MILITARY SPECIFICATION

POWER UNIT
AUXILIARY, S-3A AIRCRAFT
EQUIPMENT SPECIFICATION FOR

This specification is approved for use by the Naval Air Systems Command, Department of the Navy, and is available for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 Scope. This specification establishes the performance, operating characteristics, design features, detailed interface configuration definitions, and installation envelopes for a gas turbine auxiliary power unit (APU) with a government furnished equipment (GFE) electrical generator attached. The APU will be operated aboard the S-3A aircraft. This specification also establishes the demonstrations. tests, reports, inspection procedures, and other data required for satisfactory completion and acceptance, by the Using Service, of the Preliminary Flight Rating Tests (PFRT) and the Verification Tests (VT) for the APU. Further, this specification identifies the tests, procedures and data required for satisfactory completion of the Acceptance Tests (AT) of each production unit. Notwithstanding the requirements for test verification of individual points of performance or operating characteristics of the APU covered by this specification for purposes of PFRT, VT, or AT, the APU manufacturer shall continue to be fully responsible for all features, characteristics, and performance of the APU throughout the environmental conditions and operating envelope, to the extent required by the applicable contract. This specification also establishes the content and format to be used by the APU manufacturer for the preparation of the model specification in accordance with 6.5.

1.2 Classification. The APU shall be used as a combination electrical power and compressed air source.

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Engineering Specifications and Standards Department (Code 93), Naval Air Engineering Center, Lakehurst, NJ 08733, by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

1.3 APU Components. The APU defined in this specification shall include the following components furnished as part of and qualified with the APU.

a. GFE Generator (See Appendix I)

b. Electronic Control Unit (ECU) (See Appendix II)

c. Exhaust Duct (See figure 1)

d. GFE Seal Plate (See figure 1)

2. APPLICABLE DOCUMENTS

2.1 Government Documents.

2.1.1 Specifications and Standards. Unless otherwise specified, the following specifications and standards of the issue listed in that issue of the Department of Defense Index of Specifications and Standards (DoDISS) specified in the model specification form a part of this specification to the extent specified herein.

SPECIFICATIONS

FEDERAL

TT-S-735	Standard Test Fluids; Hydrocarbon

MILITARY

MIL-C-3702	Cable, Power, Electrical, Ignition, High Tension
MIL-B-5087	Bonding, Electrical, and Lighting Protection, for Aerospace Systems
MIL-E-5400	Electronic Equipment, Airborne, General Specification for
MIL-H-5440	Hydraulic Systems, Aircraft, Types I and II, Design and Installation, Requirements for
MIL-T-5544	Thread Compound, Antiseize, Graphite-petrolatum
MIL-H-5606	Hydraulic Fluid, Petroleum Base, Aircraft, Missile, and Ordinance
MIL-E-5607	Engine, Gas Turbine, Preparation for Storage and Shipment of, Process for
MIL-T-5624	Turbine Fuel, Aviation, Grades JP-4 and JP-5
MIL-S-6090	Steels Used in ircraft Carburizing and Nitriding, Process for
MIL-C-7024	Calibrating Fluid, Aircraft Fuel System Components
MIL-S-7742	Screw Threads, Standard, Optimum Selected Series; General Specification for
MIL-L-7808	Lubricating Oil, Aircraft Turbine Engine, Synthetic Base

MIL-M-7997	Motors, Aircraft Hydraulic, Constant Displacement, General Specification for
MIL-S-8879	Screw Threads, Controlled Radius Root with Increased Minor Diameter, General Specification for
MIL-I-18802	Fuel and Oil Lines, Aircraft, Installation of
MIL-L-23699	Lubricating Oil, Aircraft Turbine Engines, Synthetic Base
MIL-H-25579	Hose Assembly, Tetrafluoroethylene, High Temperature Medium Pressure, General Requirements for
MIL-I-27686	Inhibitor, Icing, Fuel System
MIL-W-81381	Wire, Electric, Polyimide-insulated, Copper and Copper Alloy
MIL-T-83133	Turbine Fuel, Aviation Kerosene Type, Grade JP-8
MIL-H-83282	Hydraulic Fluid, Fire Resistant Synthetic Hydrocarbon Base, Aircraft
MIL-C-83723/8	Connectors, Electrical, (Circular, Environment Resisting), Receptacle, (Cable Connecting, Bayonet Coupling, Crimp Pin Contact), (Series I, Classes A, G and R)
MIL-C-83723/9	Connectors, Electrical, (Circular, Environment Resisting). Receptacle, (Narrow Flange Mount, Bayonet Coupling, Solder Pin Contact), (Series I, Class H)

STANDARDS

FEDERAL

FED-STD-595	Color

MILITARY

DOD-STD-100	Engineering Drawing Practices
MIL-STD-130	Identification Marking of U.S. Military Equipment
MIL-STD-454	Standard General Requirements for Electronic Equipment
MIL-STD-461	Electromagnetic Emission and Susceptibility Requirements for the Control of Electromagnetic Interference
MIL-STD-462	Electromagnetic Interference Characteristics, Measurement of
MIL-STD-470	Maintainability Program Requirements (For Systems and Equipments)
MIL-STD-704	Aircraft Electric Power Characteristics
MIL-STD-756	Reliability Prediction
MIL-STD-785	Reliability Program for Systems and Equipment Development and Production

MIL-STD-810	Environmental Test Methods
MIL-STD-838	Lubrication of Military Equipment
MIL-STD-882	System Safety Program Requirements
MIL-STD-889	Dissimilar Metals
MIL-STD-1472	Human Engineering Design Criteria for Military Systems, Equipment and Facilities
MIL-STD-1523	Age Control of Age-Sensitive Elastomeric Material
MIL-STD-1629	Procedures for Performing a Failure Mode, Effects and Criticality Analysis
MS 3336	Accessory Drives Aircraft Engine, Reference Chart for
MS 3450	Connectors, Receptacle, Electric, Wall Mounting, Rear Release, Crimp Contact, AN type
MS 3459	Connectors, Plug, Electric, Self-Locking Coupling Nut, Rear Release, Crimp Contact, AN Type
MS 3470	Connectors, Receptacle, Electric, Series 2, Crimp Type, Narrow Flange Mount, Bayonet Coupling, Classes A, L, S and W
MS 3476	Connectors, Plug, Electric, Series 2, Crimp Type, Bayonet Coupling, Classes A, L, S and W
MS 21209	Insert, Screw Thread, Coarse and Fine, Screw Locking, Helical Coil, Cres
MS 24476	Adapter, Pressure Lubricating Oil Servicing, Aircraft
MS 33514	Fitting End, Standard Dimensions for Flareless Tube Connection and Gasket Seal
MS 33535	Mounting Pad - Swing Check Valve Element, Fuel
MS 33540	Safety Wiring and Cotter Pinning, General Practices for
MS 33587	Transmitter Installation Clearance, Fuel and Oil Pressure
MS 33649	Bosses, Fluid Connection - Internal Straight Thread
MS 33656	Fitting End, Standard Dimensions for Flared Tube Connection and Gasket Seal
MS 33660	Tubing End, Hose Connection, Standard Dimensions for
MS 33666	Packing, Preformed - Aeronautical, Elastomeric, Range of Sizes
MS 33668	Packing, Preformed, Elastomeric, Tube Fitting, Range of Sizes

PUBLICATIONS

BUMEDINST 6260.6	Hearing Conservation Program
OPNAVINST 4790.2	The Naval Aviation Maintenance Program

AR-10	Maintainability of Avionics Requirement and Systems, General Requirements for
NAVAIR 00-35QG-001	Accountable General Support Equipment for Intermediate Land (c) Level of Maintenance of V-Type Aircraft
NAVAIR 00-35QG-016	Consumable General Support Equipment for all Types, Classes and Models of Aircraft
MIL-BULL-543	List of Standard Drawings used by the Naval Air System Command
MIL-BULL-544	List of Specifications and Standards Approved by the Naval Air Systems Command

(Copies of specifications, standards, drawings, and publications required by manufacturer in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

2.1.2 Other Government Documents. The following other Government publications form a part of this specification to the extent specified herein.

NATIONAL PUBLICATIONS

NATIONAL BUREAU OF STANDARDS

Monograph 125	Thermocouples-Calibration

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
UNITED STATES AIR FORCE

U. S. Standard Atmosphere, 1976

UNITED STATES DEPARTMENT OF AGRICULTURE

AMS 180	Grading Standards SRA
AMS 251	Grading Standards SRA

(Application for copies should be addressed to the Superintendent of Documents, Government Printing Office, Washington, DC 20402.)

2.2 Other Publication. The following document forms a part of this specification to the extent specified herein. The issue of the document which is indicated as DoD adopted shall be the issue listed in the current DoDISS and the supplement thereto, if applicable.

SOCIETY OF AUTOMOTIVE ENGINEERS

AEROSPACE RECOMMENDED PRACTICES

ARP 1055 Fire Resistance, Fire Test, and Performance Requirements for Flexible Hose and Rigid Tube Assemblies

(Application for copies should be addressed to the Society of Automotive Engineers, Inc., 400 Commonwealth Drive, Warrendale, PA 15096.)

(Industry association specifications and standards are generally available for reference from libraries. They are also distributed among technical groups and using Federal agencies.)

3. REQUIREMENTS

3.1 Item Definition. The APU is a deliverable system comprised of all APU components necessary to satisfy the requirements of this specification. A model specification, in accordance with 6.5, shall be prepared by the APU manufacturer and submitted for approval. A brief description of the salient features of the APU shall be provided in the model specification. To be included in this description, where applicable, shall be a description of such components as intake shroud; compressors, including number of stages, variable geometry provisions, acceleration bleeds; combustor type including method of fuel injection; turbine components including number of stages, cooling provisions; exhaust duct; APU control features; gearbox provisions; type of lubrication and scavenge system; hydraulic start motor; starting and ignition system; number and location of main bearings; generator interface; ECU; instrumentation and performance indicating provisions. The performance ratings shall be specified in the model specification in accordance with Tables I and II. A detailed APU characteristics summary shall be included as shown in Table III. Terms, symbols, and their definitions shall be in accordance with Section 6.

3.1.1 Item Diagrams. Item diagrams shall be provided as specified in the model specification.

3.1.1.1 APU System Data Submittal and Approval. APU system data submittal and approval requirements will be covered by the contract and the model specification. Typical information and data required are listed in 6.3.2. The data shall be furnished in accordance with the Contractor Data Requirements List (DD Form 1423), as applicable.

3.1.2 Interface Definition. The APU shall be installed within the physical installation requirements shown on figure 1. Interface definitions for mounting provisions, compartment cooling air, service connections, electrical, fuel and hydraulic connections require approval of the Using Service. All fluid connections require approval of the Using Service prior to incorporation into the design of the APU. All interface definitions shall be shown on the APU configuration and envelope figure or in the text describing the applicable functional system.

3.1.2.1 Drawings. The following drawings, as figures, shall form a part of the model specification. Reduced size copies of these figures shall be included in the model specification.

a. APU Configuration and Envelope Figure. This drawing shall include detailed profiles in all planes to show and identify the physical interface features of the APU. The drawing shall show mounting details and tolerances for the APU and all installation items, clearances for installation and removal of accessories and components subject to separate removal, access for adjustments and other maintenance functions, and center of gravity of the APU including all of the APU components and accessories located in the APU compartment before servicing with fuel, oil or hydraulic fluid. This drawing shall show the maximum space required by the APU including tolerances and dimensional changes due to manufacturing, thermal effects, vibration, and operating and externally applied loads.

b. APU Electrical Installation Connection Figure. This drawing shall show and identify all APU systems external electrical circuit requirements and installation interface connection details.

c. APU Component Installation Figure. This drawing shall show the installation of components not mounted on the APU.

d. APU Basic Assembly Figure. This drawing shall show the major assemblies and referencing sub-assemblies and APU parts list.

3.1.2.2 Mock-up. A full scale mock-up shall be prepared in accordance with the applicable contract.

3.1.2.3 Installation Interfaces. APU features affecting APU installation interfaces shall be identified and defined in the model specification.

3.1.2.4 Moments of Inertia. The following shall be specified in the model specification.

a. The maximum effective mass moment of inertia (slug-ft^2) of the complete dry APU about three mutually perpendicular axes with the origin at the center of gravity.

b. The maximum effective mass moment of inertia (slug-ft^2) of the complete APU rotor system (including the gear train, driven components and the generator) referred to the turbine rotor. The direction of rotation of the turbine rotor when viewed looking forward from the exhaust exit shall also be specified.

3.1.2.5 Externally Applied Forces. The APU shall function satisfactorily under the conditions specified in 3.1.2.6 and figure 2 without permanent deformation and shall operate satisfactorily thereafter. The APU shall also not fail when subjected to static loads equivalent to 1.5 times those values

but the APU need not operate satisfactorily thereafter. The limit loads shall be based on a weight factor consisting of the dry weight of the APU, increased by the specific weight allowed for all APU mounted components, accessories and operating fluids. Where airframe components are supported by the APU, the weight of these components will be included in the weight factor. A report shall be submitted to the Using Service prior to the initiation of the PFRT which shall contain a detailed structural analysis of the entire APU with regard to its capability to withstand the loads specified in this paragraph, 3.1.2.5.1 and 3.1.2.6.

3.1.2.5.1 Gyroscopic Moments. At maximum allowable steady-state rotor speed, the APU shall operate satisfactorily when a gyroscope moment is imposed under the following:

a. For uncontrolled flight - A steady angular velocity of 3.5 radians per second in any axis in a plane perpendicular to the rotor axis, combined with a vertical load factor of either +1g or -1g for a total period of 15 seconds.

b. For controlled flight - A steady angular velocity of ±1.75 radians per second aircraft roll combined with a vertical load of +1g; or a steady angular velocity of +0.4 radians per second, aircraft pitch combined with a vertical load of +3.5g, for infinite cyclic life.

3.1.2.6 APU Mounts. The number, type, location, interface dimensions, and the maximum allowable load limits at each attachment point shall be shown on the APU configuration and envelope figure.

3.1.2.6.1 Ground Handling Mounts. Ground handling mounts shall be provided on the APU to support the weight of the APU increased for all APU mounted components, accessories and operating fluids. The handling mounts shall withstand loads of 4g axial, 2g lateral, and 3g vertical, without permanent deformation, based on the weight of the APU defined above. The location and dimensions for the individual ground handling mounts shall be shown on the APU configuration and envelope figure. The arrangement shall be compatible with ground handling equipment specified by the Using Service. If adapters are necessary, these will be designed and provided by the APU manufacturer as specified in the contract. The APU shall be capable of resting on a level surface without damaging lines, cables, fittings, or components attached to the surface of the APU.

3.1.2.7 Pads and Drives. Pads and drives suitable for mounting and driving the APU components shall be in accordance with the basic configuration and rating requirements specified in the model specification and presented as shown in Table IV. The APU component drive system shall be capable of simultaneous operation of all the drives when each drive is subjected to the maximum permissible torque or power rating specified for the individual drive. All drive splines shall be positively lubricated by APU oil. Complete dimensions and details of the drive pads including the clearance envelopes and alignment requirements shall be shown on the APU configuration and envelope

figure. No part of the gearbox shall prevent independent removal of any one component mounted on these drives. Pads and drives shall conform to the appropriate MS standard listed on MS 3336.

3.1.2.8 Heat Rejection and Cooling.

3.1.2.8.1 Limiting Zone Temperature. The APU and its accessories shall not exceed their allowable temperatures when surrounded by compartment air under the following conditions:

a. Continuous operation at rated compressed air and electrical loads with the compartment air either at 250°F (121°C), or at 135°F (57°C) plus the ram air temperature rise at the maximum ram pressure ratio specified for APU operation, whichever is greater.

b. In-flight shutdown from the most adverse condition and continued soaking with compartment inlet air at the maximum stagnation temperature. The most adverse condition is the operating load that releases the most heat into the APU compartment. This condition shall be specified in the model specification.

c. Ground shutdown with compartment air at 250°F (121°C).

Cooling air shall be provided by the APU, if necessary, to meet item a. If required, a fan drive shall be provided and its characteristics shall be specified in the model specification. No APU component or accessory shall require special cooling (e.g., forced convection, refrigeration or rotor rotation) to meet items b and c above.

3.1.2.8.2 Compartment Temperature. The APU shall provide for compartment cooling such that the compartment air temperature during ground operation shall not exceed 250°F (121°C) under the hot atmosphere conditions shown on figure 3. Compartment temperature transients after shutdown shall not exceed 400°F (204°C). Surface temperatures of the APU and its accessories shall not exceed 500°F (260°C) during normal operation, with the exception of the exhaust duct.

3.1.2.8.3 Oil Flow and Heat Rejection. The performance of the oil system, the associated cooling provisions and the cooling requirements shall be specified in the model specification. The oil flow, heat balance and heat rejection data based upon the maximum limiting zone termperatures of 3.1.2.8.1 shall be specified in an appendix to the model specification. The oil system heat balance shall also be presented with 59°F (15°C), 135°F (57°C) and maximum oil cooler cooling medium temperatures as specified in the model specification. If a heat exchanger is required, it shall be supplied as part of the APU.

3.1.2.8.4 Generator Cooling. The oil cooling system of the APU shall contain provisions for supplying the quantity, pressure and limited temperature of

cooling oil required by the generator specified in Appendix I. Additional items for the generator only (such as oil pump, filters, bypass valves, etc.) shall be contained within the APU and not the generator.

3.1.2.8.5 APU Heat Rejection and Cooling Report. A heat rejection and cooling requirements report which indicates cooling requirements, heat rejection rates with corresponding surface temperatures for various APU stations and components, cooling airflow and pressure distribution requirements, and any additional data necessary to define the complete installed APU cooling requirements, shall be prepared. The report shall be presented for Table I and II APU operating conditions. The report shall be submitted for approval by the Using Service 60 days prior to VT.

3.1.2.9 Air and Gas Leakage. The location, amount, temperature and pressure of APU leakages shall be specified in the model specification. There shall be no locations where leakage flow will be of sufficient temperature and concentrated impingement to present a safety hazard or affect installation requirements, in the judgment of the Using Service.

3.1.2.10 Air Inlet System.

3.1.2.10.1 Air Inlet Design and Dimensions. The APU air inlet system shall be compatible with the interface requirements of figure 1. A quick-disconnect flange shall be used when an intake attachment is required. Interface dimensions for the attachment of the inlet duct shall be shown on the APU configuration and envelope figure.

3.1.2.10.2 Allowable Inlet Connection Stresses. The maximum allowable static (1g) shear, axial and overhung moment loads at the APU inlet flange shall be specified in the model specification. The maximum allowable loads at the APU inlet flange for the maximum allowable combined maneuver and air loads shall also be specified. The maximum allowable maneuver loads are defined in figure 2.

3.1.2.10.3 Inlet Airflow Distortion Limis. Not less than five (5) sets of inlet flow distortion data and corresponding APU operating conditions shall be defined and specified in the model specification, for which stable APU operation shall occur. The inlet distortion criteria defined and specified shall result from technical coordination between the airframe and APU manufacturer. For each set of inlet flow distortion data specified, the APU interface operating conditions shall be defined, as applicable, in terms of Mach number, altitude, load condition, etc. Measurements of the APU inlet total pressure, temperature, and flow variation shall be made at the APU/inlet aerodynamic interface which shall be defined in the model specification. All inlet instrumentation utilized in measuring airflow, pressures and temperatures, the arrangement, location, response and instrumentation accuracies shall be defined and specified in the model specification. For each set of specified inlet flow distortion data, the total airflow, average

total pressure recovery and pressure and temperature for each individual probe as they occur shall be tabulated in the model specification.

3.1.2.10.4 APU Inlet Screen. If an inlet screen is integral to the APU design, the screen shall be of the lightest weight practicable with a minimum performance penalty. The assembly shall provide maximum protection against the ingestion of foreign objects greater than 1/4 inch diameter. The effects of the inlet screen on APU performance shall be included in the performance of 3.2.1.

3.1.2.10.5 Steam Ingestion. The APU shall be capable of ingesting steam and/or steam condensate at a rate of not less than 10 percent of the total APU mass airflow. The effects of steam ingestion on APU performance shall be specified in the model specification.

3.1.2.10.6 Armament Gas Ingestion. N/A

3.1.2.11 Compressed Air. The APU shall provide compressed air for main engine starting and environmental control system (ECS) cooling in accordance with the requirements of Tables I and II.

3.1.2.11.1 Compressed Air Connection. The compressed air connection shall be of the quick-disconnect type and shall be compatible with the interface requirements shown on figure 1. The quick-disconnect clamp is not required to be delivered with the APU. Interface dimensions for the compressed air attachment shall be shown on the APU configuration and envelope figure. The maximum allowable static (1g) axial, shear and overhung moment loads at the compressed air connection shall be specified in the model specification. The maximum allowable loads at the connection shall also be specified for the maximum allowable maneuver loads as defined in figure 2.

3.1.2.11.2 Compressor Air Regulating Valve(s). A pressure and airflow regulating valve shall be provided to control the APU operating variables, such as compressor surge or air pulsation, and prevent the APU from exceeding the maximum allowable measured exhaust gas temperature. The regulating valve shall also maintain a balance between the mechanical and compressed air outputs so that the total rated output of the APU is not exceeded. The regulating valve shall also maintain a minimum pressure of 16.5 psig for actuation of aircraft system valves, throughout the starting envelope of the APU.

3.1.2.11.2.1 Start and Acceleration Bleed Air. Where acceleration bleed airflow is necessary, the airflow conditions for which provision must be made shall be specified in the model specification. The ducting attachment detail shall be shown on the APU configuration and envelope figure. Compressor bleed air required for compressor surge protection, which operates continuously during steady-state APU operation in a surge-sensitive regime, shall be defined in the model specification as to the operating envelope.

3.1.2.11.3 Compressed Air Contamination. APU generated substances contained in the compressed air shall be no greater than the threshold limit values specified below. The APU manufacturer shall demonstrate, by analyzing compressed air samples, that the specified threshold limits for the substances are not exceeded. Where substances other than those listed are contributed to the compressed air by APU operation, the APU manufacturer shall report the substance(s) and the contamination in parts per million to the Using Service for determination of maximum limits. When two or more APU generated substances are present, their combined effect shall be determined and reported. In the absence of information to the contrary, the combined effects of the different substances shall be considered as additive. If cleaning fluids are specified for use during normal APU maintenance, consideration should be given to their effect on compressed air contamination.

Substance	Parts per Million
Carbon dioxide	5000.0
Carbon monoxide	50.0
Ethanol	1000.0
Fluorine (as HF)	0.1
Hydrogen peroxide	1.0
Aviation fuels	250.0
Methyl alcohol	200.0
Methyl bromide	20.0
Nitrogen oxides	5.0
Acrolein	0.1
Oil breakdown products (e.g., aldehydes)	1.0
Ozone	0.1

The compressed air shall contain a total of not more than 5 mg/cubic metre (3.12×10^{-7} lbm/cubic foot) of APU generated submicron particles.

3.1.2.12 Radar Cross Section. N/A

3.1.2.13 Connections. The APU shall be permanently marked to indicate all connections shown on the APU configuration and envelope figure for instrumentation, fuel, oil, air and electrical connections. Connections located in close proximity to each other shall be made physically non-interchangeable.

3.1.3 Major Component List. The components or component functional subsystems of the APU which require component qualification testing shall be listed in the model specification.

3.1.4 Government Furnished Property List. The Government shall supply the generator of Appendix I and the seal plate of figure 1.

3.1.5 Government Loaned Property List. No Government loaned property is to be incorporated into the APU design.

3.2 Characteristics.

3.2.1 Performance Characteristics. The APU performance characteristics defined by the APU manufacturer in the model specification shall be for the poorest performing APU that the manufacturer would expect to submit to the Using Service for acceptance. Unless otherwise specified, these APU performance characteristics shall be based on:

a. A fuel having a lower heating value of 18,300 BTU/lbm and otherwise conforming to the fuel specified in 3.7.3.2.1 and oil specified in 3.7.7.2.1.

b. US Standard Atmosphere 1976 (geopotential altitude).

c. No inlet air pressure drop.

d. No inlet pressure recovery.

e. The generator shaft horsepower versus electrical load (KW) as defined in Appendix I, figure 2.

f. The performance shall be determined using the APU control system specified in the model specification. The specified performance shall be predicated on the tolerance of the control system which produces the poorest performance.

g. Hot and cold atmosphere conditions (geopotential altitude) as defined on figure 3.

h. The starting temperature envelope as defined on figure 3.

i. The total pressure at the inlet to the oil cooling fan inlet duct equal to the free stream static pressure.

j. The compartment outlet air static pressure equal to free stream static pressure.

k. During in-flight start initiation and windmilling the local static pressure at the APU inlet equal to or greater than the static pressure at the outlet plane of the APU exhaust elbow, but will not exceed a pressure drop limit specified by the APU manufacturer.

l. Normal governed rotor speed.

3.2.1.1 Performance Ratings. The sea level and altitude uninstalled performance ratings shall be specified in the model specification in accordance with Tables I and II, respectively. Performance ratings for these

tables shall be based on the Using Service electrical power and compressed air rating requirements specified in the applicable columns on Tables I and II. In addition, the APU shall operate satisfactorily with any combination of compressed air load (from no electrical load to an open duct at the compressed air outlet flange) and electrical load (from no electrical load to 43 KW continuous and 68 KW for 5 seconds in-flight; and from no electrical load to 43 KW continuous, and 55 KW for 5 minutes and 68 KW for 5 seconds on the ground). The electrical loads shall be for a power factor of unity (1) in accordance with Appendix I, figure 2.

3.2.1.2 Performance Presentation Steady-State. APU performance data shall be provided in two forms: one in the form of standard day curves in the model specification, the other a computer program suitable for use with an automatic digital computer. The number and date of the computer program and associated user's manual shall be specified in the model specification. The computer program shall be primary, and forms a part of and shall be identified in the model specification. The performance data shall cover the operating envelope of the APU. The APU rating points of Tables I and II and the curves shall agree with the computer program. Points of rated performance shall be identified on the curves. The model specification shall contain a list of the symbols in Section 6 and a diagrammatic figure defining station identifications. The APU manufacturer shall identify the appropriate figure number here.

3.2.1.2.1 Performance Presentation Digital Computer Programs. A steady-state performance computer program will be constructed and furnished to the Using Service. This computer program shall form a part of the model specification and shall carry a suitable identification and date, including the APU model designation. The CDC 6600 computer located at Naval Ship Research and Development Center, Bethesda, MD 20084 shall be the computer upon which the program will be installed to obtain the official APU performance data. Execution of the computer program shall be demonstrated on the specified computer prior to acceptance by the Using Service. The computer program shall be prepared in accordance with the model specification.

a. Program Requirements. The performance program shall be a thermoydnamic cycle simulation in which component identity is maintained; e.g., the compressor, turbine and combustor must each be identifiable as entities in the model logic as required to obtain and maintain an accurate simulation. Using Service shall be supplied with the source code for the main input and output routines.

b. Program Capabilities. The program shall be capable of operating throughout the APU operating envelope. The program shall also be capable of operating at ambient static pressures up to 32 in. Hg. abs. Compilation shall not be necessary for each different run. Capability for determination of installation effects shall be included in the computer program. Effects of variable geometry and all applicable input parameters shall be included for the APU.

c. Documentation Requirements. A user's manual shall be provided.

(1) User's Manual. The user's manual shall include information pertinent to input preparation and output interpretation.

(2) Source Program. A source program will provide main program and input and output subroutines.

d. Inputs/Outputs. Those inputs and output parameters that the Using Service can directly influence or has reasonable need to know shall be available as input and output values; however, all other thermodynamic state points are not available. All program inputs must be independently variable and the program shall be capable of sequentially accepting multiple numerical changes to the computer inputs.

(1) Input Parameters:

1.	NIN	Input file number (INTEGER)
2.	NOUT	Output file number (INTEGER)
3.	MATCH	Thermodynamic match type MATCH=1, Main Engine Start IGV full open, fixed WB MATCH=2, Fixed IGV and WB
4.	TITLE	User title, Format (3A6)
5.	CASE	Numerical case identification
6.	ZALT	Geopotential altitude
7.	ZDTAMB	Ambient temperature minus standard atmosphere temperature
8.	ZDT1A	Temperature to be added to T1A
9.	ZTAMB	Ambient temperature
10.	ZT1A	APU inlet total temperature at station 1A
11.	ZP1A	APU inlet total pressure at station 1A
12.	ZPAMB	Ambient pressure
13.	ZXM	Mach number at the APU inlet
14.	SIM	Inlet mode selection SIM=1, Selects altitude and Mach number SIM=2, Selects pressure and temperature
15.	SERAM	Ram pressure recovery selection SERAM=1, Selects a ram pressure recovery of zero SERAM=2, Selects input value of ZERM1A SERAM=3, Selects ram pressure recovery from subroutine ERAMX
16.	ZERM1A	Ram pressure recovery at station 1A
17.	ZCPLS1	Inlet duct pressure loss coefficient
18.	ZEXP1	Inlet duct exponent on corrected airflow
19.	ZIGV	Load compressor inlet guide name position
20.	ZCPLS5	Exhaust duct pressure loss coefficient

21.	ZEXP5	Exhaust duct exponent on corrected airflow
22.	ZERMEA	Exhaust ram pressure recovery
23.	ZFHV	Lower heating value of fuel
24.	ZWB	Load compressor discharge airflow
25.	ZPWSD	Electrical power (KW)

(2) Output parameters:

1.	CLASS	APU program security classification, Format (A6)
2.	IDENT	APU program titles, Format (6A6)
3.	NSI	Numerical status indicator
4.	ALT	Geopotential altitude*
5.	DTAMB	Ambient temperature minus standard atmosphere temperature*
6.	DT1A	Temperature to be added to T1A*
7.	TAMB	Ambient temperature*
8.	T1A	APU inlet total temperature at station 1A*
9.	P1A	APU inlet total pressure at station 1A*
10.	PAMB	Ambient pressure*
11.	XM	Mach number at the APU inlet*
12.	CPLS1	Inlet duct pressure loss coefficient*
13.	EXP1	Inlet duct exponent on corrected airflow*
14.	IGV	Load compressor inlet guide vane position*
15.	WBR	Corrected load compressor discharge airflow
16.	ERM1A	Ram pressure recovery*
17.	ERMEA	Exhaust ram pressure recovery*
18.	CPLS5	Exhaust duct pressure loss coefficient*
19.	EXP5	Exhaust duct exponent on corrected airflow*
20.	WB	Load compressor discharge airflow*
21.	TB	Load compressor discharge temperature
22.	PB	Load compressor discharge pressure
23.	PWSD	Electrical power (KW)*
24.	W1A	APU inlet airflow at station 1A
25.	W2	Power section airflow
26.	P1	Power section inlet pressure
27.	P12	Load compressor inlet pressure
28.	T1	Power section inlet temperature
29.	T12	Load compressor inlet temperature
30.	PS5	Power section turbine exhaust static pressure
31.	T5	Power section turbine exhaust temperature
32.	TMG	Measured exhaust gas temperature at station _____
33.	XN	Normal governed rotor speed
34.	XNSD	Generator rotor speed
35.	FHV	Fuel lower heating valve
36.	WF	Fuel flow
37.	WEX	Exhaust mixed airflow
38.	MATCH	MATCH type*

*These locations will contain the values of each parameter used in the computation. The input values of these parameters are contained in the input parameter list where they are prefixed by the letter Z.

(3) Rating Codes. The following rating codes shall be used:

Rating Code	Definition
55	Combined Operating Load
45	Maximum Continuous Compressed Air Load
35	Maximum Continuous Electrical Load
15	No Electrical Load

The program shall be capable of calculating all the required output parameters listed below, with input options of compressed airflow rate and electrical power, in addition to the rating code options shown above.

The program output rating table parameters and all other program output parameters shall be characterized in the model specification for both rating table conditions and all other operating envelope conditions in terms of whether they are estimated minimum, guaranteed minimum, nominal or average performance values.

3.2.1.2.2 Performance Curves. Curves shall be furnished in the model specification showing APU performance under standard conditions, including altitude effects (pressure level and Reynolds number) at sea level and altitudes of 6,000 and 20,000 feet. The method for interpolation shall be specified, shall include any discontinuities in the curves, and be consistent with the computer program. These curves shall be drawn in accordance with the format of figure 4. In addition, the droop characteristic and combined load information shall be provided in the format of figure 5. A means of correcting all performance parameters to standardized conditions, due to variations in inlet pressure and temperature and exhaust outlet static pressure, shall be provided. Additional curves, shall be furnished when required by the Using Service for clarity or to describe the special characteristics of the APU.

3.2.1.3 Performance Verification. The performance presentation of 3.2.1 and 3.2.1.2 shall be used as the basis for verifying APU performance throughout the environmental conditions and operating envelope. APU performance defined by the computer program of 3.2.1.2 shall be substantiated by sufficient test data to assure that theoretical assumptions used to develop the computer program performance presentation are correct. The definition of ambient temperature and pressure lapse rates shall be a part of the substantiation test data. The substantiating data and analysis shall be submitted to the Using Service for approval prior to initiation of the PFRT endurance test and updated prior to initiation of the VT endurance test.

3.2.1.4 Operating Limits. All APU steady-state and transient operating limits (maximum, minimum) shall be specified in the model specification. The specified limits shall be predicated on the most critical tolerances of the APU.

3.2.1.4.1 Operating and Nonoperating Envelope. The APU operating and nonoperating limits as defined by aerothermodynamics and mechanical limitations for standard day and the hot and cold atmosphere conditions of figure 3 shall be specified in the model specification in the format of figure 6. As a minimum the APU operating and nonoperating envelope shall meet the requirements specified on figure 6. During inoperative service use, the APU shall be capable of withstanding exposure to the nonoperating envelope specified without incurring irreversible damage or being rendered nonfunctional in the operating envelope.

3.2.1.4.2 Sea Level Operating Limits: APU Mach number limits of figure 6 for standard day and the hot and cold atmosphere conditions of figure 3 shall be specified in the model specification.

3.2.1.4.3 Maximum Operating Altitude. The maximum operating altitude of the APU shall not be less than 30,000 feet. The range of Mach numbers at the maximum altitude for standard day shall be specified in the model specification.

3.2.1.4.4 Starting Limits. The APU starting limits shall be in accordance with the starting conditions defined on figures 3 and 6 and shall be specified in the model specification in the format of figure 6. After starting, the APU shall be capable of operating within the hot and cold atmosphere conditions of figure 3. As a minimum the APU starting and operating limits shall meet the requirements specified on figure 6. The low temperature limit for surface (ground) elevation APU starts shall be as defined on figure 3. Differences in the altitude starting limits for "hot" and "cold" APUs shall be specified in the model specification. A cold APU shall be defined as an APU in which the combustor exit temperature is within 10°F(6°C) of the compressor inlet temperature before a start is attempted. A hot APU shall be defined as one where a start is attempted within 10 seconds after a flameout or shutdown.

3.2.1.4.5 APU Measured Temperature Limits. The maximum allowable steady-state measured exhaust gas temperature, averaged over the gas path area at the measurement plane (based on the signal indication after the thermocouple electrical harness plug), shall be specified in the model specification. The location of the measurement plane, including station identification number, shall be specified. The maximum allowable transient measured exhaust gas temperature during starting and acceleration shall also be specified in the model specification. In addition, the overtemperature switch actuation temperature shall be specified in the model specification.

3.2.1.4.6 Rotor Speed Limits. The maximum and minimum steady-state rotor speed limits and the maximum allowable transient rotor speed (mechanical)

shall be specified in the model specification. The overspeed switch activation speed shall also be specified.

3.2.1.4.7 Fuel Flow Limits. The maximum and minimum APU fuel flow shall be specified in the model specification.

3.2.1.4.8 Oil Pressure and Temperature Limits. The maximum and minimum operating oil pressure limits and the maximum transient and maximum allowable steady-state oil temperature limits shall be specified in the model specification. The minimum oil pressure shall be sufficient to meet the generator cooling requirements of 3.1.2.8.4. The maximum and minimum oil pressures during starting and initial operation at the minimum ambient (starting) temperature shown on figure 3 shall be specified in the model specification. Minimum and maximum oil pressures during starting and initial operation shall not persist for more than 2.5 minutes. The minimum oil pressure switch actuation pressure shall also be specified.

3.2.1.4.9 Oil Consumption Limits. The oil consumption including all forms of oil loss shall not exceed the amount specified in the model specification. The APU shall be capable of operating for 200 hours without adding oil.

3.2.1.4.10 Vibration Limits. The maximum permissible APU vibration limits (overall velocity limit (true RMS)) at each transducer location on the APU compressor, turbine and gearbox cases, and if applicable, internal structure shall be specified in the model specification. The overall velocity limit specified for each transducer shall be applicable up to a frequency of 10 kHz. The true RMS velocity limits shall be provided 60 days prior to the initiation of the PFRT for incorporation into the model specification.

3.2.1.5 Operating Characteristics

3.2.1.5.1 Operating Attitude and Storage Limits. The APU shall be capable of continuous satisfactory operation in the shaded area shown on figure 7, and at least 30 seconds operation in the clear area. The APU shall function satisfactorily for at least 30 seconds under conditions of negative "g" and for at least 15 seconds under zero "g" conditions. The APU shall be capable of being started, stopped and stowed for an indefinite period in any of the attitudes shown in the shaded area on figure 7. APU attitude stowage capabilities outside of the figure 7 shaded area shall be specified in the model specification.

3.2.1.5.2 Starting. See 3.7.9 Starting System.

3.2.1.5.3 Stopping. Stopping (termination of fuel flow) of the APU shall be accomplished by a single, rapid method which permits remote actuation and it shall be possible to stop the APU by this means from any operating condition. No damage to the APU shall result from shutting off the fuel supply by the foregoing means or from shutting off the fuel supply to the APU inlet

connection during any operating condition. The specification shall indicate normal means of stopping and if applicable, emergency provisions.

3.2.1.5.4 Stability. Under steady-state operating conditions, throughout the complete environmental conditions and operating envelope, the APU electrical load output and rotor speed fluctuations shall not exceed ±1.0 percent of the maximum continuous electrical load and rotor speed, between no electrical load and combined operating load conditions. When a droop characteristic is provided, the speed droop range from no electrical load to the combined operating load shall not exceed 4.0 percent of the rotor speed at the no electrical load condition. In addition, the compressed air pressure fluctuations shall not exceed ±1.0 percent of the maximum continuous compressed air pressure between no load and the combined operating load conditions.

3.2.1.5.5 Transient Conditions. The time to recover to 95 percent of the steady-state performance values shall not exceed one second for any load change. The rotor speed shall not overshoot the normal governed rotor speed by more than 3.0 percent of the maximum allowable steady-state rotor speed. During these transient conditions there shall be no overtemperature beyond the limits specified in 3.2.1.4.5 and no combustion or compressor instability.

3.2.1.5.6 APU Windmilling Capability. The APU shall be capable of at least 5 hours of continuous windmilling operation throughout its entire operating envelope without damage to the APU and without excessive loss of lubricating oil.

3.2.2 Physical Characteristics.

3.2.2.1 Dry Weight. The dry weight of the complete APU, including all components located in the APU compartment, shall not exceed 200 pounds. The weight of components included in the dry weight shall be specified in the model specification. The weight of the generator is 42.9 pounds.

3.2.2.2 Weight of Additional Equipment. The weight of APU components and accessories not located in the APU compartment shall be specified in the model specification.

3.2.2.3 Weight of Fluids. The weight of residual fluids remaining in the APU after operation and drainage, while the APU is in a single specified attitude of the rotor axis relative to the level plane, shall be specified in the model specification. The weight of operating fluids required for APU operation shall also be specified. These values shall be verified or modified prior to the initiation of PFRT and VT and a report submitted to the Using Service for approval.

3.2.3 Reliability. An APU failure mode and effect analysis, in accordance with MIL-STD-756 and MIL-STD-1629, shall be performed prior to the initiation of the PFRT and revised as required prior to the intitiation of the VT. The

analysis shall show probable frequency of failure values assigned to each failure mode. After completion of all verification testing, the APU manufacturer shall prepare a reliability report based on the total development and verification effort and based on data gathered through APU manufacturer reliability programs. The APU manufacturer shall submit, for approval by the Using Service, a reliability program in accordance with MIL-STD-785. The reliability values specified herein shall be demonstrated in the endurance test of 4.6.1. The reliability values are subject to the failure definitions and exclusions specified in Section 6.

3.2.3.1 Reliability Values. The mean-time-between-failure (MTBF) of each APU shall be 1000 hours (Theta sub zero) when evaluated in accordance with the missionized duty cycle of 4.5.1.3.2.

3.2.3.2 Start Reliability. The probability of a successful start on the first attempt of the APU shall be 0.995 from sea level to 22,500 feet under the conditions specified in 3.2.1.4.4 and 3.2.5.1.1.

3.2.4 Maintainability. The APU shall be designed for ease of servicing and maintenance. The APU shall exhibit characteristics of design such that it can be retained in or restored to a working and usable condition within a specified period of time, when the maintenance is performed in accordance with prescribed procedures specified for Organizational, Intermediate, and Depot levels of maintenance in OPNAVINST 4790.2 using only the tools approved by the Using Service for support of the APU. The APU manufacturer shall submit, for approval by the Using Service, a maintainability program in accordance with MIL-STD-470, prior to the initiation of the VT.

3.2.4.1 Numerical Requirements. The APU shall be under the "on condition" maintenance concept, with complete APU repair at the Intermediate level. Deviation from this concept shall be supported by a Level of Repair Analysis/Life Cycle Cost (LORA/LCC) to be submitted to the Using Service for approval. Maintainability values are based on planned weapon systems utilization rate and mission unit, and are as follows:

a. Organization Level

(1) Maintenance (MTTR) shall not exceed 0.78 elapsed hours.

(2) The MAXCT (90th percentile) shall not exceed 1.56 utilizing a crew of two with a skill level no greater than ADJ3.

(3) Repair will include fault isolation, repair, and verification of repair to a level consistent with the repair with the use of PGSE.

b. Intermediate Level

(1) Maintenance (MTTR) shall not exceed 2.85 elapsed hours utilizing a crew of one with a skill level no greater than ADJ2. Corrective maintenance

time shall include: connect and disconnect, GSE, fault isolation, disassembly, removal and replacement of components, assembly, calibration if required and verification of repair to that level consistent with the repair; and in accordance with the approved maintenance plans and the OPNAVINST 4790.2.

3.2.4.1.1 Applicable Maintenance Functions. Maintenance, repair and inspection functions shall be as specified in the applicable contract.

3.2.4.1.2 Excluded Maintenance Functions. These maintenance and repair functions shall be as specified in the applicable contract.

3.2.4.2 Maintenance, Inspection and Repair Cycles. The estimated maintenance, inspection, and repair periods, including depot overhaul, shall be specified in the model specification together with the estimated time in manhours required to perform these functions. A tabulation shall be provided in the model specification which gives the time to remove and replace the modules listed in 3.5.1.1 and also all externally mounted APU components that are separately removable such as fuel pumps, fuel controls, igniter plugs, etc.

3.2.5 Environmental Conditions.

3.2.5.1 Ambient Temperature Conditions. The allowable ambient temperature conditions for all APU operations, except starting, shall be between the hot and cold atmosphere conditions of figure 3. For all APU starting, the ambient temperature condition shall be between the hot atmosphere and the minimum ambient starting temperature as shown on figure 3.

3.2.5.1.1 Operating Envelope Temperatures. The complete APU shall start on the first attempt under the following conditions when using the fuels and oils specified in the model specification and consistent with 3.7.3.3.3 and 3.7.3.3.4. After starting, the APU shall operate satisfactorily throughout the Mach number and altitude conditions specified in figure 6.

a. Under no ram conditions at surface (ground) elevations from sea level to the maximum altitude specified on figure 6 and with the APU rotor at rest, the APU shall:

(1) Start after a hot soak period of 6 hours at the hot ground soak temperature as shown on figure 3 and when supplied with inlet air and fuel both at the hot atmosphere condition shown on figure 3.

(2) Restart after a hot soak period of 15 minutes at the hot ground resoak temperature as shown on figure 3 and when supplied with inlet air and fuel both at the hot atmosphere condition shown on figure 3.

b. Under no ram conditions at surface (ground) elevations from sea level to the maximum altitude specified on figure 6 and with the APU rotor at rest, the APU shall:

(1) Start after a cold soak period of 6 hours when the ambient air temperature, supplied inlet air and MIL-T-5624, grade JP-4 fuel are all at the minimum ambient temperature (starting) as shown on figure 3.

(2) Start after a cold soak period of 6 hours when the ambient air temperature, supplied inlet air and MIL-T-5624, grade JP-5 fuel are all at the minimum ambient temperature (starting) as shown on figure 3 or the temperature which corresponds to a fuel viscosity of not less than 12 centistokes, whichever is warmer.

c. The APU shall start throughout the starting envelope defined on figure 6 when supplied with inlet air at any temperature between the hot atmosphere condition and the minimum ambient temperature (starting) as shown on figure 3, and when supplied with MIL-T-5624 fuel at any temperature between a maximum of 135°F(57°C) and the minimum fuel temperature or that temperature which corresponds to a fuel viscosity of 12 centistokes for JP-5, whichever is warmer.

