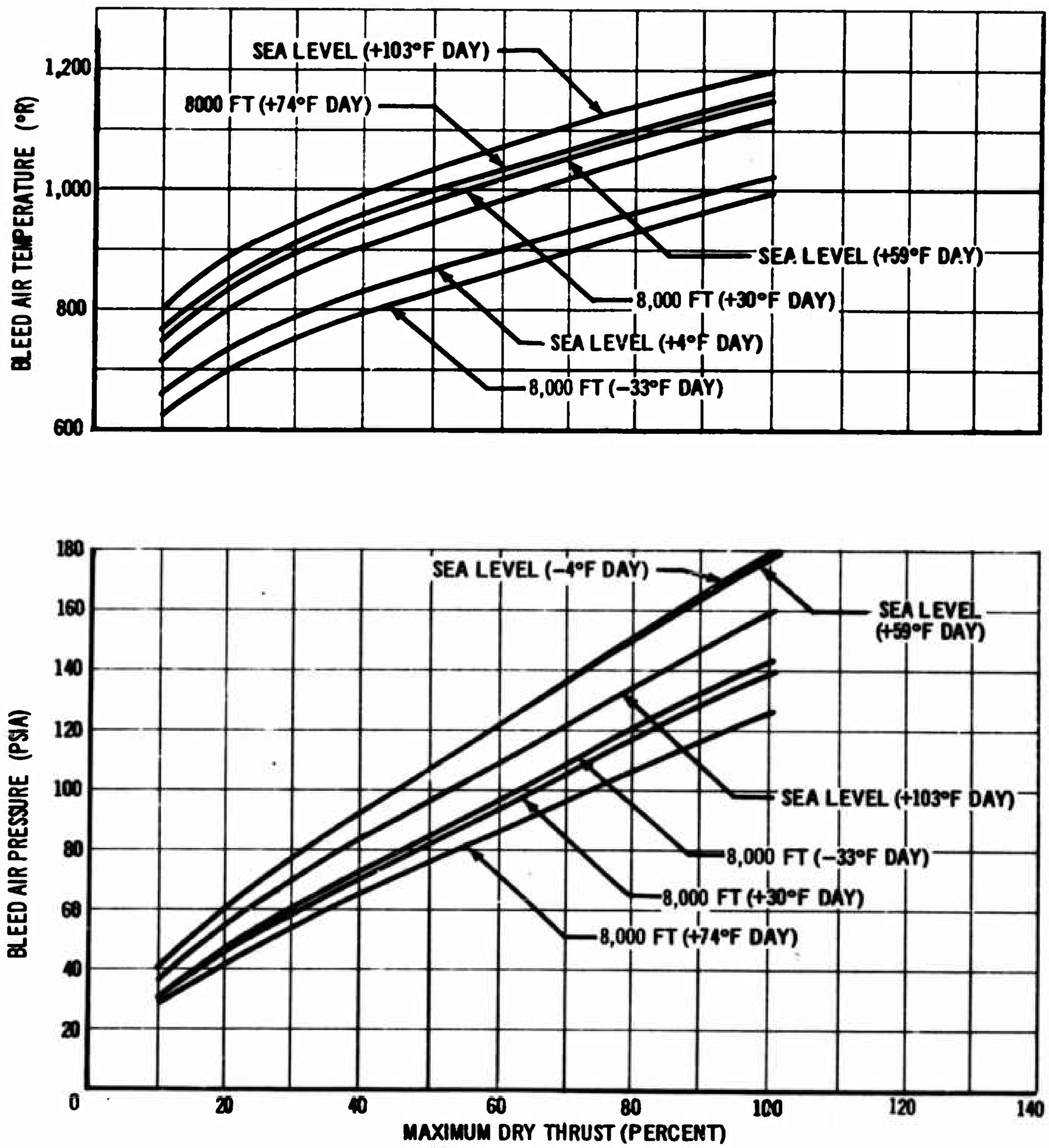


Figure 8. Engine Bleed Data, Ground Operation, B-2707 (P&WA)