3.2.5.1.2 Nonoperating Envelope Temperatures. Following a minimum 3-hour period of APU nonoperation at any condition throughout the nonoperating envelope of figure 6, the APU shall start throughout the starting envelope of figure 6 when supplied with inlet air and fuel at the temperature conditions specified in 3.2.5.1.1.c.

3.2.5.1.3 Storage Temperature Range. During storage, the complete APU shall be capable of withstanding exposure to ambient temperature extremes of 160°F (71°C) and -70°F(-57°C) for periods of 48 and 24 hours, respectively, without incurring irreversible damage or being rendered nonfunctional in the operational temperature range of 3.2.5.1.1. The APU shall withstand the storage temperature extremes at surface (ground) elevations from sea level to 15,000 feet altitude.

3.2.5.1.4 Altitude Changes. The APU shall start and operate satisfactorily after: (1) the APU has reached its maximum operating temperature at the hot atmosphere condition of figure 3 and the maximum sea level Mach number; (2) subsequently shutdown and (3) restarted within 30 seconds at the minimum ambient starting temperature at 20,000 foot altitude at the minimum Mach number. In addition, the APU shall operate without stall, surge, flameout or mechanical damage when the inlet conditions are changed at a rate of 600 feet/second.

3.2.5.2 Icing Conditions. The APU shall operate satisfactorily under the meteorological conditions shown in figures 8 and 9, and Table V, with not more than 5.0 percent total loss in electrical power or compressed air available and 5.0 percent total increase in fuel consumption. Upon termination of the icing conditions, the APU shall retain no performance deterioration. If an anti-icing system is required in order to meet the above performance under the specified environmental conditions, the anti-icing system shall be in accordance with 3.7.1.

3.2.5.3 Fungus Conditions. The APU components shall be resistant to fungus as determined by selection of non-nutrient materials which are resistant to fungus or by satisfactory completion of fungus test.

3.2.5.4 Humidity Conditions. The APU shall be resistant to malfunction and deterioration when subjected to 95 percent or higher humidity conditions for extended periods. This shall be demonstrated by satisfactory completion of the humidity test.

3.2.5.5 Corrosive Atmosphere Conditions. The APU shall perform satisfactorily and the endurance capability and useful life shall not be adversely affected while operating in or after exposure to salt laden air. This capability shall be demonstrated in the corrosion susceptibility test of 4.6.4.3. Upon completion of the corrosion susceptibility test, the APU shall be capable of operating with not greater than a 5.0 percent loss of electrical power or compressed air available and not greater than a 5.0 percent gain in fuel consumption. No impairment of capability to execute power transients shall be permitted. In addition, upon completion of the test, APU parts shall satisfy the inspection criteria of 4.6.4.3.

3.2.5.6 Environmental Ingestion Capability.

3.2.5.6.1 Bird Ingestion. N/A

3.2.5.6.2 Foreign Object Damage (FOD). The APU shall operate for at least 12.5 APU operating hours or the number of hours specified in the model specification after ingestion of foreign objects which produce damage with a minimum stress concentration factor (Kt) of 3.0 to compressor blades and stators.

3.2.5.6.3 Ice Ingestion Capability. The APU design shall be such that ingestion of ice will not produce flameouts, lengthy power recovery time, or severe sustained power losses, although some damage to the APU may occur.

3.2.5.6.4 Sand Ingestion. The APU including all components, shall operate satisfactorily throughout its operating range at ground environmental conditions with air containing sand and dust in concentrations up to 4.4×10^{-5} pounds of sand per pound of air. The APU and its components shall be operated for two hours at combined operating load with the specified concentration of sand and dust. The APU performance degradation shall not exceed 5.0 percent and the capability to execute power transients shall not be impaired. The specified sand contaminant shall consist of crushed quartz with the total particle size distribution as follows:

Particle Size, microns	Quantity, percent by weight finer than size indicated
1,000	100
900	98-99
600	93-97
400	82-86
200	46-50
125	18-22
75	3-7

3.2.5.6.5 Atmospheric Liquid Water. The APU shall operate satisfactorily throughout the flight operating envelope up to 30,000 feet from no electrical load to the combined operating load at all levels up to 5.0 percent of the total inlet airflow in the form of water (liquid and vapor) and with 50 percent of the liquid water entering the APU inlet through a segment equivalent to one-third of the inlet area. The maximum limits above a 5.0 percent water-to-air ratio, as defined above, shall be specified in the model specification.

3.2.5.7 Acoustic Noise Environment. The noise level of the APU during operation shall not exceed 105 dB(A) at a distance of 12 feet on a bare APU installation without noise control treatment. The dB(A) is defined by BUMEDINST 6260.6.

3.2.5.8 Exhaust Gas Contamination.

3.2.5.8.1 Exhaust Smoke Emission. N/A

3.2.5.8.2 Invisible Exhaust Mass Emissions. N/A

3.2.6 Transportability. The APU shall be efficiently transportable by all modes of transportation to permit employment, deployment, and logistics support. Adequate ground handling pads and other features shall be provided to permit installation on and use of appropriate static and mobile ground equipment.

3.2.6.1 Cover Plates. Cover plates for covering all component drive openings where the component is not mounted for APU shipment shall be supplied with each unit. Suitable provisions for covering or plugging all other connection openings shall be made for shipment and storage. Cover plates suitable for flight operations shall be provided on drive pads and connecting points which may not be used.

3.3 Design and Construction.

3.3.1 Materials, Processes, and Fasteners.

3.3.1.1 Materials and Processes. When manufacturers' specifications are used for materials and processes, such specifications shall be available to the government for review prior to start of the PFRT, and unless specifically disapproved, such specifications will be considered released for manufacturing purposes upon satisfactory completion and approval of the PFRT and VT. The use of non-governmental specifications shall not constitute waiver of government inspection. The use of magnesium shall be prohibited. Copper and cadmium shall not be used in APU parts which are in direct contact with fuel or oil during APU operation. The generator shall be exempt from these material restrictions. Dissimilar metals as defined in MIL-STD-889, shall not be used in direct contact with each other.

3.3.1.1.1 Age Controls. Age controls for synthetic rubber parts except for those parts made of fluorocarbon, silicone, or fluorosilicone compounds, shall comply with MIL-STD-1523.

3.3.1.1.2 O-Ring Seals and Packings. All nonmetallic O-ring seals and packings used in the design of the APU, including vendor supplied components, shall conform to the applicable dimensions and tolerances shown on MS 33666 and MS 33668. The materials selected for such O-ring seals and packings shall be compatible with the fluid being conveyed and insofar as possible shall be of such materials not subject to age controls.

3.3.1.1.2.1 Markings. O-ring seals and packings shall not be marked with any identification. Other synthetic rubber parts, such as diaphragms, shall have printed, stamped with ink or otherwise noted on the part, the year and month of curing.

3.3.1.1.3 Corrosion Protection. The materials, coatings and processes employed in the design and manufacture of the complete APU shall be corrosion resistant. Fabrication processes which might affect the basic grain structure or surface condition, so as to provide a starting point for corrosion, shall be avoided. The APU manufacturer shall identify and submit a list of all protective treatments to the Using Service prior to initiation of the PFRT.

3.3.1.1.4 External Fluid Lines. External fluid lines shall meet the requirements of 3.3.6.1, shall be as short as practicable and shall contain no moisture-collecting traps. Rigid metal lines shall be in accordance with MIL-I-18802 and of corrosion-resistant steel not less than 0.035 inch wall thickness. Flexible lines shall conform to MIL-H-25579. All external lines shall be supported to avoid the detrimental effect of vibration. Tube fittings shall conform to MS 33514 or MS 33656.

3.3.1.2 Fasteners.

3.3.1.2.1 Metallic Inserts. In general, all straight threads in soft alloys such as aluminum shall be provided with metallic inserts in accordance with MS 21209 and inserts shall be installed in accordance with MS 33537.

3.3.1.2.2 Straight 60° Screw Threads. All screw threads shall conform to the requirements of MIL-S-8879, Class 3A or 3B only. The use of MIL-S-7742 is optional for threads used for: (a) electrical connections, (b) screw threads 0.138 inch diameter and smaller, and (c) interference fits and other applications where MIL-S-7742 threads are suitable for the intended purposes such as installation end of studs or external threads of inserts and their mating tapped holes. Duplicate parts differing only in thread form are not permitted.

3.3.1.2.3 Tapered Pipe Threads. Tapered pipe threads may be employed only for permanently plugging drilled or cored openings.

3.3.2 Electromagnetic Interference (EMI). All APU electrical and electronic systems and components shall comply with MIL-STD-461, for Class A1b equipment category. The required RS03 radiated susceptibility field environment for Class A1b equipment shall be as follows:

Volts/Metre	Frequencey Range (Hz)
20	14K - 200M
65	200M - 450M
20	450M - 1.0G
100	1.0G - 12.0G
2*	12.0G - 40.0G

*100 volts/metre at 16.5 and 33.0 GHz.

The APU manufacturer shall conduct a system analysis to verify the need for those tests in MIL-STD-461 which are marked T (Tailored). The APU manufacturer shall submit this analysis for Using Service approval prior to the start of the PFRT. The APU shall not cause or be susceptible to interference beyond the limits specified in these documents. Test techniques shall comply with MIL-STD-462 with Notices 1 and 2. An EMI control plan and an EMI/EMC test plan as required by MIL-STD-461 shall be submitted 60 days prior to the initiation of the PFRT and VT.

3.3.3 Nameplate and Product Marking.

3.3.3.1 Identification of Product and Marking. Equipment, assemblies, modules, and parts shall be marked for identification in accordance with MIL-STD-130. The APU data plate shall include: (a) manufacturer's identification, (b) APU serial number, (c) purchase order or contract number and (d) APU model designation.

Parts which are cyclic or life limited shall be serially numbered and shall have a designated space for marking the number of cycles and time accumulated between each overhaul period.

3.3.3.2 Drawing Revision Marking. In addition to identification marking, all parts shall be marked with the revision letter of the issue of the drawing to which the part was made.

3.3.3.3 Part Number Marking. APU part numbers shall be limited to a maximum of 10 digits or characters.

3.3.4 Workmanship. Workmanship shall be in accordance with the applicable contract requirement.

3.3.5 Interchangeability. All parts having the same manufacturer's part number shall be functionally and dimensionally interchangeable and replaceable with each other with respect to installation and performance, except that matched parts or selective fits will be permitted where required. The use of matched parts and selective fits shall be held to a minimum. Such matched or selected fit parts shall be identified and a listing shall be provided to the Using Service, prior to PFRT and VT.

3.3.6 Safety. The safety criteria and considerations set forth in MIL-STD-882 will be used in establishing APU safety design features.

3.3.6.1 Flammable Fluid Systems. All exterior lines, fittings, and components which convey flammable fluid shall be fire resistant (5 minutes at 2000°F(1090°C)), except that the lubricating oil system and hydraulic system components shall be fireproof (15 minutes at 2000°F(1090°C)) and with exception of the gearbox. During exposure to the above conditions, the lines and components shall be conveying fluids under the worst possible combinations (i.e., lowest flow rate, highest pressure and temperature) of fluid parameters encountered over the environmental conditions and operating envelope of the APU.

3.3.6.2 Explosion-Proof. Electrical components (except igniter plug electrodes) shall not ignite any explosive mixture surrounding the equipment.

3.3.6.3 Fluid Leakage. There shall be no leakage from any part of the APU except through the purging system provided for this purpose. Leakage at the fuel pump or fuel control shaft seals shall be drained in such a manner as to prevent any fuel from entering the oil system.

3.3.6.4 Purging of Combustible Fluids. Provisions shall be made to automatically purge the combustion areas of combustible fluids. The purging system shall be capable of being purged in any of the attitudes permitted in 3.2.1.5.1. All combustible fluids shall be drained into a single bottle which shall remain vapor sealed until the bottle is emptied through the APU gas path during the next start.

3.3.6.5 Ground Safety. Warning notices shall be provided, where applicable, for high voltage electrical sources, noise, and explosive devices.

3.3.6.6 Survivability and Vulnerability.

3.3.6.6.1 Nuclear Safety and Hardening. The APU and all components and associated equipment shall have a nuclear survival capability when operating in nuclear environments as specified by the applicable contract.

3.3.6.6.2 Non-Nuclear. The APU design shall optimize the survival capability of the APU in hostile environments as specified by the applicable contract.

3.3.7 Human Performance and Human Engineering. The principles, criteria, and procedures of human engineering shall be applied to the design of the APU in accordance with the applicable contract requirements.

3.3.8 Structural Performance.

3.3.8.1 Structural Life. Castings, housings and other parts in the non-wearing category shall have unlimited life. Where wearing parts such as press fit bushings are installed, the bosses shall be provided with sufficient material to permit four such reworks and installation of oversize bushings. Expendable parts (such as gaskets and seals, ignitor plugs, etc.) shall be replaced on an on-condition basis and not a time limited basis.

3.3.8.2 High Cycle Fatigue (HCF) Life. All parts of the APU shall exhibit infinite HCF lives when subjected to the maximum total of steady and vibrating stresses which will be encountered during service operation anywhere within the APU operating envelope. For materials which do not have a discrete endurance limit knee on the stress versus cycles to failure curve, the APU manufacturer shall present in the vibration and stress analysis report the method of achieving adequate HCF life. Parts which are subjected to LCF loads in addition to HCF loads shall be designed considering the effect of LCF damage on the material HCF life.

3.3.8.3 Low Cycle Fatigue (LCF) Life. The operational LCF life of each APU part shall be consistent with the parts life requirements specified by the APU manufacturer in Table VI. LCF life requirements apply to all parts of the APU and include both pressure and temperature cyclic effects. LCF life shall be verified by the test in 4.6.6.2.

3.3.8.4 APU Pressure Balance. The APU pressure balance system shall be such that bearing thrust loads experienced throughout the APU operating envelope result in bearing life consistent with the mission and life requirements stated in Table VI. The bearings shall have no detrimental wear or damage within the stated life. An analysis of the loads shall be performed and a report verifying these loads shall be submitted to the Using Service prior to the start of PFRT.

3.3.8.5 APU Pressure Vessel/Case Design. Each APU case and each gas pressure loaded component of the APU shall withstand at least 2.00 times its maximum operating pressure without rupture.

3.3.8.6 Strength and Life Analysis. A strength and life analysis shall be performed and a report submitted, for information only, prior to PFRT and updated prior to VT. Stress analysis shall include items such as APU cases, discs, vanes, blades, mounts, combustion liners, bearing supports, gears, brackets, and tubing based upon Table VI requirement of 8,000 cycles.

3.3.8.7 Design Material Properties. Allowable strength and life material properties shall be based on minus three (-3) sigma value. Fracture toughness properties shall be considered when choosing materials.

3.3.8.8 Creep. The APU static and rotating parts shall not creep to the extent that APU operation is impaired for the operating conditions and the lifetime specified in Table VI. Creep also shall not affect disassembly and reassembly of the APU. The model specification shall state the rate of part growth as it varies with operational time during the endurance portion of verification and the LCF testing.

3.3.8.9 Containment and Rotor Structural Integrity.

3.3.8.9.1 Design. The compressor and turbine cases shall provide containment of damage from rotor blade failures or shall provide design features incorporating provisions of equal degree of safety. The APU manufacturer shall conduct a study of all possible failure modes of high rotational speed portions of the APU with the objective of eliminating the possibility of catastrophic failure where failed parts penetrate the APU cases. Fail-safe designs shall be incorporated to the maximum extent possible and where this is not possible, the design shall incorporate features which will limit the speeds prior to which failure can occur and thereby localize the case damage to an acceptable degree. Particular attention shall be given to the following:

a. The integrity of the turbine and compressor discs with the objective of having the blades fail first under overspeed or overtemperature malfunctions.

b. The integrity of the shafts connecting compressors, turbine and gearboxes such that bearing or lubrication failure shall not cause parting or decoupling of the shaft.

The results of the foregoing study and the fail-safe designs shall be submitted to the government prior to the intiation of the PFRT.

3.3.8.9.2 Rotor Integrity. To provide a necessary margin for rotor structural integrity, the rotors shall be of sufficient strength to withstand the following abnormal conditions without growth beyond the established dimensional limits:

a. Rotor speeds of 115 percent of maximum allowable steady-state speed at maximum allowable measured gas temperature for 5 minutes.

b. Measured gas temperature at least 75°F (42°C) in excess of the maximum allowable measured gas temperature and at maximum allowable steady-state rotor speed for 5 minutes.

Substantiation of this requirement shall be submitted to the Using Service prior to the initiation of the PFRT and VT.

3.3.8.9.3 Disc Burst Speeds. Loaded disc burst speeds shall be no less than 122 percent of the maximum allowable steady-state speed when the disc is subjected to the maximum temperature gradient and maximum material temperature that will occur for that component.

3.3.8.10 Vibration. The APU shall be free of destructive vibration at all APU speeds and load conditions, including steady-state and transient operation, throughout the complete environmental conditions and operating envelope of the APU. The APU mechanical vibration limits shall be specified in 3.2.1.4.10. Vibrations generated by the APU outside the specified frequency range shall not be detrimental to APU operation. The limits shall be based on the APU being installed in a mounting system which has the following dynamic characteristics: The natural frequencies of the mounting system with the APU installed shall be no higher than 80 percent of the combined operating load rotor speed in all modes of vibration which can be excited by the residual rotor unbalances.

Acceleration spectrograms shall be provided at the highest vibrational level in the operating envelope (which shall be identified) and at designated APU load conditions. These spectrograms are to be generated from each transducer shown on the APU configuration and envelope figure for APU vibration monitoring. Critical components of the APU shall be identified on each spectrogram. Each spectrogram shall cover the frequency range of 5 Hz to 10 kHz and present acceleration data in peak g's.

3.3.8.10.1 Critical Speeds. For designs with a fundamental critical speed above the no electrical load rotor speed, a minimum of 20 percent margin shall exist between the no electrical load rotor speed and critical speed. Adequate damping shall be provided if the APU passes through a critical speed below the minimum normal governed rotor speed. There shall be no critical speeds in the operating range between the minimum normal governed rotor speed and maximum allowable transient rotor speed.

3.3.8.10.2 Vibration and Stress Analysis. A vibration and stress analysis shall be accomplished on compressor and turbine stage blade, disc, and vane designs including compressor and turbine shafts and other components where high vibration and stress occur. The vibratory stress distribution and the various modes of vibration including complex modes shall be obtained. The critical speeds, excitation frequencies and stress values for the vibratory stress distributions and nodal patterns shall be determined and correlated with the strength and life analysis. The report shall include the results of actual APU operation or where that is impractical by component test and

analytical study. Analysis of the data shall include the measured and referred stress values at high stress areas on the cases, blades, vanes, discs, shafts, spacers, APU mounts and other instrumented parts. Equations and sample calculations for all analytical methods used shall be included in the report. The data shall show the effects on stress levels due to vibration throughout the operating range of the APU. The report shall show modified Goodman and Campbell diagrams for each component design. Plots of excitation frequency vs rotor speed showing the primary orders of excitation and the modes of vibration shall be plotted with points noting stress, measured and referred. A summary of all critical speeds shall be defined in the report. The vibration and stress analysis report shall be submitted prior to the endurance portion of the PFRT, and updated and re-submitted prior to VT.

3.3.9 Design Control.

3.3.9.1 Standardization. Standardization principles, standard parts, materials, processes, tools, subsystems, and components shall be used to the maximum extent possible without compromise in design or performance of the APU. All parts, materials, and processes, whether or not identified as a Government, industry or manufacturer standard shall be qualified for the intended use as a part of the verification specified herein. Items already in the Government inventory shall be used to the maximum extent possible where suitable for the intended purpose. Variation in similar components or parts shall be held to the absolute minimum. Proprietary designs shall be kept to a minimum. Under conditions wherein economics of production conflict with standardization objectives, the latter group will govern, or the Using Service shall be requested to select the component desired for use.

3.3.9.1.1 Design Standards. MS and AND design standards shall be used unless they are determined by the APU manufacturer to be unsuitable for the purpose. Safety wire shall be used only on control components and only where the safety wire is not involved in intermediate or lower level of maintenance. Safety wire practice shall conform to MS 33540. A list of locations where safety wire is used shall be provided to the Using Service prior to PFRT and VT.

3.3.9.1.2 Standard Parts. The military standard parts developed specifically for use in aircraft engines, and released for use by MIL-BULL-543 and MIL-BULL-544, shall take precedence over any other military standard. Where general purpose standards, as defined by envelope dimensions or Qualified Product List (QPLs), are used, they shall be identified by the APU manufacturer's part number. Parts derived from general purpose standards solely on an inspection or selection basis shall be identified by suppliers part numbers and all previous identification marks shall be removed.

3.3.9.2 Parts List. The parts list for the APU which is granted verification approval based on (1) the satisfactory completion of the PFRT and VT and (2) the approval of the PFRT and VT detail inspections and test reports by the Using Service shall constitute the approved parts list for any subsequent APUs of the same model to be delivered to the Using Service on a production

contract. The APU manufacturer shall assign an item configuration control number to the APU configured by the approved parts list and this number, together with the approved parts list, shall be continuously updated during the life of any production contract to reflect the incorporation of approved Class I or Class II engineering changes. This item configuration control number will be used to identify the APU to be delivered and will also be used for final acceptance of the APU. The approved parts list shall be prepared in accordance with Chapter 600 of DOD-STD-100 and this list shall also show the latest drawing revision letter or number used to manufacture the part incorporated in the APU at the time of acceptance. The use of the so-called "clip system" of attaching engineering change forms to the applicable drawing in lieu of showing the change(s) in the body of the drawing shall not be permitted.

3.3.9.3 Assembly of Components and Parts. Equipment, parts, and components which are not structurally or functionally interchangeable shall not be physically interchangeable. Parts and components shall be designed such that it is physically impossible to install them backwards, upside down, reversed in an assembly, or installed in the wrong location in an assembly. Connections located in close proximity to each other shall be made physically non-interchangeable.

3.3.9.4 Design and Construction Changes.

3.3.9.4.1 Changes in Design. No changes shall be made in the design or material of parts listed in an approved APU parts list, except when such changes are in accordance with the applicable contract requirement.

3.3.9.4.2 Changes in Vendors or Fabrication Process. Changes in vendor, fabrication source or fabrication process of those parts used in the PFRT and VT shall be in accordance with the following procedure:

The APU manufacturer shall prepare and submit to the Using Service a list of those parts, components and assemblies which require a substantiation test to qualify an alternative vendor source or process. The specific test required to qualify parts as APU parts shall be defined and submitted to the Using Service. The fabrication source and process of selected vendor components will be included in this list. The list is subject to review and disapproval by the Using Service in regard to its completeness and to the suitability of the tests. The APU manufacturer shall be responsible for insuring that all parts, components and assemblies on the substantiation list comply with the qualified fabrication source and process, and that any changes to those sources or processes are effectively controlled. The APU manufacturer shall be responsible for performance of substantiation tests to establish satisfactory alternate vendors or fabrication sources or processes. A fabrication source is defined as the prime physical source producing the part, component or assembly. Changes of fabrication location, such as to another plant of an individual vendor, shall be construed as a change of fabrication source.

3.4 Documentation. Documentation to be supplied shall be in accordance with applicable contract requirements.

3.5 Logistics.

3.5.1 Maintenance.

3.5.1.1 Modular Concept. The APU shall be designed for ease of replacement of major APU sections by incorporating the modular concept. Each module shall undergo bench adjustment, including balancing, prior to installation on the APU.

3.5.1.2 Maintenance Inspection Techniques. The APU shall be designed to permit maximum use of nondestructive inspection techniques and multi-purpose test and inspection equipment. Inspection provisions including access envelopes shall be shown on the APU configuration and envelope figure.

3.5.1.3 Service and Accessibility. The design of the APU shall be such that parts requiring routine service checking, adjustment or replacement can be readily accessible without removal of any major part, component or accessory, other than removal of access provisions and locking devices. Particular attention shall also be paid to permit easy replacement of such items as fuel nozzles, ignitors, ignition leads, fuel and oil filter elements, fuel control, air intake screens, drain plugs, etc. In addition, sufficient clearances shall be provided for connecting and removing APU driven components such as the electrical generator, hydraulic motor fluid connection fittings and electrical lead connections.

3.5.1.4 Tools. The APU shall be designed to make maximum use of standard tools and equipment listed in NAVAIR 00-35QG-001 and NAVAIR 00-35QG-016, for servicing, adjustment, assembly and disassembly. The requirement for new special tools, fixtures and test equipment shall be held to a minimum. The use of cadmium plated tools shall be prohibited if titanium materials exist in the APU.

3.5.1.5 Repair Procedures and Wear Limits. The APU manufacturer shall establish after-run wear tolerances, standards and repair procedures prior to the initiation of the endurance portion of the VT.

3.5.2 Supply. The impact of the introduction of the APU and its components on the established military supply systems shall be minimized. The APU and components shall be designed for the utilization of conventional handling equipment and storage facilities. Adequate preservation, packaging and identification shall be used. Predicted usage requirements for and availability of spaces shall be identified for all parts.

3.5.3 Facilities and Facility Equipment. The APU design shall be compatible with existing facilities and facility equipment for installation, servicing,

repair and overhaul. Requirements for new facilities or ancillary equipment to support the APU must be approved by the Using Service.

3.6 Personnel and Training. Personnel and training requirements shall be in accordance with the applicable contract requirements.

3.7 Major Component Characteristics.

3.7.1 Anti-Icing System. The APU anti-icing system shall prevent the accmulation of ice on any APU part while operating under the icing conditions specified in 3.2.5.2. The total loss in performance of 5.0 percent specified in 3.2.5.2 shall include the effects of operation in the icing environment plus the effects of operation of the anti-icing system. The effect of anti-icing system operation in a non-icing environment shall be specified in the model specification.

3.7.1.1 Anti-Icing Interface.

3.7.1.1.1 Anti-Icing System Actuation. Actuation of the system shall be accomplished automatically and the signal requirements for the actuation of the system shall be specified in the model specification.

3.7.1.1.2 Anti-Icing Inlet Ramp. If required, anti-icing air shall be provided to the front of the APU for anti-icing an airframer supplied inlet ramp. Details of the connection shall be shown on the APU configuration and envelope figure. If compressor bleed air is used for this purpose, it shall be considered part of the quantity specified in 3.1.2.11.

3.7.1.2 Type of Anti-Icing. A description of the system shall be included in the model specification. If failure of the anti-icing system occurs, it shall remain in or revert to the anti-icing mode. Continuous operation of the anti-icing system throughout the operating envelope shall not damage the APU. The acceleration performance of the APU when using anti-icing air bleed shall be as specified in 3.2.1.5.5. For electrical anti-icing systems, the APU shall be capable of simultaneous operation of the anti-icing system and all other APU electrical systems.

3.7.2 Control System. The APU control system shall include all control units necessary for complete automatic control of the APU, including remote automatic starting, fuel flow and fuel pump output control, compressor air control, and any other control units as may be required. The control system shall be completely described in the model specification. Provision shall be made in the design of the control to allow ready attachment of remotely actuated devices for all adjustments which may be required in service. The fuel control mounting pad and drive shall conform to a military or recognized industry design standard except that the drive splines shall be positively lubricated with APU lubricating oil. The electrical portion of the control system shall be powered by the APU driven permanent magnet generator (PMG).

3.7.2.1 Control Signals. The control system shall provide for input and output signals as required by the electronic control unit (ECU). The ECU shall meet the requirements of Appendix II.

3.7.2.2 Control System Performance. The control system shall provide control of the APU to obtain the steady-state and transient performance as specified in the model specification. The control system shall automatically prevent the APU from exceeding any of its mechanical or critical temperature limits throughout the environmental conditions and operating envelope of the APU. The control system shall provide the proper relationship between the controlled variables throughout the complete operating range of the APU.

3.7.2.2.1 Shutdown Conditions. The ECU shall incorporate emergency controls that shall automatically shutdown the APU for the following malfunctions:

a. Oil pressure below allowable minimum for more than 30 seconds.

b. Rotor overspeed.

c. Measured exhaust gas temperature limit exceeded for more than 3 seconds.

These controls shall be described in the model specification. The automatic features of a and c shall be rendered inoperative during starting by an overriding electrical signal from the aircraft.

3.7.2.3 Control System Adjustments. External adjustments to the controls, if required, shall be limited to adjustments which can be made correctly with the APU assembled and with reference only to the operating characteristics of the installed APU. These adjustments shall be clearly marked, accessible and adjustable with the APU running. When once adjusted, no further adjustment shall be necessary to provide within-limits operations throughout the entire environmental conditions and operating envelope of the APU. All adjustment provisions shall be shown on the APU configuration and envelope figure. The adjustment provisions shall include, but not limited to, the following.

3.7.2.3.1 Normal Governed Rotor Speed Adjustment. The normal governed rotor speed shall be adjustable within a range of ± 5 percent of the no electrical load rotor speed.

3.7.2.3.2 Acceleration Fuel Flow Adjustment. Provisions shall be provided to adjust the acceleration fuel flow to maintain the starting limits specified in 3.2.1.4.4 and load recovery limits specified in 3.2.1.5.5.

3.7.2.4 Cooling Provisions. If the APU requires a cooling system to meet the requirements of 3.1.2.8.1 the APU manufacturer shall describe the system in the model specification.

3.7.2.5 APU Overspeed System. An APU overspeed device shall be provided which shall take corrective action when any rotor system exceeds its maximum transient rotational speed. The measurement of rotor system speeds used in this system shall be provided by a device which senses rotor system rotational speed.

3.7.3 Fuel System.

3.7.3.1 Fuel Inlet.

3.7.3.1.1 Fuel Inlet Dimensions. The location and interface dimensions at the fuel inlet connections shall be in accordance with figure 1 and shall be shown on the APU configuration and envelope figure.

3.7.3.1.2 Allowable Fuel Inlet Connection Loads. The maximum allowable static (1g) axial, shear and overhung moment loads on the fuel inlet connection shall be specified in the model specification. The maximum allowable loads at this connection shall also be specified for the maximum allowable maneuver loads as defined in figure 2.

3.7.3.2 Fuels.

3.7.3.2.1 Primary Fuel. The APU shall function satisfactorily throughout its environmental conditions and operating envelope for all steady-state and transient operation conditions when using fuel conforming to and having any of the variations in characteristics permitted by MIL-T-5624, grades JP-4 and JP-5.

3.7.3.2.2 Alternate Fuel. The APU shall be capable of starting and operating when using MIL-T-83133, grade JP-8 fuel. The operating limits, performance and transients specified in the model specification, shall not be adversely affected when using alternate fuel. The effects on the APU performance characteristics, changes in fuel flow, changes in starting and stopping time and effects on the aircraft missions when using JP-8 fuel shall be specified. There shall be no effect on the established overhaul time for the APU in 3.2.4.2. Those external adjustments permitted in 3.7.2.3.1 shall be allowed in order to meet this requirement. The APU shall function satisfactorily with JP-8 fuel containing anti-icing additive conforming to MIL-I-27686 and added in a concentration up to 0.15 percent by volume.

3.7.3.2.3 Emergency Fuel. N/A

3.7.3.3 Fuel System Performance.

3.7.3.3.1 Fuel System Calibration Limits. Whenever fuel flow calibrations are required for fuel system components, the applicable limits for this calibration, using test fluid in accordance with MIL-C-7024, Type II, shall be furnished to the Using Service prior to PFRT. The APU fuel system shall not be detrimentally affected by the test fluid.

3.7.3.3.2 Fuel Contamination. The APU shall function satisfactorily when using fuel contaminated in any amount up to the extent specified in Table VII.

3.7.3.3.3 Fuel System Performance with External Assistance. No external assistance shall be required for operation of the APU throughout the environmental conditions and operating envelope.

3.7.3.3.4 Fuel System Performance with No External Assistance. The APU fuel system shall supply the required amount of fuel at the required pressures for operation of the APU throughout its complete operating envelope under the following conditions at the fuel inlet.

a. Fuel Temperature. From the minimum starting temperature shown on figure 3 when using MIL-T-5624 grade JP-4 fuel or that temperature corresponding to a fuel viscosity of 12 centistokes when using MIL-T-5624 grade JP-5 fuel to a maximum temperature of 135°F (57°C).

b. Fuel Pressure. From a minimum of 5.0 psi above the true vapor pressure of the fuel to a maximum of 50 psig with a vapor/liquid ratio of zero.

3.7.3.3.4.1 Fuel Pump. The fuel pump shall prime itself when subjected to a dry lift of one (1) foot at an inlet pressure of nine (9) inches of mercury absolute. The total fuel flow through the pump will be regulated by the fuel control in a manner to eliminate the need for a pump bypass and the resultant recirculation of fuel within the pump. Where such a fuel pump is not provided, a bypass shall be incorporated to limit the fuel discharge pressure to safe limit. The bypassed fuel shall be routed, to the suction side of the pump, by an internal passage within the pump body. The fuel pump shall tolerate the fuel contamination specified in 3.7.3.3.2 and shall pass the fuel pump cavitation test of 4.6.2.2.9 without undue wear.

3.7.3.3.5 Fuel System Performance Under Conditions of Excessive Fuel Vapor. The APU fuel and control system shall have provisions for relieving the vapor or air after operating under excessive vapor liquid ratios. Such vapor or air shall not be discharged into the airframe fuel system.

3.7.3.3.6 Fuel Resistance. In addition to meeting the requirements of 3.3.1.1, the materials and designs used in the APU and components shall conform to established aircraft industry practice. Selection of materials and designs must be based on previous applications in similar systems exposed to the same fluids and environmental conditions. Deviation from proven materials and designs requires approval of the Using Service.

3.7.3.4 Fuel Filter. A fuel filter shall be part of the APU and shall be of sufficient capacity to permit a cumulative fuel flow equivalent to a minimum of 10 hours of continuous APU operation at the combined operating load at sea level with fuel contamination as specified in 3.7.3.3.2 without replacement. The filter assembly shall incorporate a pressure relief bypass and shall be of

a design which will prevent the discharge of filter contaminant through the bypass. The filter assembly shall incorporate an integral differential pressure activated pop-out device that will give visual warning of impending bypass. Once activated, the indicator shall remain visible until manually reset after filter element removal. The filter system shall be described in the model specification.

3.7.4 Electrical Systems.

3.7.4.1 Electrical Power. The primary electrical power for APU ignition and control system operation during starting and throughout the environmental conditions and operating envelope of the APU shall be supplied by the APU driven permanent magnet generator (PMG).

3.7.4.1.1 Permanent Magnet Generator. The APU PMG shall provide the required electrical power from the specified minimum firing speed to maximum APU speed. The PMG shall not be adversely affected by continuous operation at a PMG speed equivalent to 106 percent maximum allowable APU speed under full electrical load, and shall withstand five minutes of operation at overspeeds equivalent 115 percent maximum allowable steady-state APU speed without electrical load. The PMG housing shall completely contain all damage if a mechanical failure should occur when operating at maximum design speed.

3.7.4.2 Alternate Electrical Power. N/A

3.7.4.3 Electrical Interface.

3.7.4.3.1 Electrical Connectors and Cable. All electrical connectors used shall comply with MIL-STD-454, Requirement 10 except upon specific application approval of the Using Service. At a temperature of -65°F (-54°C) it shall be possible to flex electrical cable and conductors during routine maintenance without damage to these items and to connect or disconnect electrical connectors using normal maintenance procedures.

3.7.4.3.2 Electrical Wiring. Wiring within the APU compartment shall conform to MIL-W-81381.

3.7.4.4 Electrical and Electronic Equipment. All electrical and electronic components shall be subjected to the burn-in procedure of 4.7.2.7 prior to component verification testing. All electrical and electronic equipment requiring periodic or routine checkout shall be located for easy access and shall be provided with test connections to facilitate checkout without removal.

3.7.5 Ignition System. If radioactive materials are used in the ignition system, appropriate warning decals shall be affixed to the exterior to ensure proper handling and disposal.

3.7.5.1 Ignition System Interface. The APU ignition system shall be self-contained. The interface requirements shall be shown on the electrical installation connection figure.

3.7.5.2 Ignition System Performance. The APU ignition system shall be electrically self-sufficient requiring no external power. The ignition system shall release sufficient energy for all ground and air starts throughout the complete environmental conditions and operating envelope of the APU. The ignition system shall be described in the model specification including the ratings, in terms of stored energy level and delivered energy level to each ignitor, in joules per spark and spark frequency. The point(s) in the starting envelope where the minimum stored and delivered energy level occurs shall also be specified.

3.7.5.3 Ignition Power Source. The ignition system power source shall be the APU driven PMG.

3.7.5.4 Ignition Lead Assembly. The ignition lead assembly shall be as short as practicable and its capacitance shall not exceed 10 percent of the storage capacitor within the exciter unit. It shall be possible to install or remove the ignitor(s) from the unit at -65°F (-54°C) without mechanical or electrical failure of the ignition lead assembly. The ignition lead assembly shall also be detachable from the ignition power source.

3.7.5.5 Ignition Cable. The high-tension ignition cable shall be radio shielded and shall conform to MIL-C-3702. Low-tension ignition cable, when used, shall conform to MIL-W-81381.

3.7.6 Instrumentation Systems.

3.7.6.1 Condition Indication. The APU shall incorporate sensors for exhaust gas temperature, oil low pressure and rotor speed which are required to provide information to the ECU for safe APU operation, within the established operating limits. The instrument range, system accuracy, time response, and electrical characteristics for each parameter shall be presented in tabular form in the model specification.

3.7.6.2 Pressure Connections. Connections on the APU for mounting fuel, oil, and hydraulic pressure transmitters shall conform to MS 33649-12, and a clearance envelope in accordance with MS 33587 shall be provided. Connections on the APU for transmitting air pressures shall conform to MS 33649-4.

3.7.6.3 Elapsed Time Indicator and Start Counter. The APU shall incorporate devices which indicate the total running time in hours and the total number of starts. The devices shall be easy to read in accordance with MIL-STD-1472 and shall be located for direct viewing through one of the access door openings shown on figure 1. The elapsed time indicator and start counter shall be attached to the APU in such a manner that it will not be removed when any other peripheral component is removed. The start counter shall demonstrate an

accuracy of ±5 percent and shall count each and every time the 95 percent rotor speed signal is received from the ECU. The location and attachment of the elapsed time indicator shall be shown on the APU configuration and envelope figure.

3.7.6.4 Temperature Sensing Systems. The temperature sensing systems of the APU shall provide a signal for the ECU and trouble-shooting. An electrically independent temperature sensing system shall be provided for each component or system requiring a temperature signal input. The output of the sensing devices as a function of temperature and range of normal operation shall be shown in the model specification. If thermocouples are used, the relationship between temperatures and output signal shall be in accordance with the applicable calibration of National Bureau of Standards Monograph 125. The accuracy of the signals in relation to the actual measured temperature and transient time response characteristics shall be specified. The model specification shall contain a brief description of each sensing system including circuitry, construction, number of thermocouples or measuring devices and their locations. When a multi-probe thermocouple system is provided to measure gas temperature, the system shall provide for individual thermocouple probe readings for maintenance temperature spread checks and trouble-shooting. Connectors shall be provided in the thermocouple harness at a convenient location to interface with ground test equipment. Optical or radiation pyrometer temperatures sensing systems shall not require frequent removal for cleaning or recalibration. The cleaning interval shall be specified in the model specification.

3.7.6.5 Vibration Transducer Provisions. The APU shall incorporate provisions (brackets, mountings), in appropriate locations, for installation of vibration transducers. The locations shall be shown on the APU configuration and envelope figure.

3.7.6.6 APU LCF Counter. N/A

3.7.6.7 Speed Indication. The APU shall provide a signal proportional to the rotor speed to the ECU. The speed at 100 percent rotor speed shall be specified in the model specification.

3.7.6.8 Built-In Test.

a. Fault Isolation. The following functions shall be readily visible when located on the ECU.

(1) overspeed

(2) overtemperature

(3) low oil pressure

b. GSE Electrical Connection. A connector with a cap, for connection to the GSE, shall be provided.

3.7.6.9 Servicing Indicators. Indicators shall be provided to assess the need for the services below:

(1) replace fuel filter(s), see 3.7.3.4

(2) replace oil filter(s), see 3.7.7.4.3

(3) add oil, see 3.7.7.4.1.2b

(4) replace oil (contamination), see 3.7.7.4.4

3.7.7 Lubricating System. The lubricating system shall satisfactorily lubricate the APU throughout the complete environmental conditions and operating envelope of the APU in accordance with 3.2.5.1.1. The complete lubricating system, including oil cooler(s) and oil reservoir, shall be furnished as part of the APU. The APU oil system shall provide for lubrication and cooling of the generator described in Appendix I. Degradation of the generator oil system shall not be detrimental to the APU oil system. The APU lubrication system shall be designed to prevent contamination of the oil by seepage of fuel or other fluids into the oil system.

3.7.7.1 Lubricating System Interface

3.7.7.1.1 Oil System Installation and Servicing. The location and pertinent features of oil system interfaces, such as the oil reservoir filler cap, pressure fill ports, drains, oil level indication and vents, shall be shown on the APU configuration and envelope figure and shall be located for ease of maintenance.

3.7.7.2 Lubricants. Selection of lubricants shall be in accordance with MIL-STD-838.

3.7.7.2.1 Lubricating Oil. The APU shall use lubricating oils conforming to MIL-L-7808 and MIL-L-23699, and having any of the variations in characteristics permitted by the oil specifications.

3.7.7.3 Lubricating System Performance. The APU shall function satisfactorily throughout the environmental conditions and operating envelope of the APU, including any of the flight maneuver forces and attitudes of 3.1.2.5 and 3.2.1.5.1, when the oil reservoir contains more than that quantity of oil which is defined as "unusable". The lubrication system shall provide its function within the oil pressure and temperature limits of 3.2.1.4.8, except that with MIL-L-23699 oil, operation is not required at oil temperatures below that temperature corresponding to an oil kinematic viscosity of 13,000 centistokes. Oil consumption shall not exceed the rate specified in 3.2.1.4.9.

3.7.7.3.1 Oil Flow and Heat Rejection. See 3.1.2.8.3 through 3.1.2.8.5.

3.7.7.3.2 Internal Oil Leakage. The lubricating system shall be such that oil leakage within the APU shall not cause oil discharge from the APU upon subsequent starting after shutdown, adversely affect oil supply determination, cause contamination of compressed air, cause residual fires in the APU after shutdown, or cause deposits.

3.7.7.3.3 Oil Interruption. The APU shall operate at maximum continuous compressed air load for a period of 30 seconds during which no oil is supplied to the APU oil pump inlet. As a result of this operation, there shall be no detrimental effects to the APU during the oil interruption period or during subsequent APU operation.

3.7.7.3.4 Oil Wetted Surfaces. The flow characteristics and temperatures at oil wetted surfaces and vents shall be such as to prevent coking and sludge build-up.

3.7.7.4 Lubrication System Components and Features.

3.7.7.4.1 Oil Reservoir. The APU mounted oil reservoir and mountings shall be constructed of corrosion resistant material capable of withstanding, without permanent deformation, the stresses imposed by reservoir pressurization, APU vibration, and cyclic stresses imposed by variations in pressure and temperature. The oil reservoir shall withstand a differential pressure of twice the maximum reservoir operating differential pressure within the operating envelope of the APU without visible leakage or deformation. The reservoir shall also withstand satisfactorily 10,000 cyclic pressure reversals at the maximum reservoir operating pressure within the operating envelope of the APU without visible leakage or permanent deformation. The oil reservoir shall meet the requirements of 3.3.6.1.

3.7.7.4.1.1 Oil Reservoir Capacity. The total enclosed capacity of the oil reservoir, usable oil volume, gulping oil volume, unusable oil volume, and expansion space in pints shall be specified in the model specification. The oil reservoir shall contain an expansion space equal to or greater than 20 percent of the total oil quantity of the reservoir. The oil reservoir shall be of sufficient capacity to provide a "usable" oil quantity equal to a minimum of 15 times the maximum hourly oil consumption specified in the model specification.

3.7.7.4.1.2 Oil Reservoir External Features. The oil reservoir shall contain the following external features necessary to determine the oil level and to service and drain the reservoir:

a. Both manual and pressure oil filler openings with overflow provisions shall be provided in accordance with figure 1. The pressure filler opening shall be sized and located such that with the APU in its installed position, the entire oil tank can be filled in not more than one (1) minute. It shall

not be possible to overfill the oil tank or fill the expansion space provided. The caps and adapter, where required, shall also be provided and shall completely seal the oil tank to prevent any spillage of lubricating oil onto the APU or on any of its accessories. It shall be possible to install and remove the cap by hand at -65°F (-54°C) without the use of tools. The cap shall be fully seated and locked by turning the cap not more than 180 degrees and the cap shall be fastened to the adapter by means of a chain, or its equivalent. The outside of the cap shall be painted black with a fuel and oil resistant paint and marked in yellow with the following information:

"OIL CAP_____US PINTS" indicating the capacity of the oil tank.

b. An indicating device on or in the oil reservoir shall be provided in accordance with figure 1. If a sight gage is used it shall be easily read in any aircraft attitude and shall not discolor.

c. A conveniently accessible drain plug shall be provided for draining the oil reservoir.

3.7.7.4.2 Oil Drain. A drain port shall be provided at the appropriate low point in the oil system for draining the APU oil while the APU is in attitudes ranging from horizontal to 15 degrees nose up and 20 degrees nose down. When modular construction is used, the oil drainage from each sub-unit shall be drained into the oil reservoir. The oil drain shall be provided with a tube connection for draining the oil overboard from the aircraft. The location of the oil drain shall be as shown on figure 1. A readily accessible self-locking drain valve shall be provided at an optimum location in the oil system for obtaining representative oil samples for spectrometric analysis when the APU is mounted in the aircraft. The location of the drain shall be shown on the APU configuration and envelope figure.

3.7.7.4.3 Oil Filter. A disposable oil filter shall be provided in the APU oil system downstream from the oil pressure pump. The type of element, filtration rating in microns, and capacity shall be specified in the model specification. The filter assembly shall incorporate a pressure relief bypass and be of a design which will prevent the discharge of filter contaminant through the bypass. The filter assembly shall provide visual indications when the differential pressure across the element exceeds a specified value. These indications shall remain visible until manually reset after filter element removal.

3.7.7.4.4 Magnetic Plug. Magnetic chip detectors, of a self-closing design, shall be installed in all oil drain ports or in strategic locations where ferro-magnetic particles in the oil would most likely be deposited. The magnetic plugs shall be readily accessible on an installed APU.

3.7.7.4.5 Oil Cooler. The oil cooler shall be supplied as part of the APU. The oil system shall incorporate a pressure relief bypass valve and features which will permit cleaning and inspection.

3.7.7.4.6 Wear Rate Analysis. Reports shall be provided to the Using Service, prior to the endurance portions of the PFRT and VT, which provide guidelines and trend analysis data on spectrometric oil analysis for the chemical elements in the particular APU model. The report shall list the chemical elements and the locations of these elements within all oil wetted systems for use during test and maintenance operations involving spectrometric oil analysis.

3.7.7.4.7 Oil Pressure Pump. The oil pressure pump shall be self-priming and shall maintain not less than the specified oil pressure plus or minus 5 psi for all governed operating speeds and at all altitudes up to 30,000 feet. The oil pressure pump shall also maintain the specified oil pressure when oil containing 10 percent aeration, by volume, is supplied to the oil pump inlet at a pressure of 12 inches of mercury absolute.

3.7.7.4.8 Oil Pressure Sensor. A continuous indication of the oil pressure at the location where the limits of 3.2.1.4.8 are determined, is required.

3.7.8 APU Hydraulic and Pneumatic Systems. N/A

3.7.9 APU Starting.

3.7.9.1 Starter Interface. The hydraulic fluid supply connections shall be in accordance with the interface requirements of figure 1 and shall be shown on the APU configuration and envelope figure.

3.7.9.2 APU Starting Requirements. The APU shall consistently make satisfactory starts on the first attempt within the limits of the starting envelope of 3.2.1.4.4, temperature extremes of 3.2.5.1 and attitude conditions of 3.2.1.5.1; when supplied with hydraulic fluid in accordance with 3.7.9.3 to the hydraulic motor of 3.7.9.4. A satisfactory start shall be a start during which the rotor is accelerated to 95 percent operating rpm from either rest or windmilling speed provided that:

a. The APU stays within operating limits.

b. The total starting time for starts made with no ram, from sea level to 6,000 feet shall be equal to or less than 30 seconds.

c. The total starting time for air starts is equal to or less than 60 seconds. Air starts are considered acceptable only if the APU lights-off within 30 seconds and accelerates to 95 percent operating rpm in a total elapsed time that is equal to or less than 60 seconds. Starting time shall be measured from the initiation of the starting sequence to the attainment of a stabilized uncorrected 95 percent operating rpm.

3.7.9.2.1 Restart Time. The minimum allowable time between shutdown and ground starts, or between starting attempts as determined by APU limitations

shall be specified in the model specification. The times specified shall in no case exceed 30 seconds after the driven rotor system stops turning.

3.7.9.3 Hydraulic Supply Characteristics. The start motor shall be supplied with fluid from the aircraft hydraulic system in accordance with Appendix III.

3.7.9.4 Hydraulic Start Motor. The hydraulic start motor shall be in accordance with MIL-M-7997 type II, Class 3000 motor when operated from a MIL-H-5440 Type II, Class 3000 hydraulic system with either MIL-H-5606 or MIL-H-83282 oil. The hydraulic motor shall be designed for a proof pressure at the inlet port of 1.5 times the maximum operating pressure with the output shaft locked. The burst pressure at the inlet port shall be 2.5 times the maximum operating pressure.

3.7.9.5 Automatic Starting. The APU starting system shall be suitable for complete automatic starting when supplied with fuel and hydraulic fluid in accordance with 3.7.3.3.4 and Appendix III, respectively. The cycle shall be so arranged that the APU will be purged of residual fuel mixture and the ignitor will operate a sufficient time prior to the introduction of fuel to preclude an explosion.

3.7.10 Exhaust Duct System.

3.7.10.1 Exhaust Duct Attachment.

3.7.10.1.1 Exhaust Duct Design and Dimensions. The APU exhaust duct system shall be compatible with the interface requirements of figure 1. Provisions shall be made for a quick-disconnect flange. Interface dimensions for the exhaust duct shall be shown on the APU configuration and envelope figure.

3.7.10.1.2 Allowable Exhaust Duct Connection Stresses. The maximum allowable static (1g) shear, axial and overhung moment loads at the APU exhaust duct flange shall be specified in the model specification. The maximum allowable loads at the APU exhaust duct flange for the maximum allowable combined maneuver and air loads shall also be specified. The maximum allowable maneuver loads are defined in figure 2.

3.7.10.2 Exhaust Duct. The exhaust duct shall be an integral part of the APU and shall be supplied by the APU manufacturer. A brief description of the exhaust duct including the method of attachment shall be included in the model specification. A complete dimensional description of the gas path passages shall be provided in the model specification.

3.7.10.2.1 Exhaust Wake Diagrams. Exhaust wake diagrams showing temperature and velocity profiles in the exhaust wake at sea level static standard day conditions for maximum continuous electrical load and combined operating load; shall be specified in the model specification.

3.7.10.3 Infrared Radiation (IR). N/A

3.7.10.3.1 Infrared Suppression System. N/A

3.7.11 Wash Procedure. The required pressure, flow and composition of the washing medium and the wash procedure for field service use, shall be submitted to the Using Service prior to the initiation of the PFRT.

3.8 Precedence. This specification establishes the requirements for the APU and shall take precedence over referenced documents.

3.9 Quality Verification.

3.9.1 Engineering Evaluation Tests. Engineering evaluation tests shall be conducted for the purposes of acquiring data (for safety, installation, maintainability, quality, etc.) demonstrating results to support analyses, and to establish an APU configuration capable of satisfactorily completing the PFRT and VT. The configuration of each test article and its difference from the PFRT or VT APU configuration shall be identified and justified in each test report. The engineering evaluation test reports shall be submitted as required by the applicable requirement or test paragraph for each test, or prior to the completion of the PFRT and VT as applicable, if no specific delivery dates are given. All required engineering evaluation tests shall be specified in section 4.4 of the model specification.

3.9.2 Preliminary Flight Rating Test (PFRT). The acceptability of the APU for use in experimental flight testing shall be predicated on the satisfactory completion of all PFRT tests in accordance with 4.5 and acceptance by the Using Service of all test reports and analyses required for PFRT.

3.9.3 Verification Test. Qualification of the complete APU as a production model shall be predicated on the satisfactory completion of all verification tests in accordance with 4.6 and acceptance by the Using Service of all required verification test reports, inspection reports, and analyses. Failures or deficiencies in any of the tests will be considered as a failure to qualify the APU model.

3.9.4 Acceptance Test. A test shall be conducted on each APU to be delivered to the Procuring Service and shall consist of those acceptance test requirements specified in 4.7. APUs submitted for engineering evaluation tests, PFRT or VT need not be subjected to acceptance testing. The APU manufacturer shall prepare and submit for approval by the Using Service, a detailed Acceptance Test Procedure in accordance with 4.7.

3.9.5 Sampling Tests. Sampling tests are those tests conducted on selected production APUs to assure that the production APUs are identical to the APUs that have successfully completed the PFRT and VT, and meet all of the requirements of this specification.

4. QUALITY ASSURANCE PROVISIONS

4.1 General. Verification that the APU meets the requirements specified in Section 3 shall be by inspection, analysis, demonstration or test and shall be as specified in this section.

4.1.1 Responsibility for Inspection. Unless otherwise specified in the contract, the APU manufacturer is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract, the APU manufacturer may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Using Service. The Using Service reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

4.2 Quality Conformance Inspections. APUs, components and test apparatus shall be subject to inspection by authorized Government officials who will be given the necessary information and facilities to determine conformance with this specification.

4.3 Manner of Test and Reporting.

4.3.1 Test Surveillance. Each test and demonstration described herein shall be subject to witnessing by authorized Government representatives. At convenient times prior to the tests and during teardown inspections, the APU and components shall be examined to determine if they conform to all requirements of the contract and specifications under which they were built. At no time during the PFRT or VT shall any part of the APU or component be disassembled, adjusted, cleaned, replaced, or removed without prior approval of the Government representative.

4.3.2 Test Article Configuration. The configuration of each test article shall be identified by a specific parts list. The configuration of each test article and its differences from the PFRT or VT endurance APU configuration shall be identified and justified in each detailed test procedure. The parts list for the APU which successfully completes the PFRT tests shall constitute the approved parts list for the PFRT APU model. The parts list for the APUs which successfully complete the VT tests shall constitute the approved parts list for the VT APU model. Design corrections and improvements as substantiated by development test are allowed in the identification of parts differences for each test APU; however, the mixing of parts of the same or different design such as blades in a disc or the mixing of different vendor's components and parts in a multiple assembly such as a segmented stator assembly is not allowable.

4.3.2.1 Test APUs. The particular APU intended for a specific test or demonstration shall be officially designated by the APU manufacturer prior to the start of testing.

4.3.3 Test Apparatus.

4.3.3.1 Automatic Recording Equipment. Automatic continuous recording equipment shall be used to record data during the execution of those parts of the test requiring the evaluation of time versus APU variables.

4.3.3.2 Vibration Measuring Equipment and Response Characteristics. The APU vibration shall be measured with vibration transducers. The vibration measurement and analysis equipment shall operate over a frequency band of at least 5 Hz to 10 kHz and produce acceleration spectrograms with a demonstrated accuracy confidence level of 95 percent. The maximum allowable effective filter bandwidth of the spectrum analysis equipment shall be 30 Hz. The vibration measuring equipment shall be calibrated as a complete system. The frequency response of the system, when calibrated by applying a known sinusoidal motion to the transducer pickup, shall not deviate by more than $\pm$3 dB from the known sinusoidal input at frequencies from 5 Hz to 10 kHz. If high pass filters are required when the vibration measuring system is measuring overall velocity levels, the filters shall have the following characteristics: the filters shall be 3 dB down at frequencies of 30 Hz, 70 Hz, 110 Hz, as appropriate, with a roll-off of at least 18 dB per octave. High pass filters shall not be used to produce acceleration spectrograms.

4.3.3.3 Test Stand Dynamic Characteristics. Vibratory velocity and acceleration shall be measured with the APU operating on a test stand which has the following dynamic characteristics: the natural frequencies of the test stand with the APU installed shall be no higher than 80 percent of the combined operating load rotor speed in all modes of motion which can be excited by residual rotor unbalances.

4.3.3.4 Starting. During PFRT and VT, the APU shall be supplied with hydraulic fluid and hydraulic valve opening characteristics in accordance with 3.7.9.3, and fuel in accordance with 3.7.3.3.4.

4.3.4 Test Condition.

4.3.4.1 Oil Servicing. The oil system shall be drained and filled with new oil at the start of the specific APU test or demonstration. Oil shall be drained from the system only when authorized by the Government representative. The use of external oil filters shall not be permitted.

4.3.4.2 Inlet Duct Connection. During the test of 4.6.1 and 4.6.6.6 the inlet duct connection shall be loaded as specified in 3.1.2.10.2.

4.3.4.3 Compressed Air Connections. During the tests of 4.6.1 and 4.6.6.6, the compressed air connection loads shall be as specified in 3.1.2.11.1.

4.3.4.4 Gearbox Drives. During the tests of 4.5.1.3 and 4.6.1.3, the APU gearbox shall be loaded to the rated loads and overhung moments specified in 3.1.2.7.

4.3.4.5 Accreditable Test Time. Test time shall not be credited by increments shorter than 15 minutes except when shorter periods are a test requirement.

4.3.4.6 Fuel Properties for Test. The fuels used for the PFRT and VT shall be in accordance with 3.7.3.2.1, except when otherwise noted in a particular test paragraph.

4.3.4.7 Burn-In. All new electrical and electronic equipment shall be subjected to the burn-in procedure of 4.7.2.7 prior to testing.

4.3.5 Data. Data shall be submitted or recorded during tests in accordance with the following subparagraphs.

4.3.5.1 Pretest Data. The following data shall be submitted to the Using Service for approval prior to initiation of each test or demonstration required in 4.4, 4.5 and 4.6 which is to be conducted on a specific test APU, test component or component assembly. One document for each test is required. This shall include:

a. The detailed test procedure to be used during the conduct of the test by test personnel.

b. An appropriate configuration identification of the APU, component, or assembly in accordance with 4.3.2.

4.3.5.2 Preliminary Data. The dry weight of the complete APU, center of gravity location, photographs and other pertinent data shall be obtained and recorded at the time the APU is being prepared for test. The weight shall be measured before the APU has been serviced with fuel or oil.

4.3.5.3 Accuracy of Data. For all APU and component calibrations and tests, or demonstrations, reported data shall have a steady-state accuracy within the tolerances shown below. The accuracy of transient data and the corresponding instrument calibration methods shall be subject to the approval of the Using Service and shall be described in the test reports. All instruments and equipment shall be calibrated as necessary to ensure that the required degree of accuracy is maintained.

ITEM OF DATA	
Rotor Speed(s)	±0.2 percent of the value obtained at no load.
Fuel Flow	±1.0 percent of the value being measured.
Airflow	±1.5 percent of the value being measured.
Pressure	±1.0 percent of the value being measured.
Temperature	±5°F (±3°C) or ±1.0 percent of the value being measured, whichever is greater.
Weight	±1.0 pound or ±0.1 percent of the value being measured, whichever is greater.
Vibration Velocity	±5.0 percent of the specified limit.
All Other Data	±2.0 percent of the value obtained at the combined operating load.

4.3.5.4 Steady-State Data. During operation at each specified steady-state condition and after performance stabilization, data shall be recorded as specified in Table VIII.

4.3.5.5 Transient Data. For each transient performed during the transient operations, the data shall be recorded as specified in Table VIII.

4.3.5.6 Starting Data. During each start, the data shall be recorded as specified in Table VIII.

4.3.5.7 Miscellaneous Data. The date, test title, APU model designation, and serial number shall be recorded on each log sheet.

4.3.5.8 Test Notes. Notes shall be placed on the log sheets of all incidents of the run, such as leaks, vibrations and other irregular functioning of the APU or the equipment, such as "flat spots" in acceleration, and corrective measures taken.

4.3.5.9 Barometer Reading. The barometer reading shall be corrected for temperature and shall be read and recorded at intervals not exceeding three hours.

4.3.5.10 Relative Humidity Data. Water vapor pressure readings shall be taken at intervals not exceeding three hours.

4.3.5.11 Fuel and Oil Data. Samples of the fuel and oil shall be taken at the start and completion of the tests of 4.5.1 and 4.6.1 and for other tests as applicable. The fuel and oil samples shall be analyzed for physical and chemical properties to determine conformance with the applicable fuel and oil specifications. The results of these analyses shall be included as part of the applicable test reports.

4.3.5.12 Correction of Data. Data corrections shall be made by a method mutually agreed upon by the Using Service and the APU manufacturer. The agreed upon method shall be submitted to the Using Service prior to the initiation of the VT.

4.3.6 Reports.

4.3.6.1 Test Reports. Following the completion of each separate APU or component test, demonstration or consecutive group of tests or demonstrations conducted on any single test assembly or component, a report shall be submitted. These reports, certified by a Government representative as to proper conduct of the tests, shall constitute the basis for approval of the individual tests. Each report shall contain but is not limited to the following items:

a. Cover (title of report, number of the report, source of report, date, names of the authors, and contract number).

b. Title page (title of report, number of report, source of the report, date, names of the authors, and contract number).

c. Abstract (a brief statement of the contents of the report, including the objective).

d. Table of contents.

e. List of illustrations (provide figure numbers and captions of all illustrations. Photographs, charts and graphs should be treated as illustrations and given figure numbers. When used in a separate series, tables should be given Roman numerals. Examples: figure 1, figure 2, etc., Table I, Table II, and Table III).

f. Summary (brief resume of the test conducted, including objective, procedure, results, conclusions and recommendations referencing the applicable paragraph of the model specification).

g. Body of the report

(1) Brief general description of the APU or of the component and a detailed description of all features which differ from the previous model, if applicable.

(2) If approval is being requested, without test, based on similarity to a component or assembly for which previous test approval was obtained, any physical or functional dissimilarities or differences in testing requirements with respect to the tested component and reference to the approved component test report shall be included.

(3) Method of test (general description of test facility, equipment and methods used in conducting the test).

(4) Record of test (chronological history of all events and incidents in connection with all of the testing, including details of all leaks, vibrations and other irregular functioning, and any adjustments, repairs, replacements of parts and the corresponding APU operating time).

(5) Analysis of results (a complete discussion of all phases of the test, such as probable reason for failure or unusual wear, comparison in performance with previous models, analysis of general operation and any items that are significant from an engineering viewpoint).

(6) Calibrations and recalibration data including acceptance limits. (Data in uncorrected form and corrected form, if applicable, shall be shown by suitable curves. A plot of vibration characteristics in three planes shall be provided for both calibration and recalibration runs.)

(7) For the altitude tests specified in 4.5.3 and 4.6.3 the performance shall be verified as specified in 3.2.1.3.

(8) Tabulated data for all pertinent instrument readings and all required instrument readings taken during the test.

(9) Description of the condition of the APU or components at disassembly inspection. A completed disassembly inspection and material discrepancy description shall be provided for each identified discrepancy.

(10) Conclusions and recommendations, with respect to approval of the APU or components tests, supplemented by such discussion as is necessary for their justification.

(11) Appendix (final approved test procedure).

4.3.6.2 Summary Reports. Following completion of the preliminary flight rating requirements and qualification requirements specified herein, a summary

report for each shall be prepared. These reports shall contain essentially the following items:

a. Cover (title of report, number of the report, source of report, date, security markings).

b. Title page (title of report, number of report, source of report, name of authors, contract number).

c. Abstract (a brief statement of the contents of the report, including the objective).

d. Table of contents.

e. Summary (a brief resume and summary of each of the tests conducted, giving the title of each test, test report number, the items tested, dates of testing, and a general statement of the results).

f. Conclusions and recommendations.

4.4 Engineering Evaluation Tests.

4.4.1 APU Heat Rejection and Oil Cooling. APU heat rejection and cooling requirements data, including the oil system, will be obtained from APUs having substantially the same parts list and configuration as the PFRT endurance test APU, when installed in a simulated aircraft installation. This data shall include cooling requirements, heat rejection rates, and corresponding skin temperatures for various APU components and stations. The data necessary to define the installed cooling requirements shall be obtained for various APU operating conditions, throughout the environmental conditions and APU operating envelope. Reports, including sample calculations, shall be furnished in accordance with the requirements of 3.1.2.8.5.

4.4.2 Oil Flow Interruption Test. An APU, having substantially the same parts list and configuration as the PFRT endurance test APU, shall be subjected to an oil flow interruption test to demonstrate compliance with 3.7.7.3.3. The APU shall be operated at maximum continuous compressed air load for 30 seconds with only air supplied to the inlet of the oil pump. The APU shall operate without damage during the oil flow interruption period and for 30 minutes thereafter with the normal lubrication having been restored. The APU shall be disassembled and inspected to ensure that no damage has occurred. A report on the test results shall be submitted to the Using Service prior to the completion of the PFRT.

4.4.3 APU Electrical Power Failure Tests. N/A

4.4.4 APU Vibration Survey. A vibration survey which demonstrates compliance with the requirements of 3.2.1.4.10 and 3.3.8.10 shall be conducted and a report submitted to the Using Service prior to the initiation of the endurance

portion of the PFRT. The vibration survey shall include, but not necessarily be limited to, data showing true RMS velocity spectrograms and peak acceleration spectrograms for each transducer location and for each internally mounted transducer at the highest vibration point in the operating envelope (which shall be identified) and at each of the APU rating points. The spectrograms shall cover the frequency range of at least 5 Hz to 10 kHz. Critical components of the APU shall be identified on both velocity and acceleration spectrograms. The method used for determining the overall true RMS velocity from the velocity spectrogram and the maximum permissible overall true RMS velocity limit shall be described.

4.4.5 Starting. Prior to start of PFRT, an APU shall be tested to demonstrate compliance with the starting requirements of 3.7.9.2. The APU shall be started and operated for one minute and shutdown. This procedure shall be repeated until the APU has started, satisfactorily, 10 consecutive times. A test report shall be submitted to the Using Service prior to the initiation of the PFRT.

4.4.6 APU Pressure Balance Verification. Tests shall be conducted to verify the APU pressure balance analysis specified in 3.3.8.4. A test report shall be submitted to the Using Service prior to the initiation of the PFRT.

4.4.7 Maintainability/Maintenance Demonstration. A maintainability/maintenance demonstration shall be performed by the APU manufacturer on an APU substantially identical to the VT endurance APU and having an accumulated operating time of 200 hours or more to demonstrate compliance with 3.2.4 and 3.5.1. The demonstration activity shall cover complete disassembly and reassembly of the APU including a demonstration of the length of time and procedures used to remove and replace APU modules and APU components that are separately removable. During this demonstration, the extent to which standard tools can be used for APU disassembly and reassembly and the suitability of all special tooling shall be demonstrated.

A demonstration of APU maintenance inspection provisions shall be performed to demonstrate that location and access will permit suitable inspection.

After the APU has been reassembled, a demonstration of APU rigging procedures (control, guide vanes, etc.) shall be performed to evaluate the equipment used, checking procedures and range of tolerances. In addition, all components which require routine or relatively frequent removal and replacement in service such as fuel and oil filters, ignitor plugs, oil tank filler caps, etc., shall be removed and reassembled at least 100 times.

At the completion of the above demonstrations, the reassembled APU shall be installed on a test stand and subjected to a test run of sufficient duration to verify satisfactory steady-state and transient performance.

A report on the maintainability maintenance demonstration and the test run shall be submitted to the Using Service prior to the completion of the VT.

4.4.8 Material Corrosion Test. Material corrosion tests shall be conducted on selected materials and coatings in accordance with 3.2.5.5. After test, specimens shall be free of reaction products.

4.5 Preliminary Flight Rating Test (PFRT).

4.5.1 Endurance Test.

4.5.1.1 Pretest Verification.

4.5.1.1.1 APU Dry Weight. Prior to initiation of calibrations, the dry weight of the APU, as specified in 3.2.2.1 shall be verified in accordance with 4.3.5.2.

4.5.1.1.2 Electromagnetic Interference and Susceptibility Tests. Electromagnetic interference and susceptibility tests shall be made on all electrical and electronic components or systems of the APU prior to initiation of the PFRT endurance test. The tests shall be consistent with 3.3.2 requirements when using the measuring equipment described in MIL-STD-461. The tests shall be conducted in accordance with the methods, procedures and techniques of MIL-STD-462.

4.5.1.1.3 Overspeed Control Test. With the normal speed governing system rendered inoperative, the APU shall be oversped at no electrical load condition until the overspeed control functions. This test shall be repeated until the ECU has demonstrated, on 10 consecutive trials, the ability to limit the APU rotor speed to the actuation speed specified in 3.2.1.4.6.

4.5.1.1.4 Stopping. Tests shall be performed to demonstrate the requirements of 3.2.1.5.3.

4.5.1.2 Calibration (PFRT).

4.5.1.2.1 Temperature Sensing System Calibration. The APU temperature sensing systems shall be checked on the bench and on the APU to establish their proper functioning and calibration over the range of the APU operating conditions. The performance shall meet the tolerance and thermal response characteristics of 3.7.6.4.

4.5.1.2.2 APU Control System Calibration. Prior to the initiation of the APU calibration specified in 4.5.1.2.3, all fuel nozzles, and the components of the APU control system, shall undergo bench calibrations using fluid in accordance with 3.7.3.3.1. The system shall conform to the design tolerance range required by the applicable design specification.

4.5.1.2.3 APU Calibration. The procedure during the APU calibration shall be such as to establish the performance characteristics of the complete APU. Prior to the beginning of the calibration, the APU shall be cleaned using the wash procedure of 3.7.11. The APU controls shall be adjusted and shall not be

readjusted throughout the calibration. During calibration, APU inlet air shall be controlled to the temperature specified for the APU rating. The fuel and oil used shall be the same as those used during 4.5.1.3. Data indicated for calibration in 4.3.5.4 and 4.3.5.5 shall be recorded. During calibration, conformance with the leakage requirement of 3.3.6.3 and shutdown drainage requirements of 3.3.6.4 shall be demonstrated. The following data shall be obtained:

a. Data required to establish compliance with sea level performance ratings in Table I of the model specification.

b. Data required to establish compliance with 3.2.1.5.4, 3.2.1.5.5 and 3.7.9.2.

4.5.1.2.3.1 Compressed Air Analysis. Compressed air shall be sampled from the compressed air outlet during a combined operating load run. A sample of air entering the APU inlet shall be taken at the same time the compressed air samples are obtained. The samples shall be properly identified and processed through laboratory analysis to determine whether the contaminant levels are within the limits specified in 3.1.2.11.3. The results of the analysis and the methods and test apparatus used shall be detailed in the APU test report.

4.5.1.3 Endurance Test Procedure.

4.5.1.3.1 Endurance Test Requirements.

a. The endurance test shall be run at prevailing ambient conditions.

b. The oil pressure, if adjustable, shall be adjusted at the beginning of the test to the minimum steady-state value specified in 3.2.1.4.8. No further adjustment shall be permitted during the test except when authorized by the Using Service. Oil consumption shall be determined and reported after each cycle. Samples of oil shall be taken and spectrometric oil analysis performed, after the calibration run and at the completion of each endurance cycle. Analysis and reporting of any one sample shall not lag the actual sampling by more than 3 cycles. Oil drained for analysis shall not be charged to APU oil consumption and shall be replaced by an equivalent amount of new oil.

c. Drive pads shall be subjected to rated loads and overhung moments. The actual torque loading and overhung moments imposed during the endurance test shall be stated in the test report.

d. Hydraulic starting fluid shall be supplied per 3.7.9.3.

e. At the completion of the endurance runs, the APU oil drain provisions specified in 3.7.7.4.2 shall be demonstrated. This demonstration shall also verify the adequacy of the port provided for obtaining oil samples for

spectrometric analysis, and the drain locations for the magnetic chip detectors.

f. If the APU is equipped with an anti-icing system it shall be operated every 8th cycle.

4.5.1.3.2 Endurance Test Schedule. The APU shall be subjected to a 300-hour endurance test consisting of 100 three-hour cycles, when using MIL-L-23699 oil and MIL-T-5624 grade JP-5 fuel. Each PFRT cycle shall consist of the sequence of APU loadings specified in Table VI for the durations specified in the two starts/hour column. Each cycle shall be preceded by a minimum six-minute shutdown. The time for changing load conditions shall be charged to the duration of the lower load. Change in load conditions shall be accomplished in not more than 0.5 second.

4.5.1.3.3 Starts. A minimum of 600 starts shall be made on the endurance test APU. In addition to the 600 endurance test starts, there shall be 10 false starts (a starting sequence without benefit of light-off followed immediately after the permissible APU draining time by a successful start), and 20 restarts (a start within a maximum of 100 minutes time from shutdown). During these starts, immediately after the APU has reached no electrical load, an acceleration to maximum continuous electrical load shall be accomplished in not more than 0.5 second. The APU shall be held at maximum electrical power for one minute and immediately shutdown. The shutdown time between the 20 restarts shall be of durations of 5, 10, 15 minutes and increasing by 5 minute increments for each shutdown period thereafter up to and including 100 minutes.

4.5.1.4 Recalibrations (PFRT).

4.5.1.4.1 APU Recalibration. After completion of the tests specified in 4.5.1.3, a recalibration in accordance with the requirements of 4.5.1.2.3 shall be made on the endurance test, APU. The recalibration shall be conducted with the APU adjusted to produce the values of measured exhaust gas temperatures and rotor speeds obtained during the initial calibration. The recalibration may be preceded by a specified run during which the cleaning procedures of 3.7.11 shall be applied. The fuel and oil used shall be the same as those during the initial calibration.

4.5.1.4.2 Temperature Sensing System Recalibration. After completion of the APU recalibration, the APU temperature sensing system shall be rechecked to establish its proper functioning and calibration in accordance with 4.5.1.2.1. The performance shall meet the tolerance range and thermal response characteristics of 3.7.6.4.

4.5.1.4.3 APU Control System Recalibration. After completion of the APU recalibration, all components, including fuel nozzles, of the APU control system shall undergo a bench recalibration to determine conformance with the design tolerance range required by the applicable design specifications. For

this recalibration, external APU control adjustments shall be established at their pretest bench calibration physical settings.

4.5.1.5 APU Disassembly and Inspection. The APU completing the endurance test shall be completely disassembled for examination of all parts. Prior to cleaning, the APU parts shall be given a "dirty inspection" for evidence of leakage, oil coking, unusual heat patterns, and abnormal conditions. The "dirty inspection" shall be completed before any parts are cleaned. The APU parts shall then be cleaned and a "clean inspection" shall then be performed. APU part measurements shall be taken as necessary to inspect for excessive wear and distortion. These measurements shall be compared with the APU manufacturer's drawing dimensions and tolerances and with similar measurements made prior to the test. Inspection techniques may also include but not be limited to: magnetic particles, fluorescent penetration, X-ray, and ultrasonics. During the "clean inspection" a visible examination and condition assessment shall be conducted. Upon completion of "clean inspection", the Using Service shall be provided all results of non-destructive tests and recommendations for modification or redesign of deficient parts. The Using Service shall be notified of the inspection commencement date prior to each inspection. The following data shall be made available to the Using Service during both inspections:

a. Inspection forms filled out by the APU manufacturer listing all observed deficiencies.

b. Tabulation of all parts found deficient.

c. Detailed configuration list of the component or system tested.

d. Test logs and list of test events.

e. Spectrometric oil analysis report.

f. Other as required.

4.5.1.6 Endurance Test Completion. The endurance test will be considered to be satisfactorily completed when the APU has completed the endurance test of 4.5.1 and during the APU recalibration, the corrected electrical power and compressed air flow ratio and pressures are not less than 97.5 percent of the initial calibration values and the fuel flows and measured exhaust gas temperatures are not greater than 102.5 percent of the initial calibration values; the APU meets all other specified performance requirements which can be checked by the calibration procedure; and, in the judgment of the Using Service, the test APU and components are operating satisfactorily at the end of the tests, recalibrations do not reveal excessive performance deteriorations, and teardown inspections do not disclose parts failure nor indicate imminent failures. Parts will not be judged to have passed the endurance test until they have successfully completed the entire 300 hours of the endurance test.

4.5.2 APU Component Tests. The following tests shall be conducted on components conforming to the same parts list and configuration used on the PFRT endurance test.

4.5.2.1 Previous Component Approval. APU components requiring testing as specified herein may have these tests waived at the option of the Using Service, if the component has been previously approved by the Using Service for use on another APU. All such components must conform to the same parts list and configuration as the components previously approved.

4.5.2.2 Explosion-Proof Test. All electrical components, including electrical connectors, not hermetically sealed shall be subjected to explosion-proof testing in accordance with MIL-STD-810, Method 511, Procedure I. During the test, components shall have maximum input voltage applied to them and shall be operated continuously at their maximum loads. During each altitude condition, all make and break contacts shall be operated at least 10 times. An overvoltage power supply transient shall be applied to the components at least 4 times during each altitude condition. At least 4 of these power supply transients shall be applied during operation of make and break contracts. Power supply transients shall consist of the application of an overvoltage for the times specified in MIL-STD-704. The 4 points selected for performance of an overvoltage shall include points within 10 percent of the following: 150, 140, 130, and 125 volts ac, RMS line to neutral, or 80, 60, 40, and 35 volts dc. Ignition components or systems shall be operated continuously. Electrodes of spark igniters shall be mounted in such a manner that the explosive vapor in the test chamber shall not be contacted. Electrically self-sufficient ignition systems shall be exempted from the application of power supply transients. Failure criteria shall be as defined in MIL-STD-810, Method 511.

4.5.2.3 Fuel Pump Altitude Test. The portion of the APU fuel system from the fuel inlet of the APU to the APU fuel pump, shall be simulated in the test assembly. This shall include lines, fittings, filters, and other items as applicable between the APU fuel inlet and fuel pump inlet as well as any elements of the fuel system downstream of the pump which might have an effect on the pump. All independent and separately replaceable fuel pumps shall be operated for 5 hours at flow and pressure conditions corresponding to those required by design maximum APU performance at 30,000 feet altitude conditions. The fuel shall be in accordance with MIL-T-5624, grade JP-4.

The fuel pressure at the APU inlet shall be maintained from a minimum of 5.0 psi above the true vapor pressure to a maximum of 50 psig with a vapor/liquid rate of zero.

During this test the fuel pump dry lift capability defined in 3.7.3.3.4.1 shall also be verified.

The fuel pump altitude test shall be considered to be satisfactorily completed when, in the judgment of the Using Service, the pump performance during the

course of testing and the performance deterioration, determined from calibration runs, conform to the requirements established by the applicable design specification and do not adversely affect APU performance; the pump dry lift capability as defined in 3.7.3.3.4.1 has been verified; and the component teardown inspection does not disclose parts failure or impending failures.

4.5.2.4 Oil Reservoir Pressure Test. The reservoir with filler cap installed shall be subjected to differential pressures in accordance with 3.7.7.4.1 for a period of 30 minutes. No leakage or deformation shall occur.

4.5.2.5 Fire Test. Lines, fittings and components, which convey flammable fluids shall be tested to verify conformance with 3.3.6.1. Individual lines, fittings, components or assemblies shall be tested as specified in ARP 1055 while conveying fluids at the lowest flow rate, highest system pressure and highest fluid temperature possible over the complete APU operating envelope. The requirements of 3.3.6.1 shall be considered verified, if at the completion of the test period, there are no leaks.

4.5.3 Altitude Tests. An APU, conforming to the same parts list and configuration as the endurance test APU, shall be subjected to altitude tests which shall consist of operation and air starting checks at several selected conditions within the operating limits envelope specified for the APU and at least those given in the model specification as shown in figure 10. The test points shall include the effects of inlet recovery on performance and stability. Data to be taken and recorded during the test shall be as specified in Table VIII. Control system adjustments shall not be made without approval of the Government representative. The altitude tests shall be accomplished using MIL-T-5624 grade JP-5 fuel and MIL-L-23699 oil. Fuel temperature shall be varied over a range sufficient to encompass all anticipated APU operating environments.

Overall true RMS velocity measurements and acceleration spectrograms shall be obtained for each transducer mounted on the APU case at the load conditions selected for the test. The points selected shall include at least the altitude rating points and the point in the operating envelope where the highest vibrational levels are generated. Critical components of the APU shall be identified on each spectrogram. The compressed air flow shall be sampled and analyzed in accordance with 4.5.1.2.3.1 during runs selected by the Using Service.

4.5.3.1 Altitude APU Calibration. Prior to the initiation of the testing described in 4.5.3.2, the APU shall be calibrated in accordance with 4.5.1.2.3 and 4.5.1.2.3.1. No control readjustments shall be made after the initial adjustments at the beginning of the calibration.

4.5.3.2 Altitude Test Procedure. Operation at each test point shall be of sufficient duration to stabilize the APU and to establish the performance and operating characteristics of the APU. Operation shall be conducted to obtain the following data:

a. Altitude Rating Points. The test conditions shall be those specified for altitude ratings in Table II of the model specification. A sufficient number of additional APU load conditions shall be selected for each specified altitude test point to establish operating and performance characteristics at rated conditions. The time elapsed versus rotor speed, electrical power, compressed air, measured exhaust gas temperature and fuel flow shall be obtained for stability verification with load conditions of no electrical load, maximum continuous compressed air load, maximum continuous electrical load and combined operating load. The time period for stability verification shall be a minumum of 5 minutes at each load condition.

b. Transient Operation. The applicable transient performance specified in 3.2.1.5.5 shall be demonstrated at each rating condition. The effects of compressed air singularly and in combination with electrical power, on transient performance, shall be determined.

c. Functional Test. The operating envelope of the APU shall be verified by running the APU at the extremities of the operating envelope. APU steady-state and transient characteristics shall be determined at each test point over the range of load conditions. Effect of inlet distortion on transient operation and steady-state performance shall be determined.

d. Starts and Restarts. APU starts and restarts, shall be accomplished at each of the starting points specified on figure 10.

4.5.3.3 Altitude Test Completion. Comparison of observed data obtained during the test to the specified performance and operating characteristics shall be made by a method acceptable to the Using Service to determine compliance with the model specification. The test shall be considered to be satisfactorily completed when, in the judgment of the Using Service:

a. The APU performance is at least that specified in the performance curves and rating tables; except that the compressed air temperature, rotor speed and total inlet airflow shall be within the applicable tolerance band.

b. The altitude starting and transients conducted during the test are in accordance with the model specification requirements.

c. The functional test points demonstrate satisfactory APU operation and do not show any discrepancies with the performance curves altitude starting data or transient data.

d. The APU operates satisfactorily under the distortion conditions specified for test.

4.5.4 Structural Tests. APUs or components conforming to the parts list and configuration of the PFRT endurance test APU shall be used for the following tests.

4.5.4.1 APU Power Section Pressure Tests. Each APU power section case and all gas pressure loaded components of the APU subjected to compressor discharge pressure shall be tested to 2.0 times maximum operating pressure without rupture to verify the requirements of 3.3.8.5. These tests shall be conducted at the maximum operating temperature of the component or the test pressure shall be adjusted for material properties at the test temperatures.

4.5.4.2 Rotor Structural Integrity.

4.5.4.2.1 Overspeed. Turbine and compressor rotors shall be subjected to APU operation for a stabilized period of at least 5 minutes duration, at maximum allowable measured temperature at 115 percent of maximum allowable steady-state speed. Following the test, parts and assemblies shall be within allowable dimensional limits and there shall be no evidence of imminent failure.

4.5.4.2.2 Overtemperature. Upon successful completion of the overspeed test of 4.5.4.2.1, the same APU shall be operated at a measured temperature of at least 75°F (42°C) in excess of the maximum allowable steady-state measured exhaust gas temperature at no less than maximum allowable steady-state speed for 5 minutes. Following the test, parts and assemblies shall be within allowable dimensional limits and there shall be no evidence of imminent failure.

4.5.4.2.3 Disk Burst Test. Spin pit testing shall be conducted on all critical rotating disk components of the APU. Components shall be operated to a minumum of 122 percent of maximum allowable steady-state speed with the bore metal at maximum design bore metal temperature without failure or evidence of imminent failure.

4.5.4.3 APU Static Load Test. The APU cases and mounts of the endurance APU configuration shall be subjected to a static test to verify the requirements of 3.1.2.5 and 3.1.2.6. A static rig test utilizing the applicable APU static structure shall be conducted to demonstrate the capability of the APU and its supports to withstand maximum externally applied forces specified in 3.1.2.5 without permanent deformation of any component and 1.5 times those forces without failure of any component. In this test, maximum thrust loads, acceleration loads, gyroscopic moments, torque and APU reaction loads will be applied separately and then in combination. Stress and deflection data will be obtained at critical locations as determined by analysis and preliminary stress coating tests.

4.5.4.4 Attitude Test. The APU shall be subjected to an attitude test to demonstrate compliance with the requirements of 3.2.1.5.1 and 3.7.7.3. The APU shall be started, and then operated at the combined operating load for at least 30 minutes at each of the test points shown in the shaded area of figure 7. The APU shall also be operated at shaded rotor speeds for at least 30 seconds at each of the test points shown in the clear area of figure 7. This test will be considered satisfactorily completed when, in the judgment of the

Using Service, the APU started satisfactorily, remained within all operating limits, and there is no evidence of mechanical damage.

4.6 Verification Test (VT).

4.6.1 Endurance Test.

4.6.1.1 Pretest Verification.

4.6.1.1.1 APU Dry Weight. Prior to initiation of the calibration, the dry weight of the APU as specified in 3.2.2.1 shall be verified in accordance with 4.3.5.2.

4.6.1.1.2 Electromagnetic Interference and Susceptibility Tests. Electromagnetic interference and susceptibility tests shall be made on all electrical and electronic components or systems of the APU prior to initiation of the VT endurance test. The tests shall be consistent with the 3.3.2 requirements when using the measuring equipment described in MIL-STD-461. The tests shall be conducted in accordance with the methods, procedures, and techniques of MIL-STD-462.

4.6.1.1.3 Overspeed Control Test. With the normal speed governing system rendered inoperative, the APU shall be oversped with no electrical load until the overspeed control functions. This test shall be repeated until the ECU has demonstrated, on 10 consecutive trials, the ability to limit the APU rotor speed to the actuation speed specified in 3.2.1.4.6.

4.6.1.1.4 Stopping. Tests shall be performed to demonstrate the requirements of 3.2.1.5.3.

4.6.1.2 Calibrations (VT).

4.6.1.2.1 Temperature Sensing System Calibration. The APU temperature sensing systems shall be checked on the bench and in the APU to establish their proper functioning and calibration over the range of the APU operating conditions. The performance shall meet the tolerance and thermal response characteristics specified in 3.7.6.4.

4.6.1.2.2 APU Control System Calibration. Prior to the initiation of the APU calibration specified in 4.6.1.2.3 all fuel nozzles, and the components of the APU control system, shall undergo bench calibrations using fluid in accordance with 3.7.3.3.1. The system shall conform to the design tolerance range required by the applicable design specifications.

4.6.1.2.3 APU Calibration. The procedure during the APU calibration shall be such as to establish the performance characteristics of the complete APU. Prior to the beginning of the calibration, the APU shall be cleaned using the wash procedure of 3.7.11. The APU controls shall be adjusted and shall not be readjusted throughout the calibration. During calibration, APU inlet air

shall be controlled to the temperature for the APU rating. The fuel and oil used shall be the same as those used during 4.6.1.3. Data indicated for calibration in 4.3.5.4 and 4.3.5.5 shall be recorded. During calibration, conformance with the leakage requirements of 3.3.6.3 and the shutdown drain requirements of 3.3.6.4 shall be demonstrated. The following data shall be obtained:

a. Data required to establish compliance with the sea level performance ratings in Table I of the model specification.

b. Data required to establish compliance with 3.2.1.5.4, 3.2.1.5.5 and 3.7.9.2.

4.6.1.2.3.1 Compressed Air Analysis Compressed air shall be sampled from the compressed air outlet during a combined operating load run. A sample of air entering the APU inlet shall be taken at the same time the compressed air samples are obtained. The samples shall be properly identified and processed through laboratory analysis to determine whether the contaminant levels are within the limits specified in 3.1.2.11.3. The results of the analysis, the methods and test apparatus used shall be detailed in the APU test report.

4.6.1.3 Endurance Test Procedure.

4.6.1.3.1 Endurance Test Requirements.

a. The endurance test shall be run at prevailing ambient conditions.

b. The oil pressure, if adjustable, shall be adjusted at the beginning of the test to the minimum steady-state value specified in 3.2.1.4.8. No further adjustments shall be permitted during the test except when authorized by the Using Service. Oil consumption shall be determined and reported after each cycle. Samples of oil shall be taken and spectrometric oil analysis performed, after the calibration run and at the completion of each endurance cycle. Analysis and reporting of any one sample shall not lag the actual sampling by more than 3 cycles. Oil drained for analysis shall not be charged to APU oil consumption and shall be replaced by an equivalent amount of new oil.

c. Drive pads shall be subjected to rated loads and overhung moments. The actual torque loading and overhung moments imposed during the endurance test shall be stated in the test report.

d. Hydraulic starter fluid shall be supplied per 3.7.9.3.

e. At the completion of the endurance runs, the APU oil drain provisions specified in 3.7.7.4.2 shall be demonstrated. This demonstration shall also verify the adequacy of the port provided for obtaining oil samples for spectrometric analysis, and the drain locations for the magnetic chip detectors.

f. If the APU is equipped with an anti-icing system it shall be operated every 16th cycle.

g. During the test, the exhaust duct, inlet duct, and compressed air duct connections shall be loaded as specified in the model specification.

h. Inlet fuel shall be maintained at minimum specified fuel pressure throughout the test. During 5 successive cycles of the endurance test, the temperature of the fuel shall be maintained at the maximum temperature specified in 3.7.3.3.4.

i. During every 4th cycle the oil temperature shall be maintained at no less than the maximum oil temperature specified in 3.2.1.4.8.

4.6.1.3.2 Endurance Test Schedule. The APU shall be subjected to a 1002-hour endurance test consisting of 334 three-hour cycles, when using MIL-L-23699 oil and MIL-T-5624 grade JP-5 fuel. Each VT cycle shall consist of the sequence of APU loadings specified in Table VI for the durations specified in the ten starts/hour column, when repeated four times. Each cycle shall be preceded by a minimum six-minute shutdown. The time for changing load conditions shall be charged to the duration of the lower load.