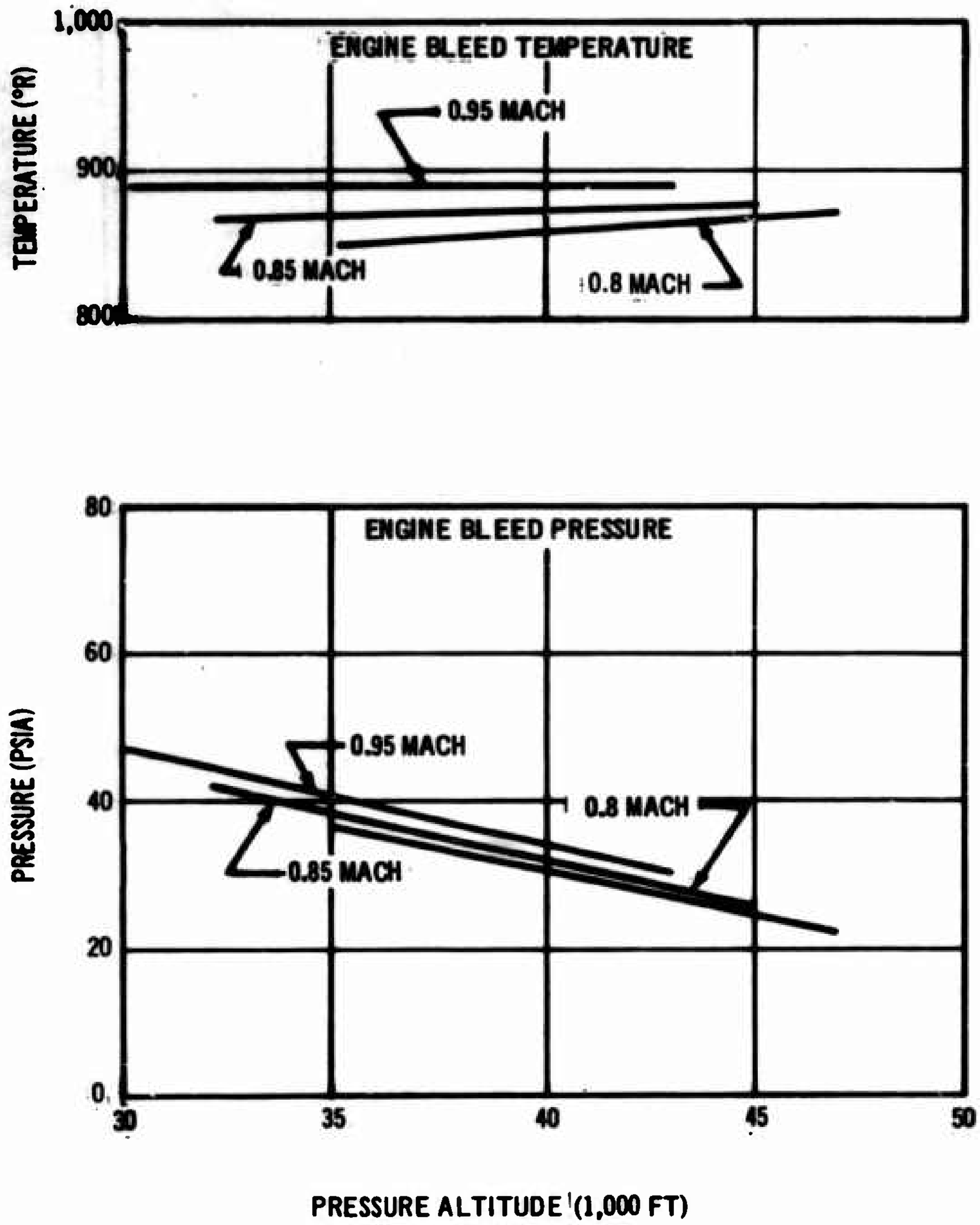


Figure 9. Engine Bleed Data, Subsonic Cruise, B-2707 (GE)

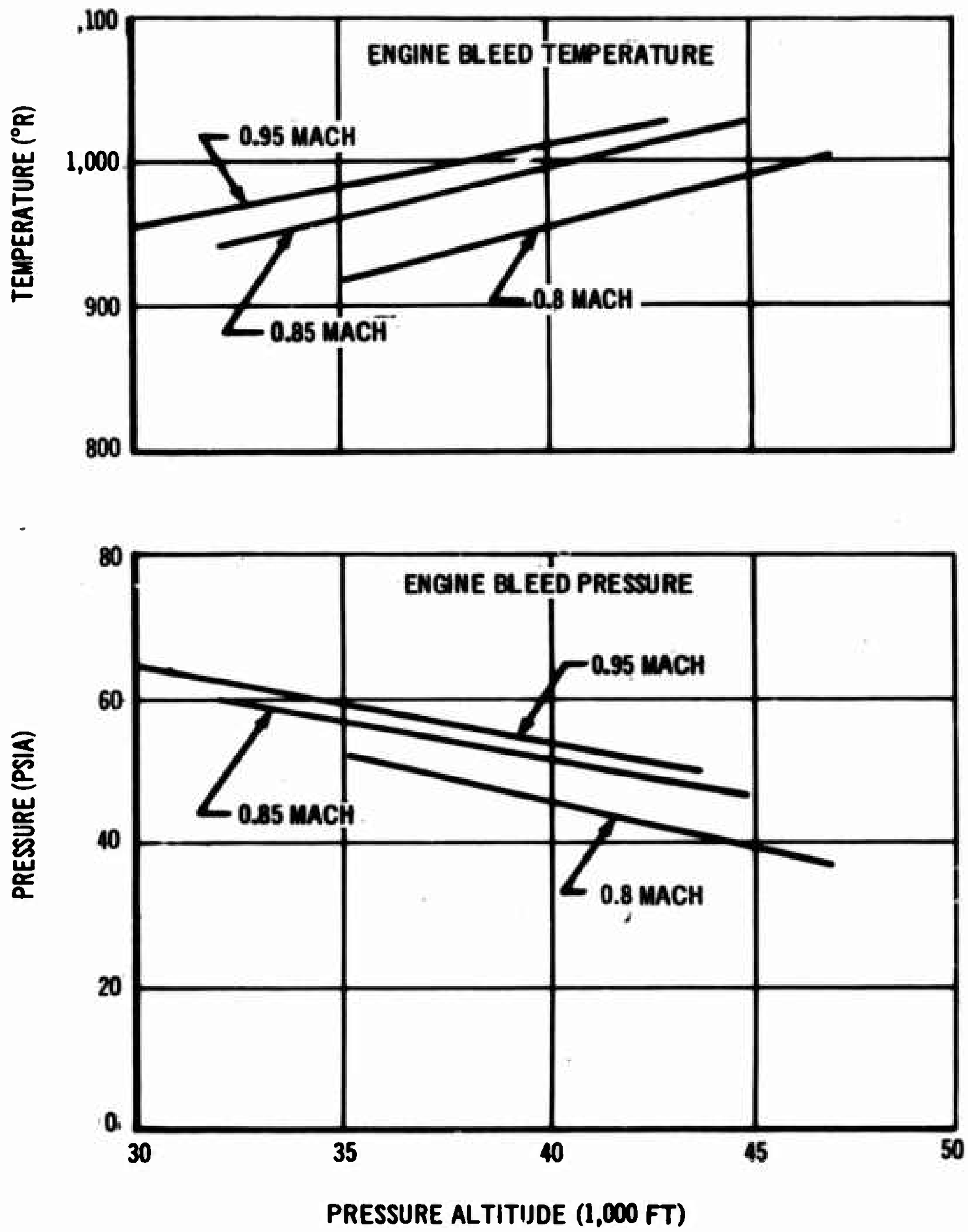


Figure 10. Engine Bleed Data, Subsonic Cruise, B-2707 (P&WA)

5.1.4 Engine Windmill Brake. The SS shall deliver 1.25 lb/min of engine bleed air at 5 psi minimum to the windmill brake of any non-operating engine.

5.2 Envelope. The SS components shall not exceed the following envelopes (dimensions in inches):

Component	Width	Height	Length	Diameter
Air turbine starter	---	---	5 0	13.7
Pressure regulator shutoff valve	8	11	8	---
Air ducts	---	---	---	6.0
Valving and controls	9	9	7	---

5.3 Weight. The weight of the starter subsystem shall not exceed 430 lb. This weight is an allocation of the overall airplane weight based on analysis and design experience and may be revised when the overall airplane weight defined in specification D6A10107-1 is not exceeded.

5.4 Design Features.

5.4.1 Controls.

5.4.1.1 Air Starter Valve. The starter valve shall be controlled by a switch at the flight deck.

5.4.1.2 Shutoff Valves. The isolation and engine bleed shutoff valves shown in Fig. 11 shall be controlled by a switch at the flight deck.

5.4.1.3 Air Starter Speed. The air starter shall incorporate a speed control to control the output speed to 4,3000 $\pm$ 200 rpm.

5.4.2 Overrunning. The air starter shall include an overrunning clutch on its output shaft to permit the starter to be overrun by the engine.

5.4.3 Manual Override. The starter control valve shall incorporate provisions for opening and closing the valve manually in the event of a valve malfunction.

5.4.4 Valve Position Indicator. The starter control valve shall incorporate a position indicator readable from the exterior of the unit.

5.4.5 Mounting. The air starters, starter control valves, isolation valves, and engine bleed shutoff valves shall incorporate quick-attach-detach (QAD) type mounting provisions. The air starter QAD pad is shown in Fig. 12.

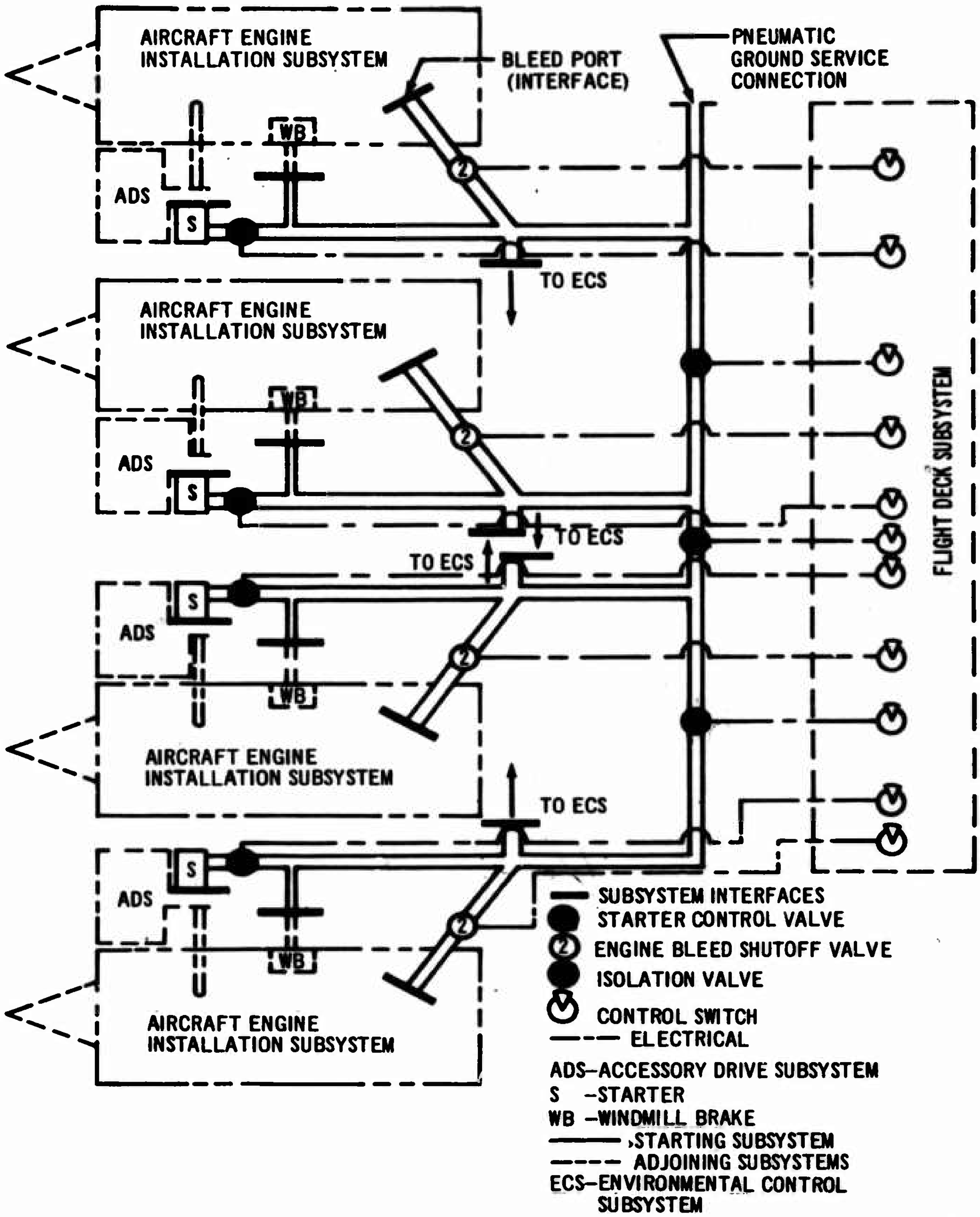
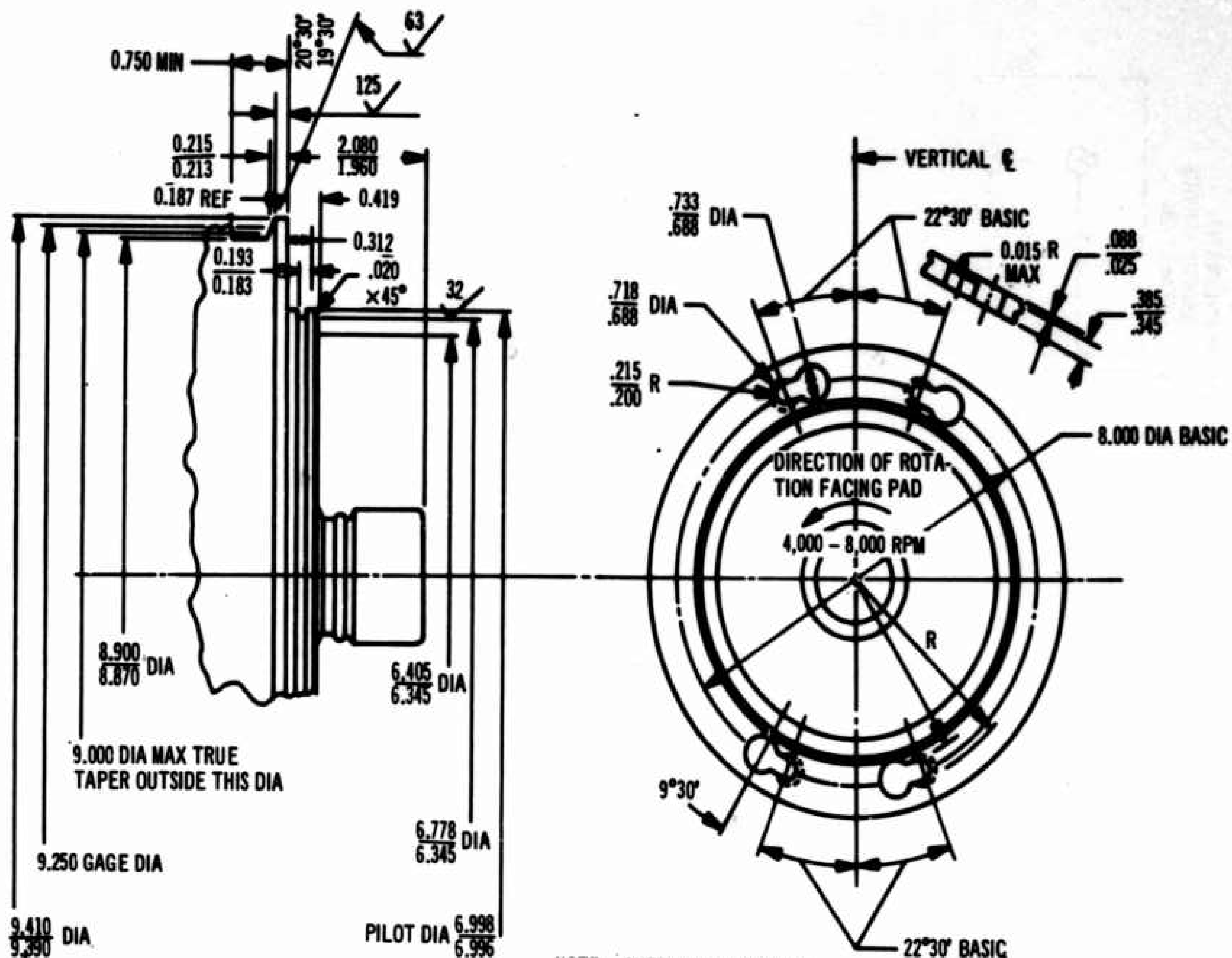