4.6.1.3.3 Starts. A minimum of 8016 starts shall be made on the endurance test APU. In addition to the 8016 endurance test starts, there shall be 10 false starts (a starting sequence without benefit of light-off followed immediately after the permissible APU draining time by a successful start), and 20 restarts (a start within a maximum of 100 minutes times from shutdown). During these starts, immediately after the APU has reached no electrical load, and acceleration to maximum continuous electrical load shall be accomplished in not more than 0.5 seconds. The APU shall be held at maximum electrical power for one minute and immediately shutdown. The shutdown time between the 20 restarts shall be of durations of 5, 10, 15 minutes and increasing by 5 minute increments for each shutdown period thereafter up to and including 100 minutes.

4.6.1.4 Recalibrations (VT).

4.6.1.4.1 APU Recalibration. After completion of the tests specified in 4.6.1.3, a recalibration in accordance with the requirements of 4.6.1.2.3 shall be made on the endurance test APU. The recalibration shall be conducted with the APU adjusted to produce the values of measured exhaust gas temperatures and rotor speeds obtained during the initial calibration. The recalibration may be preceded by a specified run during which the cleaning procedures of 3.7.11 shall be applied. The fuel and oil used shall be the same as those during the initial calibration.

4.6.1.4.2 Temperature Sensing System Recalibration. After completion of the APU recalibration, the APU temperature sensing system shall be rechecked to establish its proper functioning and calibration in accordance with 4.6.1.2.1.

The performance shall meet the tolerance range and thermal response characteristics of 3.7.6.4.

4.6.1.4.3 APU Control System Recalibration. After completion of the APU recalibration, all components, including fuel nozzles, of the APU control system shall undergo a bench recalibration to determine conformance with allowable service limits specified by the applicable design specifications. For this recalibration, external APU control adjustments shall be established at their pretest bench calibration physical settings.

4.6.1.5 APU Disassembly and Inspection. Each APU completing the endurance test shall be completely disassembled for examination of all parts. Prior to cleaning, the APU parts shall be given a "dirty inspection" for evidence of leakage, oil coking, unusual heat patterns, and abnormal conditions. The "dirty inspection" shall be completed before any parts are cleaned. The APU parts shall then be cleaned and a "clean inspection" shall then be performed. APU part measurements shall be taken as necessary to inspect for excessive wear and distortion. These measurements shall be compared with the APU manufacturer's drawing dimensions and tolerances and with similar measurements made prior to the test. Inspection techniques may also include but not be limited to: magnetic particles, fluorescent penetration, X-ray, and ultrasonics. During the "clean inspection" a visible examination and condition assessment shall be conducted. Upon completion of "clean inspection", the Using Service shall be provided all results of non-destructive tests and recommendations for modification or redesign of deficient parts. The Using Service shall be notified of the inspection commencement date prior to each inspection. The following data shall be made available to the Using Service during both inspections:

a. Inspection forms filled out by the APU manufacturer listing all observed deficiencies.

b. Tabulation of all parts found deficient.

c. Detailed configuration list of the component or system tested.

d. Test logs and list of test events.

e. Spectrometric oil analysis report.

f. Other as required.

4.6.1.6 Endurance Test Completion. The endurance test will be considered to be satisfactorily completed when the APU has completed the endurance test of 4.6.1 and during the APU recalibration, the corrected electrical power and compressed air flow rates and pressures are not less than 97.5 percent of the initial calibration values and the fuel flows and measured exhaust gas temperatures are not greater than 102.5 percent of the initial calibration values; the APU meets all other specified performance requirements which can

be checked by the calibration procedure; and, in the judgment of the Using Service, the test APU and components are operating satisfactorily at the end of the tests, recalibrations do not reveal excessive performance deteriorations, and teardown inspections do not disclose parts failure or impending failures. Parts will not be judged to have passed the endurance test until they have successfully completed the entire 1002 hours of the endurance test.

4.6.2 APU Component Tests. The following tests shall be conducted on all components listed under 3.1.3 of the model specification. All components shall conform to the same parts list and configuration as those used on the endurance test APUs.

4.6.2.1 Previous Component Approval. APU components requiring testing as specified herein may have these tests waived at the option of the Using Service, if the component has been previously approved by the Using Service for use on another APU. All such components must conform to the same parts list and configuration as the components previously approved.

4.6.2.2 Simulated Operational Component Tests. The following test pertains to the fuel system, ignition system, anti-icing system, and APU control system, including temperature sensing components. Tests shall be conducted in the order listed. All simulated operational tests shall be conducted on the same test assemblies, consisting of groups of related components so arranged and interconnected as to simulate their normal relationship and function on the APU. However, subassemblies or components of a system may be tested separately if such separation does not prevent simulation of the complete function of the components or subassemblies. Insofar as practicable components shall be mounted in their normal position as mounted on the APU. No adjustments shall be made subsequent to the component calibration. Fuel pumps which are integral with the fuel control shall be tested to the requirements established for the APU control system.

4.6.2.2.1 Component Calibration. Prior to the initiation of the simulated operational tests, each component for which the establishment of input-output relationships is a function of the component, shall be subjected to a calibration. The calibration shall be extensive enough to cover the steady-state and dynamic ranges of operation of the component on the APU and shall indicate conformance with the design tolerance range of the component. The APU control components shall be shown to conform to accuracy, stability, and response requirements stated in the component test procedure. Each calibration shall be recorded. Components not subject to calibration shall be operated under normal operating conditions to demonstrate satisfactory functioning. Prior to initiation of the calibration, the APU manufacturer shall provide the Using Service with a list of components not considered to require calibration. This list shall be subject to approval of the Using Service.

4.6.2.2.2 Component Test Procedures. All components shall be cleaned of oil, grease, or other corrosion-preventive compounds used for preparation for storage prior to the start of testing. Test assemblies or components shall be subjected to operating loads simulating those encountered on the APU. Sufficient instrumentation shall be provided to indicate the performance of each component and to indicate that the functional relationships of components are maintained as required by the applicable test schedule. Functional checks shall be performed at the end of each test or group of tests, and at other times at the option of the APU manufacturer, to indicate that no calibrated component has changed its calibration beyond allowable service limits and that the function of uncalibrated components is unimpaired. All components shall be supplied with such fluids as they normally handle or contact, except components normally in contact with fuel will be supplied with test fluids as specified for the individual tests.

4.6.2.2.3 Component Test Cycles. All APU components excluding the fuel pump, APU control system, and ignition system shall have a test cycle defined by the APU manufacturer and submitted to the Using Service in the pretest data. Test cycles shall be consistent with the following requirements:

a. Each component shall pass through its maximum range of functions at least once during each cycle.

b. Components in test assemblies shall function in their normal sequence of operation on the APU.

c. Cycling shall be controlled by varying simulated inputs to the test assembly or component. APU supplied inputs shall be varied in their usual relations to component outputs insofar as practicable

d. Input variables substantially independent of other control inputs, such as ambient temperatures and pressures, shall be cycled at a rate faster or slower than the basic functional cycle, in order that every component shall eventually have accomplished each part of its function at each value of the independent variables.

e. Components designed to prevent the APU from exceeding its operating limits, but which are not actuated by normal operation, shall be actuated at least once during each cycle by causing their input variables to reach the necessary range of values.

4.6.2.2.3.1 Fuel Pump Test Cycle. The cycle to be used for fuel pump tests shall be as defined herein. Fuel flow is to be measured at the entrance to the fuel pump. Fuel pressure is to be measured at both the inlet and outlet of the pump. Pump speed, acceleration fuel flow and other unspecified variables shall not be prevented from assuming normal responses to transient stimuli. Transients shall be accomplished by varying the usual system inputs to achieve the specified steady-state flow conditions. Input variables substantially independent of the pump inputs such as altitude pressure and

fuel temperatures, shall be cycled at a rate faster or slower than the basic functional cycle in order that the pump shall eventually have accomplished each part of its function at each value of the independent variables. Fuel pumps in test assemblies shall function in approximately their normal sequence of operation as on the APU. When the pumps contain special emergency features, such as dual-element or a back-up pumping system, these features will be cycled for 100 hours at room temperature in addition to the 100 hours in 4.6.2.2.6.b.

a. For fixed displacement pumps, the cycle shall be as defined below. Ten minutes of each 12 minute cycle is accreditable running time. The time specified for the transients below shall not be charged to the accreditable running time.

(1) Linearly increase speed and/or flow from 0 to 60 percent of the maximum speed and/or flow required by the APU at any point within its operating envelope, in 45 ±5 seconds, and hold at this point for 2 minutes.

(2) Linearly increase speed and/or flow from 60 percent to 100 percent of the maximum speed and/or flow required by the APU at any point within its operating envelope in 25 ±5 seconds, and hold at this point for two minutes.

(3) Hold at the speed and/or flow 100 percent of the maximum speed and/or flow required by the APU at any point within its operating envelope for one minute.

(4) Linearly decrease speed and/or flow from 100 percent to 90 percent of the maximum speed and/or flow required by the APU at any point within its operating envelope, in 10 ±5 seconds and hold at this point for one minute.

(5) Linearly decrease speed and/or flow from 90 percent to 60 percent of the maximum speed and/or flow required by the APU at any point within its operating envelope in 15 ±5 seconds and hold at this point for 2 minutes.

(6) Linearly decrease speed and/or flow from 60 percent to 0 percent of the maximum speed and/or flow required by the APU at any point within its operating envelope within 45 ±5 seconds, and remain shut down for a minimum of 2 minutes.

b. For variable flow or displacement fuel pumps, a test cycle with 10 minutes of accreditable running time shall be defined in the pre-test data by the APU manufacturer and submitted to the Using Service. During this cycle, all valves, clutches, and any other variable flow or variable displacement features of the pump shall be cycled in a manner to simulate their normal operation.

4.6.2.2.3.2 APU Control System Test Cycle. The APU control system shall be considered as the group of components whose primary function is to control the APU. All inputs or sensors which are required by the APU control system shall

be included in the test. The APU manufacturer shall define a 10 minute cycle consistent with the following requirements, and shall submit it to the Using Service in the pretest data.

a. All input variables shall be cycled in accordance with cycles described in the pretest data. Each limiting function shall be demonstrated to provide limiting, as required by design, at least once in every 10 cycles.

b. Input variables which are independent of the APU (such as ambient temperatures and pressures shall be cycled at a rate faster or slower than the basic functional cycle in order that every component shall eventually have accomplished each part of its function at each value of the independent variable.

c. Cycling shall be controlled by varying simulated inputs to the test assembly or component. APU supplied shall be varied in inputs shall be varied in their usual relations to component outputs insofar as practicable.

The pretest data shall include a list of inputs to be cycled, the corresponding ranges for each input, and procedures to be used in testing. Disturbing functions such as variations in fuel pressure shall be included in the list of inputs. Continuous data recording of input and output parameters versus time shall be taken throughout the test.

4.6.2.2.3.3 Ignition System Test Cycle. The self-contained ignition system or component test assemblies shall be tested in accordance with the following 4 hour cycle. For the purpose of these tests the minimum and maximum voltages and frequencies shall correspond to those extreme conditions permitted on the APU for satisfactory functioning of the ignition system. The APU manufacturer shall submit, in the test report, the ignition system's output characteristics. The ignition system shall be tested with the same number of ignitors connected, as used on the APU. The ignitors shall be installed in a suitable chamber and the chamber shall be purged with air or nitrogen, at a rate specified in the pretest data. The chamber pressure shall be regulated to simulate the internal APU pressure from minimum windmilling pressure to the maximum pressures the ignitors will see in the APU operating envelope. The complete ignition system shall be placed in a suitable chamber to simulate conditions of 95 $\pm$5 percent relative humidity, during the high temperature test. Each cycle shall consist of the following:

		ON	OFF
(1)	MIN voltage	2 minutes	3 minutes
(2)	MIN voltage	2 minutes	23 minutes
(3)	MAX voltage	2 minutes	3 minutes
(4)	MAX voltage	2 minutes	23 minutes
(5)	Repeat for a total of 4 times		

4.6.2.2.4 Accelerated Aging. Upon completion of the component calibrations all components containing non-metallic parts shall be placed dry, in an air oven and maintained in an ambient temperature of not less than 160°F (71°C) for a minimum of 168 hours. Components may be aged individually or in test assemblies.

4.6.2.2.5 Salt Water. Upon the completion of the accelerated aging test, each fuel and APU control system shall undergo functional cycling for 30 minutes with test fluid conforming to TT-S-735, Type III. At the end of this period, 1 pint of salt water conforming to the requirements of Note 4 on Table IX shall be introduced into the inlet of each system. After the introduction of salt water, the supply of test fluid shall be resumend and the functional cycling shall be continued for a 20-minute period. The cycling shall then be stopped and the entire test setup allowed to remain idle for 10 hours. During this period, the test fluid shall not be drained from any component. Control of the ambient or fluid temperature shall not be required during this test.

4.6.2.2.6 High Temperature. Upon completion of the accelerated aging or salt water test, the necessary test assemblies shall be assembled and each test assembly or component shall be operated as specified in the following subparagraphs. Components normally in contact with fuel shall be supplied with the fuel specified in the model specification but with an aromatic content of at least 25 percent. Toluene may be added to the fuel to attain the required aromatic content.

a. APU Components (Excluding Fuel Pump, APU Control System and Ignition System). Each test assembly or component shall be operated according to an appropriate test cycle for 100 hours or 600 cycles, whichever represents the longer period. During this cycling, ambient and fluid temperatures shall be maintained as follows:

(1) The ambient temperature shall be maintained at 160°F (71°C) for 60 minutes. The ambient temperature shall then be increased, within one minute to the maximum temperature for the component specified in the model specification and maintained at this temperature for 120 minutes. The ambient temperature shall then be returned to 160°F (71°C) within 5 minutes. This procedure shall be repeated until completion of the test.

(2) Components normally in contact with fuel shall be supplied with the fuel controlled to the maximum temperature specified in 3.7.3.3.4.

(3) Other fluids used for cooling or control purposes shall be maintained at their maximum allowable temperatures.

b. Fuel Pump. Each fuel pump shall be operated, according to the test cycle specified in 4.6.2.2.3.1 for 100 hours or 600 cycles, whichever represents the longer period. During this cycling, ambient and fluid temperatures shall be maintained as described in "a" above.

c. APU Control System. The APU control system shall be operated in accordance with 4.6.2.2.3.2 for 100 hours or 600 cycles, whichever represents the longer period. During this cycling, ambient and fluid temperatures shall be maintained as described in "a" above.

d. Ignition System. The ignition system shall be operated for 300 hours of cycling in accordance with the appropriate schedule outlined in 4.6.2.2.3.3 and at the maximum component limiting temperature given in 3.1.2.8.1. A 2-hour shutdown shall follow each cycle at the temperature conditions corresponding to the requirements of 3.1.2.8.1.c. At the conclusion of testing, checks shall be made of insulation resistance, over-voltage capability, ignitor output energy, and spark rate.

4.6.2.2.7 Room Temperature. Each test assembly or component shall undergo functional cycling in accordance with the following subparagraphs. Test assemblies containing components normally in contact with fuel shall be supplied with fluid conforming to TT-S-735 Type I, contaminated downstream from the fluid tank with at least the amount of contaminant specified in 3.7.3.3.2. The solid contaminant shall not be recirculated. During the above testing, the fuel filters, if furnished for the APU fuel system, shall be serviced as recommended by the APU manufacturer, but at intervals representing a cumulative fuel flow equivalent to not less than that obtained in 10 hours continuous operation at maximum continuous load.

Components requiring pneumatic input signals shall be subjected to air at pressure and temperature values corresponding to those occurring throughout the range of APU operation. During the first hour and each succeeding tenth hour of testing this air shall be contaminated as follows:

(1) Three parts per million APU lubricating oil by weight.

(2) A salt concentration of 0.2 parts salt (NaCl) per million parts of air by weight (salt shall be introduced using 4 percent water solution).

(3) Distilled water to saturate the air at 125°F (52°C) at an ambient pressure of 14.7 psia.

(4) Crushed quartz, 1.46×10^{-4} pounds of quartz per pound of air.

Microns	Percent
0-5	39 ± 2
5-10	18 ± 3
10-20	16 ± 3
20-40	18 ± 3
40-80	9 ± 3

a. APU Component (Excluding Fuel Pump, APU Control System and Ignition System). Each test assembly or component shall undergo functional cycling for at least 300 hours or 1800 cycles, whichever represents the longer period. The test cycle shall be in accordance with 4.6.2.2.3. Control of ambient or fluid temperatures shall not be required during this test.

b. Fuel Pump. The fuel pumps shall undergo functional cycling for at least 300 hours or 1800 cycles, whichever represents the longer period. The test cycle shall be in accordance with 4.6.2.2.3.1. Control of ambient or fluid temperatures shall not be required during this test. During this test the inlet pressure at the first pump in each assembly shall not exceed 5 psi plus the true vapor pressure of the fuel.

c. APU Control System. The APU control system shall be operated in accordance with 4.6.2.2.3.2 for 300 hours or 1800 cycles, whichever represents the longer period. The following procedure shall be used for the room temperature test:

(1) The APU control system shall be subjected to a 95 ±5 percent relative humidity and temperature of 140 ±10°F (60 ±4°C) for 120 hours before cyclic endurance.

(2) Operate the APU control system per 4.6.2.2.3.2 for 100 hours or 600 cycles, whichever represents the longer period. Temperature and humidity control are not required.

(3) Repeat (1), except the temperature will be 70 ±10°F (21 ±4°C) for the 120 hours.

(4) Repeat (2).

(5) Repeat (1).

(6) Repeat (2).

d. Ignition System. The ignition system shall be operated at an ambient temperature between 100°F (38°C) and 60°F (16°C) for 100 hours of cycling in accordance with the appropriate schedule outlined in 4.6.2.2.3.3.

4.6.2.2.8 Low Temperature. Upon completion of the room temperature test, each test assembly or component shall be soaked in an ambient temperature of

lower than -65°F (-54°C) for a minimum period of 10 hours. Upon completion of soaking, the soaking temperature of -65°F (-54°C) shall be maintained while each test assembly or component is operated as detailed below. During the entire low temperature test, fluid conforming to TT-S-735, Type I shall be present in each test assembly or component part normally coming in contact with fuel. Prior to each cycling period the test fluid temperature shall be reduced to below -65°F (-54°C). Other fluid temperatures may rise as anticipated in service operation under similar ambient conditions. If -30°F (-34°C) is reached before completion of a cycling period, the cycling shall be stopped and restarted when the fluid temperature has been reduced to below -65°F (-54°C).

a. APU Component (Excluding Fuel Pump, APU Control System and Ignition System). Each assembly or component shall undergo a test of functional cycling for at least a total of 20 hours or 120 cycles, whichever represents the longer period. The test shall consist of at least 10 separate runs with the cycle sequence of operation in each run as defined in 4.6.2.2.3.

b. Fuel Pump. The fuel pumps shall undergo a test of functional cycling for at least a total of 20 hours or 120 cycles, whichever represents the longer period. The test shall consist of at least 10 separate runs with the cycle sequence of operation in each run as defined in 4.6.2.2.3.1.

c. APU Control System. The APU control system shall undergo a test of functional cycling for at least a total of 20 hours or 120 cycles, whichever represents the longer period. The test shall consist of at least 10 separate runs with a cycle sequence of operation in each run as defined in 4.6.2.2.3.2.

d. Ignition System. The ignition system shall be tested for 24 hours at an ambient temperature of -65°F (-54°C). The system shall be operated for 12 hours of cycling in accordance with the appropriate schedule outlined in 4.6.2.2.3.3 followed by a 10-hour minimum inoperative soaking period, and a final 12 hours of cycling.

4.6.2.2.9 Fuel Pump Cavitation. For the fuel pump cavitation test, the portion of the APU fuel system from the fuel inlet of the APU to the APU fuel pump, shall be simulated in the test assembly. This shall include lines, fittings, filters, and other items as applicable between the APU fuel inlet and fuel pump inlet as well as any elements of the fuel system downstream of the pump which might have an effect on the pump. Prior to the start of this test, the system shall have had fuel passed through it at maximum continuous load fuel flow for 2 hours contaminated with at least twice the amount of contaminant specified in 3.7.3.3.2. Unweathered, clean fuel may be used to conduct the test. The fuel shall be in accordance with MIL-T-5624, grade JP-4. The pumps shall be operated for 47 hours at normal governed speed and at the maximum flow and discharge pressure required ty the APU at sea level standard altitude conditions and a ram pressure ratio of 1.15. Pressure on the fuel tank will be maintained at 20 inches Hg absolute during the cavitation test. An additional restriction may be introduced ahead of the APU

fuel inlet to provide the required vapor/liquid ratio. The fuel pressure at the APU inlet shall be maintained from a minimum of 5.0 psi above the true vapor pressure to a maximum of 50 psig with a vapor/liquid ratio of zero.

4.6.2.2.10 Recalibration. Upon completion of the preceding tests, component calibrations shall be repeated and shall indicate that no component has changed its calibration beyond allowable limits specified in the pretest data. Components not subjected to calibration shall be operated under normal operating conditions to demonstrate satisfactory functioning. During recalibration the same fluids, inputs, and operating cycles shall be used as in the calibration. All components shall then be completely disassembled and inspected for indications of failure or excessive wear. Each recalibration shall be recorded.

4.6.2.2.11 Component Test Completion. The simulated operational tests shall be considered to be satisfactorily completed when, in the judgment of the Using Service:

a. During the tests, component performance and function were within established limits.

b. During the tests, there was no fluid leakage from any component other than of a nature and rate specified in the model specification.

c. Recalibrations indicate that no component has changed its calibration beyond allowable service limits.

d. The component teardown inspection shows no indication of failed, excessively worn, distorted, or weakened parts. During this teardown inspection, the components shall be completely disassembled for examination of all parts, and measured as necessary to disclose excessively worn, distorted, or weakened parts. These measurements shall be compared with the APU drawing dimensions and tolerances and with similar measurements made prior to the test.

4.6.2.3 Environmental Electrical Component Tests. The following tests apply to electrical components or sub-components, including electrical connectors, and electrical and electronic portions of the APU control system. Electrical components and sub-components not mounted on the APU shall also be subjected to these environmental tests. Tests of additional components shall be conducted when specified in the model specification. The same physical components shall be subjected to all the following tests. These tests may be conducted on test assemblies or individual components, either of which may be new and not previously subjected to any testing.

4.6.2.3.1 Component Calibrations. Before and after each of the following tests, each component subject to calibration shall be calibrated. These calibrations shall indicate that each component is operating within its design tolerance range. Components not subject to calibration shall be operated at

maximum and minimum input voltage to demonstrate satisfactory functioning. Prior to the initiation of the calibration, the APU manufacturer shall provide the Using Service with a list of components not considered to require calibration. This list shall be subject to approval of the Using Service.

4.6.2.3.2 Component Test Procedures. Prior to the start of any testing, all components shall be cleaned of any corrosion-preventive compounds used for storage protection. Components shall be subject to operational loads simulating the maximum operating loads encountered on the APU. Power supply transients, when required herein, shall consist of the application of an overvoltage for the times specified in MIL-STD-704. The four points selected for performance of an overvoltage shall include points within 10 percent of the following: 150, 140, 130, and 125 volts ac, RMS line to neutral, or 80, 60, 40, and 35 volts dc. Transient spike voltages shall consist of the application of a spike voltage of +200 volts and -170 volts for 5 x 10^{-8} seconds and a spike voltage of $\pm$600 volts for 1 x 10^{-8} seconds each to be applied 5 times within one minute. When a single hermetically sealed component is used in a series of the tests below, the component need not be disassembled for inspection until the last test of such series has been completed. At this time, the components shall be inspected for defects or damage which may have been incurred during any of the tests performed. In addition, hermetically sealed components need not be subjected to the explosion-proof, sand and dust, and fungus tests. Prior to disassembly, a test to determine hermetic seal integrity shall be performed. Failure of the hermetic seals during any test shall be cause for rejection of that component.

4.6.2.3.3 Explosion-Proof. All electrical components not hermetically sealed shall be subjected to explosion-proof testing in accordance with MIL-STD-810, Method 511, Procedure I. During the test, components shall have maximum input voltage applied to them and shall be operated continuously at their maximum loads. During each altitude condition, all make and break contacts shall be operated at least 10 times. An overvoltage power supply transient shall be applied to the components at least four times during each altitude condition. At least four of these power supply transients shall be applied during operation of make and break contacts. Power supply transients shall be as stated in 4.6.2.3.2. Ignition components or systems shall be operated continuously. Electrodes of spark ignitors shall be mounted in such a manner that the explosive vapor in the test chamber shall not be contacted. Electrically self-sufficient ignition systems shall be exempted from the application of power supply transients. Failure criteria shall be as defined in MIL-STD-810, Method 511.

4.6.2.3.4 Sand and Dust. Components shall be subjected to a sand and dust test in accordance with MIL-STD-810, Method 510. Components need not be operated during the test; however, at the conclusion of the test, and prior to any cleaning of the components, four power supply transients, covering the transient range, shall be applied to the component. Criteria for passing the test shall be as defined in MIL-STD-810, Method 510.

4.6.2.3.5 Sustained Acceleration. Components shall be subjected to an acceleration test in accordance with MIL-STD-810, Method 513. The test item shall be subjected to the operational test in accordance with Procedure II and Table II for the aircraft vehicle category. Test time may be increased beyond the minimum specified if necessary to determine proper operation. The test shall be conducted at a Government facility as specified in the applicable contract.

4.6.2.3.6 Ignition System Fouling. The following tests, in addition to the other environmental tests, are applicable to all ignition systems and are required to demonstrate that the ignition system will be capable of consistently starting the APU under fouling conditions. The power input for the tests shall be the minimum defined by 4.6.2.2.3.3.

4.6.2.3.6.1 Carbon Fouling. The spark ignitors of the ignition system test assembly shall demonstrate sparking performance with spark gaps covered, filled or bridged with a generous application of graphite petrolatum compound MIL-T-5544. With the minimum power input supplied as specified in the model specification, the ignition system shall demonstrate satisfactory operation. Under these carbon fouling conditions, the sparking rate shall not be less than the minimum design value.

4.6.2.3.6.2 Water Fouling. With the spark ignitors positioned in a manner simulating the mounted position in the APU, the minimum power input specified in the model specification shall be supplied. The spark ignitors of the ignition system test assembly shall be thoroughly drenched with water to simulate extreme atmospheric conditions. The ignition system shall then demonstrate satisfactory operation, with the sparking rate being not less than the minimum design value.

4.6.2.4 Individual Components Tests.

4.6.2.4.1 Oil Reservoir. The filler cap and other fittings shall be installed, the tank mounted in a manner similar to that as found on the APU, and the entire test assembly shall be subjected to the following tests:

a. Cyclic Fatigue Test. N/A

b. Proof Pressure Test. Upon successful completion of the cyclic fatigue test, the same oil reservoir assembly shall be subjected to a proof pressure test to demonstrate compliance with 3.7.7.4.1. The proof pressure shall be held for a minimum of 10 minutes with the wall temperature of the oil reservoir at the maximum oil operating temperature. The APU manufacturer shall specify in the pretest data the pressure to be used for the proof pressure test. No leakage or permanent deformation of the oil reservoir, filler cap, or fittings shall occur.

c. Valve Tests. If the oil reservoir assembly incorporates a pressurizing valve or pressure relief valve, the assembly shall be tested in

such a manner as to demonstrate proper functioning. The APU manufacturer shall specify in the pretest data the procedure to be used.

4.6.2.4.2 PMG Test. The following tests, in addition to the environmental tests, shall be conducted on each PMG:

a. Overspeed. The PMG shall be operated at a speed which corresponds to 115 percent of maximum allowable APU speed for 5 minutes. At the completion of the test, there shall be no evidence of mechanical or electrical damage or failure.

b. Load Test. The PMG shall be operated at a speed corresponding to 106 percent of maximum allowable APU speed under full rated electrical load for one hour. During this test, the PMG shall be subjected to its maximum component limiting temperature. At the completion of the test, there shall be no evidence of mechanical or electrical damage or failure.

c. Containment. The PMG shall be operated at the maximum design speed in a manner to cause a mechanical failure of the rotor system. All damage shall be contained within the PMG housing.

4.6.2.4.3 Heat Exchangers. Heat exchangers for cooling or heating of APU fluids or components shall be subjected to the following tests. If non-metallic parts are included in the heat exchanger assembly, the entire assembly shall be subjected to the accelerated aging test per the requirements of 4.6.2.2.4. If the heat exchanger assembly incorporates a bypass valve, regulator or indicating feature, appropriate tests shall be conducted to demonstrate proper functioning and shall be specified in the pretest data.

a. Flow, Pressure and Temperature Cycling Test. The heat exchanger shall be subjected to a flow, pressure, and temperature cycling test for one design life. The number of cycles shall be specified in the pretest data with a cycle defined as follows: Simultaneously introduce both fluids at ambient temperature and pressure to the heat exchanger, then while increasing the flow to the maximum value encountered in the operating envelope, raise the temperature and pressure of the fluids to their corresponding maximum values. Once the output flow conditions have stabilized, begin decreasing the flow to the minimum value encountered in the operating envelope, and decreasing accordingly the temperature and pressure of the fluids to their ambient values. Once output flow conditions have been stabilized, the flow of both fluids shall be terminated. Twenty-five percent of the test cycles shall be run with the ambient air surrounding the heat exchanger at its maximum component limiting temperature and the balance of the cycles shall be run with the surrounding air at ambient temperatures. At the completion of this test there shall be no evidence of leakage or permanent deformation.

b. Heat Exchanger Proof Pressure. Upon successful completion of the flow, pressure and temperature cycling the same heat exchanger shall be subjected to a proof pressure test. Each fluid side of the heat exchanger

shall be individually subjected to twice its maximum working pressure for at least 2 successive times and held 2 minutes for each pressure application. During the application of pressure to one side the other element shall be empty and at atmospheric pressure. There shall be no evidence of external leakage or internal leakage into the dry side. Following this test, both sides of the heat exchanger shall be simultaneously subjected to their maximum working pressures for at least 2 successive times and held 2 minutes for each pressure application. At the completion of this test there shall be no evidence of leakage or permanent deformation.

4.6.2.4.4 Fire Test. Lines, fittings, and components, which convey flammable fluids shall be tested to verify conformance with 3.3.6.1. Individual lines, fittings, components or assemblies shall be tested as specified in ARP 1055 while conveying fluids at the lowest flow rate, highest system pressure and highest fluid temperature expected over the environmental conditions and operating envelope of the APU. The requirements of 3.3.6.1 shall be considered verified, if at the completion of the test period, there are no leaks. The above test may be waived for identical components which have successfully completed the test of 4.5.2.5.

4.6.2.4.5 Hydraulic System. N/A

4.6.3 Altitude Tests. An APU, conforming to the same parts list and configuration as the endurance test APU, shall be subjected to altitude tests which shall consist of operation and air starting checks at selected conditions throughout the operating envelope specified for the APU and at least those given in the model specification as shown in figure 10. The test points shall include the effects of inlet recovery and inlet distortion on APU performance and stability. Control system adjustments shall not be made without approval of the Government representative. The altitude tests shall be accomplished using the oil and fuel combinations of: (1) MIL-L-23699 oil and MIL-T-5624, grade JP-5 fuel, and (2) MIL-L-7808 oil MIL-T-5624, grade JP-5 fuel. Fuel temperature shall be varied over a range sufficient to encompass all anticipated APU operating environments. Data to be taken and recorded during the test shall be as specified in Table VIII.

Overall true RMS velocity measurements and acceleration spectrograms shall be obtained for each transducer mounted on the APU case and gearbox case at load conditions selected for the test. The points selected shall include at least the altitude rating points and the point in the operating envelope where the highest APU vibrational levels are generated. Critical components of the APU shall be identified on each spectrogram.

The compressed air flow shall be sampled and analyzed in accordance with 4.6.1.2.3.1 during runs selected by the Using Service.

4.6.3.1 Altitude APU Calibration. Prior to initiation of the testing described in 4.6.3.2, the APU shall be calibrated in accordance with 4.6.1.2.3

and 4.6.1.2.3.1. No control readjustments shall be made after the initial adjustments at the beginning of the calibration.

4.6.3.2 Altitude Test Procedure. Operation at each test point shall be of sufficient duration to stabilize the APU and to establish the performance and operating characteristics of the APU. Operation shall be conducted to obtain the following data:

a. Altitude Rating Points. The test points shall be those specified for altitude ratings in Table II of the model specification. A sufficient number of additional APU load conditions shall be selected for each specified altitude test condition to establish operating and performance characteristics at each rated point. The time elapsed versus rotor speed, electrical power, compressed air, measured exhaust gas temperature, and fuel flow shall be obtained for stability verification with load conditions of no electrical load, maximum continuous compressed air load, and maximum continuous electrical load and combined operating load. The time period for stability verification shall be a minimum of 5 minutes at each load condition.

b. Transient Operation. The applicable transient performance specified in 3.2.1.5.5 shall be demonstrated at each rating condition. The effects of compressed air, singularly, and in combination with electrical power, on transient performance, shall be determined.

c. Functional Test. The operating envelope of the APU shall be verified by running the APU at the extremities of the operating envelope. APU steady-state and transient characteristics shall be determined at each test point over the range of load conditions.

d. Inlet Distortion. The inlet airflow distortion limits of the APU shall be demonstrated at the inlet conditions specified in 3.1.2.10.3. Effect of inlet distortion on transient operation and steady-state performance shall be determined.

e. Starts and Restarts. APU starts and restarts shall be accomplished at each of the starting points specified on figure 10.

f. Changes in Altitude. The APU shall be operated for 15 minutes at combined operating load under the hot atmosphere condition of figure 3 and at the maximum sea level Mach number, to demonstrate the requirements of 3.2.5.1.4. The APU shall then be shutdown, the inlet conditions changed to the minimum Mach number at 20,000 feet, -40°F (-40°C) within 30 seconds, and restarted. Following this demonstration the APU shall be operated at combined operating load while the inlet conditions are changed at a rate of 600 feet/second, standard day temperatures, for the altitude ranges shown on figure 10.

g. Altitude Windmilling and Nonwindmilling Test. Altitude windmilling and nonwindmilling tests shall be conducted within the nonoperating envelope

to verify the requirements of 3.2.1.5.6 and 3.2.5.1.2. In addition, testing shall be accomplished to verify that the lubricating system will provide proper lubrication, as defined in the pretest data, and operate without excessive loss of oil during windmilling operation. Following each windmilling and nonwindmilling test point shown on figure 10 the APU shall be returned to the closest extreme of the starting envelope and started. APU shafts may be driven by any suitable external means.

h. Altitude Rate Test. Tests shall be conducted to verify the requirements of 3.1.2.10.6 throughout the altitude range of the APU.

4.6.3.3 Altitude Test Completion. Comparison of observed data obtained during the test to the specified performance and operating characteristics shall be made by a method acceptable to the Using Service to determine compliance with the model specification. The test shall be considered to be satisfactorily completed when, in the judgment of the Using Service:

a. The APU performance is at least that specified in the performance curves and rating tables; except that the compressed air temperature, rotor speed and total inlet airflow shall be within the applicable tolerance band.

b. The altitude starting and transients conducted during the test are in accordance with the model specification requirements.

c. The functional test points demonstrate satisfactory APU operation and do not show any discrepancies with the performance curves, altitude starting data or transient data.

d. The APU operates satisfactorily under distortion, windmilling and changes in altitude conditions specified for the test.

4.6.4 APU Environmental and Ingestion Tests. The tests in the following subparagraphs shall be conducted on APUs having the same parts list and configuration as the endurance test APU of 4.6.1. Unless otherwise specified in the individual test, the APU shall be calibrated before and recalibrated after each test, but only to the extent necessary to determine any deterioration in steady-state or transient performance capability which occurred during the course of testing. All starts shall be performed with hydraulic fluid supplied in accordance with 3.7.9.3. Unless otherwise specified for a particular test, the test shall be conducted at the ambient conditions which prevail at the test site.

4.6.4.1 Low and High Temperature Starting and Acceleration Test. The test APU shall be subjected to low and high temperature tests to demonstrate compliance with 3.2.1.4.8, 3.2.1.5.5, 3.2.5.1 and 3.7.9.2. All data required in 4.3.5.6 shall be recorded during each start. Starting and operating capabilities shall be accomplished with no electrical power, and with the compressed air flow controlled by the APU control valve. Recalibration shall not be required. The point within the APU where temperature shall be measured

for determining the APU soak temperature shall be specified in the model specification.

a. Low Temperature Test. The APU, serviced with the oil specified in the model specification, shall be subjected to a soaking period of at least 6 hours duration at an ambient temperature of -40°F (-40°C). The 6-hour soaking period shall be started after the point specified in the model specification has reached -40°F (-40°C). At the end of the low temperature soaking period, the electrical connectors shall be disconnected and reconnected and the ignitor(s) shall be removed and reinstalled to verify the requirements of 3.7.4.3.1 and 3.7.5.4, respectively. In addition, the oil reservoir filler cap and all other servicing features shall be functionally checked to demonstrate their proper functioning under cold soak conditions. After the soak period and when supplied with fuel, inlet air and hydraulic starter fluid at a temperature of -40°F (-40°C), the APU shall be started. Immediately after the APU has reached no electrical load, the APU shall be accelerated to maximum continuous electrical load for one minute and returned to no electrical load. The APU shall then be accelerated to maximum continuous compressed air load for one minute, returned to no electrical load and shut down. The above procedure, including the soak period, shall be repeated twice.

If more than one fuel or oil is specified in the model specification, the complete test above shall be repeated using these fuels or oils. The soak, oil, air and fuel temperatures shall be subject to fuel or oil temperature limitations of 3.2.5.1.

The test will be considered to be satisfactorily completed when, in the judgment of the Using Service, the above 3 successive starts have been satisfactorily accomplished within 30 seconds; the APU has demonstrated its ability to accelerate without exceeding any APU starting or operating limits; there were no fuel or oil leaks; and functional checks of electrical connectors and servicing features have revealed no damage or difficulties during operation.

b. High Temperature Test. The APU, serviced with the oil specified in the model specification, shall be subjected to a soaking period of at least 6 hours duration at the hot ground soak temperature shown on figure 3. The 6-hour soaking period shall be started after the point specified in the model specification has reached the hot ground soak temperature shown on figure 3. After the soak period and when supplied with fuel, inlet air and hydraulic starter fluid at the hot atmosphere condition shown on figure 3, the APU shall be started. Immediately after the APU has reached no electrical load, the APU shall be accelerated to maximum continuous electrical load for one minute and returned to no electrical load. The APU shall then be accelerated to maximum continuous compressed air load for one minute, returned to no electrical load and shutdown. The above procedure, including soak period shall be repeated.

If more than one fuel or oil is specified in the model specification, the complete test above shall be repeated using these fuels or oils.

The test will be considered to be satisfactorily completed when, in the judgment of the Using Service, the above two successive starts have been satisfactorily accomplished within 30 seconds; the APU has demonstrated its ability to accelerate without exceeding any APU starting or operating limits and there were no fuel or oil leaks.

4.6.4.2 Environmental Icing Test. The APU shall be subjected to an environmental icing test to demonstrate compliance with 3.2.5.2. For this test, the APU shall be operated under the free air conditions listed in Table V. For each test run, the liquid water content and droplet size shall be measured at a distance within five feet of the APU inlet face and still within the APU inlet duct. The liquid water content measured at this station shall correct to the free air conditions as specified in Table V. This meteorological data shall be recorded at suitable intervals during each test run. The method and procedure for collecting and determining the the water droplet size and liquid content shall be specified in the pretest data. During the testing, electrical power, compressed air, rotor speed, and vibration shall be continuously recorded and high speed photographic coverage of the APU inlet shall be provided. The base line for determining APU performance loss shall be established by operating the APU under the inlet temperature conditions of Table V with air between 80 and 100 percent relative humidity and zero liquid water content. The electrical power, compressed air and fuel consumption losses shall be determined by comparison of APU performance when operating at the icing conditions defined in Table V with the aforementioned base line values. Oil temperature shall be maintained at the minimum operating oil temperature specified in the model specification or less during all runs except at no load condition where the oil will be maintained at the same temperatrue as the APU inlet air. The test shall consist of two runs at each of several load conditions under each of the conditions of Table V. The load conditions shall include: no electrical load, maximum continuous compressed air load, maximum continuous electrical load and combined operating load. At each icing condition and at each load condition, the APU shall be operated for a period of not less than 10 minutes. During each period, at intervals after ice buildup, the APU shall be rapidly accelerated to demonstrate the acceleration response.

The testing will be considered satisfactorily completed when, in the judgment of the Using Service, there was no damage to the APU and performance was within the requirements of 3.2.5.2 and 3.7.1.

4.6.4.3 Corrosion Susceptibility Test. A new or newly overhauled test APU shall be subjected to a corrosion susceptibility test to demonstrate compliance with 3.2.5.5. The test shall be in accordance with the schedule of Table IX requirements which comprise 480 hours total duration, of which 60 hours are APU operating time. The test shall be conducted at a Government facility as specified in the applicable contract. Prior to starting the test,

the APU shall be disassembled sufficiently to inspect the surface condition of all parts normally exposed to atmospheric conditions. Detailed photographic coverage of these parts shall be provided. Upon reassembly and after an initial calibration, including data required to establish compliance with 3.2.1.5.5, the APU shall be subjected to 10 cycles of 48 hours each in accordance with Table IX. The APU shall be washed if, during the test, the APU performance deteriorates 5.0 percent below that determined during the initial calibration. If performance cannot be recovered after washing, the APU shall be disassembled and inspected to determine the effect of the corrosion testing on performance loss. During the test, the APU shall be subjected to internal inspections after the 3rd cycle to detect any evidence of corrosion or progression of corrosion of internal parts. Additional inspection may be conducted with approval of the Using Service.

After completion of the corrosion susceptibility test, the APU shall be washed prior to recalibration of the APU. During recalibration the applicable transient performance specified in 3.2.1.5.5 shall be demonstrated at each load condition. Following recalibration, the APU shall be disassembled and inspected for evidence of corrosion. Detailed photographs shall be taken of all parts which show evidence of corrosion. Metallurgical analyses that completely characterize the types of corrosion found and test specimen evidence shall be provided.

The corrosion susceptibility test will be considered to be satisfactorily completed when upon recalibration: (1) the APU non-recoverable performance deterioration at the rated measured exhaust gas temperatures and rotor speeds does not exceed 5.0 percent total loss in electrical power or compressed air values obtained during the initial calibration, (2) the APU exhibits not more than a 5.0 percent increase in fuel consumption, (3) the transients conducted are in accordance with the model specification requirements, and (4) in the judgment of the Using Service, the extent of corrosion evident at test completion satisfies the following criteria for all APU parts.

a. All internal parts exposed to gas path air, upon cleaning, shall show no impairment of their function due to corrosion. Minor corrosive attack is acceptable only when the part design criteria (e.g., fatigue resistance) are not affected.

b. All corrosion-protected parts shall indicate no effects of corrosion upon cleaning and stripping of the protective schemes. Recoating of parts designed for recoating shall restore such parts to as-new condition.

c. All other parts shall show no corrosion that affects component integrity or prescribed maintenance procedures.

4.6.4.4 Bird Ingestion Test. N/A

4.6.4.5 Foreign Object Damage Test. The test APU shall be subjected to a foreign object damage test to demonstrate compliance with 3.2.5.6.2.

Simulated foreign object damage shall be applied to three first stage blades at one or more sections of the leading edge at a location where the highest steady-state and vibratory stresses occur at no electrical load rotor speed. The damage applied shall produce at least a stress concentration factor (Kt) of 3.0. Following the foreign object damage application, the APU, with damaged blades installed, shall be subjected to a 6-hour test in accordance with 4.5.1.3.2. No calibration or recalibration shall be required for this test. At the completion of the running there shall be no evidence of blade failure or cracking as the result of the foreign object damage.

Subject to approval of the Using Service, the foreign object damage test may be conducted by bench testing on individual blades or rig testing on full scale fan or compressor components in lieu of complete APU testing. If the test is to be conducted on a component basis, details of the test shall be presented in the pretest data. However, conditions, duration and severity of testing shall be equivalent to the complete APU test described above.

4.6.4.6 Ice Ingestion Test. The test APU shall be subjected to an ice ingestion test to demonstrate compliance with the requirements of 3.2.5.6.3. The type of ice and the conditions for ingestion shall be as follows:

a. N/A

b. Sheet ice of 0.80 to 0.90 specific gravity in typical sizes, forms and thicknesses as approved by the Using Service, of inlet duct and lip formations in quantities likely to be ingested during cruise conditions.

The APU manufacturer shall specify in the pretest data the procedures to be used for introduction of ice at the APU inlet and the load conditions at which the ice is to be ingested. The time for APU power recovery shall be recorded. During the tests, high speed photographic coverage of the inlet is required. The test will be considered to be satisfactorily completed when, in the judgment of the Using Service, the criteria of 3.2.5.6.3 has been met.