Figure 11. Starting Subsystem Schematic



NOTE: OVERHUNG MOMENT IS 375 IN-LB

Figure 12. Quick-Attach-Detach (QAD) Pad or Starter

5.4.6 Casing. The starter casing shall be designed to contain the turbine fragments in the event of failure.

5.5 Selection of Specifications and Standards. The SS shall conform to requirements of Par. 3.3.2 of specification D6A10107-1.

5.6 Materials, Parts, and Processes. The SS shall conform to the requirements of Par. 3.3.3 of specification D6A10107-1.

5.6.1 Fluids and Lubricants. Lubricating oils shall conform to spccification MIL-L-23699.

5.7 Standard and Commercial Parts. The SS shall conform to requirements of Par. 3.3.4 of specification D6A10107-1.

5.8 Moisture and Fungus Resistance. The SS shall conform to the requirements of Par. 3.3.5 of specification D6A10107-1.

5.9 Corrosion of Metal Parts. The SS shall conform to the requirements of Par. 3.3.6 of specification D6A10107-1.

5.10 Interchangeability and Replaceability. The SS shall conform to requirements of Par. 3.3.7 of specification D6A10107-1.

5.11 Workmanship. The SS shall conform to the requirements of Par. 3.3.8 of specification D6A10107-1.

5.12 Electromagnetic Interference. The SS shall conform to the requirements of Par. 3.3.9 of specification D6A10107-1.

5.13 Identification and Marking. The SS shall conform to the requirements of specification D6A10107-1.

5.14 Storage. The SS shall conform to the requirements of specification D6A10107-1.

6. SUBSYSTEM DESCRIPTION

6.1 General. The SS arrangement is shown schematically in Fig. 11. The SS consists of:

a. An air turbine starter for each engine. Each air turbine starter is mounted on an ADS gearbox. The starter consists of an air turbine and a starter control valve. Speed controls, overspeed protection, overrunning provisions, gearing, and rotating component containment are included within the starter.

b. Valving and ducting to interconnect the turbine starter to the aircraft engine installation subsystem and ground support equipment (GSE) subsystem supply duct interfaces. The

Table I. (Continued)

Interface			Relationship	
Interface Subsystem	Type of Interface		Unit	Parameter
	Input	Physical		
Flight Controls and Hydraulics Subsystem D6A10120-1 (Concluded)	Electrical	Wiring	Hydraulic oil reservoir	Liquid quantity Liquid temperature
			Case drain filter No. 1	Filter differential pressure Mechanical wear (Chip detection)
			Hydraulic oil pump No. 1	Pressure Temperature
			Return filter	Filter differential pressure
			Pressure filter	Filter differential pressure
Environmental Control Subsystem D6A10121-1	Electrical	Wiring	Cabin air boost compressor	Vibration Discharge air temperature Mechanical wear (Chip detection) Oil pressure Oil temperature
			Secondary air/fuel heat exchanger	Cabin output air temperature
			Air cycle machine	Turbine discharge air temperature Vibration Mechanical wear (Chip detection) Oil temperature
			Ram air valve	Valve position

TABLE II. Starting Subsystem Interface Requirements

SS Interface		Relationship	
Interfaces Subsystem	Type of Interface	Physical	Functional
Accessory Drive Subsystem D6A10089-1	Structural	Starter Pad	
	Mechanical	Starter Drive Shaft spline	Transmit shaft Support starter power to ADS
	Lubrication	Starter Pad	Lubricate starter and drive shaft spline
	Electrical	Starter Controls	Safety Interlock
	Pneumatic	Tubing	Provide gearbox pressurization
Environmental Control Subsystem D6A10121-1	Pneumatic	Ducting	Transfer Air
Aircraft Integrated Data Subsystem D6A10040-1	Electrical	Wiring	To provide performance data
Aircraft Engine Installation Subsystem D6A10113-1	Structural	Ducting	Support of ducting
	Pneumatic	Ducting	Transfer Air
Flight Deck Subsystem D6A10104-1	Structural	Mounting instruments and controls	To locate controls and instrumentation at flight deck
Airframe Subsystem D6A10117-1	Structural	Ducting	To support SS ducts and starter exhaust
Electrical Sub Power Subsystem D6A10040-1	Electrical	Controls and Instrumentation	Provide electrical power to controls and instrumentation
Ground Support Equipment D6A10180-1	Pneumatic	Ground Service Connection	Transfer ground cart air