4.6.4.7 Sand Ingestion Test. The test APU shall be subjected to a run of two hours duration at the combined operating load, with sand contaminant in accordance with 3.2.5.6.4 introduced into the APU inlet. During each hour of operation at least one deceleration shall be made. The compressed air shall be continually filtered, the total deposits measured and results reported. Following the 2-hour run and post test performance check, the APU shall be disassembled as necessary to inspect for the extent of sand erosion and the degree to which sand may have entered critical areas in the APUs internal air cooling system. The test will be considered to be satisfactorily completed when, in the judgment of the Using Service, the performance criteria of 3.2.5.6.4 have been met and teardown inspection reveals no failure or evidence of impending failure.

4.6.4.8 Atmospheric Water Ingestion Test. The test APU shall be subjected to a water ingestion test to demonstrate compliance with the requirements of

3.2.5.6.5. With the APU operating at the combined operating load, 2, 3.5 and 5 percent of the total airflow mass in the form of water (liquid and vapor) shall be introduced into the inlet of the APU with 50 percent of the liquid water entering the APU inlet through a segment equivalent to one-third the inlet area. The APU shall be operated at each condition for 5 minutes. During the test, the effects of the water ingestion on APU performance shall be noted and recorded. At the completion of the test, the APU shall be shut down and allowed to cool to ambient temperature before making the post test performance check. Following the performance check, the APU shall be disassembled sufficiently for inspection. This test shall be considered to be satisfactorily completed when, in the judgment of the Using Service, adequate clearances were maintained, no damaging rub or detrimental rubbing occurred during the test, the performance has not deteriorated, and the gas-flow path parts show no damage.

4.6.4.9 Armament Gas Ingestion Test. N/A

4.6.4.10 Noise Survey. The survey shall be conducted to substantiate the requirements of 3.2.5.7. The APU shall be mounted on an outdoor test stand with a minimum clearance as specified in the model specification, between the lowest part of the APU and the ground. Microphones shall be located in relatively flat terrain free of excessive ground absorption characteristics. There shall be no obstructions that significantly influence the APU noise field. The weather shall be free of precipitation with relative humidity between 30 percent and 90 percent, ambient temperature between 32°F (0°C) and 86°F (30°C), wind velocity less than six miles per hour and no temperature inversions or anomalous wind conditions. No post-test APU recalibration shall be required. The signal level shall be at least 10 dB greater than the background noise-level in each third octave band in the frequency range of interest. This test shall be considered to be satisfactorily completed, when in the judgment of the Using Service, the A-weighted average has not exceeded 105dB(A) at 12 feet.

4.6.4.11 Exhaust Gas Emission Test.

4.6.4.11.1 Exhaust Smoke Emission. N/A

4.6.4.11.2 Invisible Exhaust Mass Emissions. N/A

4.6.4.12 Nuclear Hardening Test. The APU shall undergo tests to determine its ability to meet the nuclear survivability/vulnerability requirements specified in the applicable contract. The test requirements shall be as specified in the pretest data.

4.6.4.13 Steam Ingestion Test. The test APU shall be subjected to a steam ingestion test to demonstrate compliance with the requirements of 3.1.2.10.5. With the APU operating at the combined operating load, steam and/or steam condensate shall be introduced into the inlet at a rate of 2.5, 5.0, 7.5 and 10.0 percent of the total APU inlet airflow. The APU shall be operated at

each condition for 5 minutes. During the test, the effects of the steam ingestion on APU performance shall be noted and recorded. At the completion of the test, the APU shall be shut down and allowed to cool to ambient temperature before making the post test performance check. Following the performance check, the APU shall be disassembled sufficiently for inspection. This test shall be considered to be satisfactorily completed when, in the judgment of the Using Service, adequate clearances were maintained, no damaging rub or detrimental rubbing occurred during the test, the performance has not deteriorated, and the gas-flow path parts show no damage.

4.6.4.14 Humidity. The test APU shall be subjected to a humidity test in accordance with MIL-STD-810, Method 507, Procedure I. During steps 6 and 7 the electrical and electronic components shall be subjected to the overvoltages of 4.6.2.3.2 for the times specified. At the conclusion of this test, the APU shall be disassembled sufficiently to show that there is no corrosion or other defects that affect the function or structural strength of the APU.

4.6.4.15 Fungus. The test APU shall be subjected to a fungus test in accordance with MIL-STD-810, Method 508. Evidence that all materials used do not support fungus growth shall constitute grounds for waiver of this test, when approved by the Using Service. Electrical and electronic components need not be operated during the test, but shall be subjected to the overvoltages of 4.6.2.3.2, after the test, for the times specified. Criteria for passing the test shall be as defined in MIL-STD-810.

4.6.4.16 Impact. The test APU shall be subjected to an impact test in accordance with MIL-STD-810, Method 516, Procedure I. The shock pulse shape shall be in accordance with Figure 516-2 of amplitude "a" and time duration "c". Tests shall be conducted under room ambient conditions. Electrical and electronic components need not be operated during the test, but shall be subjected to the overvoltages of 4.6.2.3.2, after the test, for the times specified. At the completion of this test, the APU shall be operated to demonstrate compliance with the Table I.

4.6.4.17 Vibration. The test APU shall be subjected to a vibration test in accordance with MIL-STD-810, Method 514, Equipment Category b.2, Procedure IA. Tests shall be conducted in accordance with Table 514-IIA, and curve "A" of Figure 514-2A. During the test the APU shall be subjected to the maximum compartment temperature specified in 3.1.2.8.2. At the completion of this test, the APU shall be operated to demonstrate compliance with the Table I.

4.6.5 APU Characteristics and Fuel Tests. The tests in the following subparagraphs shall be conducted on APUs having the same parts list and configuration as the endurance test APU of 4.6.1. Unless otherwise specified in the individual test, the APU need not be calibrated before and recalibrated after each test. Unless otherwise specified for a particular test, the test shall be conducted at the ambient conditions which prevail at the test site, using the fuel specified in the model specification.

4.6.5.1 Starting Torque. N/A

4.6.5.2 Radar Cross Section (RCS). N/A

4.6.5.3 Infrared Radiation Test. N/A

4.6.5.4 Alternate Fuel Test. The test APU shall be subjected to a 400-hour test run in accordance with 4.5.1.3.2 when using MIL-T-83133, grade JP-8 fuel. The APU shall be calibrated before and recalibrated after the test to the extent necessary to determine any deterioration in steady-state or transient performance. At the completion of the test, the APU shall be disassembled to the extent necessary to perform a hot section inspection. The test will be considered satisfactorily completed, when, in the judgment of the Using Service, APU performance meets the requirements specified in 3.7.3.2.2 and results of the hot section inspection do not reveal abnormal hot section distress. This test shall be performed as a segment of the VT endurance test.

4.6.5.5 Emergency Fuel Test. N/A

4.6.6 Structural Tests. APU or components conforming to the parts list and configuration of the VT endurance test APU shall be used for the following tests.

4.6.6.1 APU Power Section Pressure Tests. Each APU power section case and all gas pressure loaded components of the APU subjected to compressor discharge pressure shall be proof tested to at least twice the maximum operating pressure without rupture. These tests shall be conducted at the maximum operating temperature of the component or the pressure shall be adjusted for materials properties at the test temperature. The above test may be waived for identical components which have successfully completed the test of 4.5.4.1.

4.6.6.2 Low Cycle Fatigue APU Test. A cyclic endurance test, which shall subject an APU to at least one lifetime of cycling in accordance with Table VI shall be performed.

All repairs and parts replacement shall be recorded and reported. The actual number of cycles, duty times and length of cool down time shall be based upon the study of 3.3.8.6 and shall be that required to obtain at least the same LCF damage on the test APU as one operational lifetime predicted in the strength and life analysis. This test substantiation of one life may require certain parts to receive more than one lifetime of damage. If this damage on those parts exceeds the parts' required operation life, part replacement or repair may be accomplished in order to continue the test. Following completion of the test, the APU shall be disassembled and inspected for evidence of cracking and shall be within the allowable dimensional limits.

The duty cycle shall be defined as follows with the times as specified by the APU manufacturer. The duty cycle shall be submitted to the Using Service for review and approval.

TOTAL TIME	SCHEDULED TIME	EVENT
___sec.	___sec.	Start APU.
___sec.	___sec.	Run at no electrical load.
___sec.	___sec.	Accelerate to maximum electrical power and maintain as specified.
___sec.	___sec.	Decelerate from maximum electrical power to no electrical load and hold as specified.
___sec.	___sec.	Shut APU down and coast to stop - cool down.

4.6.6.3 Containment. The requirements of 3.3.8.9.1 shall be demonstrated by full scale APU test or spin pit testing of rotor assemblies. This test (or tests) shall be conducted at or above the maximum allowable rotor speed and maximum component operating temperatures with selected blades from the compressor and turbine sections, determined to be most critical by analysis, undercut to fail at a predetermined speed. The test will be considered satisfactorily completed when, in the judgment of the Using Service, all damage is contained.

4.6.6.4 Rotor Structural Integrity.

4.6.6.4.1 Overspeed. Turbine and compressor rotors shall be subjected to APU operation for a stabilized period of at least five minutes duration, at maximum allowable measured exhaust gas temperature at 115 percent of maximum allowable steady-state speed. Following the test, parts and assemblies shall be within allowable dimensional limits and there shall be no evidence of imminent failure. This test may be waived for components identical to those successfully completing the test in 4.5.4.2.1.

4.6.6.4.2 Overtemperature. Upon successful completion of the overspeed test of 4.6.6.4.1, the same APU shall be operated at a measured temperature of at least 75°F (42°C) in excess of the maximum allowable steady-state measured exhaust gas temperature and at no less than maximum allowable steady-state speed for five minutes. Following the test, parts and assemblies shall be within allowable dimensional limits and there shall be no evidence of imminent failure. This test may be waived for components identical to those successfully completing the test in 4.5.4.2.2.

4.6.6.4.3 Disk Burst Test. Spin pit testing shall be conducted on all critical rotating disk components of VT APU configuration. Components shall be operated to a minimum of 122 percent of maximum allowable steady-state speed with the bore metal at maximum design metal temperature without failure or evidence of imminent failure. This may be waived for components identical to those successfully completing the test of 4.5.4.2.3.

4.6.6.5 APU Static Load Test. The APU cases and mounts of the endurance APU configuration shall be subjected to a static test to verify the requirements of 3.1.2.5 and 3.1.2.6. A static rig test utilizing the applicable APU static structure shall be conducted to demonstrate the capability of the APU and its supports to withstand maximum externally applied forces specified in 3.1.2.5 without permanent deformation of any component and 1.5 times those forces without failure of any component. In this test, maximum thrust loads, acceleration loads, gryroscopic moments, torque and APU reaction loads will be applied separately and then in combination. Stress and deflection data will be obtained at critical locations as determined by analysis and preliminary stress coating tests. This test may be waived for identical components which have successfully completed the test of 4.5.4.3.

4.6.6.6 Vibration and Stress Test. A vibration and stress test shall be conducted on an APU to obtain data to substantiate the vibration and stress analysis report of 3.3.8.10.2 and the requirements of 3.3.8.6. Prior to the test, the APU shall be disassembled sufficiently to install test instrumentation. A sufficient number of blades and vanes in each stage of the compressor shall be instrumented with strain gauges in order to obtain continuous strain gauge data. Each strain gauge shall be mounted in a location on the blade or vane where the highest stress occurs, as determined from the vibration and stress analysis. Sufficient instrumentation shall be installed at appropriate locations on main bearings to permit measurement of bearing loads, cage rotation and rotor deflections. During buildup, the APU shall be assembled with at least the maximum allowable imbalances specified for the APU rotating components and assemblies. External components such as fuel controls, fuel pumps, valves, plumbing lines, etc., shall be instrumented at appropriate locations with transducers as detailed in the pretest data. Following assembly, the APU shall be installed in a test stand having APU mounting arrangements and test stand dynamic characteristics as defined by the APU manufacturer, subject to approval of the Using Service. Inlet and exhaust systems that are mounted directly on or supported by the APU in the aircraft installation shall be mounted in the same manner for this test. The test shall check all critical rotor speeds where by analysis, substantial stress or vibratory conditions occur on any component. Vibration and stress measurements shall be made during all APU operating modes and shall include but not be limited to conditions of maximum inlet distortion, stall, limits of variable geometry travel if applicable, maximum inlet pressure and temperature capabilities of the APU and combinations thereof. During the test, overall true RMS velocity measurements and acceleration spectrograms shall be obtained for each transducer mounted on the APU core and external components. The test will be considered to be satisfactorily completed when, in the judgment of the

Using Service, the vibration stress and load measurements are within acceptable limits.

4.6.6.7 Gyroscopic Test. An APU shall be subjected to a gyroscopic test to demonstrate compliance with the requirements of 3.1.2.5.1. Prior to the test, the APU shall be assembled with special emphasis placed on measuring and recording clearances between blades and cases and radial and axial rotor clearances. Rub probes shall be installed around compressor and turbine cases at symmetrical locations and at blade tip locations as designated in the pretest data. Instrumentation shall be sufficient to permit measurement of rotor deflection and shift under gyroscopic loads. Strain gauge instrumentation shall be provided to measure stresses at critical locations. Sufficient instrumentation of the oil system shall be provided to evaluate the oil system's ability to scavenge and function properly during the test. Test data to be taken during the test. In addition to the data required above, shall include vibration measurements at locations as specified in 3.7.6.5.

The APU shall be installed on a gyro test stand with an inlet and exhaust configuration as designated in the pretest data. Prior to the test, the APU shall be subjected to an APU performance check.

The test shall be conducted with the gyro rig operated in steps from 0.5 rad/sec to and including 3.5 rad/sec in step increments of 0.5 rad/sec. At each step, the APU shall be operated as follows:

a. No electrical load for one minute.

b. Gradually increase the APU output from no electrical load to the combined operating load in 30 seconds. The power factor shall be unity (1).

c. Dwell at the combined operating load for 10 seconds or time sufficient to record data.

d. Gradually decrease the APU output from the combined operating load to no electrical load in 30 seconds.

e. Stop rig and APU for visual check of rub.

NOTE: At gyro loads above 1.5 rad/sec, snap accelerations and decelerations may be made to reduce time exposure. The total time at 3.5 rad/sec gyro load shall not exceed the time specified in 3.1.2.5.1.

The above test shall be conducted with the gyro rig rotating in one direction and then the test shall be repeated with the rig rotating in the opposite direction. At the completion of the test, the APU shall be subjected to a post test performance check and then disassembled for inspection.

The test shall be satisfactorily completed, when in the judgment of the Using Service: the post test calibration reveals no significant loss in

performance, the APU and its systems operated properly during the test, structural loads were within acceptable limits and teardown inspection reveals no evidence of excessive blade rubbing or evidence of impending failure.

This test shall be run at a Government facility as specified in the applicable contract.

4.7 Acceptance Test. An acceptance test, as specified herein, shall be conducted on each APU submitted for delivery. The APU manufacturer shall prepare and submit for approval by the Using Service a detailed Acceptance Test Procedure. APUs submitted for PFRT or VT need not be subjected to acceptance tests.

4.7.1 Test Apparatus.

4.7.1.1 Automatic Recording Equipment. Automatic continuous recording equipment shall be used to record data during the execution of that part of the APU tests requiring the evaluation of APU variables vs time.

4.7.1.2 Vibration Measuring Equipment and Response Characteristics. The APU vibration shall be measured with transducers. The vibration measurement and analysis equipment shall operate over a frequency band of at least 5 Hz to 10 kHz and produce acceleration spectrograms with a demonstrated accuracy confidence level of 95 percent. The maximum allowable effective filter bandwidth of the spectrum analysis equipment shall be 30 Hz. The vibration measuring equipment shall be calibrated as a complete system. The frequency response of the system, when calibrated by applying a known sinusoidal motion to the transducer pickup, shall not deviate by more than ± 3 dB from the known sinusoidal input at frequencies from 5 Hz to 10 kHz. If high pass filters are required when the vibration measuring system is measuring overall velocity levels, they shall have the following characteristics: the filters shall be 3 dB down at frequencies of 30 Hz, 70 Hz, or 110 Hz as appropriate, with a roll-off of at least 18 dB per octave. High pass filters shall not be used to produce acceleration spectrograms.

4.7.1.3 Test Cell and Test Equipment. APUs shall be subjected to acceptance testing in a test cell and with test equipment that is acceptable to the Using Service. The natural frequencies of the test stand with the APU installed shall be no higher than 80 percent of the combined operating load rotor speed in all modes of motion which can be excited by residual rotor unbalances.

4.7.1.4 Starting. The APU shall be supplied with hydraulic fluid and hydraulic valve opening characteristics in accordance with 3.7.9.3.

4.7.2 Test Conditions.

4.7.2.1 Servicing.

4.7.2.1.1 Oil Servicing. The oil used for acceptance testing shall be as specified in the model specification. All oil filter inspection results shall be recorded in the APU records.

4.7.2.1.2 Fuel Servicing. The fuel used for acceptance testing shall be as specified in the model specification.

4.7.2.2 Electrical and Electronic Interference and Susceptibility Check. Electrical and electronic systems or components of production APUs shall be subjected to an interference test in accordance with 4.5.1.1.2 until three consecutive like systems or components have passed the test without reworking. Thereafter, one APU will be selected at random by the Government representative from each lot for these tests. A lot shall consist of not more than 25 consecutive APUs of models using identical electrical and electronic systems. When a change is made which, in the judgment of the Using Service, might affect the interference level, APUs, systems, or components incorporating the change shall be tested in accordance with 4.5.1.1.2, until three consecutive like APUs, systems, or components have passed the tests without reworking. Thereafter, one APU will be selected at random by the Government representative from each lot for these tests.

When any system or component fails to pass the interference and susceptibility test, all like systems or components in that lot shall be tested in accordance with 4.5.1.1.2, until three consecutive systems or components have passed the test without reworking. Systems or components which have been rejected may be reworked to correct the defects and resubmitted for testing. Before reworking, full particulars concerning rejection and the action proposed to correct the original defects shall be furnished to the Government representative for approval.

4.7.2.3 APU Control Calibration. All fuel nozzles and components of the APU utilizing fuel shall be calibrated using fluid in accordance with 3.7.3.3.1.

4.7.2.4 APU Temperature Sensing System Calibration. The APU temperature sensing system shall be checked to establish its functioning in accordance with 3.7.6.4 of the model specification. The actual thermal responses of the system shall be reported.

4.7.2.5 Overspeed Control Test. With the normal speed governing system rendered inoperative, the APU shall be overspeeded with no load until the overspeed control functions. This test shall be repeated until the ECU has demonstrated, on 10 consecutive trials, the ability to limit the APU rotor speed to the actuation speed specified in 3.2.1.4.6.

4.7.2.6 Stopping. Tests shall be performed to demonstrate the requirements of 3.2.1.5.3.

4.7.2.7 Burn-In. Each APU component which includes any electronic part, shall be subjected to this procedure. Temperature sensors shall be installed

in the first component of each manufacturer's part number in the locations which are the last to stabilize in temperature as a result of following a temperature change, and subjected to a cycle of temperature as described below, starting with step b. The times required for steps c and a shall be recorded. Each component shall then be tested as follows: The component shall be placed in the temperature chamber, operated in normal (rated) conditions, and subjected to vibration in accordance with 4.6.4.17 procedure throughout the test. The component shall be subjected to cycles of temperature as follows until it has achieved three consecutive failure-free cycles:

a. The temperature of the chamber shall be reduced to and maintained at -67 ±4°F (-55 ±2°C) until the temperature at all locations in the component are below -49°F (-45°C) (the capacity of the chamber shall be such that this shall not require more than one hour).

b. The temperature of the chamber shall be reduced to and maintained at -67°F (-55°C) for four hours.

c. The temperature of the chamber shall be increased to and maintained at 158 ±4°F (70 ±2°C) (until the temperature at all locations in the component are above 140°F (60°C) (the capacity of the chamber shall be such that this shall not require more than one hour).

d. The temperature of the chamber shall be maintained at 158 ±4°F (70 ±2°C) for a minimum of four hours. The time for steps a and c shall be the same in testing subsequent components as that which was found necessary for the first component. Whenever there is any change in the manufacturer's part number for this component, or in the temperature chamber, temperature sensors shall be installed in the first component as described above and it shall be tested as described above to determine the time needed for steps a and c.

4.7.3 Test Records.

4.7.3.1 Acceptance Test Log Sheet. The following information shall be recorded on the test log sheets for each APU run:

a. Date

b. APU Type and Model

c. APU Serial Number

d. Cell Number

e. Bellmouth and Area, Sq. In.

f. Exhaust Duct Serial Number and Area, Sq. In.

g. Type of Fuel Used

h. Type of Oil Used

i. Fuel Lower Heating Value

j. Total Running Time and Total Number of Starts

k. Vibration (Max Recorded in 4.7.4)

l. All Data Required in 4.7.4, except 4.7.4.3.

The APU manufacturer shall retain copies of acceptance test log sheets for each APU for two years. Copies of test sheets shall be furnished to the Using Service upon request.

4.7.4 Test Data. The data in the following subparagraphs shall be taken during the acceptance test and recorded in the acceptance test log sheets.

4.7.4.1 Preliminary Data. The APU dry weight shall be determined and recorded. If the APU dry weight is measured after the APU has been serviced with fuel and oil, and after subsequent draining, the dry weight may be calculated by subtracting the weight of residual fluids specified in 3.2.2.3 from the measured APU weight.

4.7.4.2 Steady-State Data. During operation at each specified steady-state condition and after performance stabilization, data shall be recorded as specified in Table VIII.

4.7.4.3 Transient Data. For each transient performed during the transient operations, the data shall be recorded as specified in Table VIII.

4.7.4.4 Starting Data. During each start, the data shall be recorded as specified in Table VIII.

4.7.4.5 Miscellaneous Data. All stops and coastdown times shall be measured and recorded. At least once during each test, readings shall be taken of barometric pressure, ambient air temperature, water vapor pressure, and fuel specific gravity. Oil consumption for the entire test run shall be measured and recorded. Spectrometric oil analysis samples shall be taken and analyzed at the end of each run. Notes shall be placed on the log sheets of all incidents of the run, such as leaks, unusual vibrations, and other irregular functioning of the APU together with corrective measures taken.

4.7.4.6 Accuracy of Data. For all APU acceptance testing, reported data shall have a steady-state accuracy within the tolerances shown in 4.3.5.3. The accuracy of transient data and the corresponding instrument calibration methods shall be subject to the approval of the Using Service and shall be described in the test procedure. All instruments and equipment shall be

calibrated as necessary to insure that the required degree of accuracy is maintained.

4.7.5 Test Procedure. The acceptance test shall consist of the initial and final runs specified below. When special APU features which would not function under the following test schedules are provided, these features shall be tested in a manner approved by the Using Service. Recorded time at each load condition shall start upon completion of the movement necessary to obtain that load condition. Prior to initiation of the final run, the APU controls shall be adjusted if necessary while installed on the APU, using only routine field adjustments, to produce at standard sea level static conditions rated power, or higher, and rated fuel consumption, or lower, within the limits of the measured exhaust gas temperatures and rotor speeds associated with the ratings. If any further adjustment to the APU or its components becomes necessary, a re-run of those portions of the test run already completed shall be required.

4.7.5.1 Initial Run. The APU shall be subjected to an initial run in accordance with the Using Service approved acceptance test procedure. The steady-state load times may be increased at the option of the APU manufacturer if needed to obtain stable performance data required to verify sea level static rated performance. All load changes shall be accomplished in one-half second or less except where otherwise stated. The nature and extent of checks, adjustments, and running prior to the initial run shall be specified by the APU manufacturer.

4.7.5.1.1 Inspection After Initial Run. Upon completion of the initial run, the APU shall be disassembled sufficiently to allow a detailed inspection of all vital working parts. The extent of disassembly is to be described in the Using Service approved acceptance test procedure. If any part is found to be defective, an approved part shall be supplied to replace it, and at the discretion of the Government representative, a penalty run of suitable duration shall be made.

4.7.5.1.2 Penalty Run. The duration of the penalty run shall be at the discretion of the Government representative. The maximum penalty run shall be a complete repetition of the initial run. Additional running-in prior to the penalty run may, at the option of the APU manufacturer, be performed for the accommodation of replaced parts.

4.7.5.1.3 Inspection After Penalty Run. Upon completion of the penalty run, the APU shall, at the discretion of the Government representative, be disassembled to allow for inspection of the APU.

4.7.5.2 Final Run. The final run, if required, shall consist of a repeat of the initial run of 4.7.5.1.

4.7.5.3 Rejection and Retest. Whenever there is evidence that the APU is malfunctioning or is not meeting model specification requirements, the

difficulty shall be investigated and its cause corrected to the satisfaction of the Government representative before the test is continued. If such investigation requires disassembly of the APU or any of its components, this shall be considered a rejection of the APU. A complete re-run or a repetition of the portion of the test prior to encountering the difficulty shall, at the option of the Government representative, be made.

4.7.5.3.1 APU Vibration. When any APU exceeds the vibration limits as specified in the model specification, this shall be considered a malfunction.

4.7.5.3.2 Maximum Measured Temperature. If at any time the temperature exceeds the maximum allowable measured exhaust gas temperatures specified in the model specification, this shall be considered a malfunction.

4.7.5.3.3 Stoppage. Interruptions or stoppage from any cause other than an APU malfunction shall require a repetition of the particular period during which the interruption or stoppage occurred.

4.7.5.3.4 Fluid Leakage. If fluid leaks beyond the limits specified in 3.3.6.3 are discovered, a check run or a complete re-run after correction of the leak shall be made at the discretion of the Government representative.

4.7.5.3.5 Maximum Hours of Running. Any APU which has more than a total of 30 hours of operation, or more than a total of 25 starts, including all runs, checks and adjustments of 4.7.5 and any runs, checks and adjustments prior to the initial run, shall stand rejected. Parts and components from these rejected APUs may be used in other APUs being built, providing these parts and components from the rejected APUs are resubmitted for inspection required for new parts and components, with full particulars being given the Government representative concerning previous rejection of the APU.

4.7.6 Test Completion. The acceptance test shall be considered to be satisfactorily completed when the conditions of 4.7.5 have been met and the data demonstrates compliance with applicable portions of the following model specification requirements.

a. 3.2.1 - Performance Characteristics

b. 3.2.1.4.6 - Rotor Speed Limits

c. 3.2.1.4.8 - Oil Pressure and Temperature Limits

d. 3.2.1.4.9 - Oil Consumption

e. 3.2.1.4.10 - Vibration Limits

f. 3.2.1.5.3 - Stopping

g. 3.2.1.5.4 - Stability

h. 3.2.1.5.5 - Transients Conditions

i. 3.2.2.1 - Dry Weight

j. 3.3.6.3 - Fluid Leakage

k. 3.7.7.4.2 - Oil Drain

l. 3.7.9 - APU Starting

4.7.7 Sampling Tests. Each APU of the same model designation delivered as a qualified item under this specification shall be numbered sequentially in essentially the order that it is submitted for government acceptance regardless of the contract under which delivered or by whom purchased. To meet the delivery requirement for the first 50 APUs, 51 APUs must successfully complete the required acceptance test; 50 of which are to be shipped as directed by the applicable contract; and one APU selected at random by the Government Inspector is to be forwarded to the Naval Air Propulsion Center (PE61), Trenton, New Jersey 08628. Additional samples will not be required unless directed by the applicable contract. The span of serial numbers of the production APUs from which each verification sample was selected shall be recorded and this information included with the sample. The sample shall be shipped no later than the final APU in the production group from which selected. The APUs forwarded to the Naval Air Propulsion Center will be inspected and examined for conformance to this specification. Tests will be conducted at the discretion of the verifying activity. The sample APU will be returned to the APU manufacturer with a report of the government test results at the conclusion of the design verification tests. Delivery of production APUs successfully passing the acceptance tests are to be accepted until the APU manufacturer is officially notified of noncompliance of APUs with this specification.

Shipping authorization and instructions are to be given by the cognizant Government Inspector when the sample APU is selected.

5. PREPARATION FOR DELIVERY

5.1 Preparation for Storage and Shipment. The APU, components and accessories shall be prepared for storage and shipment in accordance with MIL-E-5607. The level of preservation of the APU, the type of shipping container for the APU and the furnishing of the APU historical records shall be in accordance with contract requirements. A packing list shall be furnished with each APU which includes all components and tools which are not installed on the APU, but which are shipped with the APU.

6. NOTES

6.1 Intended Use. The APU covered by this specification is intended for use aboard the S-3A aircraft to provide self-sufficiency for starting main engines

and for checkout, maintenance and calibration of avionic and non-avionic systems on the ground; and to provide emergency main engine starts and electrical power while in-flight.

6.2 Definitions and Symbols. Definitions and symbols used herein and in the model specification will be as specified below.

6.2.1 Definitions.

6.2.1.1 Acceptance Test (AT). The acceptance tests are those tests conducted on APUs submitted for acceptance under contract to demonstrate correct assembly and performance to the extent specified in the model specification.

6.2.1.2 Accessories. Accessories are items of APU-mounted equipment not furnished by the APU manufacturer, which are required for aircraft operation or as auxiliaries for APU operation.

6.2.1.3 Additional Equipment. Additional equipment is any item shipped with the APU that is not mounted in the APU compartment.

6.2.1.4 Air Starting. Air starting is APU starting in-flight under a specified range of inlet conditions and temperature soak conditions, and is obtained using the starting procedure specified in the model specification.

6.2.1.5 APU Axes. The APU axes are geometric reference lines passing through the APU in the longitudinal, lateral, and vertical directions.

6.2.1.6 APU Components. APU components are items of equipment, furnished as part of and qualified with the APU whose size, conformation, dynamic or static characteristics are essential to attain the APU performance specified in the model specification. Fuel pumps, APU controls, variable guide vane actuators, anti-icing valves, GFE generator and the temperature sensing system(s) or device(s) are included in this category. Components may require separate qualification, calibration, or adjustment. The GFE generator and ECU have been or will be qualified separately and will be used in the qualification of the APU.

6.2.1.7 APU Coordinate System. The APU coordinate system is a position indicating system employing the X,Y, and Z-axes. The origin of the system is at the center of gravity of the APU. When looking from the rear of the APU, the positive directions shall be as follows:

X-Axis - forward from the origin
Y-Axis - to the left of the origin
Z-Axis - above the origin.

6.2.1.8 APU Duty Cycle. The APU duty cycle is a composite cycle derived from the mission profiles and mission mix.

6.2.1.9 APU Inlet Area. The APU inlet area is the net area in a plane perpendicular to the airflow path at the junction of the aircraft intake airduct and the APU.

6.2.1.10 Auxiliary Power Unit (APU). The APU is a deliverable system comprised of all the APU components necessary to satisfy the requirements of this specification for the intended use delineated in 6.1.

6.2.1.11 Burn-In. Burn-in is a procedure by which each component containing electronic parts are subjected to a temperature cycle and vibration simultaneously.

6.2.1.12 Catastrophic APU Failure. A catastrophic APU failure is a failure which results in APU stoppage and extensive damage to the APU. This is distinguished from those failures which cause only a partial degradation of capability or a gradual degradation over an extended period of time.

6.2.1.13 Center of Gravity. The center of gravity is a point at which the dry APU weight may be assumed to be concentrated.

6.2.1.14 Combined Operating Load. The combined operating load is an operating condition where the APU delivers both compressed air and electrical output simultaneously and the APU is capable of continuous operation at this condition.

6.2.1.15 Compressor Inlet Area. The compressor inlet area is the flowpath area at the station defined by the first-stage rotor airfoil root leading edge.

6.2.1.16 Dry Weight. The dry weight is the combined physical weight of the APU, and its components located in the APU compartment, with no liquids in the system.

6.2.1.17 Environmental Conditions and Operating Envelope. The environmental conditions and operating envelope of the APU are the extremes and limits such as externally applied loads, attitudes, and environmental extremes independently and concurrently in all combinations within the scope of the model specification.

6.2.1.18 Exhaust Duct Effective Area. Exhaust duct effective area is that area at the exit plane of duct required to pass the APU flow with the ideal velocity and density calculated at the exit plane. This definition accounts for the boundary layer along the outer wall of the duct, the very low flow or ineffective area behind the center body, the expansion of metal parts when raised to operating temperature and the actual velocity and density profiles that exist at the exit plane.

6.2.1.19 Fully Loaded Drive Pads. The fully loaded drive pads is the maximum rated torque applied to all drive pads.

6.2.1.20 Gulping Volume. Gulping volume is the difference between oil reservoir volumes with the oil at 59°F (15°C) and the APU at zero speed; and with the APU at stabilized no electrical load rotor speed. The gulping volume represents the initial amount of oil required to fill the lubrication system lines, pumps, sumps, bearing cavities, etc., each time the APU is started.

6.2.1.21 Low Oil Pressure Switch Actuation Pressure. The low oil pressure switch actuation pressure is the operating oil pressure at which the low oil pressure switch activates, sending a signal to the ECU which subsequently terminates the fuel flow to the APU after a 30-second delay.

6.2.1.22 Maintainability Definitions.

6.2.1.22.1 APU Maintainability. The capability (i.e., the inherent design characteristics) of an APU and its parts which permits its maintenance (inspection, adjustment, removal, test, repair and overhaul) within specified periods of time without excessive expenditure of maintenance manpower, personnel skill levels, test equipments, and maintenance support facilities.

6.2.1.22.2 Mean Time to Repair (MTTR). MTTR is defined as elapsed maintenance time per maintenance action (as in the Navy 3-M system, OPNAVINST 4790.2).

6.2.1.22.3 Direct Maintenance Man-Hours (DMMH). DMMH is defined as the total time in direct man-hours required to restore or maintain an item in serviceable condition.

6.2.1.22.4 APU Operating Hours (AOH). AOH is defined as the total number of operating hours accumulated by all the APUs in the sample.

6.2.1.22.5 Maintainability Index (MI). The MI is the ratio of direct maintenance man-hours (6.2.1.22.3) for APU and APU-caused maintenance to APU operating hours (6.2.1.22.4).

6.2.1.22.6 Scheduled Preventive Maintenance. Scheduled preventive maintenance consists only of:

a. Scheduled inspection ('look' phase) (e.g., pre-and post-flight inspections, daily inspections, etc.).

b. Replenishment of the consumable items identified in Table VI, at an interval not less than the frequencies in Table VI.

c. Scheduled replacement of life-limited items identified in the specification in compliance with 3.3.8.1.

6.2.1.22.7 Unscheduled Maintenance. Unscheduled maintenance is any maintenance other than scheduled preventive maintenance (6.2.1.22.6) (e.g.,

corrective maintenance required as a result of a problem uncovered during scheduled preventive maintenance or during APU operation.).

6.2.1.22.8 Non-Concurrent Downtime Rate (NCDR). The NCDR is the summation of time rates for certain maintenance tasks or types of tasks specified as downtime tasks by the Using Service. For each task the time in hours per task is multiplied by the task frequency expressed as tasks per unit time (flight hour, operating hour, etc., as specified).

6.2.1.22.9 Time Between Overhaul (TBO). TBO is the sum of actual number of hours operated on each individual APU between depot overhauls (or between manufacture and first overhaul).

6.2.1.23 Maximum Allowable Measured Exhaust Gas Temperature. The maximum allowable measured exhaust gas temperature, as specified for either steady-state or transient conditions, is the limit beyond which operation of the APU is not allowed.

6.2.1.24 Maximum Allowable Rotor Speed. Maximum allowable rotor speed, as specified for either steady-state or transient conditions, is the limit beyond which operation of the APU is not allowed.

6.2.1.25 Maximum Continuous. Maximum continuous compressed air load and maximum continuous electrical load are operating conditions at which the APU is capable of operating continuously.

6.2.1.26 Maximum Operating Altitude. The maximum operating altitude is the maximum altitude at which the APU will operate satisfactorily within the Mach number range specified in the model specification.

6.2.1.27 Measured Exhaust Gas Temperature. Measured exhaust gas temperature is the signal indication after the thermocouple electrical harness plug of the gas path total temperature at the APU station designated.

6.2.1.28 Mission. A mission is defined as that period beginning with the start of the APU in the air or on the ground and ending at APU shutdown.

6.2.1.29 Mission Mix. The relative frequency that each mission profile is encountered during a specified time period.

6.2.1.30 Mission Profile. A mission profile is a representation of a specific mission in terms of inlet conditions and electrical power and compressed air loads.

6.2.1.31 No Electrical Load. No electrical load is an operating condition at which the normal governed rotor speed is maintained and there is no electrical load on the generator.

6.2.1.32 Normal Governed Rotor Speed. The normal governed rotor speed is the rotor speed at which the fuel control system maintains the APU and is shown in the applicable columns of Tables I and II.

6.2.1.33 Overspeed Switch Actuation Speed. The overspeed switch actuation speed is the rotor speed at which the overspeed switch activates, sending a signal to the ECU which subsequently terminates the fuel flow to the APU.

6.2.1.34 Overtemperature Switch Actuation Temperature. The overtemperature switch actuation temperature is the measured exhaust gas temperature at which the overtemperature switch activates, sending a signal to the ECU which subsequently terminates the fuel flow to the APU.

6.2.1.35 Power Section. The power section consists of all APU parts located in the gas path.

6.2.1.36 Preliminary Flight Rating Test (PFRT). The preliminary flight rating test is the sum of test, demonstration and analysis activity accomplished on APUs and components to demonstrate suitability of an APU model for limited use in-flight testing. For reference purposes, the tests, demonstrations and analyses required for PFRT are listed in Appendix IV.

6.2.1.37 Procuring Service. The procuring service is the service which negotiates the APU contract.

6.2.1.38 Rated Load. The rated load is the value of the combined electrical power and compressed air outputs for a given rating when the APU is operating at the normal governed rotor speed for that condition, and the rated measured exhaust gas temperature has not been exceeded.

6.2.1.39 Rated Measured Exhaust Gas Temperature. The rated measured exhaust gas temperature is the maximum measured temperature permitted to attain a given Table I or Table II rating, at the normal governed rotor speed.

6.2.1.40 Rating. A rating is a characteristic value of performance specified in Table I or II of the model specification.

6.2.1.41 Reliability Definitions.

6.2.1.41.1 APU Failures-Observed. The APU failures-observed is the inability of the APU to perform within the model specification limits or the service manual limits.

6.2.1.41.2 Excluded Failures.

a. Failures resulting where transportation, storage, inspections, maintenance, repair, installation, overhaul, or replacements were improperly performed, contrary to currently applicable instructions, or reasonable standard of aircraft quality workmanship.

b. Failures resulting from operation of the APU beyond the model specification-defined environmental conditions and time cycle limitation, or with fuels or lubricants not conforming to the applicable specification.

c. Failures which are the result of the fuel system contaminations, where the contamination levels are outside the limits specified in this specification, unless evidence exists that the contamination was APU generated.

d. Failures for which a corrective APU design change or an operational procedure change has been verified and engineering approved by the appropriate Using Service will not be counted after date of approval, unless the failures are identical and the corrective change was in place, or used, on the failed APU.

e. Failures where the primary failure cause was not directly attributable to the design or quality of the APU; such as failures attributed to foreign object damage (FOD) which is in excess of the model specification requirements.

f. Failure of equipment not furnished by the APU manufacturer, which do not occur as a result of failure of the APU to provide a proper function or interface within the limits stated in this specification.

g. Any reported malfunctions which cannot be verified by subsequent investigation and do not occur in subsequent operation.

h. Discrepancies due to manufacturing defects discovered during green, final and penalty runs, provided these defects are corrected prior to acceptance of the APU by the Using Service.

i. Filter changes, chip detector inspection and cleaning, APU wash procedures, or removal of APU or components due to life and/or cycle limitations. APU failures detected by any of these procedures shall be included, unless excluded for other reasons.

j. Multiple part removals performed to correct a single failure mode or secondary damage from a single failure are counted as one failure against the APU.

6.2.1.41.3 APU Failures-Chargeable. APU failures-chargeable shall consist of all APU failures-observed (6.2.1.41.1) less the excluded failures (6.2.1.41.2).

6.2.1.41.4 Mean Time Between Failures (MTBF) - Observed. The MTBF-observed is the ratio of APU operating hours (6.2.1.22.4) to the number of APU failures-observed (6.2.1.41.1).

6.2.1.41.5 Mean Time Between Failure (MTBF) - Chargeable. The MTBF-chargeable shall be generated by using APU failures-chargeable per 6.2.1.37.3 and presented as an instantaneous value to be used for the reliability assessments specified in the applicable contract. The method for computing instantaneous MTBF shall be as mutually agreed upon by the manufacturer and the Using Service.

6.2.1.42 Sampling Tests. The sampling test is conducted on a randomly selected APU from the first 50 production APUs which have completed the acceptance test. The test assures that the production APUs are identical to the APUs which have successfully completed the PFRT and VT, and that the production APUs meet the requirements of this specification.

6.2.1.43 Satisfactorily. The words "satisfactorily" or "satisfactory" as used in this specification in conjunction with words or terms relating to operation or performance of APU described in the model specification, shall mean: Under the conditions specified, throughout the entire operating envelope, the APU operating characteristics and performance are not affected, and the operating and physical limits shown in the specification are not exceeded and no permanent deformation or other damage to the APU occurs.

6.2.1.44 Stall. Stall is an internal aerodynamic disturbance in the APU compression system which does not result in total loss of function.

6.2.1.45 Standard Condition. Standard conditions are the values of air temperature and pressure given in the US Standard Atmosphere 1976. The standard humidity, for the purpose of this specification, is zero vapor pressure at all altitudes. All heights noted in the specification shall be geopotential altitudes.

6.2.1.46 Start Time. The start time is the time from the opening of the hydraulic start valve to the APU RUN signal.

6.2.1.47 Surge. Surge is an internal aerodynamic disturbance in the APU compression system which results in total loss of function

6.2.1.48 Surge Margin. Surge margin is the calculated and/or demonstrated tolerance of the APU to adverse operating conditions while maintaining the required steady-state and transient performance capability.

6.2.1.49 Using Service. For the purposes of this specification the Using Service shall be the Naval Air Systems Command.

6.2.1.50 Unusable Oil. Unusable oil is the maximum quantity of oil in the APU lubrication system which is not available to meet APU lubrication requirements throughout the operating envelope under the maneuver forces and attitudes specified in the model specification.

6.2.1.51 Verification Test (VT). The verification test is the sum of test, demonstration and analysis activity accomplished on APUs and components submitted for APU qualification to demonstrate the suitability of an APU model for production and service use. For reference purposes, the tests, demonstrations and analyses required for VT are listed in Appendix IV.

6.2.1.52 Weight of Operating Fluids. The weight of operating fluids includes all fluid weights required for APU operation when all APU fluid reservoirs and lines are filled to their maximum capacities.

6.2.1.53 Windmilling. Windmilling is the rotation of any or all shafts by any external means other than the normal starter mechanism.

6.2.2 Symbols, Subscripts, and Abbreviations. The symbols, subscripts and abbreviations used in this specification shall be listed in the model specification.

6.3 Ordering Data.

6.3.1 Procurement Requirements. Procurement shall be in accordance with the applicable contract.

6.3.2 Contract Data Requirements. When this specification is used in an acquisition which incorporates a DD Form 1423, Contract Data Requirements List (CDRL), the data requirements identified below shall be developed as specified by an approved Data Item Description (DD Form 1664) and delivered in accordance with the approved CDRL incorporated into the contract. When the provisions of DAR 7-104.9 (n) (2) are invoked and the DD Form 1423 is not used, the data specified below shall be delivered by the APU manufacturer in accordance with the contract requirements. Deliverable data required shall be specified in the model specification as follows:

Paragraph No.	Data Requirement Title	Applicable DID No.	Option

(Data item descriptions related to this specification, and identified in section 6 will be approved and listed as such in DoD 5000.19L., Vol. II, AMSDL. Copies of data item descriptions required by the contractors in connection with specific acquisition functions should be obtained from the Naval Publications and Forms Center or as directed by the contracting officer.)

6.3.2.1 Structural Load Analysis Report. A structural load analysis report, in accordance with the requirement of 3.1.2.5 shall be submitted prior to the initiation of PFRT.

6.3.2.2 APU Heat Rejection and Cooling Report. An APU heat rejection and cooling report, in accordance with the requirements of 3.1.2.8.5, shall be submitted for approval by the Using Service 60 days prior to VT.

6.3.2.3 Radar Cross Section Report. N/A

6.3.2.4 Performance Presentation Digital Computer Program. The steady-state performance computer program and user's manual of 3.2.1.2 shall be submitted for approval by the Using Service prior to initiation of the PFRT endurance test and updated prior to initiation of the VT endurance test.

6.3.2.5 Verification of Performance. APU test data and analyses required for performance verification, in accordance with 3.2.1.3, shall be submitted to the Using Service for approval prior to initiation of the PFRT endurance test and updated prior to initiation of the VT endurance test.

6.3.2.6 Weight of Operating Fluids. The weight of operating fluids, in accordance with 3.2.2.3, shall be submitted to the Using Service for approval prior to the initiation of the PFRT and VT.

6.3.2.7 Failure Mode and Effect Analysis. A failure mode and effect analysis in accordance with 3.2.3 shall be submitted prior to the initiation of the PFRT and updated prior to initiation of the VT endurance test.

6.3.2.8 Reliability Analysis Report. An APU reliability report in accordance with 3.2.3 shall be submitted at the completion of VT.

6.3.2.9 Maintainability Program Plan. A maintainability program plan shall be submitted to the Using Service, in accordance with 3.2.4, prior to the initiation of the VT.

6.3.2.10 Materials and Process Documents. APU manufacturer's materials and process documents shall be submitted to the Using Service, as required by 3.3.1.1, prior to the start of PFRT.

6.3.2.11 Protective Treatments. A list of all of the protective treatments, in accordance with 3.3.1.1.3, shall be submitted to the Using Service prior to the initation of the PFRT.

6.3.2.12 Electromagnetic Interference. A systems analysis, interference control plan and an EMI/EMC test plan, in accordance with 3.3.2, shall be submitted to the Using Service 60 days prior to the initiation of the PFRT and VT.

6.3.2.13 Interchangeability and Replaceability. A listing which identifies matched or selected fit parts shall be submitted to the Using Service prior to PFRT and VT in accordance with 3.3.5.

6.3.2.14 APU Pressure Balance Report. A report containing the load analysis of 3.3.8.4 and the load verification of 4.4.6, shall be submitted to the Using Service prior to PFRT.

6.3.2.15 Strength and Life Analysis. A strength and life analysis report shall be submitted to the Using Service prior to PFRT and updated prior to VT as required by 3.3.8.6.

6.3.2.16 Design Report. A design report including the containment study and the fail-safe designs, in accordance with 3.3.8.9.1, shall be submitted to the Using Service prior to the initiation of the PFRT.

6.3.2.17 Rotor Integrity Report. A report substantiating the rotor integrity requirements of 3.3.8.9.2, shall be submitted to the Using Service prior to the initiation of the PFRT and VT.

6.3.2.18 Vibration and Stress Report. A vibration and stress analysis report in accordance with 3.3.8.10.2 shall be submitted to the Using Service prior to the endurance portion of the PFRT and updated and re-submitted prior to VT.

6.3.2.19 Safety Wire. A list of locations where safety wire is used, in accordance with 3.3.9.1.1, shall be provided to the Using Service prior to PFRT and VT.

6.3.2.20 Changes in Vendors or Fabrication Process. The APU manufacturer shall prepare and submit to the Using Service a list of those parts, components, and assemblies which require a substantiation test to qualify an alternative vendor source or process as well as the specific tests required to qualify parts as APU parts as specified in 3.3.9.4.2.

6.3.2.21 Repair Procedures and Wear Limits. Prior to the initiation of the endurance portion of the VT, the APU manufacturer shall furnish the repair procedures and wear limit information of 3.5.1.5 to the Using Service.

6.3.2.22 Fuel System Calibration Limits. A report in accordance with 3.7.3.3.1 shall be furnished to the Using Service prior to PFRT.

6.3.2.23 Wear Rate Analysis Reports. Wear rate analysis reports shall be provided to the Using Service prior to the endurance portions of the PFRT and VT as required in 3.7.7.4.6.

6.3.2.24 Wash Procedure and Washing Medium. The wash procedure and washing medium, in accordance with 3.7.11, shall be submitted to the Using Service prior to the initiation of the PFRT.

6.3.2.25 Pretest Data. The pretest data specified in 4.3.5.1 shall be submitted to the Using Service for approval prior to initiation of each test required in 4.4, 4.5 and 4.6.

6.3.2.26 Data Correction Method. The method of correcting data, in accordance with 4.3.5.12, shall be submitted to the Using Service prior to the initiation of the VT.

6.3.2.27 Test Reports. Separate test reports, prepared in accordance with 4.3.6.1, covering each individual test of 4.5 and 4.6 shall be submitted to the Using Service within 30 days after completion of the individual test.

6.3.2.28 Summary Reports. Separate reports summarizing the results of the PFRT specified herein and the VT specified herein, prepared in accordance with 4.3.6.2, shall be submitted to the Using Service within 30 days after completion of the last individual test.

6.3.2.29 APU Heat Rejection and Oil Cooling Report. The APU manufacturer shall supply to the Using Service the report containing the heat rejection and cooling requirements data as required in 4.4.1.

6.3.2.30 Oil Flow Interruption Test Report. The APU manufacturer shall supply to the Using Service the oil flow interruption test report as required in 4.4.2 prior to the completion of PFRT.

6.3.2.31 APU Electrical Power Failure Test. N/A

6.3.2.32 APU Vibration Survey Report. A vibration survey report, in accordance with 4.4.4, shall be submitted to the Using Service prior to the endurance portion of the PFRT.

6.3.2.33 Starting Demonstration Procedure. Prior to the start of PFRT, the procedure for demonstrating the starting requirements shall be submitted to the Using Service for approval. After approval of the procedure, the report on the actual demonstration shall be submitted to the Using Service as required in 4.4.5.

6.3.2.34 Maintainability/Maintenance Demonstration Report. A report describing the procedure and results of the demonstrations and test run of 4.4.7 shall be submitted to the Using Service prior to completion of the VT.

6.3.2.35 Packing List. A packing list, shall be furnished with each APU, which includes all components and tools which are shipped with the APU as required by 5.1.

6.4 International Standardization. N/A

6.5 Model Specification Preparation. A complete model specification conforming to the instructions for preparation contained herein shall be prepared and submitted by the contractor for approval by the Using Service.

6.5.1 Instructions for Preparation. The model specification shall be prepared as follows:

a. The headings and numbering of sections and paragraphs shall correspond to those of this specification.

b. Paragraphs herein which are applicable as written shall be copied into the specification. Any change, addition or deletion shall be identified by placing an identifying mark or symbol in the margin.

c. Paragraphs herein which are not applicable to the particular APU design shall have the words "not applicable" entered following the appropriate paragraph number and headings.

d. Paragraphs requiring modification to define a particular design shall be modified only to the extent necessary to describe the characteristics of that particular APU and model.

e. New requirements or additions shall be added as additional subparagraphs or as new paragraphs in logical sequence and location.

f. Items such as tables, figures, drawings, diagrams, and appendices, shall be presented in complete form in the specification. Complete statements calling out these items shall be included in the text of the specification.

g. All curves shall be presented on graph paper having an adequate number of subdivisions to permit necessary interpolations.

h. The prepared specification shall have identifying dividers between major sections and indices to provide easy access and reference.

i. The specification number and APU model identification shall be displayed on the spine of the document.

j. The APU sea level and altitude performance tables shall be designated as Table I and Table II, respectively.

k. All parameters appearing in the model specification shall be presented in pound-foot units. Temperature shall be presented in degrees Fahrenheit and degrees Celsius. Degrees Fahrenheit is primary and shall be followed parenthetically by degrees Celsius.

l. Section 2 of the model specification shall list all of the documents referenced in this specification, including revisions, amendments, supplements, notices, etc. Documents cited in the text need only reference the document number.

6.5.2 Approval Status. The first page of the model specification shall contain information indicating the approval status of the specification in the upper left hand corner. If approval has been obtained, enter the word "approved" and cite the communication which conveys the approval. If the specification is not yet approved, enter the words "not approved".

6.5.3 Specification Dates. The date of the specification shall be provided in the upper right hand corner.

6.5.4 Revisions. When revisions are made, they shall be designated by the use of a letter following the specification number with a revision date therefore, which shall be shown on page 1 only of the model specification. Only the specification number and revision suffix letter, if applicable, shall be shown on subsequent pages. Revision by preparation of revised pages for insertion into previously submitted copies of the model specification shall not be used.

6.5.5 Verification Table. The requirements of the PFRT and VT verification table (Appendix IV) shall be included in the model specification.

6.5.6 Index Requirements. Numerical and alphabetical indices of paragraphs and an index of figures, tables and appendices, shall be prepared as part of the model specification and submitted for approval by the Using Service.

6.6 Instructions for Preparation of APU Summaries. Instructions for preparation of APU summaries (See Table III) shall be as follows:

BLOCK 1 SECURITY CLASSIFICATION - Indicate the highest classification of the data presented on the summary. Include the special notation which identifies its status in the automatic, time-phased downgrading and declassification system, in accordance with current applicable security regulations.

BLOCK 2 MILITARY DESIGNATION - Show the official military designation. If there is none assigned, show all other designations by which the particular APU is identified.

BLOCK 3 APU MANUFACTURER'S DESIGNATION - Show the APU manufacturer's designation and popular name for the APU. If not applicable, insert "None".

BLOCK 4 SPECIFICATION DATA - Insert APU manufacturer's name, location (city and state), model specification number from which the data is derived (if none, indicate the source and date of data such as report number, bulletin, or progress reports), the latest date of the specification, and whether it has been approved or not approved by the cognizant Government agency.

BLOCK 5 PICTORIAL DATA - Furnish a glossy photograph (side view) with the exhaust duct to the right. If there is none available, a linear drawing, blueprint drawing, or artist's sketch will be satisfactory. This pictorial data may be furnished in its original form.

BLOCK 6 SPONSORING AGENCY - Show name of Government agency originally sponsoring the project, i.e., ARMY, NAVY, USAF, NASA, SANDIA, ARPA, etc. If not Government sponsored, indicate responsible contractor.

BLOCK 7 GENERAL DESCRIPTION - Show a general description as well as special data relative to cooling, reliability, specialties, limitations, APU life expectancy, advancements and similarities over previous models, etc., as applicable.

BLOCK 8 AVAILABILITY

a. Program Initiated ..... _____
(Give month and year program was initiated.)

b. Development Contract Award ..... _____
(Give month and year of contract award. If not applicable, insert "None".)

c. APU Mock-Up Inspection ..... _____
(Give month and year scheduled for official completion. If not applicable, insert "None".)

d. Experimental APU ..... _____
(Give month and year scheduled for initial operation as a complete assembly. If not applicable, insert "None". An experimental APU is basically defined as an APU that has not completed the Preliminary Flight Rating Test.)

e. Mock-Up for Aircraft ..... _____
(Give month and year scheduled for official completion. If not applicable, insert "None".)

f. Installation APU ..... _____
(Give month and year that first flight APU could be or is made available for prototype vehicle application. If not applicable, insert "None".)

g. Preliminary Flight Rating Test... _____
(Give month and year scheduled for official completion. If not applicable, insert "None".)

h. Verification Test ..... _____
(Give month and year scheduled for official completion. If not applicable, insert "None". If demonstration or FAA Certification only is required, indicate month and year scheduled and insert below the Verification Test line.)

BLOCK 9 CONTRACTUAL - If demonstration, experimental, or research APU, give all contract numbers, contract coverage, and total contract cost. If production or service test APU, give all contract numbers, quantities per contract, and unit cost.

BLOCK 10 STATUS - Give current status, i.e., in design stage, undergoing component development, first firing date, in production, production completed in (mo-year), currently undergoing production buildup, number of APUs produced to date, etc., as applicable. Also, give approximate lead time that the APU would be available after contract initiation. Give the full story as required to fully portray the current status, stage of development, and availability.

BLOCK 11 SPECIFIC FEATURES - All applicable performance and characteristics parameters are based on sea level static, standard day conditions.

a. (If single rotor compressor, show)

Compressor ..... _____
(Show type, single rotor, number of stages, variable geometry, etc.)

(If dual rotor compressor, show)

Compressor ..... _____
LP Rotor ..... _____
HP Rotor ..... _____
(Show compressor type, dual rotor, number of stages for each rotor, variable geometry, etc.)

b. (If single rotor compressor, show)

Max Design Pressure Ratio/SLS:

Overall ..... _____:1
(Express to nearest 0.1)

(If dual rotor compressor, show)

Max Design Pressure Ratio/SLS:

LP Rotor ..... _____:1
HP Rotor ..... _____:1
Overall ..... _____:1
(Express to nearest 0.1)

c. Max Compressed Air..... _____%
(Equals compressed air divided by total max APU airflow, express to nearest 0.1.)

d. Total Max APU Airflow / SLS.... _____lbm/sec

e. Combustion chamber ..... _____
(Show type, number, flow, etc.)

f. (If single rotor turbine, show)

Turbine ..... _____
(Show type, single rotor, number of stages, variable geometry, etc.)

(If dual rotor turbine, show)

Turbine ..... _____
LP Rotor ..... _____
HP Rotor ..... _____
(Show turbine type, dual rotor, number of stages per rotor, variable geometry, etc.)

g. Turbine Cooling ..... _____
(Show type, i.e., air, liquid, none, etc.)

h. Max Allowable Measured Exhaust Gas Temp (Steady-State)....._____°F(_____°C)
(Specify Measuring Station)

i. Max Turbine Inlet Temp/SLS (Estimated)....._____°F(_____°C)

j. Overtemp Switch Actuation Temp....._____°F(_____°C)

k. Max Allowable Rotor Speeds (Steady-State)
LP Rotor..... _____rpm
HP Rotor ..... _____rpm

l. Overspeed Switch Actuation
Speed..... _____ rpm

m. Exhaust Duct ..... _____
(Show type, variable, fixed area, exit area, etc.)

n. Performance Data - Max Cont hp available for electrical power and compressed air at SLS..___hp at ___rpm

o. Electrical System ..... _____
(Show voltage, cycle and max amperage requirements.)

p. Ignition ..... _____
(Show type, number of igniters, etc.)

q. Fuel Control ..... _____
(Show type, i.e., electrical, hydromechanical, pneumatic, digital computer, etc.)

r. Fuel ..... _____
(List designation type and Military Specification for both primary and alternate fuels.)

s. Oil ..... _____
(List designation type, grade and Military Specification.)

t. Maximum Oil Consumption ..... _____

u. Low-Oil Pressure Switch
Actuation Pressure..... _____psig

v. Reduction Gear Ratio ..... _____

w. Accessory Drive Provisions ..... _____
(List number of drives provided.)

BLOCK 12 SIZE & WEIGHT - Show all data at room temperature.

a. Length, Overall ..... _____ in
(Parallel to centerline axis, express to nearest 0.01.)

b. Diameter, Nominal ..... _____ in
(Perpendicular to the centerline axis, express to nearest 0.01.)

c. Max Radial Projection ..... _____ in
(Perpendicular to the centerline axis, express to nearest 0.01.)

d. Weight, Installed, Dry(nearest lbf)..._____lbf

e. Weight, Residual Fluids(nearest lbf).._____lbf

f. Weight, Operating Fluids(nearest lbf).._____lbf

g. Weight, Generator(nearest lbf)....._____lbf

h. Weight, ECU(nearest lbf)....._____lbf

i. Weight, Mounts(nearest lbf)....._____lbf

BLOCK 13 UTILIZATION - Indicate the vehicle application by both nickname and military designation. Include number of APU's per application, and indicate the Using Service for each vehicle.

BLOCK 14 DATE - Add date indicating currency of summary.

10. S-3A GENERATOR

10.1 SCOPE

10.1.1 Scope. This appendix specifies the unique requirements for the S-3A generator of 10.2.1 when mounted and driven by the APU specified in 3.1. This appendix is a mandatory part of the specification. The information contained herein is intended for compliance.

10.2 REQUIREMENT

10.2.1 Item Definition. The generator conforming to the following definition shall be mounted on and be driven directly by the APU which shall act as a constant speed drive and provide adequate cooling for the generator to the requirements herein:

Federal Stock Number (FSN) 2-RE-6115-01-047-1348

Westinghouse Part Number (P/N) 976-J936-11

10.2.1.1 Interface Definition. The generator shall be mounted directly on the APU gearbox which will provide the drive end bearing and support as specified in 3.1. The generator lubricating/cooling oil system is external to the generator and shall interface with the APU gearbox.

10.2.1.1.1 Direction of Rotation. The generator rotation shall be clockwise when viewed from the generator driven end.

10.2.1.1.2 Heat Rejection and Cooling. The cooling/lubrication oil shall be provided by the APU. The APU oil pumping system shall provide a minimum flow rate of 2.0 gallons per minute of solid oil at 55 psig minimum and 300°F (149°C) maximum to the generator for cooling. The maximum continuous heat rejection into the cooling oil shall be as shown in figure 1.

10.2.2 Characteristics.

10.2.2.1 Performance Characteristics. The generator shall provide the specified electrical power for the cooling conditions defined in 10.2.1.1.2.

10.2.2.1.1 System Rating. The APU generator channel shall be nominally rated at 45 KVA, 0.75 to 0.95 power factor.

10.2.2.1.2 System Power Capability. The APU generator channel shall be capable of delivering 45 KVA at 0.75 to 0.95 power factor continously. The APU generator also shall be capable of delivering 67.5 KVA for 5 minutes and 90 KVA for 5 seconds.

10.2.2.2 Operating Characteristics.

10.2.2.2.1 Operating Mode. The APU generator will be operated as follows:

a. Operating of the APU generating channel to supply both primary AC busses.

b. Operation of one generating channel to supply its primary AC bus while the other bus is supplied from the APU generator.

10.2.2.2.2 System Start-Up with External or APU Generator Power. With the generator transfer contactors closed in the LB and RB position (see figure 3) and the EPC/APU transfer contactor closed in either position, and with the primary AC busses energized from external power or APU generator, starting the first engine shall result in the operating generator supplying its associated load bus. The load bus of the non-operating generator will continue to be supplied from external power or APU generator.

10.2.2.2.3 Start of the Second Engine. With the load bus of the operating channel being supplied by its associated generator, and the load bus of the non-operating generator being supplied by external power or APU generator, start of the second engine will result in the EPC/APU contactor opening after both generator contactors have transferred (LA and RA closed, see figure 3).

10.2.2.2.4 Shutdown of the Second Engine. Shutdown of the second engine, for any cause, shall result in either the external power source or the APU generator supplying all busses.

10.2.2.2.5 Underspeed Protection. Underspeed protection shall be provided by a tachometer signal from the APU. The APU tachometer signal output voltage level shall be within the limits of 5-20 VAC peak-to-peak at generator shaft speeds above 11,160 rpm into a 1000 Ohm load. The signal shall be single phase with a frequency of 2075 Hz at generator shaft speed of 11,640 rpm.

10.2.2.3 Physical Characteristics.

10.2.2.3.1 Generator Weight. The dry weight of the generator is 42.9 pounds.

10.2.2.3.2 Generator Center of Gravity. The center of gravity of the generator is 4.2 inches from the mounting flange.

10.2.2.3.3 Generator Overhung Moment. The maximum overhung moment of the generator is 185 inch-pounds.

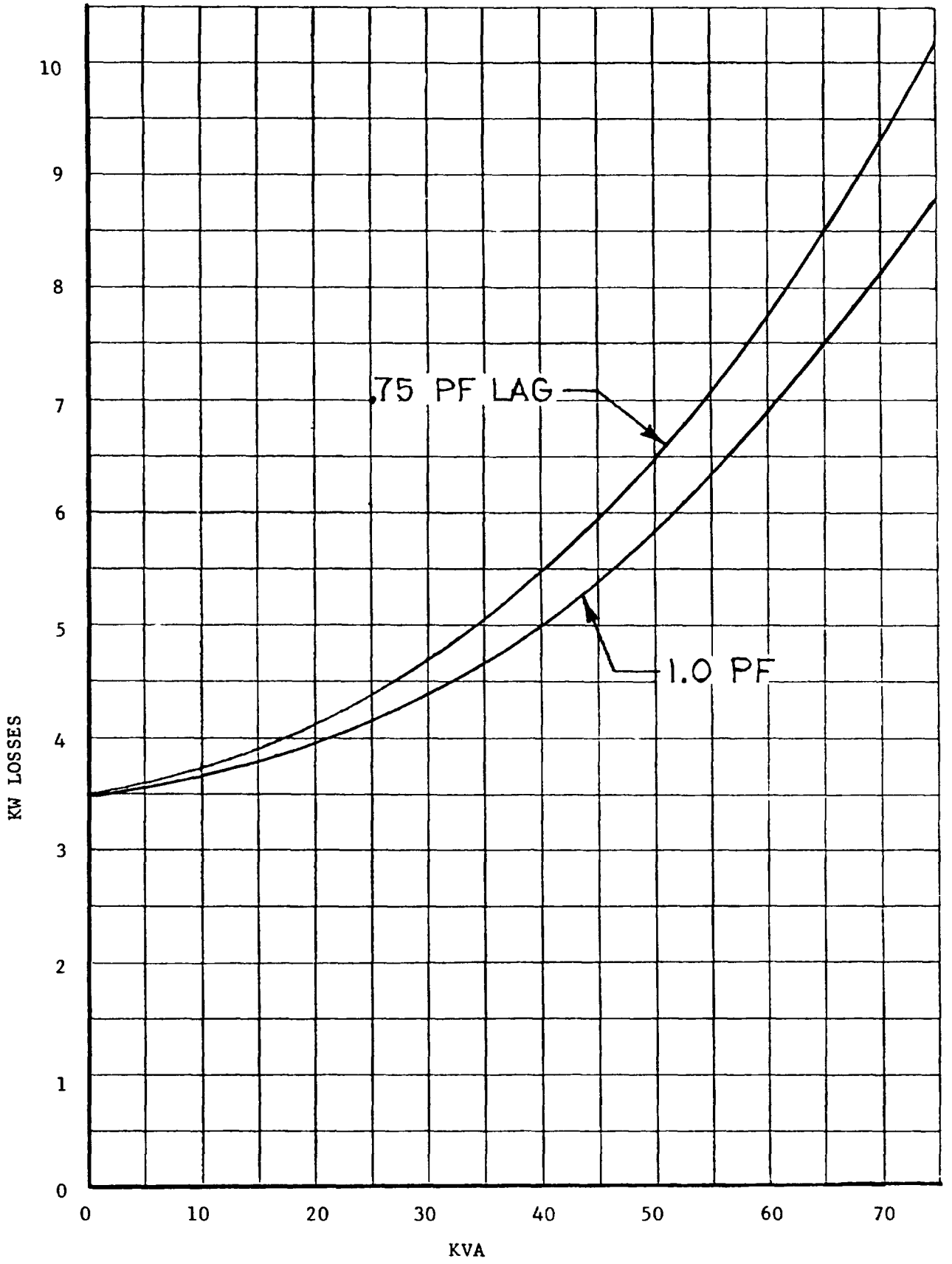


FIGURE 1. S-3A generator heat rejection.

Ref. - 10.2.1.1.2

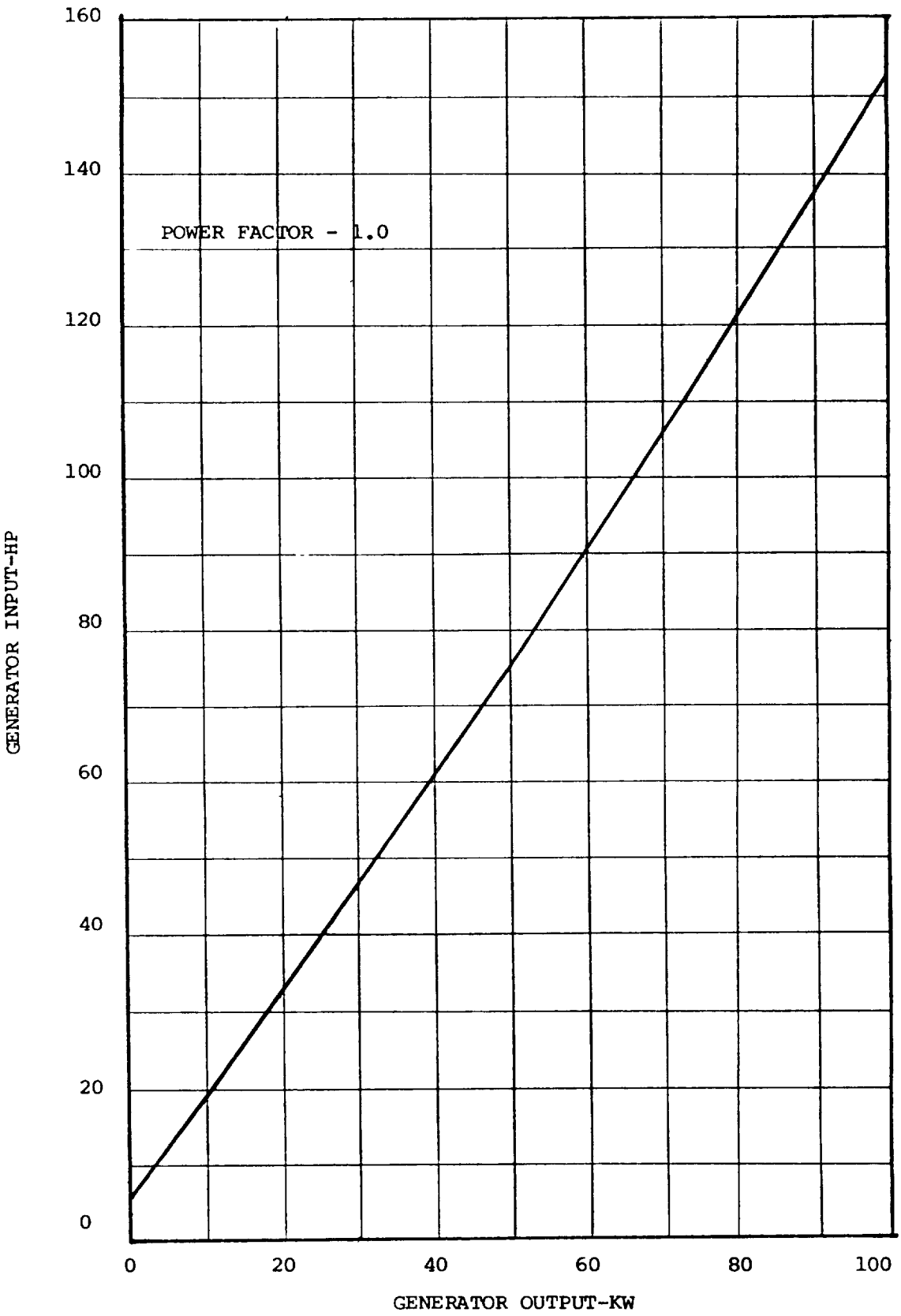


FIGURE 2. Generator input shaft power versus output KW.

Ref. - 3.2.1e, 3.2.1.1

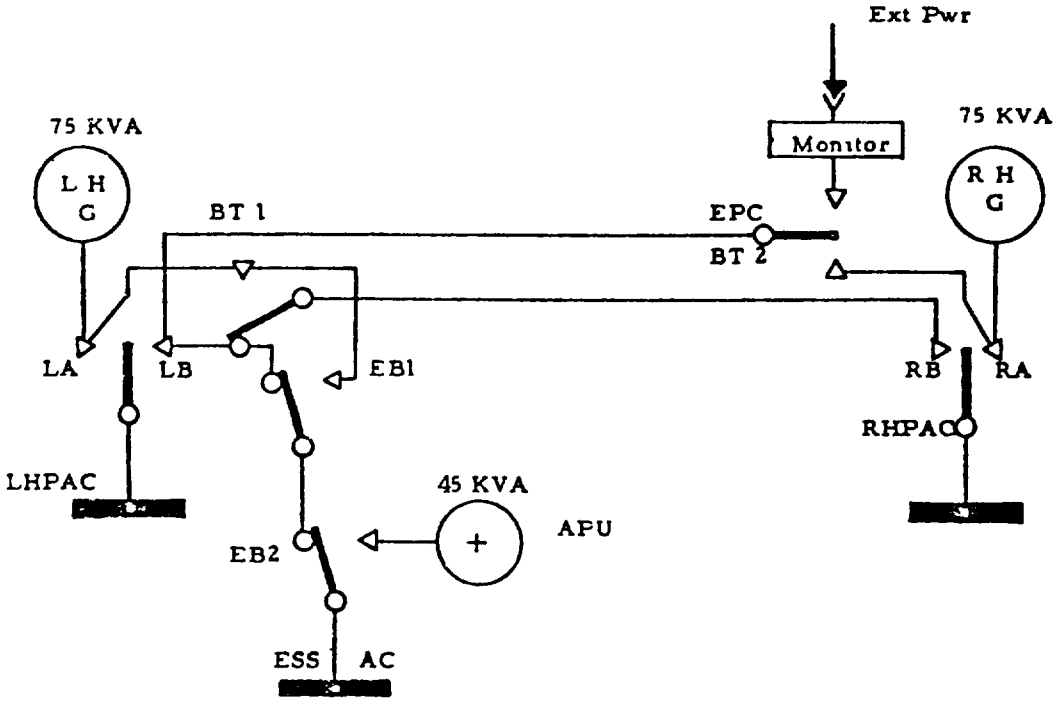


FIGURE 3. Power transfer system.

Ref. - 10.2.2.2.2, 10.2.2.2.3

20. ELECTRONIC CONTROL UNIT, APU, REQUIREMENTS FOR

20.1 SCOPE

20.1.1 Scope. This appendix defines the requirements for the Electronic Control Unit, hereinafter referred to as the ECU, to be used with the Auxiliary Power Unit (APU) on the S-3A aircraft. This appendix is a mandatory part of the specification. The information contained herein is intended for compliance.

20.2 APPLICABLE DOCUMENTS

20.2.1 Applicable Documents. The documents listed in Section 2 of the basic specification for the APU are applicable to the ECU to the extent specified in this Appendix.

20.3 REQUIREMENTS

20.3.1 Item Definition.

20.3.1.1 Dimensions. The dimensions of the ECU shall be in accordance with the envelope shown on figure 1.

20.3.1.2 Electrical Connectors. One connector shall be employed for all circuits connecting the ECU to the APU, and another connector to carry the signals to the aircraft circuits. Interconnections with the APU wiring harness shall be shown in the APU model specification and other connections as shown on figure 2.

20.3.1.3 Mounting. The ECU shall be attached by a standard mounting or mechanism that permits replacement without the need for special tools, and that results in the lowest weight and least mounting space. The mounting and attachment means are shown on figure 1.

20.3.1.4 Heat Loss. Under all steady-state load conditions, the power dissipation of the ECU shall not exceed 40 watts.

20.3.1.5 Generator Circuit. A signal shall be provided to protect the circuits supplied from the generator from low generator RPM. The signal shall be provided at 95 percent APU speed and removed when the APU speed drops below 93 percent.

20.3.1.5.1 Voltage. The limits of the speed signal are 5 to 20 VAC peak-to-peak looking into a 1000 Ohm load.

20.3.1.5.2 Frequency. The frequency of the speed signal shall be 2140 ±65 Hz.

20.3.1.6 Flight Control Circuits. Circuits between the ECU and the flight station shall provide for APU controls, both normal and emergency, and status information.

20.3.1.6.1 Operation and Control.

a. The APU-T handle operates a switch which connects two (2) lines in the ECU for arming after a delay to insure the exhaust door has had time to open and for arming the permanent magnet generator circuit.

b. The APU control panel has two lighted switches. One requires a ground (160 ma minimum) when the APU reaches 95 percent of normal governed rotor speed to indicate "RUN" (the APU is ready to load), and it activates the automatic shutdown circuit in the ECU when depressed by providing a momentary ground. The second switch is lighted to indicate "DISARMED" by the ECU providing a ground (160 ma minimum), and when the switch is depressed to activate the Safety Override circuit in the ECU, it provides a momentary ground for the ECU circuit.

20.3.1.6.2 Master Caution Panel.

a. The APU Oil Pressure indicator shall be lit by the ECU providing a ground (100 ma minimum) when the APU oil pressure switch closes for more than 30 seconds.

b. The APU Over (OV) Temperature indicator shall be lit by the ECU providing a ground (100 ma minimum) when the APU measured exhaust gas temperature exceeds its limits.

20.3.2 Characteristics.

20.3.2.1 Performance Characteristics. The values specified herein shall define the requirements for satisfactory performance and shall apply to performance under the standard conditions as specified in 20.3.2.5.1 and the environmental conditions as specified in 20.3.2.5.2.

20.3.2.1.1 Input Power. The ECU shall provide the electrical signals and power specified in 20.3.2.1 over all the environmental conditions of 20.3.2.5 when supplied with power from the permanent magnet generator (PMG) on the APU. The input power characteristics shall be specified in the model specification.

20.3.2.1.2 Loads. The ECU shall be capable of supplying the currents at the specified voltages to all devices required for APU operation.

20.3.2.1.3 Starting Sequence. The sequence of operations during a normal APU start shall be as specified in the APU model specification and shall include the following:

(1) Pulling the aircraft APU handle assembly to first detent opens the manual fuel supply shutoff valve and releases the APU compartment exhaust door actuator to the open position.

(2) Pulling the aircraft APU handle to the end of its stroke manually opens the start valve (to allow fluid to flow from the APU start accumulator to the hydraulic starter mounted on the APU) and actuates a microswitch which arms the circuit of the permanent magnet generator to supply power to the ECU.

(3) The ECU will sense APU rotor speed and DC control power voltage to sequence fuel flow and ignition as required for light-off and acceleration of the APU to normal governed speed.

(4) From 50 to 95 percent rotor speed, the ECU will energize a solenoid by supplying 1.0 amperes minimum at 28 VDC continuously which will close the start valve and actuate the APU start counter and hourmeter.

(5) At 95 percent rotor speed, the ECU will energize the "APU RUN" flight station switchlight on to indicate that the APU is at operating speed and ready to load and provide the speed signal to the generator control unit.

20.3.2.1.4 Shutdown. Normal APU shutdown shall be accomplished by pushing the aircraft APU handle to close the fuel supply shutoff valve.

20.3.2.1.5 Safety Provisions. The ECU shall remove power from a fuel solenoid on the APU under the following conditions:

a. Overspeed. If the rotor speed reaches 68,829 RPM as detected by a monopole signal of 22,660 Hz ±1 percent, the ECU shall remove power from the fuel solenoid after a time delay of 10 milliseconds. The override of 20.3.2.1.6 shall not apply to this feature.

b. Overtemperature. When the measured exhaust gas temperature exceeds the overtemperature limit, the overtemperature switch shall close within 2 seconds, removing power from the fuel solenoid.

c. Oil Pressure. When power is first applied to the ECU and the rotor speed has not reached 95 percent of nominal, a low oil pressure condition (oil pressure switch is closed) shall not remove power from the fuel solenoid. If, during operation of the APU, the oil pressure switch is closed for a period longer than 30 to 35 seconds, the ECU shall remove power from the fuel solenoid.

20.3.2.1.6 Safety Override. A circuit shall be provided to bypass the safety features of 20.3.2.1.5b and c and to illuminate the "DISARMED" switch light. This circuit will be activated by the momentary closure for at least 100 milliseconds of the "DISARMED" switch light located at the flight station.

20.3.2.1.7 Failure Indicators. Signals to actuate failure indicators (BITS) shall be provided. Such signals may be continuous. The output resistance of the "BIT" drivers shall be 5 milliamperes. The "BIT" indicators shall be dark for normal operation with a change to a light color indicating a failure. The ECU shall provide BIT signals as follows:

(1) Overtemperature signal provided by Overtemperature Switch. See 20.3.2.1.5b.

(2) Overspeed signal provided by ECU speed circuit. See 20.3.2.1.5a.

(3) Low oil pressure signal, after 30 second time delay. See 20.3.2.1.5c.

(4) Clear signals at start of power from PMG.

20.3.2.1.8 Protection Against Long Lines. The input lines identified in 20.3.2.1.6 and 20.3.2.1.9 shall be filtered internally to provide an attenuation of 0 dB at a frequency of 15 kHz.

20.3.2.1.9 Safety Shutdown. The ECU shall be designed to accept a simulated overspeed signal provided by pushing the "APU RUN" switchlight at the flight station to demonstrate proper operation of the overspeed shutdown circuit. Proper functioning of the low oil pressure sensor and indicator shall also be demonstrated during the simulated overspeed shutdown as the APU coasts down.

20.3.2.1.10 Logic Voltage Levels. Logic voltage levels shall be maximized within the input supply voltage available to minimize the effects of electromagnetic interference.

20.3.2.1.11 Accuracy of Speed Sensing. Speed sensing shall be accurate to ±0.75 percent at 100 percent rotor speed and ±2 percent at overspeed threshold.

20.3.2.1.12 Logic Reset. All logic functions shall be reset to initial conditions upon opening and subsequent reclosure of the APU handle switch. All logic functions shall start at normal initial conditions with closure of the APU handle switch and subsequent application of power to the ECU.

20.3.2.2 Physical Characteristics.

20.3.2.2.1 Weight. The weight of the ECU shall not exceed 12 lbs. The actual weight shall be specified in the model specification.

20.3.2.2.2 Color. The ECU shall be finished in a color conforming to FED-STD-595, color number 17875 (white).

20.3.2.3 Reliability. The ECU shall be designed to have an MTBF of 40,000 hours, when maintained, inspected, and overhauled according to the supplier's instructions.

20.3.2.4 Maintainability.

20.3.2.4.1 Life Requirements. The ECU shall provide the following life characteristics.

20.3.2.4.1.1 Operating Life. The ECU shall operate a minimum of 10,000 hours without maintenance.

20.3.2.4.1.2 Flight Nonoperating Life. The ECU shall endure the environmental conditions of 20.3.2.5.2 in a nonoperating condition during aircraft flights without impairment of the operating life.

20.3.2.4.1.3 Calendar Life. The ECU shall have an overall useful life, including operation, flight nonoperation, and repairs, of ten years.

20.3.2.4.1.4 Life of Parts. Castings, housings and other parts in the non-wearing category shall be designed for unlimited life.

20.3.2.5 Environmental Conditions.

20.3.2.5.1 Standard Conditions. For design purposes the following conditions shall be used to establish performance characteristics:

Temperature	Normal room (77 ±11°F (25 ±5°C))
Altitude	Normal ground
Humidity	Room ambient (up to 90 percent relative humidity)

20.3.2.5.2 Environmental Requirements. The ECU shall perform as required in this specification while exposed to any combination of operational environments in 20.3.2.5.2.1 and after repeated prolonged exposure to any combination of environments in 20.3.2.5.2.1 and 20.3.2.5.2.2.

20.3.2.5.2.1 Operational Environments

Temperature	-65 to +165°F (-54 to 74°C)
Altitude	Sea level to 30,000 feet, operating
	Sea level to 40,000 feet, nonoperating
Vibration	MIL-STD-810, Equipment Category b.2

20.3.2.5.2.2 Exposure Environments. The ECU shall perform as required in this specification after exposure to any combination of the following environments:

Storage temperature	-65 to 165°F (-54 to 74°C)

Temperature shock	-65 to 165°F (-54 to 74°C) in 5 minutes
Humidity	100 percent humidity at tropical temperatures
Salt fog	Sea level marine atmosphere
Dust	Dry wind-driven fine sharp sand
Fungus	All known fungi under conditions of warmth, humidity and the presence of inorganic salts
Explosive atm.	The optimum fuel-air and oil-air mixtures that require the least amount of energy for ignition.

20.3.2.6 Transportability. The ECU shall be transported in packaging suitable to the Using Service.

20.3.3 Design and Construction. The ECU shall conform to the requirements of AR-10 and shall fulfill all design and performance requirements specified herein.

20.3.3.1 Parts, Materials, Processes and Standards. The requirements of the basic specification are applicable to this Appendix, with the following additions.

20.3.3.1.1 Plating. Parts in moving contact, or other operating parts, shall not be plated with cadmium, zinc, or magnesium.

20.3.3.1.2 Microelectronic Modular Assemblies. When used, microelectronic modular assemblies shall meet the requirements of AR-10.

20.3.3.1.3 Modules. The control unit shall be functionally modularized. The references in MIL-E-5400 to detailed mechanical and electrical design and to maintainability and to accessibility are applicable.

20.3.3.1.4 Electron Devices. Transistors and diodes shall be chosen and applied as outlined in Requirement 30 of MIL-STD-454.

20.3.3.1.5 Electrical Bonding. All faying surfaces shall be conductive as specified in MIL-B-5087, Class R. The bonding resistance shall be 0.0025 ohms maximum.

20.3.3.1.6 Dielectric Strength. The ECU shall be able to withstand the application of 500 volts RMS at 60 Hz for one minute between each pin connection and the case. Components connected between a pin and the case may be disconnected when applying the 500 Vrms.

20.3.3.1.6.1 Voltage Rating. Capacitors and semi-conductor components shall be capable of withstanding 100 volts or twice the peak operational value, whichever is greater, and may be disconnected during tests of dielectric strength between terminal points and the case. Tests of capacitors and semi-conductors may be performed on components prior to assembly.

20.3.3.2 Electromagnetic Interference (EMI). The circuits of the ECU shall meet the EMI requirements of MIL-STD-461, Class AIg equipment for engine accessories. In addition, conducted and radiated susceptibility tests CS01, CS06, RS01 and RS02 shall be performed on an operating ECU to verify compatibility with the electromagnetic environment. Incorporation of transient and spike protection to meet MIL-STD-704 characteristics and incorporation of filters to meet EMI requirements shall be included if necessary to meet requirements.

20.3.3.3 Nameplates and Product Marking. The nameplate shall be readable without removal of the unit and without dismantling any parts. The nameplate shall be in a location unobstructed by the unit connector or cable. The ECU shall be identified in accordance with MIL-STD-130.

20.3.3.4 Workmanship. The ECU shall be constructed and finished to produce a product free from all defects which would affect proper functioning in service. Particular attention shall be given to thoroughness of assembly, alignment of parts, tightness of screws and bolts, marking of parts, protective finish and removal of burrs, sharp edges and excessive roughness.

20.3.3.5 Interchangeability. All parts having the same manufacturer's part number shall be functionally and dimensionally interchangeable and replaceable with each other with respect to installation and performance, except that matched parts or selective fits will be permitted when required. The use of matched parts and selective fits shall be held to a minimum.

20.3.3.6 Safety. The contractor shall conform to the general requirements of MIL-STD-882 when designing to ensure system safety design.

20.3.3.7 Human Performance and Human Engineering. The principles, criteria, and procedures of human engineering shall be applied to the design of the ECU in accordance with the applicable contract requirements.

20.3.4 Documentation. Documentation to be supplied shall be in accordance with applicable contract requirements.

20.3.5 Logistics.

20.3.5.1 Maintenance.

20.3.5.1.1 Adjustments. No external adjustments access shall be required during installation of this unit. All adjustments are to be made at the time of manufacture or overhaul. If devices for making adjustment are installed within system components, suitable locking and sealing means shall be provided to indicate when an unauthorized adjustment has been made. Potentiometers and adjustable resistors shall not be used.

20.3.5.1.2 Standard Tools. On items suitable for economic repair, assembly and disassembly shall be accomplished using tools and equipment listed in NAVAIR 00-35QG-001 and NAVAIR 00-35QG-016. If special tools are required for the ECU, justification must be presented to the Using Service for approval.

20.3.5.2 Supply. Supply provisions shall be in accordance with the applicable contract requirements.

20.3.6 Personnel and Training. Personnel and training requirements shall be in accordance with the applicable contract requirements.

20.4 QUALITY ASSURANCE PROVISIONS

20.4.1 General.

20.4.1.1 Responsibility for Inspection. Unless otherwise specified in the purchase order, the contractor is responsible for the performance of all inspection and test requirements as specified herein. The contractor may utilize his own facilities or any commercial laboratory acceptable to the Using Service. The Using Service reserves the right to perform any of the inspections and tests set forth in this specification where such inspections are deemed necessary to assure that the ECU conforms to prescribed requirements.

20.4.2 Classification of Tests. The item covered by this specification shall be subjected to the following examinations and tests:

a. Verification tests

(1) Bench test	20.4.5
(2) Environmental tests	20.4.6
(3) APU powered verification tests	20.4.7

b. Acceptance tests 20.4.11

20.4.3 Test Procedures. Tests shall be performed in accordance with a contractor submitted test procedure which shall be approved by the Using Service prior to test initiation. The test procedures shall include test sequence requirements where applicable.

20.4.3.1 Rejection and Retest of Components. Any system component that has been rejected for any reason during preproduction or acceptance tests may be reworked or have parts replaced to correct defects. Before resubmitting the component or system, full particulars concerning the rejection and the corrective action taken shall be reviewed and approved by the Using Service. Tests shall not be resumed until approval of the corrective action is granted in writing by the Using Service.

20.4.3.2 Disassembly and Inspection. At the conclusion of contractor verification tests, the components shall be inspected for excessive wear, defects, and overheating.

20.4.3.3 Instrumentation. All instruments used to obtain data supporting the requirements of 20.4.5, 20.4.6, 20.4.7 and 20.4.11 shall have the accuracies shown below. Calibrations shall be traceable to the National Bureau of Standards, and shall be within a calibration interval satisfactory to the Using Service.

ACCURACIES OF INSTRUMENTS FOR
QUALIFICATION AND ACCEPTANCE TESTS

Measured Quantity	Indicating Instruments	Recording Instruments
Time	±1 second	
Frequency	±1 Hz	±10 Hz
Temperature	±2°F (±1°C)	±5°F (±3°C)
Voltage	±1 percent	±3 percent
Current, power, distance, acceleration (full scale)	±3 percent	±3 percent

Recording instruments shall be adjusted to produce a deflection of at least one inch for the maximum quantity actually measured.

20.4.4 Sampling Instructions. The test samples for tests specified in 20.4.5, 20.4.6, 20.4.7 and 20.4.11 shall consist of two ECUs, differing in no significant detail from deliverable production units. One ECU shall be instrumented by the contractor to facilitate measurement of critical internal temperatures during tests in which temperature is a factor or is required data. The instrumentation shall not modify the electrical or thermal characteristics of the units. The samples used in the tests specified in 20.4.7 and 20.4.11 may be the same units as samples 1 and 2 used in the tests specified for 20.4.5 and 20.4.6, or may be additional systems.