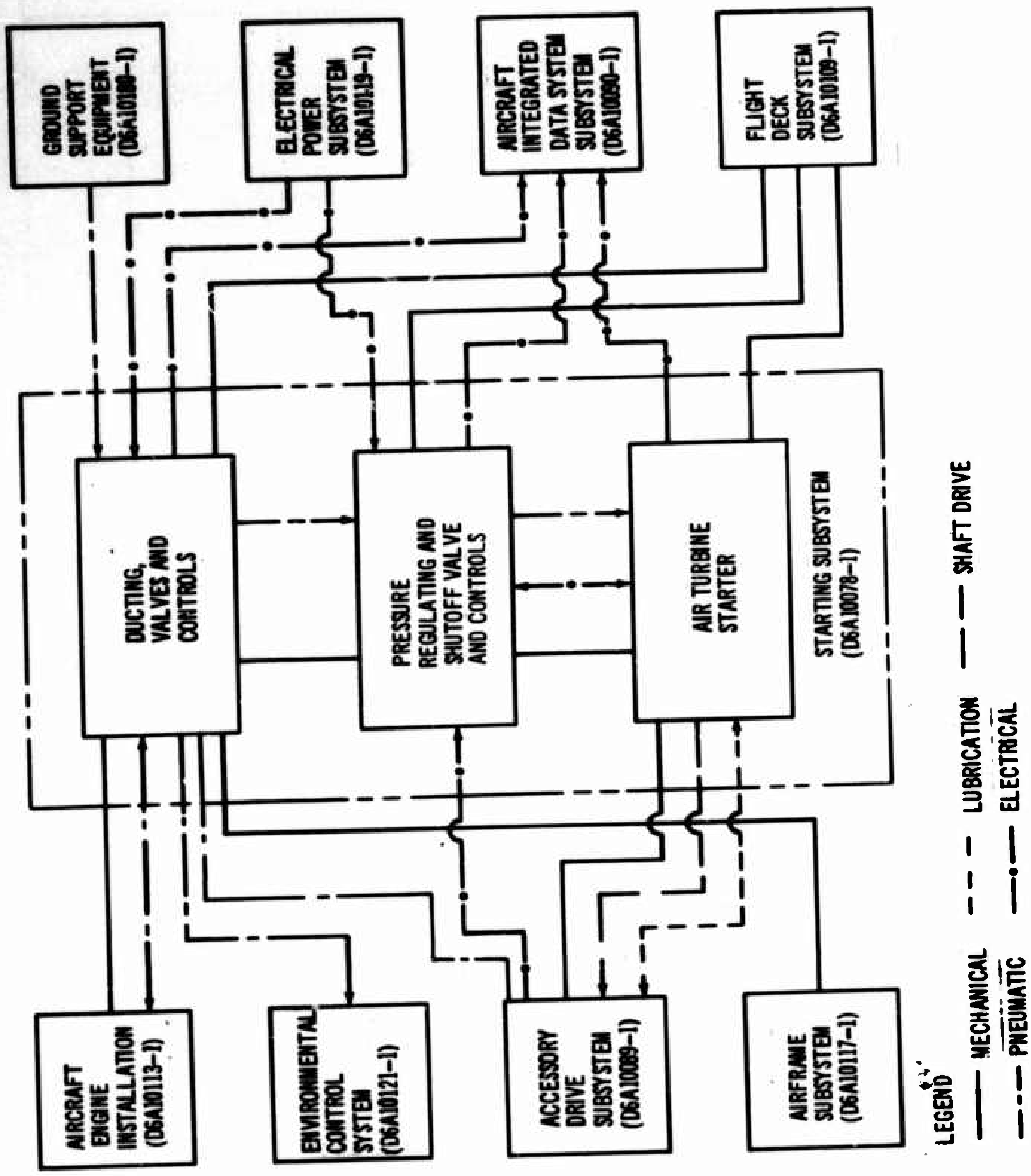


Figure 13. Starting Subsystem Interface Schematic

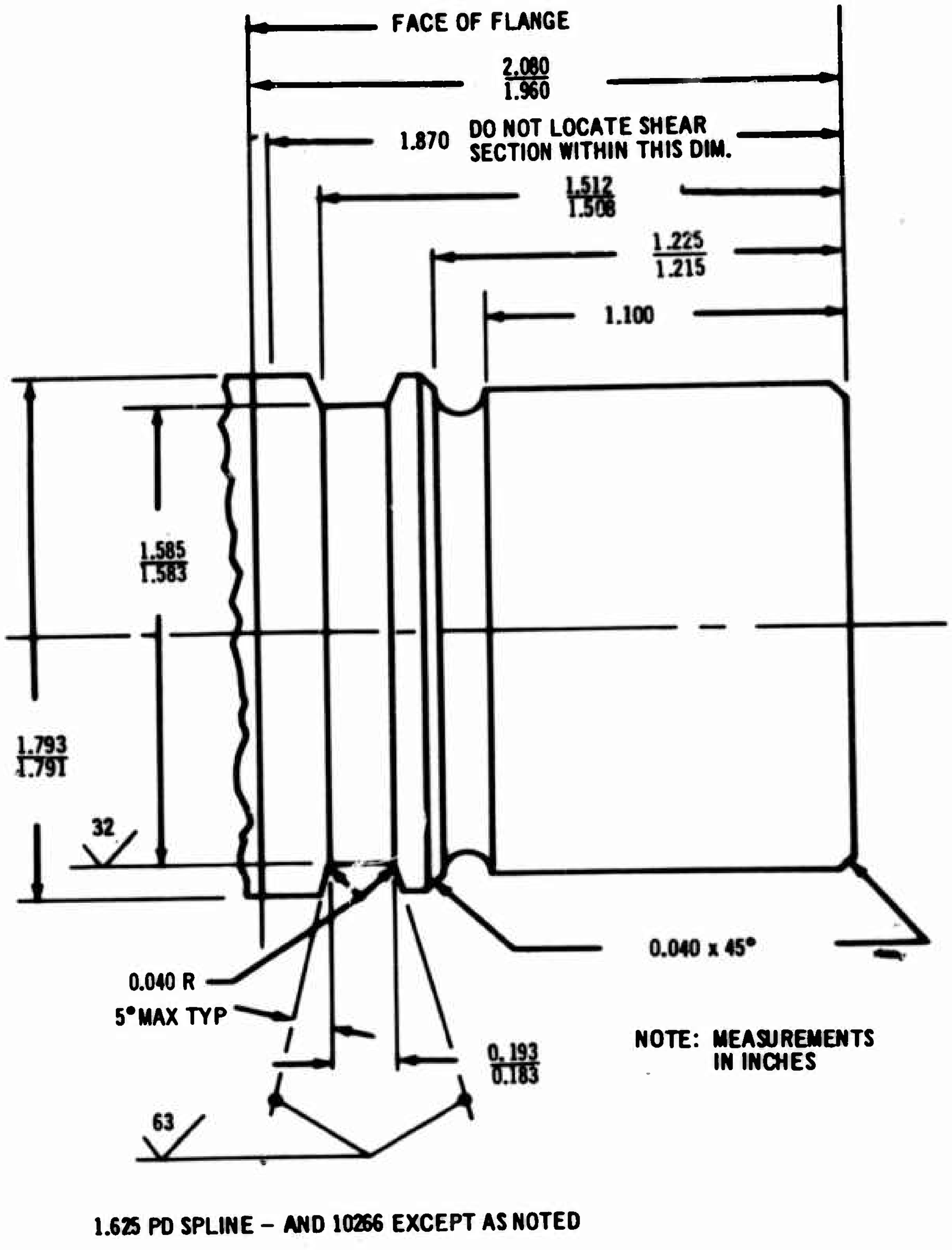


Figure 14. Starter Spline

7. SUBSYSTEM PERFORMANCE

The status of subsystem design and testing or analysis, for compliance with the criteria and requirements established in Secs. 4 and 5 and listed in Table III, will be reported bi-monthly by revisions to this specification.

Table III. Starting Subsystem Performance

Criteria or Requirement					
Par.	Item	Value	Current Status	Last Reported Status	Notes*
4.1.1	Reliability	1.0 deviation or turnbacks 1,000,000 flights 0.078 delays 100 departures	1.0 deviation or turnbacks 1,000,000 flights 0.078 delays 100 departures.		
4.1.2.	Maintainability	80 man-hours 1,000 flt-hour	80 man-hours 1,000 flt-hour		
5.1.1	Starting torque	Fig. 2	Fig. 2		
5.1.2	Acc Motoring	175 hp at nominal 4,000 rpm	175 hp at nominal 4,000 rpm		
5.3	Subsystem weight	430 lb	430 lb		

* Notes called out here will explicitly explain each incremental change, reasons for the change and actions taken to correct any deficiency.

8. SUBSYSTEM OPERATION

8.1 Ground Operation.

8.1.1 Engine Starting. The compressed air for starting is supplied to the airplane ground service connection by two conventional ground carts. Air is supplied to the starter valve by use of the cross-bleed manifold and valves shown in Fig. 11. The start switch on the pilot's control panel (Fig. 15) is placed in the GRND position, which opens the starter control valve allowing air to enter the air turbine. The starter accelerates the engine rotor by driving through the ADS to a speed above the self-sustaining speed at which time the start switch is placed in the OFF position, closing the starter valve. The remaining three engines may be started using ground air or engine bleed air.

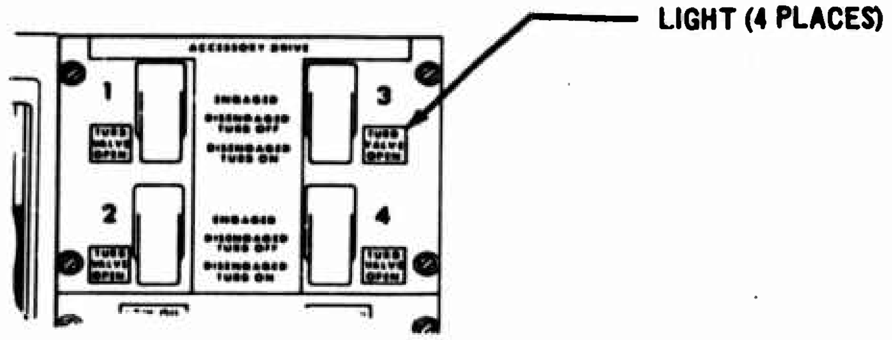
8.1.2 Accessory Motoring. The continuous duty capability of the air turbine starter provides for motoring the accessories on the ADS for subsystem checkout. With ground air connected to the airplane motoring of the accessories is initiated by placing the switch on the ADS control panel (Fig. 15) to the position marked ADS DRIVE DISENGAGED TURB ON. The indicator light marked TURB VALVE OPEN indicates that the air starter control valve for that particular ADS is open for the motoring mode of operation. This switch position automatically accomplishes the disengagement of the ADS from the engine, and upon completion of the disengagement cycle, opens the starter control valve and allows air to enter the turbine for driving the ADS.

During accessory motoring, speed is controlled to a nominal 4,300 rpm by a speed sensor which modulates the starter control valve, thus controlling the amount of air entering the turbine. In the event of a failure of the speed sensor, an overspeed device is provided for shutdown of the unit to prevent structural damage.