20.4.5 Bench Tests. The ECUs shall be operated by a laboratory power supply during these tests. Supply voltage shall be programmed to simulate APU generator furnished voltage during starts.

20.4.5.1 Test Conditions. Tests shall be run at laboratory altitude and temperature, specifically sea level to 4000 ft. altitude and 60 to 90°F (16 to 32°C), except where other conditions are required by the nature of the test.

20.4.5.1.1 Speed Signal. A speed signal which simulates the voltage and waveform of 20.3.1.5 shall be used.

20.4.5.2 Functional. The contractor shall perform tests to verify the requirements of 20.3.2.5.1 and 20.3.2.5.2 and subparagraphs.

20.4.5.3 Endurance. An endurance test which includes a minimum of 500 hours of testing, 2000 simulated starts, and 200 simulated APU failures shall be performed. The simulated failures shall be equally divided between low oil pressure, overtemperature, overspeed, and loss of speed signal events. If two units are used for this test, simultaneous cycling is permissible with 750 total hours, 3000 simulated starts, and 300 simulated failures required.

20.4.6 Environmental Tests. Tests shall be performed to verify the hot and cold, altitude, and miscellaneous environmental capabilities of the ECU. The test procedure shall provide for suitable temperature soaking periods and complete stabilization to assure adequate evaluation of the ECU in the specified environment.

20.4.6.1 High Temperature. At laboratory altitude the ECU shall be subjected to a rise in ambient temperature to 165°F (74°C). Cyclic functional tests shall be performed to assure continuous operational capability during the period until the ECU temperature stabilizes.

20.4.6.2 Low Temperature. After soaking at -65°F (-54°C), the ECU shall be subjected to a rise in ambient temperature to 150°F (66°C). Cyclic functional testing shall be performed to assure continuous operational capability until the ECU temperature stabilizes.

20.4.6.3 Altitude. While at a temperature of 165°F (74°C), the pressure altitude shall be slowly decreased from 30,000 feet to laboratory altitude. Cyclic functional testing shall be performed continuously until normal ambient pressure is reached.

20.4.6.4 Vibration. At normal ambient temperature, the ECU shall be vibrated in accordance with MIL-STD-810, Method 514, Equipment Category b.2, Procedure IA. Tests shall be conducted in accordance with Table 514-IIA, and curve "A" of figure 514-2A. Cyclic functional testing shall be performed throughout this test.

20.4.6.5 Miscellaneous Environment. The tests shown below shall be performed using the specified methods of MIL-STD-810.

MISCELLANEOUS ENVIRONMENTAL TESTS

Type of Exposure	Test Method	Procedure
Humidity	507	I
Fungus	508	I
Salt Spray	509	I
Sand & Dust	510	I
Explosion	511	I
Shock	516	I
	followed by 516	Fig. 516-1 Amplitude (a) V

20.4.7 APU Powered Verification Tests. Each ECU shall be tested before delivery. The tests may be performed with any type of input that simulates the APU installation. The test shall be performed under the standard conditions of 20.3.2.5. The test procedures shall be subject to Using Service approval. As a minimum, the tests shall verify that the following design requirements have been met:

a. Turn on voltage and operational minimum voltage for all functions	20.3.2.1.1
b. Voltage drop	20.3.2.1.2
c. 50 percent and 95 percent rotor speed signals	20.3.2.1.3
d. Overspeed 29,540 Hz ±1 percent signal	20.3.2.1.5a
e. Dielectric strength	20.3.3.1.6

20.4.7.1 Acceptance Test Vibration. The ECU shall be vibrated in accordance with MIL-STD-810, Method 514, Equipment Category b.2, Procedure IA. Tests shall be conducted in accordance with Table 514-IIA, and curve "A" of figure 514-2A, to determine compliance with the requirements of 20.4.8.

20.4.8 Reliability Assurance Program. During the initial design phase, the contractor shall perform the following engineering analyses and reliability

tasks to verify that the quantitative reliability requirements specified in Section 20.3 will be met.

a. Apportionment and mathematical models.

b. Reliability prediction.

c. Failure mode and effects analysis.

Analyses shall be revised, as required, to reflect design changes, test results, and related engineering analysis and studies.

20.4.9 Maintainability Assurance Program.

20.4.9.1 MTTR. The contractor shall determine the probable failure modes which are repairable at the organizational or intermediate maintenance level. Demonstration or analysis verifying repair of these failure modes, within the time specified in this specification will be provided by the contractor. Repairs shall be accomplished using only those tools and equipment available at the particular maintenance level (organizational or intermediate).

20.4.9.2 MTBUMA and DMMH/FH. The Mean-Time-Between-Unscheduled -Maintenance-Actions and the Direct Maintenance Manhours per Flight Hour will be verified during the formal demonstration phase.

20.4.10 Burn-In. Each ECU shall be subjected to this procedure. Temperature sensors shall be installed in the first component of each manufacturer's part number in the locations which are the last to stabilize in temperature as a result of following a temperature change, and subjected to a cycle of temperature as described below, starting with step b. The times required for steps c and a shall be recorded. Each component shall then be tested as follows: The component shall be placed in the temperature chamber, operated in normal (rated) conditions, and subjected to vibration in accordance with 20.4.6.4 procedure throughout the test. The component shall be subjected to cycles of temperature as follows until it has achieved three consecutive failure-free cycles:

a. The temperature of the chamber shall be reduced to and maintained at -67 +4°F (-55 ±2°C) until the temperature at all locations in the component are below -49°F (-45°C) (the capacity of the chamber shall be such that this shall not require more than one hour).

b. The temperature of the chamber shall be reduced to and maintained at -67°F (-55°C) for four hours.

c. The temperature of the chamber shall be increased to and maintained at 158 +4°F (70 ±2°C) until the temperature at all locations in the component are

above 140°F (60°C) (the capacity of the chamber shall be such that this shall not require more than one hour).

d. The temperature of the chamber shall be maintained at 158 +4°F (70 ±2°C) for a minimum of four hours.

The time for steps a and c shall be the same in testing subsequent components as that which was found necessary for the first component. Whenever there is any change in the manufacturer's part number for this component, or in the temperature chamber, temperature sensors shall be installed in the first component as described above and it shall be tested as described above to determine the time needed for steps a and c.

20.4.11 Acceptance Tests. The acceptance tests shall consist of a repeat of the APU power verification tests of 20.4.7.

20.5 PREPARATION FOR DELIVERY

20.5.1 Preparation for Delivery. The ECUs shall be prepared for delivery as required by the basic APU specification.

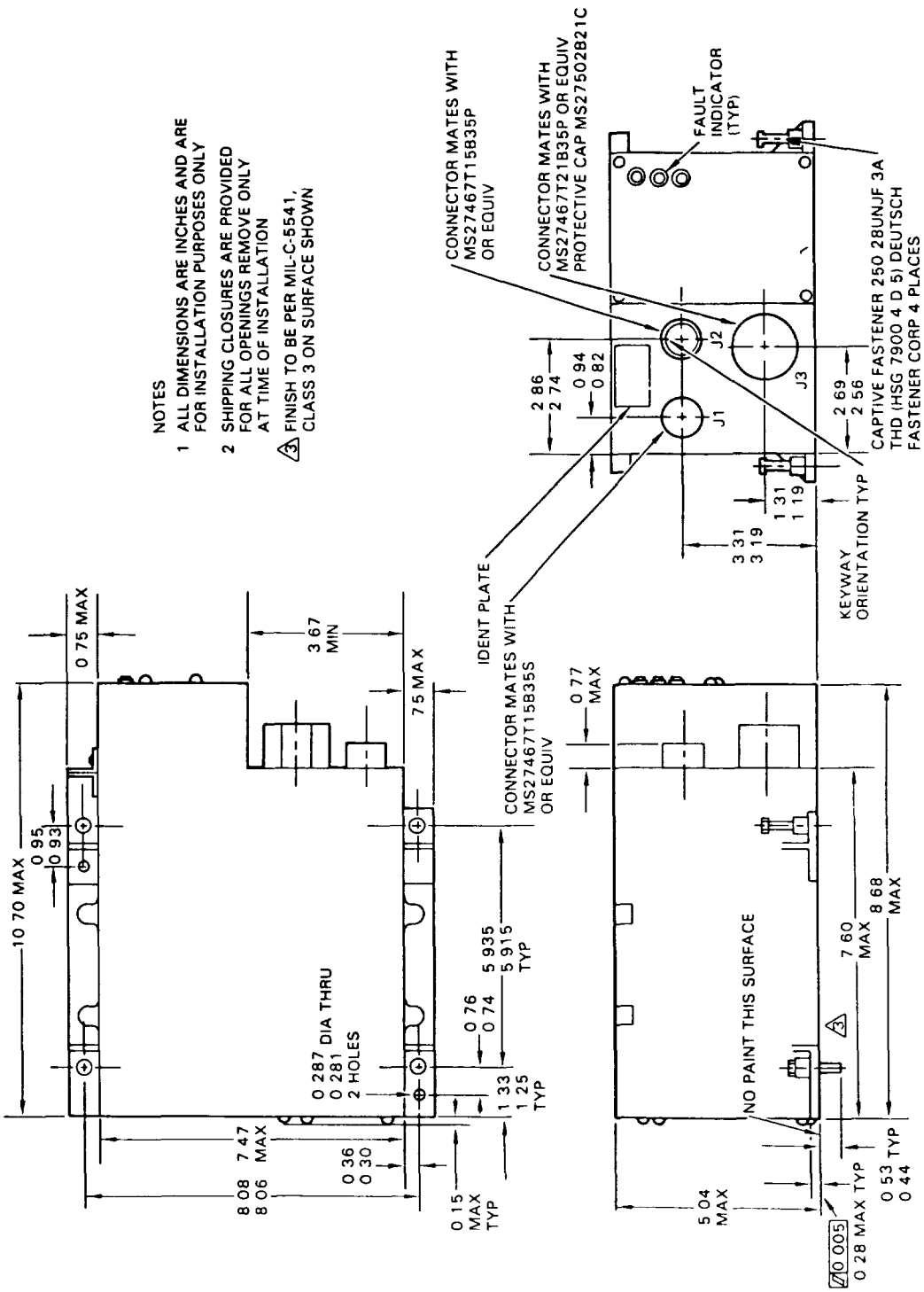


FIGURE 1. Interface control drawing, S-3A ECU.

Ref. - 20.3.1.1, 20.3.1.3

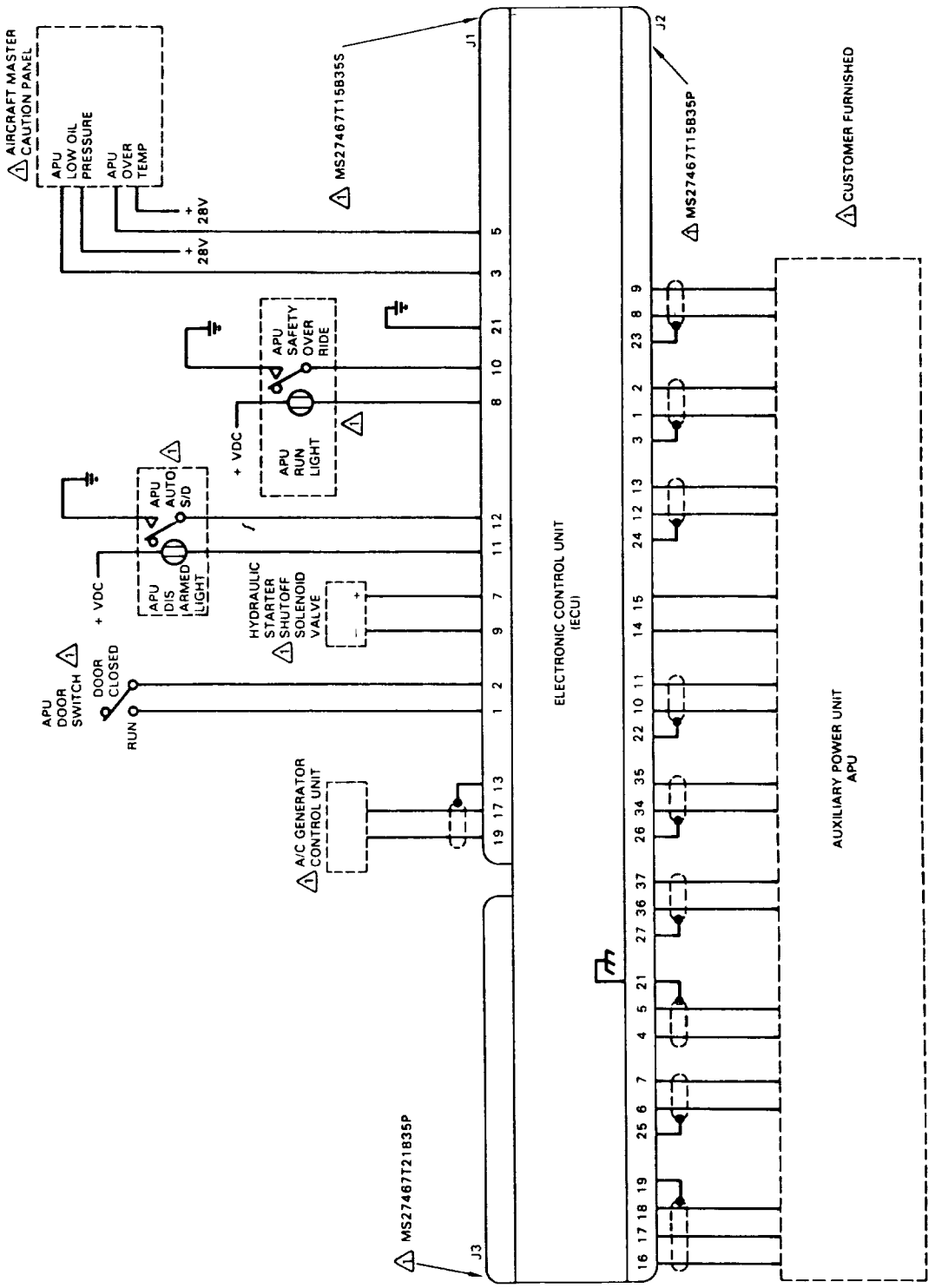


FIGURE 2. Electrical interface, S-3A ECU.

Ref. - 20.3.1.2

30. S-3A AIRCRAFT APU HYDRAULIC START SYSTEM

30.1 SCOPE

30.1.1 Scope. This appendix specifies the hydraulic system providing the hydraulic oil to the APU for starting. This appendix is a mandatory part of the specification. The information contained herein is intended for compliance.

30.2 REQUIREMENT

30.2.1 Item Definition. The hydraulic system schematic for starting the S-3A aircraft will be as shown in figure 1.

30.2.2 System Description. The general description of the components making up the hydraulic system are as follows:

30.2.2.1 Pressure System. The items to the interface specified in 3.1.2 on the pressure side (inlet) of the APU starter motor are as follows:

a. Hydraulic tubing is approximately 21 inches long of 0.750 inch diameter and 0.049 inch wall stainless steel, 137 inches long of 1.000 inch diameter and 0.065 inch stainless steel, and has four (4) equivalent 90° bends with bend r/d = 3.0.

b. Hydraulic fittings are one 90° elbow and one bulkhead union.

c. Hydraulic Teflon hose is approximately 16 inches long of 0.602 inch inside diameter with 45° and straight end fittings having 0.568 inch inside diameter with bend r/d = 1.55.

d. Pneumatic tubing is approximately 304 inches long of 0.375 inch diameter and 0.028 inch wall stainless steel, and with seventeen (17) 90° bends with bend r/d = 3.0.

e. Pneumatic fitting is one tee (straight through run) and bulkhead union.

f. Component items.

(1) One QAD coupling -16 size.

(2) One APU start valve.

(3) One hydraulic accumulator of 445 cubic inches air volume where the swept fluid volume equals 424 cubic inches.

(4) One air bottle of 470 cubic inches volume.

30.2.2.2 Return System. The items from the interface specified in 3.1.2 on the return side (outlet) of the APU start motor are as follows:

a. Hydraulic tubing is approximately 304 inches long of 1.000 inch diameter and 0.035 inch wall stainless steel, and has eleven (11) equivalent 90° bends with bend r/d = 3.0. Also 32 inches long tubing of 0.750 inch diameter and 0.028 inch wall stainless steel.

b. Fittings

(1) One tee (straight through run).

(2) One contraction from -16 size to -12 size tube in 2.5 inches length.

(3) Three bulkhead union fittings of -16 size.

c. Components

(1) One check valve -12 size.

(2) One QAD coupling -16 size.

d. Hydraulic Teflon hose is approximately 16 inches long of 0.875 inch inside diameter with one 45° end fitting, and one straight fitting both of 0.828 inch inside diameter.

30.2.3 Performance Characteristics. The performance of the system specified in 30.2.1 is dependent upon the oil used and environmental conditions. The oils and ambient environments are specified in 3.2.5.1. Further, the start performance is dependent upon the following:

a. In-flight environment for:

(1) Hydraulic system is 0°F (-17.8°C) or above.

(2) APU compartment is -27°F (-32.8°C) or above.

b. The air bottle precharge is 2000 psig at 60°F (15.6°C), and the minimum charge pressure is:

(1) In-flight: 3000 psig for first start attempt, and all subsequent attempts at 2850 psig.

(2) On the ground: 2850 psig.

c. The reservoir pressure (starting back pressure) is:

(1) In-flight: 107 psig.

(2) On the ground: 0 psig.

d. The operating characteristics of the hardware specified in 30.2.2 shall be:

(1) The APU start valve (30.2.2.1.f.(2)) has an opening rate as shown in figure 2, and at a flow of 14 GPM it has a pressure drop of 65 psid at -40°F (-40°C) or 45 psid at 70°F (21.1°C).

(2) The check valve (30.2.2.2.c.(1)) has a pressure drop of 18 psid at -40°F (-40°C) for a flow rate of 14 GPM.

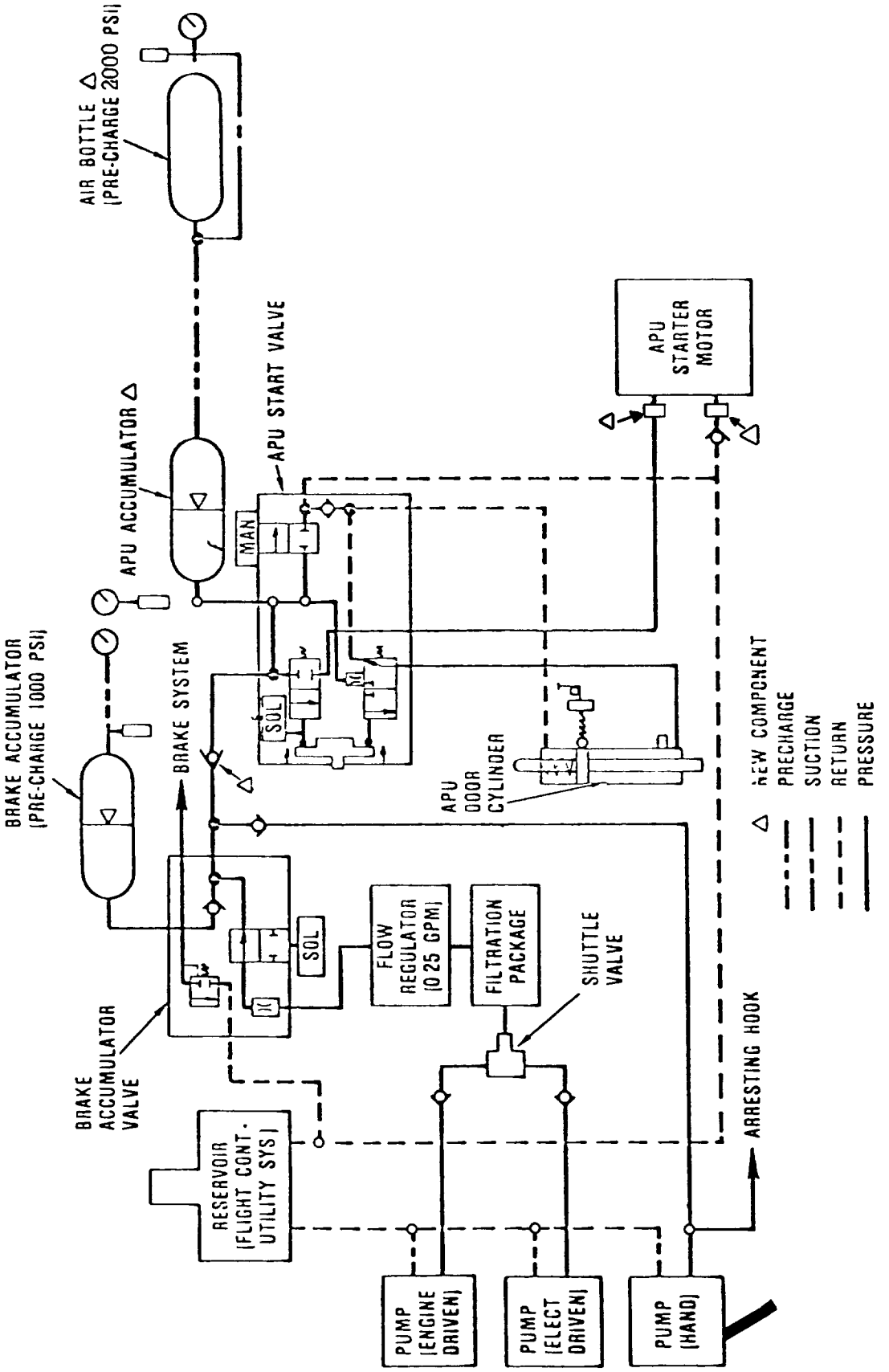


FIGURE 1. S-3A modified hydraulic APU starting system.

Ref. - 30.2.1

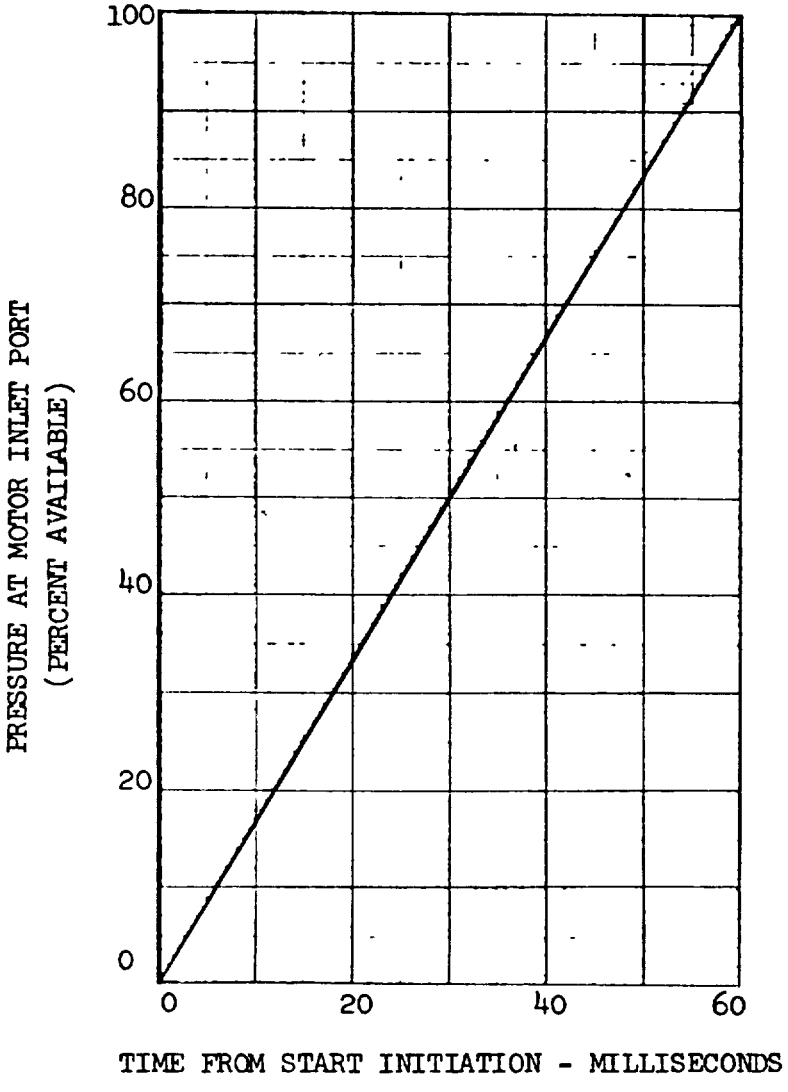


FIGURE 2. Start valve characteristic (valve opening rate).

Ref. - 30.2.3d(1)

ANALYSIS AND TEST SUMMARY

This appendix is a mandatory part of the specification. The information contained herein is intended for compliance.

Paragraph Number	Requirements	Analysis	Demonstration	Test	PFRT	VT
3.1.2.5	Externally Applied Forces	X			X	
3.1.2.8.5	APU Heat Rejection and Cooling Test Report	X			X	
3.2.1.3	Performance Verification	X			X	X
3.2.2.3	Weight of Fluids	X			X	X
3.2.3	Reliability	X			X	X
3.2.4	Maintainability	X				X
3.3.1.1	Material and Processes	X			X	X
3.3.1.1.3	Corrosion Protection	X			X	
3.3.2	Electromagnetic Interference (EMI)	X			X	X
3.3.5	Interchangeability	X			X	X
3.3.8.4	APU Pressure Balance	X			X	
3.3.8.6	Strength and Life Analysis	X			X	X
3.3.8.9.1	Design	X			X	
3.3.8.9.2	Rotor Integrity	X			X	X
3.3.8.10.2	Vibration and Stress Analysis	X			X	X
3.3.9.1.1	Design Standards	X			X	X
3.5.1.5	Repair Procedures and Wear Limits	X				X
3.7.3.3.1	Fuel Systems Calibration Limits	X			X	
3.7.7.4.6	Wear Rate Analysis	X			X	X
3.7.11	Wash Procedure and Washing Medium	X			X	
4.3.5.1	Pretest Data	X			X	X
4.3.5.12	Correction of Data	X				X
4.3.6.1	Test Reports	X			X	X
4.3.6.2	Summary Reports	X			X	X
4.4.1	APU Heat Rejection and Oil Cooling			X	X	
4.4.2	Oil Flow Interruption Test			X	X	
4.4.4	APU Vibration Survey	X			X	
4.4.5	Starting		X		X	
4.4.6	APU Pressure Balance Verification			X	X	

Paragraph Number	Requirements	Analysis	Demonstration	Test	PFRT	VT
4.4.7	Maintainability/Maintenance Demonstration		X			X
4.4.8	Material Corrosion Test			X	X	
4.5.1.1.1	APU Dry Weight		X		X	
4.5.1.1.2	Electromagnetic Interference and Susceptibility Tests			X	X	
4.5.1.1.3	Overspeed Control Test			X	X	
4.5.1.1.4	Stopping			X	X	
4.5.1.2.1	Temperature Sensing System Calibration			X	X	
4.5.1.2.2	APU Control System Calibration			X	X	
4.5.1.2.3	APU Calibration			X	X	
4.5.1.2.3.1	Compressed Air Analysis	X		X	X	
4.5.1.3.1	Endurance Test Requirements			X	X	
4.5.1.3.2	Endurance Test Schedule			X	X	
4.5.1.3.3	Starts			X	X	
4.5.1.4.1	APU Recalibration			X	X	
4.5.1.4.2	Temperature Sensing System Recalibration			X	X	
4.5.1.4.3	APU Control System Recliabration			X	X	
4.5.1.5	APU Disassembly and Inspection	X			X	
4.5.1.6	Endurance Test Completion	X			X	
4.5.2.2	Explosion-Proof Test			X	X	
4.5.2.3	Fuel Pump Altitude Test			X	X	
4.5.2.4	Oil Reservoir Pressure Test			X	X	
4.5.2.5	Fire Test			X	X	
4.5.3	Altitude Tests			X	X	
4.5.3.1	Altitude APU Calibration			X	X	
4.5.3.2	Altitude Test Procedure			X	X	
4.5.3.3	Altitude Test Completion	X			X	
4.5.4.1	APU Pressure Tests			X	X	
4.5.4.2.1	Overspeed			X	X	
4.5.4.2.2	Overtemperature			X	X	
4.5.4.2.3	Disc Burst Test			X	X	
4.5.4.3	APU Static Load Test			X	X	
4.5.4.4	Attitude Test			X	X	
4.6.1.1.1	APU Dry Weight		X			X
4.6.1.1.2	Electromagnetic Interference and Susceptibility Tests			X		X
4.6.1.1.3	Overspeed Control Test			X		X
4.6.1.1.4	Stopping			X		X

Paragraph Number	Requirements	Analysis	Demonstration	Test	PFRT	VT
4.6.1.2.1	Temperature Sensing System Calibration			X		X
4.6.1.2.2	APU Control System Calibration			X		X
4.6.1.2.3	APU Calibration			X		X
4.6.1.2.3.1	Compressed Air Analysis	X		X		X
4.6.1.3.1	Endurance Test Requirements			X		X
4.6.1.3.2	Endurance Test Schedule			X		X
4.6.1.3.3	Starts			X		X
4.6.1.4.1	APU Recalibration			X		X
4.6.1.4.2	Temperature Sensing System Recalibration			X		X
4.6.1.4.3	APU Control System Recalibration			X		X
4.6.1.5	APU Disassembly and Inspection	X				X
4.6.1.6	Endurance Test Completion	X				X
4.6.2.2	Simulated Operational Component Tests		X			X
4.6.2.2.1	Component Calibration		X			X
4.6.2.2.2	Component Test Procedures			X		X
4.6.2.2.3	Component Test Cycles			X		X
4.6.2.2.3.1	Fuel Pump Test Cycle			X		X
4.6.2.2.3.2	APU Control System Test Cycle			X		X
4.6.2.2.3.3	Ignition System Test Cycle			X		X
4.6.2.2.4	Accelerated Aging			X		X
4.6.2.2.5	Salt Water			X		X
4.6.2.2.6	High Temperature			X		X
4.6.2.2.7	Room Temperature			X		X
4.6.2.2.8	Low Temperature			X		X
4.6.2.2.9	Fuel Pump Cavitation			X		X
4.6.2.2.10	Recalibration			X		X
4.6.2.2.11	Component Test Completion	X				X
4.6.2.3	Environmental Component Tests			X		X
4.6.2.3.1	Component Calibrations			X		X
4.6.2.3.2	Component Test Procedures			X		X
4.6.2.3.3	Explosion-Proof			X		X
4.6.2.3.4	Sand and Dust			X		X
4.6.2.3.5	Sustained Acceleration			X		X
4.6.2.3.6	Ignition System Fouling			X		X
4.6.2.3.6.1	Carbon Fouling			X		X
4.6.2.3.6.2	Water Fouling			X		X

Paragraph Number	Requirements	Analysis	Demonstration	Test	PFRT	VT
4.6.2.4.1	Oil Reservoir			X		X
4.6.2.4.3	Heat Exchangers			X		X
4.6.2.4.4	Fire Tests			X		X
4.6.3	Altitude Test			X		X
4.6.3.1	Altitude APU Calibration			X		X
4.6.3.2	Altitude Test Procedure			X		X
4.6.3.3	Altitude Test Completion	X				X
4.6.4	APU Environmental and Ingestion Tests			X		X
4.6.4.1	Low and High Temperature Starting and Acceleration Test			X		X
4.6.4.2	Environmental Icing Test			X		X
4.6.4.3	Corrosion Susceptibility Test			X		X
4.6.4.5	Foreign Object Damage Test			X		X
4.6.4.6	Ice Ingestion Test			X		X
4.6.4.7	Sand Ingestion Test			X		X
4.6.4.8	Atmospheric Water Ingestion Test			X		X
4.6.4.10	Noise Survey			X		X
4.6.4.12	Nuclear Hardening Test			X		X
4.6.4.13	Steam Ingestion Test			X		X
4.6.4.14	Humidity			X		X
4.6.4.15	Fungus			X		X
4.6.4.16	Impact			X		X
4.6.4.17	Vibration			X		X
4.6.6.1	APU Pressure Tests			X		X
4.6.6.2	Low Cycle Fatigue APU Test			X		X
4.6.6.3	Containment			X		X
4.6.6.4.1	Overspeed			X		X
4.6.6.4.2	Overtemperature			X		X
4.6.6.4.3	Disc Burst Test			X		X
4.6.6.5	APU Static Load Test			X		X
4.6.6.6	Vibration and Stress Test			X		X
4.6.6.7	Gyroscopic Test			X		X

NUMERICAL INDEX

Paragraph Number	Paragraph Title	Page Number
1.	SCOPE	1
1.1	Scope	1
1.2	Classification	1
1.3	APU Components	2
2.	APPLICABLE DOCUMENTS	2
2.1	Govercment Documents	2
2.1.1	Specifications and Standards	2
2.1.2	Other Government Documents	5
2.2	Other Publication	5
3.	REQUIREMENTS	6
3.1	Item Definition	6
3.1.1	Item Diagrams	6
3.1.1.1	APU System Data Submittal and Approval	6
3.1.2	Interface Definition	6
3.1.2.1	Drawings	7
3.1.2.2	Mock-up	7
3.1.2.3	Installation Interfaces	7
3.1.2.4	Moments of Inertia	7
3.1.2.5	Externally Applied Forces	7
3.1.2.5.1	Gyroscopic Moments	8
3.1.2.6	APU Mounts	8
3.1.2.6.1	Ground Handling Mounts	8
3.1.2.7	Pads and Drives	8
3.1.2.8	Heat Rejection and Cooling	9
3.1.2.8.1	Limiting Zone Temperature	9
3.1.2.8.2	Compartment Temperature	9
3.1.2.8.3	Oil Flow and Heat Rejection	9
3.1.2.8.4	Generator Cooling	9
3.1.2.8.5	APU Heat Rejection and Cooling Report	10
3.1.2.9	Air and Gas Leakage	10
3.1.2.10	Air Inlet System	10
3.1.2.10.1	Air Inlet Design and Dimensions	10
3.1.2.10.2	Allowable Inlet Connection Stresses	10
3.1.2.10.3	Inlet Airflow Distortion Limits	10
3.1.2.10.4	APU Inlet Screen	11
3.1.2.10.5	Steam Ingestion	11
3.1.2.10.6	Armament Gas Ingestion	11
3.1.2.11	Compressed Air	11
3.1.2.11.1	Compressed Air Connection	11
3.1.2.11.2	Compressor Air Regulating Valve(s)	11

Paragraph Number	Paragraph Title	Page Number
3.1.2.11.2.1	Start and Acceleration Bleed Air	11
3.1.2.11.3	Compressed Air Contamination	12
3.1.2.12	Radar Cross Section	12
3.1.2.13	Connections	12
3.1.3	Major Component List	12
3.1.4	Government Furnished Property List	12
3.1.5	Government Loaned Property List	13
3.2	Characteristics	13
3.2.1	Performance Characteristics	13
3.2.1.1	Performance Ratings	13
3.2.1.2	Performance Presentation Steady-State	14
3.2.1.2.1	Performance Presentation Digital Computer Program	14
3.2.1.2.2	Performance Curves	17
3.2.1.3	Performance Verification	17
3.2.1.4	Operating Limits	18
3.2.1.4.1	Operating and Nonoperation Envelope	18
3.2.1.4.2	Sea Level Operating Limits	18
3.2.1.4.3	Maximum Operating Altitude	18
3.2.1.4.4	Starting Limits	18
3.2.1.4.5	APU Measured Temperature Limits	18
3.2.1.4.6	Rotor Speed Limits	18
3.2.1.4.7	Fuel Flow Limits	19
3.2.1.4.8	Oil Pressure and Temperature Limits	19
3.2.1.4.9	Oil Consumption Limits	19
3.2.1.4.10	Vibration Limits	19
3.2.1.5	Operating Characteristics	19
3.2.1.5.1	Operating Attitude and Storage Limits	19
3.2.1.5.2	Starting	19
3.2.1.5.3	Stopping	19
3.2.1.5.4	Stability	20
3.2.1.5.5	Transient Conditions	20
3.2.1.5.6	APU Windmilling Capability	20
3.2.2	Physical Characteristics	20
3.2.2.1	Dry Weight	20
3.2.2.2	Weight of Additional Equipment	20
3.2.2.3	Weight of Fluids	20
3.2.3	Reliability	20
3.2.3.1	Reliability Values	21
3.2.3.2	Start Reliability	21
3.2.4	Maintainability	21
3.2.4.1	Numerical Requirements	21
3.2.4.1.1	Applicable Maintenance Functions	22
3.2.4.1.2	Excluded Maintenance Functions	22
3.2.4.2	Maintenance, Inspection and Repair Cycles	22
3.2.5	Environmental Conditions	22

Paragraph Number	Paragraph Title	Page Number
3.2.5.1	Ambient Temperature Conditions	22
3.2.5.1.1	Operating Envelope Temperatures	22
3.2.5.1.2	Nonoperating Envelope Temperatures	23
3.2.5.1.3	Storage Temperature Range	23
3.2.5.1.4	Altitude Changes	23
3.2.5.2	Icing Conditions	23
3.2.5.3	Fungus Conditions	24
3.2.5.4	Humidity Conditions	24
3.2.5.5	Corrosive Atmosphere Conditions	24
3.2.5.6	Environmental Ingestion Capability	24
3.2.5.6.1	Bird Ingestion	24
3.2.5.6.2	Foreign Object Damage (FOD)	24
3.2.5.6.3	Ice Ingestion Capability	24
3.2.5.6.4	Sand Ingestion	24
3.2.5.6.5	Atmospheric Liquid Water	25
3.2.5.7	Acoustic Noise Environment	25
3.2.5.8	Exhaust Gas Contamination	25
3.2.5.8.1	Exhaust Smoke Emission	25
3.2.5.8.2	Invisible Exhaust Mass Emissions	25
3.2.6	Transportability	25
3.2.6.1	Cover Plates	25
3.3	Design and Construction	25
3.3.1	Materials, Processes, and Fasteners	25
3.3.1.1	Materials and Processes	26
3.3.1.1.1	Age Controls	26
3.3.1.1.2	O-Ring Seals and Packings	26
3.3.1.1.2.1	Markings	26
3.3.1.1.3	Corrosion Protection	26
3.3.1.1.4	External Fluid Lines	26
3.3.1.2	Fasteners	26
3.3.1.2.1	Metallic Inserts	26
3.3.1.2.2	Straight 60° Screw Threads	27
3.3.1.2.3	Tapered Pipe Threads	27
3.3.2	Electromagnetic Interference (EMI)	27
3.3.3	Nameplate and Product Marking	27
3.3.3.1	Identification of Product and Marking	27
3.3.3.2	Drawing Revision Marking	28
3.3.3.3	Part Number Marking	28
3.3.4	Workmanship	28
3.3.5	Interchangeability	28
3.3.6	Safety	28
3.3.6.1	Flammable Fluid Systems	28
3.3.6.2	Explosion-Proof	28
3.3.6.3	Fluid Leakage	28
3.3.6.4	Piping of Combustible Fluids	28

Paragraph Number	Paragraph Title	Page Number
3.3.6.5	Ground Safety	28
3.3.6.6	Survivability and Vulnerability	29
3.3.6.6.1	Nuclear Safety and Hardening	29
3.3.6.6.2	Non-Nuclear	29
3.3.7	Human Performance and Human Engineering	29
3.3.8	Structural Performance	29
3.3.8.1	Structural Life	29
3.3.8.2	High Cycle Fatigue (HCF) Life	29
3.3.8.3	Low Cycle Fatigue (LCF) Life	29
3.3.8.4	APU Pressure Balance	29
3.3.8.5	APU Pressure Vessel/Case Design	29
3.3.8.6	Strength and Life Analysis	30
3.3.8.7	Design Material Properties	30
3.3.8.8	Creep	30
3.3.8.9	Containment and Rotor Structural Integrity	30
3.3.8.9.1	Design	30
3.3.8.9.2	Rotor Integrity	30
3.3.8.9.3	Disc Burst Speeds	31
3.3.8.10	Vibration	31
3.3.8.10.1	Critical Speeds	31
3.3.8.10.2	Vibration and Stress Analysis	31
3.3.9	Design Control	32
3.3.9.1	Standardization	32
3.3.9.1.1	Design Standards	32
3.3.9.1.2	Standard Parts	32
3.3.9.2	Parts List	32
3.3.9.3	Assembly of Components and Parts	33
3.3.9.4	Design and Construction Changes	33
3.3.9.4.1	Changes in Design	33
3.3.9.4.2	Changes in Vendors or Fabrication Process	33
3.4	Documentation	34
3.5	Logistics	34
3.5.1	Maintenance	34
3.5.1.1	Modular Concept	34
3.5.1.2	Maintenance Inspection Techniques	34
3.5.1.3	Service and Accessibility	34
3.5.1.4	Tools	34
3.5.1.5	Repair Procedure and Wear Limits	34
3.5.2	Supply	34
3.5.3	Facilities and Facility Equipment	34
3.6	Personnel and Training	35
3.7	Major Component Characteristics	35
3.7.1	Anti-Icing System	35
3.7.1.1	Anti-Icing Interface	35
3.7.1.1.1	Anti-Icing System Actuation	35

Paragraph Number	Paragraph Title	Page Number
3.7.1.1.2	Anti-Icing Inlet Ramp	35
3.7.1.2	Type of Anti-Icing	35
3.7.2	Control System	35
3.7.2.1	Control Signals	36
3.7.2.2	Control System Performance	36
3.7.2.2.1	Shutdown Conditions	36
3.7.2.3	Control System Adjustments	36
3.7.2.3.1	Normal Governed Rotor Speed Adjustment	36
3.7.2.3.2	Acceleration Fuel Flow Adjustment	36
3.7.2.4	Cooling Provisions	36
3.7.2.5	APU Overspeed System	37
3.7.3	Fuel System	37
3.7.3.1	Fuel Inlet	37
3.7.3.1.1	Fuel Inlet Dimensions	37
3.7.3.1.2	Allowable Fuel Inlet Connection Loads	37
3.7.3.2	Fuels	37
3.7.3.2.1	Primary Fuel	37
3.7.3.2.2	Alternate Fuel	37
3.7.3.2.3	Emergency Fuel	37
3.7.3.3	Fuel System Performance	37
3.7.3.3.1	Fuel System Calibration Limits	37
3.7.3.3.2	Fuel Contamination	38
3.7.3.3.3	Fuel System Performance with External Assistance	38
3.7.3.3.4	Fuel System Performance with No External Assistance	38
3.7.3.3.4.1	Fuel Pump	38
3.7.3.3.5	Fuel System Performance Under Conditions of Excessive Fuel Vapor	38
3.7.3.3.6	Fuel Resistance	38
3.7.3.4	Fuel Filter	38
3.7.4	Electrical Systems	39
3.7.4.1	Electrical Power	39
3.7.4.1.1	Permanent Magnet Generator	39
3.7.4.2	Alternate Electrical Power	39
3.7.4.3	Electrical Interface	39
3.7.4.3.1	Electrical Connections and Cable	39
3.7.4.3.2	Electrical Wiring	39
3.7.4.4	Electrical and Electronic Equipment	39
3.7.5	Ignition System	39
3.7.5.1	Ignition System Interface	40
3.7.5.2	Ignition System Performance	40
3.7.5.3	Ignition Power Source	40
3.7.5.4	Ignition Lead Assembly	40
3.7.5.5	Ignition Cable	40
3.7.6	Instrumentation Systems	40

Paragraph Number	Paragraph Title	Page Number
3.7.6.1	Condition Indication	40
3.7.6.2	Pressure Connections	40
3.7.6.3	Elapsed Time Indicator and Start Counter	40
3.7.6.4	Temperature Sensing Systems	41
3.7.6.5	Vibration Transducer Provisions	41
3.7.6.6	APU LCF Counter	41
3.7.6.7	Speed Indication	41
3.7.6.8	Built-In Test Equipment	41
3.7.6.9	Servicing Indicators	42
3.7.7	Lubricating System	42
3.7.7.1	Lubricating System Interface	42
3.7.7.1.1	Oil System Installation and Servicing	42
3.7.7.2	Lubricants	42
3.7.7.2.1	Lubricating Oil	42
3.7.7.3	Lubricating System Performance	42
3.7.7.3.1	Oil Flow and Heat Rejection	43
3.7.7.3.2	Internal Oil Leakage	43
3.7.7.3.3	Oil Interruption	43
3.7.7.3.4	Oil Wetted Surfaces	43
3.7.7.4	Lubrication System Components and Features	43
3.7.7.4.1	Oil Reservoir	43
3.7.7.4.1.1	Oil Reservoir Capacity	43
3.7.7.4.1.2	Oil Reservoir External Features	43
3.7.7.4.2	Oil Drain	44
3.7.7.4.3	Oil Filter	44
3.7.7.4.4	Magnetic Plug	44
3.7.7.4.5	Oil Cooler	44
3.7.7.4.6	Wear Rate Analysis	45
3.7.7.4.7	Oil Pressure Pump	45
3.7.7.4.8	Oil Pressure Sensor	45
3.7.8	APU Hydraulic and Pneumatic Systems	45
3.7.9	APU Starting	45
3.7.9.1	Starter Interface	45
3.7.9.2	APU Starting Requirements	45
3.7.9.2.1	Restart Time	45
3.7.9.3	Hydraulic Supply Characteristics	46
3.7.9.4	Hydraulic Start Motor	46
3.7.9.5	Automatic Starting	46
3.7.10	Exhaust Duct System	46
3.7.10.1	Exhaust Duct Attachment	46
3.7.10.1.1	Exhaust Duct Design and Dimensions	46
3.7.10.1.2	Allowable Exhaust Duct Connection Stresses	46
3.7.10.2	Exhaust Duct	46
3.7.10.2.1	Exhaust Wake Diagrams	46
3.7.10.3	Infrared Radiation (IR)	47