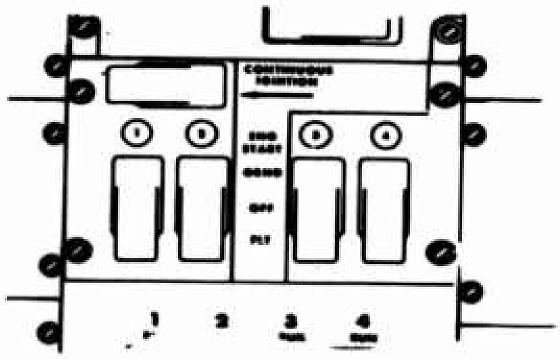
8.2 Flight Operation, Normal. The only normal function of the SS, while in flight, is to transfer engine bleed air through the duct manifold and valves to the windmill brake and the ECS as shown in Fig. 11.

8.3 Flight Operation, Abnormal. Accessory motoring, if required in flight, is initiated by placing the switch on the ADS control panel to the position of ADS DRIVE DISENGAGED TURB ON, allowing engine bleed air to drive the air turbine.

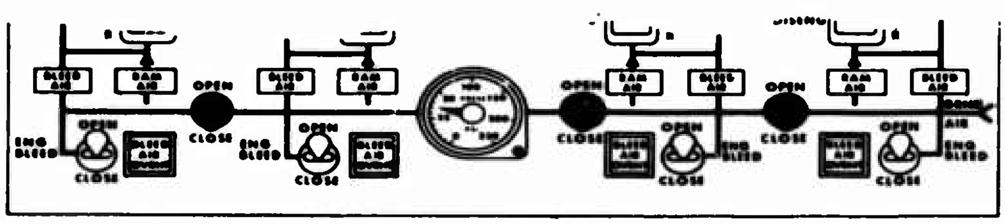
8.4 Valve Operation. The isolation valves and engine bleed shutoff valves shown in Fig. 11 are controlled from the panel shown in Fig. 15. The cross-bleed manifold ducting is shown schematically on the panel and the valves are shown in their respective positions on the schematic to visually aid the flight engineer. The three isolation valves are controlled by toggle switches and are identified by OPEN and CLOSE.



ACCESSORY DRIVE CONTROL PANEL
(CONTROLS ONLY)



PILOTS' CONTROL STAND PANEL
(ENGINE START PANEL ONLY)



ECS CONTROLS AND INDICATORS
(LOWER PANEL ONLY)

Figure 15. Control Panels

The four engine bleed shutoff valves are controlled by toggle switches and are identified by ENG BLEED with OPEN and CLOSE. The OVER HEAT warning indicator lights are located beside their respective engine bleed shutoff valve switch. The cross-bleed manifold pressure gage shown on the panel serves as an operating and trouble shooting aid to the flight engineer for operating the SS.

9. SUBSYSTEM TESTING

9.1 Engineering Test and Evaluation. Engineering tests and evaluation (ET and E) shall be performed as an integral part of the subsystem development process. The results of these tests, as well as the tests conducted by the component suppliers, shall supplement and support the formal qualification tests and shall be used to verify Sec. 5. Engineering laboratory tests shall integrate the air turbine starter and starter control valve with the ADS of specification D6A10089-1; hydraulic pumps of specification D6A10120-1; the electrical power generator of specification D6A10119-1; an airplane engine of specification D6A10113-1; and an ADS drive stand. The starter shall accumulate a total of 50 hr of engine and drive stand overrunning, and 5 hr of ADS motoring. A minimum of 10 engine starts shall be accomplished during these tests. The tests shall be conducted at laboratory ambient conditions with lubricating oil temperatures in accordance with specification D6A10089-1. The overrunning condition time shall be accumulated in approximately 2-hr cycles simulating engine speed expected on a typical airline flight. The ADS motoring condition time shall be accumulated with a total ADS and accessory load as specified in Par. 5.1.2. The starter air source shall simulate engine bleed air and ground cart air. Instrumentation shall be provided to identify shaft steady state speeds, accelerations, temperatures, pressures, loads, and efficiencies, as appropriate to use in the verification process. The starter and control valve shall be disassembled upon completion of this test to permit inspection for wear and damage to any of the components.

9.2 Component Testing. Development and qualification tests of subsystem components shall be conducted by the equipment supplier to insure that these equipments meet design and allocated performance requirements as specified in the detail procurement specification. The capability of the SS to provide the torque and power specified in Par. 5.1, shall be a requirement in the procurement specification.

9.2.1 Performance Testing. Subsystem components shall be subjected to performance tests which verify compliance with allocated performance requirements established by analysis of the subsystem design and the requirements of Sec. 4 and 5 of this specification.

9.2.2 Environmental Testing. Subsystem components shall be subjected to environmental testing in accordance with the detail procurement specification to insure suitability of operation for the conditions specified in Pars. 4.1.4.1, 4.1.4.2, 4.1.4.3, 4.1.4.4, 4.1.4.5, 4.1.4.6, and 4.1.4.7 of this specification. Similar components previously qualified to these requirements shall be excluded from this requirement.

9.2.3 Endurance and Safety Testing. Endurance tests shall include a minimum of 300 hr on all rotating equipment prior to first flight. Safety testing shall be performed to support verification of the safety requirements of Par. 4.1.6. Such testing shall include testing to verify containment of high speed rotating equipment and proper functioning of safety devices.

9.3 Formal Qualification Tests. Formal qualification tests shall be conducted to verify that requirements of Secs. 4 and 5 are satisfied. Formal qualification of the SS shall be accomplished by the following:

9.3.1 Inspection. Inspection of the prototype airplane drawings and specifications shall be conducted to verify compliance with the following paragraphs:

4.1.2.2	Service and Access
4.1.6.2	Ground Safety
4.1.6.3	Personnel Safety
5.2	Envelope
5.3	Weight
5.5	Selection of Specifications and Standards
5.6	Materials, Parts, and Processes
5.6.1	Fluids and Lubricants
5.7	Standard and Commercial Parts
5.8	Moisture and Fungus Resistance
5.9	Corrosion of Metal Parts
5.10	Interchangeability and Replaceability
5.11	Workmanship
5.13	Identification and Marking
5.14	Storage

9.3.2 Analyses. Analyses of available data shall be used to verify the requirements listed in the following subparagraphs. Available data shall include but is not necessarily limited to design drawings, and the results of tests specified in Par. 9.1, results of supplier component qualification tests, and results of airplane ground and flight tests specified in Par. 9.3.4.

9.3.2.1 Performance. A detailed performance analysis shall be made to verify the design requirements of Pars. 4.1.4.8 and 4.1.4.9, and Sec. 5. The analysis shall use applicable component data from Par. 9.1 and shall include a complete pressure drop analysis of the air ducts. A failure mode and effect analysis, which includes applicable data from supplier qualification tests, shall be made to substantiate safety of operation and suitability of protective devices as specified in Par. 4.1.6.1.

9.3.2.2 Maintainability. The maintainability requirements of Par. 4.1.2, and subparagraphs represent the mature system operated in representative scheduled airline revenue service. Projections of the requirements above shall be verified by analysis of data acquired as a result of, and in conjunction with, mockup evaluations, qualification tests, developmental tests, engineering airplane ground tests, and flight tests. All activities involving scheduled checks, repairs and servicing of line replaceable units (LRU) shall be observed and data recorded. The suitability of service and access provisions shall be determined by observation of technicians performing maintenance and servicing tasks on the subsystem.

9.3.2.3 Useful Life. Analytical review of applicable design, tests, and service data shall be provided to justify useful life requirements of Par. 4.1.3.

9.3.2.4 Environmental. Verification shall be based on analytical review of development tests and component qualification tests of Par. 9.2. Flight tests shall be monitored for evidence of inadequate performance in the operational environment.

9.3.2.5 Human Performance. Human performance requirements as defined in Par. 4.1.5 shall be verified in accordance with specification D6A10109-1.

9.3.2.6 Safety. The safety requirements identified in Par. 4.1.6 shall be verified analytically by the identification of compensating provisions for each failure mode defined in the failure mode effect and criticality analysis and by inspection during the engineering safety review.

9.3.3 Demonstrations. Maintainability demonstration shall be made and data collected as maintenance occurs in the development and test programs of Par. 9.1 and 9.3.4 to verify the requirements in the following:

4.1.2	Maintainability
4.1.2.1	Maintenance and Repair Cycles
4.1.2.2	Service and Access

9.3.4 Tests. Subsystem formal qualification tests shall be performed to verify that the SS meets the requirements of Sec. 4 and 5 as follows, and as specified in the contractor's procurement specification.

9.3.4.1 Ground Tests. The following tests shall be performed prior to the first flight. These tests shall be conducted using flight quality test articles. A test article is defined herein as a subsystem built to the latest prototype drawings using components built and tested to applicable detail procurement specifications.

a. Engine Starting Test. Verification of engine start requirements of Par. 5.1.1 shall be accomplished by performing engine starts. Separate tests shall be conducted using ground cart air sources and engine bleed air. Satisfactory verification shall be achieved by completing engine starts under the conditions noted in Fig. 2. Five starts are required for each air source.

b. Airflow to Subsystem Interfaces. Ground tests shall be conducted to verify that the starter subsystem is capable of transferring air as specified in Par. 5.1.3 to each of four ECS subsystem interfaces. This capability shall be demonstrated using separately, a ground air source and engine bleed sources. Tests shall be conducted to demonstrate that any engine can singly supply air to any of the four ECS interfaces at the rates, pressures, and temperatures specified.

Tests shall be conducted to demonstrate that the starter subsystem can transfer the airflow requirements to each windmill brake as defined in Par. 5.1.4.

c. Accessory Operational Tests. Tests shall be conducted to verify the requirements of Par. 5.1.2. The delivery of power for one hour shall constitute verification of this requirement.

d. Electromagnetic Interference Test. There will be no electromagnetic interference test conducted solely for the evaluation of the SS. However, the SS shall be tested as a part of the airframe electromagnetic interference test. A satisfactory airframe electromagnetic test in accordance with Sec. 4 of D6A10107-1 shall constitute verification of the requirement in Par. 5.12.

9.3.4.2 Flight Tests. During the airplane flight test program the SS shall be monitored to determine nominal operational performance and subsystem malfunction. At least one test wherein the ADS is disconnected from the engine shall be run. Under this condition the ADS shall be driven by the air starter. Engine bleed air shall be used during this test.

9.4 Reliability Tests and Analysis. The criteria of Par. 4.1.1, represent the mature system operated in representative scheduled airline revenue service. Inasmuch as the tests and data specified in Par. 9.3.4 are limited and the hardware may be of a prototype nature, compliance with the requirements of Par. 4.1.1 shall be accomplished as follows:

9.4.1 Reliability Tests. Tests specifically designed to verify the reliability of the subsystem shall not be conducted. Data obtained from tests conducted to Par. 9.3.4 shall be applied to the reliability analysis specified in Par. 9.4.2, extrapolated to anticipated airlines operational conditions.

9.4.2 Reliability Analyses. A reliability analysis shall be performed to demonstrate that the requirements of Par. 4.1.1 can be achieved. This shall be accomplished as follows:

a. A growth curve shall be established to base the target reliability levels projected by the end of Phase III.

b. Design data and test results shall be applied to a reliability analysis model incorporating:

   (1) Block diagrams summarizing the logical relationships between components success or failure and system success or failure.

   (2) A mathematical reliability model derived from (1) above and incorporating minimum equipment requirements for continued flight.

   (3) A mathematical reliability model simulating typical airline operations and routes.

c. Comparison shall be provided with the Phase III targets and the results extrapolated to determine expectation of achieving the requirements of Par. 4.1.1, in airline operation.

10. PREPARATION FOR DELIVERY

The subsystem shall be delivered as part of the prototype airplane delivered as defined in specification D6A10107-1. Delivery requirements for the subsystem or components shall be defined by the contract.

11. NOTES

11.1 Definitions. The definitions shown in Sec. 6 of specification D6A10107-1 shall apply.

11.2 Supporting Data.

11.2.1 Maintenance Design Guide. The Maintenance Design Guide - Commercial Supersonic Transport, D6-9458, may be used for subsystem maintainability design guidance.

11.2.2 Reliability Analysis. Specification D6A10064-2 contains the current reliability analysis referred to in Par. 9.4.2.

SUPPLEMENT I

There are no differences in the performance requirements, defined in Secs. 4 and 5 between the prototype and production airplanes.