Paragraph Number	Paragraph Title	Page Number
3.7.10.3.1	Infrared Suppression System	47
3.7.11	Wash Procedure	47
3.8	Precedence	47
3.9	Quality Verification	47
3.9.1	Engineering Evaluation Tests	47
3.9.2	Preliminary Flight Rating Test (PFRT)	47
3.9.3	Verification Test	47
3.9.4	Acceptance Test	47
3.9.5	Sampling Tests	47
4.	QUALITY ASSURANCE PROVISIONS	48
4.1	General	48
4.1.1	Responsibility for Inspection	48
4.2	Quality Conformance Inspections	48
4.3	Manner of Test and Reporting	48
4.3.1	Test Surveillance	48
4.3.2	Test Article Configuration	48
4.3.2.1	Test APUs	48
4.3.3	Test Apparatus	49
4.3.3.1	Automatic Recording Equipment	49
4.3.3.2	Vibration Measuring Equipment and Response Characteristics	49
4.3.3.3	Test Stand Dynamic Characteristics	49
4.3.3.4	Starting	49
4.3.4	Test Condition	49
4.3.4.1	Oil Servicing	49
4.3.4.2	Inlet Duct Connection	49
4.3.4.3	Compressed Air Connections	49
4.3.4.4	Gearbox Drives	49
4.3.4.5	Accreditable Test Time	50
4.3.4.6	Fuel Properties for Test	50
4.3.4.7	Burn-In	50
4.3.5	Data	50
4.3.5.1	Pretest Data	50
4.3.5.2	Preliminary Data	50
4.3.5.3	Accuracy of Data	50
4.3.5.4	Steady-State Data	51
4.3.5.5	Transient Data	51
4.3.5.6	Starting Data	51
4.3.5.7	Miscellaneous Data	51
4.3.5.8	Test Notes	51
4.3.5.9	Barometer Reading	52
4.3.5.10	Relative Humidity Data	52
4.3.5.11	Fuel and Oil Data	52
4.3.5.12	Correction of Data	52

Paragraph Number	Paragraph Title	Page Number
4.3.6	Reports	52
4.3.6.1	Test Reports	52
4.3.6.2	Summary Reports	53
4.4	Engineering Evaluation Tests	54
4.4.1	APU Heat Rejection and Oil Cooling	54
4.4.2	Oil Flow Interruption Test	54
4.4.3	APU Electrical Power Failure Tests	54
4.4.4	APU Vibration Survey	54
4.4.5	Starting	55
4.4.6	APU Pressure Balance Verification	55
4.4.7	Maintainability/Maintenance Demonstration	55
4.4.8	Material Corrosion Test	56
4.5	Preliminary Flight Rating Test (PFRT)	56
4.5.1	Endurance Test	56
4.5.1.1	Pretest Verification	56
4.5.1.1.1	APU Dry Weight	56
4.5.1.1.2	Electromagnetic Interference and Susceptibility Test	56
4.5.1.1.3	Overspeed Control Test	56
4.5.1.1.4	Stopping	56
4.5.1.2	Calibration (PFRT)	56
4.5.1.2.1	Temperature Sensing System Calibration	56
4.5.1.2.2	APU Control System Calibration	56
4.5.1.2.3	APU Calibration	56
4.5.1.2.3.1	Compressed Air Analysis	57
4.5.1.3	Endurance Test Procedure	57
4.5.1.3.1	Endurance Test Requirements	57
4.5.1.3.2	Endurance Test Schedule	58
4.5.1.3.3	Starts	58
4.5.1.4	Recalibration (PFRT)	58
4.5.1.4.1	APU Recalibration	58
4.5.1.4.2	Temperature Sensing System Recalibration	58
4.5.1.4.3	APU Control System Recalibration	58
4.5.1.5	APU Disassembly and Inspection	59
4.5.1.6	Endurance Test Completion	59
4.5.2	APU Component Tests	60
4.5.2.1	Previous Component Approval	60
4.5.2.2	Explosion-Proof Test	60
4.5.2.3	Fuel Pump Altitude Test	60
4.5.2.4	Oil Reservoir Pressure Test	61
4.5.2.5	Fire Test	61
4.5.3	Altitude Tests	61
4.5.3.1	Altitude APU Calibration	61
4.5.3.2	Altitude Test Procedure	61
4.5.3.3	Altitude Test Completion	62

Paragraph Number	Paragraph Title	Page Number
4.5.4	Structural Tests	62
4.5.4.1	APU Power Section Pressure Tests	63
4.5.4.2	Rotor Structural Integrity	63
4.5.4.2.1	Overspeed	63
4.5.4.2.2	Overtemperature	63
4.5.4.2.3	Disk Burst Test	63
4.5.4.3	APU Static Load Test	63
4.5.4.4	Attitude Test	63
4.6	Verification Test (VT)	64
4.6.1	Endurance Test	64
4.6.1.1	Pretest Verification	64
4.6.1.1.1	APU Dry Weight	64
4.6.1.1.2	Electromagnetic Interference and Susceptibility Tests	64
4.6.1.1.3	Overspeed Control Test	64
4.6.1.1.4	Stopping	64
4.6.1.2	Calibration (VT)	64
4.6.1.2.1	Temperature Sensing System Calibration	64
4.6.1.2.2	APU Control System Calibration	64
4.6.1.2.3	APU Calibration	64
4.6.1.2.3.1	Compressed Air Analysis	65
4.6.1.3	Endurance Test Procedure	65
4.6.1.3.1	Endurance Test Requirements	65
4.6.1.3.2	Endurance Test Schedule	66
4.6.1.3.3	Starts	66
4.6.1.4	Recalibrations (VT)	66
4.6.1.4.1	APU Recalibration	66
4.6.1.4.2	Temperature Sensing System Recalibration	66
4.6.1.4.3	APU Control System Recalibrations	67
4.6.1.5	APU Disassembly and Inspection	67
4.6.1.6	Endurance Test Completion	67
4.6.2	APU Component Tests	68
4.6.2.1	Previous Component Approval	68
4.6.2.2	Simulated Operational Component Tests	68
4.6.2.2.1	Component Calibration	68
4.6.2.2.2	Component Test Procedures	69
4.6.2.2.3	Component Test Cycles	69
4.6.2.2.3.1	Fuel Pump Test Cycle	69
4.6.2.2.3.2	APU Control System Test Cycle	70
4.6.2.2.3.3	Ignition System Test Cycle	71
4.6.2.2.4	Accelerated Aging	72
4.6.2.2.5	Salt Water	72
4.6.2.2.6	High Temperature	72
4.6.2.2.7	Room Temperature	73
4.6.2.2.8	Low Temperature	74

Paragraph Number	Paragraph Title	Page Number
4.6.2.2.9	Fuel Pump Cavitation	75
4.6.2.2.10	Recalibration	76
4.6.2.2.11	Component Test Completion	76
4.6.2.3	Environmental Electrical Component Tests	76
4.6.2.3.1	Component Calibrations	76
4.6.2.3.2	Component Test Procedures	77
4.6.2.3.3	Explosion-Proof	77
4.6.2.3.4	Sand and Dust	77
4.6.2.3.5	Sustained Acceleration	78
4.6.2.3.6	Ignition System Fouling	78
4.6.2.3.6.1	Carbon Fouling	78
4.6.2.3.6.2	Water Fouling	78
4.6.2.4	Individual Components Tests	78
4.6.2.4.1	Oil Reservoir	78
4.6.2.4.2	PMG Test	79
4.6.2.4.3	Heat Exchangers	79
4.6.2.4.4	Fire Test	80
4.6.2.4.5	Hydraulic System	80
4.6.3	Altitude Tests	80
4.6.3.1	Altitude APU Calibration	80
4.6.3.2	Altitude Test Procedure	81
4.6.3.3	Altitude Test Completion	82
4.6.4	APU Environmental and Ingestion Tests	82
4.6.4.1	Low and High Temperature Starting and Acceleration Test	82
4.6.4.2	Environmental Icing Test	84
4.6.4.3	Corrosion Susceptibility Test	84
4.6.4.4	Bird Ingestion Test	85
4.6.4.5	Foreign Object Damage Test	85
4.6.4.6	Ice Ingestion Test	86
4.6.4.7	Sand Ingestion Test	86
4.6.4.8	Atmospheric Water Ingestion Test	86
4.6.4.9	Armament Gas Ingestion Test	87
4.6.4.10	Noise Survey	87
4.6.4.11	Exhaust Gas Emission Test	87
4.6.4.11.1	Exhaust Smoke Emission	87
4.6.4.11.2	Invisible Exhaust Mass Emissions	87
4.6.4.12	Nuclear Hardening Test	87
4.6.4.13	Steam Ingestion Test	87
4.6.4.14	Humidity	88
4.6.4.15	Fungus	88
4.6.4.16	Impact	88
4.6.4.17	Vibration	88
4.6.5	APU Characteristics and Fuel Tests	88
4.6.5.1	Starting Torque	89

Paragraph Number	Paragraph Title	Page Number
4.6.5.2	Radar Cross Section (RCS)	89
4.6.5.3	Infrared Radiation Test	89
4.6.5.4	Alternate Fuel Test	89
4.6.5.5	Emergency Fuel Test	89
4.6.6	Structural Tests	89
4.6.6.1	APU Power Section Pressure Tests	89
4.6.6.2	Low Cycle Fatigue APU Test	89
4.6.6.3	Containment	90
4.6.6.4	Rotor Structural Integrity	90
4.6.6.4.1	Overspeed	90
4.6.6.4.2	Overtemperature	90
4.6.6.4.3	Disk Burst Test	91
4.6.6.5	APU Static Load Test	91
4.6.6.6	Vibration and Stress Test	91
4.6.6.7	Gyroscopic Test	92
4.7	Acceptance Test	93
4.7.1	Test Apparatus	93
4.7.1.1	Automatic Recording Equipment	93
4.7.1.2	Vibration Measuring Equipment and Response Characteristics	93
4.7.1.3	Test Cell and Test Equipment	93
4.7.1.4	Starting	93
4.7.2	Test Conditions	93
4.7.2.1	Servicing	93
4.7.2.1.1	Oil Servicing	94
4.7.2.1.2	Fuel Servicing	94
4.7.2.2	Electrical and Electronic Interference and Susceptibility Check	94
4.7.2.3	APU Control Calibration	94
4.7.2.4	APU Temperature Sensing System Calibration	94
4.7.2.5	Overspeed Control Test	94
4.7.2.6	Stopping	94
4.7.2.7	Burn-In	94
4.7.3	Test Records	95
4.7.3.1	Acceptance Test Log Sheet	95
4.7.4	Test Data	96
4.7.4.1	Preliminary Data	96
4.7.4.2	Steady-State Data	96
4.7.4.3	Transient Data	96
4.7.4.4	Starting Data	96
4.7.4.5	Miscellaneous Data	96
4.7.4.6	Accuracy of Data	96
4.7.5	Test Procedure	97
4.7.5.1	Initial Run	97
4.7.5.1.1	Inspection After Initial Run	97

Paragraph Number	Paragraph Title	Page Number
4.7.5.1.2	Penalty Run	97
4.7.5.1.3	Inspection After Penalty Run	97
4.7.5.2	Final Run	97
4.7.5.3	Rejection and Retest	97
4.7.5.3.1	APU Vibration	98
4.7.5.3.2	Maximum Measured Temperature	98
4.7.5.3.3	Stoppage	98
4.7.5.3.4	Fluid Leakage	98
4.7.5.3.5	Maximum Hours of Running	98
4.7.6	Test Completion	98
4.7.7	Sampling Tests	99
5.	PREPARATION FOR DELIVERY	99
5.1	Preparation for Storage and Shipment	99
6.	NOTES	99
6.1	Intended Use	99
6.2	Definitions and Symbols	100
6.2.1	Definitions	100
6.2.1.1	Acceptance Test (AT)	100
6.2.1.2	Accessories	100
6.2.1.3	Additional Equipment	100
6.2.1.4	Air Starting	100
6.2.1.5	APU Axes	100
6.2.1.6	APU Components	100
6.2.1.7	APU Coordinate System	100
6.2.1.8	APU Duty Cycle	100
6.2.1.9	APU Inlet Area	101
6.2.1.10	Auxiliary Power Unit (APU)	101
6.2.1.11	Burn-In	101
6.2.1.12	Catastrophic APU Failure	101
6.2.1.13	Center of Gravity	101
6.2.1.14	Combined Operating Load	101
6.2.1.15	Compressor Inlet Area	101
6.2.1.16	Dry Weight	101
6.2.1.17	Environmental Conditions and Operating Envelope	101
6.2.1.18	Exhaust Duct Effective Area	101
6.2.1.19	Fully Loaded Drive Pads	101
6.2.1.20	Gulping Volume	102
6.2.1.21	Low Oil Pressure Switch Actuation Pressure	102
6.2.1.22	Maintainability Definitions	102
6.2.1.22.1	APU Maintainability	102
6.2.1.22.2	Mean Time to Repair (MTTR)	102
6.2.1.22.3	Direct Maintenance Man-hours (DMMH)	102
6.2.1.22.4	APU Operating Hours (AOH)	102

Paragraph Number	Paragraph Title	Page Number
6.2.1.22.5	Maintainbility Index (MI)	102
6.2.1.22.6	Scheduled Preventative Maintenance	102
6.2.1.22.7	Unscheduled Maintenance	102
6.2.1.22.8	Non-Concurrent Downtime Rate (NCDR)	103
6.2.1.22.9	Time Between Overhaul (TBO)	103
6.2.1.23	Maximum Allowable Measured Exhaust Gas Temperature	103
6.2.1.24	Maximum Allowable Rotor Speed	103
6.2.1.25	Maximum Continuous	103
6.2.1.26	Maximum Operating Altitude	103
6.2.1.27	Measured Exhaust Gas Temperature	103
6.2.1.28	Mission	103
6.2.1.29	Mission Mix	103
6.2.1.30	Mission Profile	103
6.2.1.31	No Electrical Load	103
6.2.1.32	Normal Governed Rotor Speed	104
6.2.1.33	Overspeed Switch Actuation Speed	104
6.2.1.34	Overtemperature Switch Actuation Temperature	104
6.2.1.35	Power Section	104
6.2.1.36	Preliminary Flight Rating Test (PFRT)	104
6.2.1.37	Procuring Service	104
6.2.1.38	Rated Load	104
6.2.1.39	Rated Measured Exhaust Gas Temperature	104
6.2.1.40	Rating	104
6.2.1.41	Reliability Definitions	104
6.2.1.41.1	APU Failures-Observed	104
6.2.1.41.2	Excluded Failures	104
6.2.1.41.3	APU Failures - Chargeable	105
6.2.1.41.4	Mean Time Between Failures (MTBF) - Observed	105
6.2.1.41.5	Mean Time Between Failure (MTBF) - Chargeable	106
6.2.1.42	Sampling Tests	106
6.2.1.43	Satisfactorily	106
6.2.1.44	Stall	106
6.2.1.45	Standard Condition	106
6.2.1.46	Start Time	106
6.2.1.47	Surge	106
6.2.1.48	Surge Margin	106
6.2.1.49	Using Service	106
6.2.1.50	Unusable Oil	106
6.2.1.51	Verification Test (VT)	107
6.2.1.52	Weight of Operating Fluids	107
6.2.1.53	Windmilling	107
6.2.2	Symbols, Subscripts, and Abbreviations	107
6.3	Ordering Data	107
6.3.1	Procurement Requirements	107
6.3.2	Contract Data Requirements	107

Paragraph Number	Paragraph Title	Page Number
6.3.2.1	Structural Load Analysis Report	107
6.3.2.2	APU Heat Rejection and Cooling Report	107
6.3.2.3	Radar Cross Section Report	108
6.3.2.4	Performance Presentation Digital Computer Program	108
6.3.2.5	Verification of Performance	108
6.3.2.6	Weight of Operating Fluids	108
6.3.2.7	Failure Mode and Effect Analysis	108
6.3.2.8	Reliability Analysis Report	108
6.3.2.9	Maintainability Program Plan	108
6.3.2.10	Materials and Process Documents	108
6.3.2.11	Protective Treatments	108
6.3.2.12	Electromagnetic Interference	108
6.3.2.13	Interchangeability and Replaceability	108
6.3.2.14	APU Pressure Balance Report	108
6.3.2.15	Strength and Life Analysis	109
6.3.2.16	Design Report	109
6.3.2.17	Rotor Integrity Report	109
6.3.2.18	Vibration and Stress Report	109
6.3.2.19	Safety Wire	109
6.3.2.20	Changes in Vendors or Fabrication Process	109
6.3.2.21	Repair Procedures and Wear Limits	109
6.3.2.22	Fuel System Calibration Limits	109
6.3.2.23	Wear Rate Analysis Reports	109
6.3.2.24	Wash Procedure and Washing Medium	109
6.3.2.25	Pretest Data	109
6.3.2.26	Data Correction Method	109
6.3.2.27	Test Reports	110
6.3.2.28	Summary Reports	110
6.3.2.29	APU Heat Rejection and Oil Cooling Report	110
6.3.2.30	Oil Flow Interruption Test Report	110
6.3.2.31	APU Electrical Power Failure Test	110
6.3.2.32	APU Vibration Survey Report	110
6.3.2.33	Starting Demonstration Procedure	110
6.3.2.34	Maintainability/Maintenance Demonstration Report	110
6.3.2.35	Packing List	110
6.4	International Standardization	110
6.5	Model Specification Preparation	110
6.5.1	Instructions for Preparation	110
6.5.2	Approval Status	111
6.5.3	Specification Dates	111
6.5.4	Revisions	112
6.5.5	Verification Table	112
6.5.6	Index Requirements	112
6.6	Instructions for Preparation of APU Summaries	112

Paragraph Number	Paragraph Title	Page Number
10.	S-3A GENERATOR	117
10.1	SCOPE	117
10.1.1	Scope	117
10.2	REQUIREMENT	117
10.2.1	Item Definition	117
10.2.1.1	Interface Definition	117
10.2.1.1.1	Direction of Rotation	117
10.2.1.1.2	Heat Rejection and Cooling	117
10.2.2	Characteristics	117
10.2.2.1	Performance Characteristics	117
10.2.2.1.1	System Rating	117
10.2.2.1.2	System Power Capability	117
10.2.2.2	Operating Characteristics	118
10.2.2.2.1	Operating Mode	118
10.2.2.2.2	System Start-Up with External or APU Generator Power	118
10.2.2.2.3	Start of the Second Engine	118
10.2.2.2.4	Shutdown of the Second Engine	118
10.2.2.2.5	Underspeed Protection	118
10.2.2.3	Physical Characteristics	118
10.2.2.3.1	Generator Weight	118
10.2.2.3.2	Generator Center of Gravity	118
10.2.2.3.3	Generator Overhung Moment	118
20.	ELECTRONIC CONTROL UNIT, APU, REQUIRMENTS FOR	122
20.1	SCOPE	122
20.1.1	Scope	122
20.2	APPLICABLE DOCUMENTS	122
20.2.1	Applicable Documents	122
20.3	REQUIREMENTS	122
20.3.1	Item Definition	122
20.3.1.1	Dimensions	122
20.3.1.2	Electrical Connectors	122
20.3.1.3	Mounting	122
20.3.1.4	Heat Loss	122
20.3.1.5	Generator Circuit	122
20.3.1.5.1	Voltage	122
20.3.1.5.2	Frequency	122
20.3.1.6	Flight Control Circuits	123
20.3.1.6.1	Operation and Control	123
20.3.1.6.2	Master Caution Panel	123
20.3.2	Characteristics	123
20.3.2.1	Performance Characteristics	123
20.3.2.1.1	Input Power	123
20.3.2.1.2	Loads	123

Paragraph Number	Paragraph Title	Page Number
20.3.2.1.3	Starting Sequence	123
20.3.2.1.4	Shutdown	124
20.3.2.1.5	Safety Provisions	124
20.3.2.1.6	Safety Override	124
20.3.2.1.7	Failure Indicators	125
20.3.2.1.8	Protection Against Long Lines	125
20.3.2.1.9	Safety Shutdown	125
20.3.2.1.10	Logic Voltage Levels	125
20.3.2.1.11	Accuracy of Speed Sensing	125
20.3.2.1.12	Logic Reset	125
20.3.2.2	Physical Characteristics	125
20.3.2.2.1	Weight	125
20.3.2.2.2	Color	125
20.3.2.3	Reliability	126
20.3.2.4	Maintainability	126
20.3.2.4.1	Life Requirements	126
20.3.2.4.1.1	Operating Life	126
20.3.2.4.1.2	Flight Nonoperating Life	126
20.3.2.4.1.3	Calendar Life	126
20.3.2.4.1.4	Life of Parts	126
20.3.2.5	Environmental Conditions	126
20.3.2.5.1	Standard Conditions	126
20.3.2.5.2	Environmental Requirements	126
20.3.2.5.2.1	Operational Environments	126
20.3.2.5.2.2	Exposure Environments	126
20.3.2.6	Transportability	127
20.3.3	Design and Construction	127
20.3.3.1	Parts, Materials, Processes and Standards	127
20.3.3.1.1	Plating	127
20.3.3.1.2	Microelectronic Modular Assemblies	127
20.3.3.1.3	Modules	127
20.3.3.1.4	Electron Devices	127
20.3.3.1.5	Electrical Bonding	127
20.3.3.1.6	Dielectric Strength	127
20.3.3.1.6.1	Voltage Rating	127
20.3.3.2	Electromagnetic Interference (EMI)	128
20.3.3.3	Nameplates and Product Marking	128
20.3.3.4	Workmanship	128
20.3.3.5	Interchangeability	128
20.3.3.6	Safety	128
20.3.3.7	Human Performance and Human Engineering	128
20.3.4	Documentation	128
20.3.5	Logistics	128
20.3.5.1	Maintenance	128
20.3.5.1.1	Adjustments	128

Paragraph Number	Paragraph Title	Page Number
20.3.5.1.2	Standard Tools	129
20.3.5.2	Supply	129
20.3.6	Personnel and Training	129
20.4	QUALITY ASSURANCE PROVISIONS	129
20.4.1	General	129
20.4.1.1	Responsibility for Inspection	129
20.4.2	Classification of Tests	129
20.4.3	Test Procedures	129
20.4.3.1	Rejection and Retest of Components	129
20.4.3.2	Disassembly and Inspection	130
20.4.3.3	Instrumentation	130
20.4.4	Sampling Instructions	130
20.4.5	Bench Tests	130
20.4.5.1	Test Conditions	131
20.4.5.1.1	Speed Signal	131
20.4.5.2	Functional	131
20.4.5.3	Endurance	131
20.4.6	Environmental Tests	131
20.4.6.1	High Temperature	131
20.4.6.2	Low Temperature	131
20.4.6.3	Altitude	131
20.4.6.4	Vibration	131
20.4.6.5	Miscellaneous Environment	131
20.4.7	APU Powered Verification Tests	132
20.4.7.1	Acceptance Test Vibration	132
20.4.8	Reliability Assurance Program	132
20.4.9	Maintainability Assurance Program	133
20.4.9.1	MTTR	133
20.4.9.2	MTBUMA and DMMH/FH	133
20.4.10	Burn-In	133
20.4.11	Acceptance Tests	134
20.5	PREPARATION FOR DELIVERY	134
20.5.1	Preparation for Delivery	134
30.	S-3A AIRCRAFT APU HYDRAULIC START SYSTEM	137
30.1	SCOPE	137
30.1.1	Scope	137
30.2	REQUIREMENT	137
30.2.1	Item Definition	137
30.2.2	System Description	137
30.2.2.1	Pressure System	137
30.2.2.2	Return System	138
30.2.3	Performance Characteristics	138

ALPHABETICAL INDEX

Paragraph Title	Paragraph Number	Page Number
Accelerated Aging	4.6.2.2.4	72
Acceleration Fuel Flow Adjustment	3.7.2.3.2	36
Acceptance Test	3.9.4	47
Acceptance Test	4.7	93
Acceptance Test (AT)	6.2.1.1	100
Acceptance Test Log Sheet	4.7.3.1	95
Acceptance Test Vibration	20.4.7.1	132
Acceptance Tests	20.4.11	134
Accessories	6.2.1.2	100
Accreditable Test Time	4.3.4.5	50
Accuracy of Data	4.3.5.3	50
Accuracy of Data	4.7.4.6	96
Accuracy of Speed Sensing	20.3.2.1.11	125
Acoustic Noise Environment	3.2.5.7	25
Additional Equipment	6.2.1.3	100
Adjustments	20.3.5.1.1	128
Age Controls	3.3.1.1.1	26
Air and Gas Leakage	3.1.2.9	10
Air Inlet Design and Dimensions	3.1.2.10.1	10
Air Inlet System	3.1.2.10	10
Air Starting	6.2.1.4	100
Allowable Exhaust Duct Connection Stresses	3.7.10.1.2	46
Allowable Fuel Inlet Connection Loads	3.7.3.1.2	37
Allowable Inlet Connection Stresses	3.1.2.10.2	10
Alternate Electrical Power	3.7.4.2	39
Alternate Fuel	3.7.3.2.2	37
Alternate Fuel Test	4.6.5.4	89
Altitude	20.4.6.3	131
Altitude APU Calibration	4.5.3.1	61
Altitude APU Calibration	4.6.3.1	80
Altitude Changes	3.2.5.1.4	23
Altitude Test Completion	4.5.3.3	62
Altitude Test Completion	4.6.3.3	82
Altitude Test Procedure	4.5.3.2	61
Altitude Test Procedure	4.6.3.2	81
Altitude Tests	4.5.3	61
Altitude Tests	4.6.3	80
Ambient Temperature Conditions	3.2.5.1	22
Anti-Icing Inlet Ramp	3.7.1.1.2	35
Anti-Icing Interface	3.7.1.1	35
Anti-Icing System	3.7.1	35
Anti-Icing System Actuation	3.7.1.1.1	35

Paragraph Title	Paragraph No.	Page No.
Applicable Documents	20.2.1	122
APPLICABLE DOCUMENTS	2	2
APPLICABLE DOCUMENTS	20.2	122
Applicable Maintenance Functions	3.2.4.1.1	22
Approval Status	6.5.2	111
APU Axes	6.2.1.5	100
APU Calibration	4.5.1.2.3	56
APU Calibration	4.6.1.2.3	64
APU Characteristics and Fuel Tests	4.6.5	88
APU Component Tests	4.5.2	60
APU Component Tests	4.6.2	68
APU Components	1.3	2
APU Components	6.2.1.6	100
APU Control Calibration	4.7.2.3	94
APU Control System Calibration	4.5.1.2.2	56
APU Control System Calibration	4.6.1.2.2	64
APU Control System Recalibration	4.5.1.4.3	58
APU Control System Recalibrations	4.6.1.4.3	67
APU Control System Test Cycle	4.6.2.2.3.2	70
APU Coordinate System	6.2.1.7	100
APU Disassembly and Inspection	4.5.1.5	59
APU Disassembly and Inspection	4.6.1.5	67
APU Dry Weight	4.5.1.1.1	56
APU Dry Weight	4.6.1.1.1	64
APU Duty Cycle	6.2.1.8	100
APU Electrical Power Failure Test	6.3.2.31	110
APU Electrical Power Failure Tests	4.4.3	54
APU Environmental and Ingestion Tests	4.6.4	82
APU Failures - Chargeable	6.2.1.41.3	105
APU Failures-Observed	6.2.1.41.1	104
APU Heat Rejection and Cooling Report	3.1.2.8.5	10
APU Heat Rejection and Cooling Report	6.3.2.2	107
APU Heat Rejection and Oil Cooling	4.4.1	54
APU Heat Rejection and Oil Cooling Report	6.3.2.29	110
APU Hydraulic and Pneumatic Systems	3.7.8	45
APU Inlet Area	6.2.1.9	101
APU Inlet Screen	3.1.2.10.4	11
APU LCF Counter	3.7.6.6	41
APU Maintainability	6.2.1.22.1	102
APU Measured Temperature Limits	3.2.1.4.5	18
APU Mounts	3.1.2.6	8
APU Operating Hours (AOH)	6.2.1.22.4	102
APU Overspeed System	3.7.2.5	37
APU Power Section Pressure Tests	4.5.4.1	63
APU Power Section Pressure Tests	4.6.6.1	89

Paragraph Title	Paragraph Number	Page Number
APU Powered Verification Tests	20.4.7	132
APU Pressure Balance	3.3.8.4	29
APU Pressure Balance Report	6.3.2.14	108
APU Pressure Balance Verification	4.4.6	55
APU Pressure Vessel/Case Design	3.3.8.5	29
APU Recalibration	4.5.1.4.1	58
APU Recalibration	4.6.1.4.1	66
APU Starting	3.7.9	45
APU Starting Requirements	3.7.9.2	45
APU Static Load Test	4.5.4.3	63
APU Static Load Test	4.6.6.5	91
APU System Data Submittal and Approval	3.1.1.1	6
APU Temperature Sensing System Calibration	4.7.2.4	94
APU Vibration	4.7.5.3.1	98
APU Vibration Survey	4.4.4	54
APU Vibration Survey Report	6.3.2.32	110
APU Windmilling Capability	3.2.1.5.6	20
Armament Gas Ingestion	3.1.2.10.6	11
Armament Gas Ingestion Test	4.6.4.9	87
Assembly of Components and Parts	3.3.9.3	33
Atmospheric Liquid Water	3.2.5.6.5	25
Atmospheric Water Ingestion Test	4.6.4.8	86
Attitude Test	4.5.4.4	63
Automatic Recording Equipment	4.3.3.1	49
Automatic Recording Equipment	4.7.1.1	93
Automatic Starting	3.7.9.5	46
Auxiliary Power Unit (APU)	6.2.1.10	101
Barometer Reading	4.3.5.9	52
Bench Tests	20.4.5	130
Bird Ingestion	3.2.5.6.1	24
Bird Ingestion Test	4.6.4.4	85
Built-In Test Equipment	3.7.6.8	41
Burn-In	4.3.4.7	50
Burn-In	4.7.2.7	94
Burn-In	6.2.1.11	101
Burn-In	20.4.10	133
Calendar Life	20.3.2.4.1.3	126
Calibration (PFRT)	4.5.1.2	56
Calibration (VT)	4.6.1.2	64
Carbon Fouling	4.6.2.3.6.1	78
Catastrophic APU Failure	6.2.1.12	101
Center of Gravity	6.2.1.13	101
Changes in Design	3.3.9.4.1	33

Paragraph Title	Paragraph No.	Page No.
Changes in Vendors or Fabrication Process	3.3.9.4.2	33
Changes in Vendors or Fabrication Process	6.3.2.20	109
Characteristics	3.2	13
Characteristics	10.2.2	117
Characteristics	20.3.2	123
Classification	1.2	1
Classification of Tests	20.4.2	129
Color	20.3.2.2.2	125
Combined Operating Load	6.2.1.14	101
Compartment Temperature	3.1.2.8.2	9
Component Calibration	4.6.2.2.1	68
Component Calibrations	4.6.2.3.1	76
Component Test Completion	4.6.2.2.11	76
Component Test Cycles	4.6.2.2.3	69
Component Test Procedures	4.6.2.2.2	69
Component Test Procedures	4.6.2.3.2	77
Compressed Air	3.1.2.11	11
Compressed Air Analysis	4.5.1.2.3.1	57
Compressed Air Analysis	4.6.1.2.3.1	65
Compressed Air Connection	3.1.2.11.1	11
Compressed Air Connections	4.3.4.3	49
Compressed Air Contamination	3.1.2.11.3	12
Compressor Air Regulating Valve(s)	3.1.2.11.2	11
Compressor Inlet Area	6.2.1.15	101
Condition Indication	3.7.6.1	40
Connections	3.1.2.13	12
Containment	4.6.6.3	90
Containment and Rotor Structural Integrity	3.3.8.9	30
Contract Data Requirements	6.3.2	107
Control Signals	3.7.2.1	36
Control System	3.7.2	35
Control System Adjustments	3.7.2.3	36
Control System Performance	3.7.2.2	36
Cooling Provisions	3.7.2.4	36
Correction of Data	4.3.5.12	52
Corrosion Protection	3.3.1.1.3	26
Corrosion Susceptibility Test	4.6.4.3	84
Corrosive Atmosphere Conditions	3.2.5.5	24
Cover Plates	3.2.6.1	25
Creep	3.3.8.8	30
Critical Speeds	3.3.8.10.1	31
Data	4.3.5	50
Data Correction Method	6.3.2.26	109
Definitions	6.2.1	100

Paragraph Title	Paragraph Number	Page Number
Definitions and Symbols	6.2	100
Design	3.3.8.9.1	30
Design and Construction	3.3	25
Design and Construction	20.3.3	127
Design and Construction Changes	3.3.9.4	33
Design Control	3.3.9	32
Design Material Properties	3.3.8.7	30
Design Report	6.3.2.16	109
Design Standards	3.3.9.1.1	32
Dielectric Strength	20.3.3.1.6	127
Dimensions	20.3.1.1	122
Direct Maintenance Man-hours (DMMH)	6.2.1.22.3	102
Direction of Rotation	10.2.1.1.1	117
Disassembly and Inspection	20.4.3.2	130
Disc Burst Speeds	3.3.8.9.3	31
Disk Burst Test	4.5.4.2.3	63
Disk Burst Test	4.6.6.4.3	91
Documentation	3.4	34
Documentation	20.3.4	128
Drawing Revision Marking	3.3.3.2	28
Drawings	3.1.2.1	7
Dry Weight	3.2.2.1	20
Dry Weight	6.2.1.16	101
Elapsed Time Indicator and Start Counter	3.7.6.3	40
Electrical and Electronic Equipment	3.7.4.4	39
Electrical and Electronic Interference and Susceptibility Check	4.7.2.2	94
Electrical Bonding	20.3.3.1.5	127
Electrical Connections and Cable	3.7.4.3.1	39
Electrical Connectors	20.3.1.2	122
Electrical Interface	3.7.4.3	39
Electrical Power	3.7.4.1	39
Electrical Systems	3.7.4	39
Electrical Wiring	3.7.4.3.2	39
Electromagnetic Interference	6.3.2.12	108
Electromagnetic Interference (EMI)	3.3.2	27
Electromagnetic Interference (EMI)	20.3.3.2	128
Electromagnetic Interference and Susceptibility Tests	4.6.1.1.2	64
Electromagnetic Interference and Susceptibility Test	4.5.1.1.2	56
Electron Devices	20.3.3.1.4	127
ELECTRONIC CONTROL UNIT, APU, REQUIRMENTS FOR	20	122
Emergency Fuel	3.7.3.2.3	37

Paragraph Title	Paragraph No.	Page No.
Emergency Fuel Test	4.6.5.5	89
Endurance	20.4.5.3	131
Endurance Test	4.5.1	56
Endurance Test	4.6.1	64
Endurance Test Completion	4.5.1.6	59
Endurance Test Completion	4.6.1.6	67
Endurance Test Procedure	4.5.1.3	57
Endurance Test Procedure	4.6.1.3	65
Endurance Test Requirements	4.5.1.3.1	57
Endurance Test Requirements	4.6.1.3.1	65
Endurance Test Schedule	4.5.1.3.2	58
Endurance Test Schedule	4.6.1.3.2	66
Engineering Evaluation Tests	3.9.1	47
Engineering Evaluation Tests	4.4	54
Environmental Conditions	3.2.5	22
Environmental Conditions	20.3.2.5	126
Environmental Conditions and Operating Envelope	6.2.1.17	101
Environmental Electrical Component Tests	4.6.2.3	76
Environmental Icing Test	4.6.4.2	84
Environmental Ingestion Capability	3.2.5.6	24
Environmental Requirements	20.3.2.5.2	126
Environmental Tests	20.4.6	131
Excluded Failures	6.2.1.41.2	104
Excluded Maintenance Functions	3.2.4.1.2	22
Exhaust Duct	3.7.10.2	46
Exhaust Duct Attachment	3.7.10.1	46
Exhaust Duct Design and Dimensions	3.7.10.1.1	46
Exhaust Duct Effective Area	6.2.1.18	101
Exhaust Duct System	3.7.10	46
Exhaust Gas Contamination	3.2.5.8	25
Exhaust Gas Emission Test	4.6.4.11	87
Exhaust Smoke Emission	3.2.5.8.1	25
Exhaust Smoke Emission	4.6.4.11.1	87
Exhaust Wake Diagrams	3.7.10.2.1	46
Explosion-Proof	4.6.2.3.3	77
Explosion-Proof Test	4.5.2.2	60
Explosion-Proof	3.3.6.2	28
Exposure Environments	20.3.2.5.2.2	126
External Fluid Lines	3.3.1.1.4	26
Externally Applied Forces	3.1.2.5	7
Facilities and Facility Equipment	3.5.3	34
Failure Indicators	20.3.2.1.7	125
Failure Mode and Effect Analysis	6.3.2.7	108
Fasteners	3.3.1.2	26

Paragraph Title	Paragraph Number	Page Number
Final Run	4.7.5.2	97
Fire Test	4.5.2.5	61
Fire Test	4.6.2.4.4	80
Flammable Fluid Systems	3.3.6.1	28
Flight Control Circuits	20.3.1.6	123
Flight Nonoperating Life	20.3.2.4.1.2	126
Fluid Leakage	3.3.6.3	28
Fluid Leakage	4.7.5.3.4	98
Foreign Object Damage (FOD)	3.2.5.6.2	24
Foreign Object Damage Test	4.6.4.5	85
Frequency	20.3.1.5.2	122
Fuel and Oil Data	4.3.5.11	52
Fuel Contamination	3.7.3.3.2	38
Fuel Filter	3.7.3.4	38
Fuel Flow Limits	3.2.1.4.7	19
Fuel Inlet	3.7.3.1	37
Fuel Inlet Dimensions	3.7.3.1.1	37
Fuel Properties for Test	4.3.4.6	50
Fuel Pump	3.7.3.3.4.1	38
Fuel Pump Altitude Test	4.5.2.3	60
Fuel Pump Cavitation	4.6.2.2.9	75
Fuel Pump Test Cycle	4.6.2.2.3.1	69
Fuel Resistance	3.7.3.3.6	38
Fuel Servicing	4.7.2.1.2	94
Fuel System	3.7.3	37
Fuel System Calibration Limits	3.7.3.3.1	37
Fuel System Calibration Limits	6.3.2.22	109
Fuel System Performance	3.7.3.3	37
Fuel System Performance with External Assistance	3.7.3.3.3	38
Fuel System Performance with No External Assistance	3.7.3.3.4	38
Fuel System Performance Under Conditions of Excessive Fuel Vapor	3.7.3.3.5	38
Fuels	3.7.3.2	37
Fully Loaded Drive Pads	6.2.1.19	101
Functional	20.4.5.2	131
Fungus	4.6.4.15	88
Fungus Conditions	3.2.5.3	24
Gearbox Drives	4.3.4.4	49
General	4.1	48
General	20.4.1	129
Generator Center of Gravity	10.2.2.3.2	118
Generator Circuit	20.3.1.5	122
Generator Cooling	3.1.2.8.4	9

Paragraph Title	Paragraph No.	Page No.
Generator Overhung Moment	10.2.2.3.3	118
Generator Weight	10.2.2.3.1	118
Government Furnished Property List	3.1.4	12
Government Documents	2.1	2
Government Loaned Property List	3.1.5	13
Ground Handling Mounts	3.1.2.6.1	8
Ground Safety	3.3.6.5	28
Gulping Volume	6.2.1.20	102
Gyroscopic Moments	3.1.2.5.1	8
Gyroscopic Test	4.6.6.7	92
Heat Exchangers	4.6.2.4.3	79
Heat Loss	20.3.1.4	122
Heat Rejection and Cooling	3.1.2.8	9
Heat Rejection and Cooling	10.2.1.1.2	117
High Cycle Fatigue (HCF) Life	3.3.8.2	29
High Temperature	4.6.2.2.6	72
High Temperature	20.4.6.1	131
Human Performance and Human Engineering	3.3.7	29
Human Performance and Human Engineering	20.3.3.7	128
Humidity	4.6.4.14	88
Humidity Conditions	3.2.5.4	24
Hydraulic Start Motor	3.7.9.4	46
Hydraulic Supply Characteristics	3.7.9.3	46
Hydraulic System	4.6.2.4.5	80
Ice Ingestion Capability	3.2.5.6.3	24
Ice Ingestion Test	4.6.4.6	86
Icing Conditions	3.2.5.2	23
Identification of Product and Marking	3.3.3.1	27
Ignition Cable	3.7.5.5	40
Ignition Lead Assembly	3.7.5.4	40
Ignition Power Source	3.7.5.3	40
Ignition System	3.7.5	39
Ignition System Fouling	4.6.2.3.6	78
Ignition System Interface	3.7.5.1	40
Ignition System Performance	3.7.5.2	40
Ignition System Test Cycle	4.6.2.2.3.3	71
Impact	4.6.4.16	88
Index Requirements	6.5.6	112
Individual Components Tests	4.6.2.4	78
Infrared Radiation (IR)	3.7.10.3	47
Infrared Radiation Test	4.6.5.3	89
Infrared Suppression System	3.7.10.3.1	47
Initial Run	4.7.5.1	97

Paragraph Title	Paragraph Number	Page Number
Inlet Airflow Distortion Limits	3.1.2.10.3	10
Inlet Duct Connection	4.3.4.2	49
Input Power	20.3.2.1.1	123
Inspection After Initial Run	4.7.5.1.1	97
Inspection After Penalty Run	4.7.5.1.3	97
Installation Interfaces	3.1.2.3	7
Instructions for Preparation	6.5.1	110
Instructions for Preparation of APU Summaries	6.6	112
Instrumentation	20.4.3.3	130
Instrumentation Systems	3.7.6	40
Intended Use	6.1	99
Interchangeability	3.3.5	28
Interchangeability	20.3.3.5	128
Interchangeability and Replaceability	6.3.2.13	108
Interface Definition	3.1.2	6
Interface Definition	10.2.1.1	117
Internal Oil Leakage	3.7.7.3.2	43
International Standardization	6.4	110
Invisible Exhaust Mass Emissions	3.2.5.8.2	25
Invisible Exhaust Mass Emissions	4.6.4.11.2	87
Item Definition	3.1	6
Item Definition	10.2.1	117
Item Definition	20.3.1	122
Item Definition	30.2.1	137
Item Diagrams	3.1.1	6
Life of Parts	20.3.2.4.1.4	126
Life Requirements	20.3.2.4.1	126
Limiting Zone Temperature	3.1.2.8.1	9
Loads	20.3.2.1.2	123
Logic Reset	20.3.2.1.12	125
Logic Voltage Levels	20.3.2.1.10	125
Logistics	3.5	34
Logistics	20.3.5	128
Low and High Temperature Starting and Acceleration Test	4.6.4.1	82
Low Cycle Fatigue (LCF) Life	3.3.8.3	29
Low Cycle Fatigue APU Test	4.6.6.2	89
Low Oil Pressure Switch Actuation Pressure	6.2.1.21	102
Low Temperature	4.6.2.2.8	74
Low Temperature	20.4.6.2	131
Lubricants	3.7.7.2	42
Lubricating Oil	3.7.7.2.1	42
Lubricating System	3.7.7	42
Lubricating System Interface	3.7.7.1	42

Paragraph Title	Paragraph No.	Page No.
Lubricating System Performance	3.7.7.3	42
Lubrication System Components and Features	3.7.7.4	43
Magnetic Plug	3.7.7.4.4	44
Maintainability	3.2.4	21
Maintainability	20.3.2.4	126
Maintainability Assurance Program	20.4.9	133
Maintainability Definitions	6.2.1.22	102
Maintainability Program Plan	6.3.2.9	108
Maintainability/Maintenance Demonstration	4.4.7	55
Maintainability/Maintenance Demonstration Report	6.3.2.34	110
Maintainbility Index (MI)	6.2.1.22.5	102
Maintenance	3.5.1	34
Maintenance	20.3.5.1	128
Maintenance Inspection Techniques	3.5.1.2	34
Maintenance, Inspection and Repair Cycles	3.2.4.2	22
Major Component Characteristics	3.7	35
Major Component List	3.1.3	12
Manner of Test and Reporting	4.3	48
Markings	3.3.1.1.2.1	26
Master Caution Panel	20.3.1.6.2	123
Material Corrosion Test	4.4.8	56
Materials and Process Documents	6.3.2.10	108
Materials and Processes	3.3.1.1	26
Materials, Processes, and Fasteners	3.3.1	25
Maximum Allowable Measured Exhaust Gas Temperature	6.2.1.23	103
Maximum Allowable Rotor Speed	6.2.1.24	103
Maximum Continuous	6.2.1.25	103
Maximum Hours of Running	4.7.5.3.5	98
Maximum Measured Temperature	4.7.5.3.2	98
Maximum Operating Altitude	3.2.1.4.3	18
Maximum Operating Altitude	6.2.1.26	103
Mean Time to Repair (MTTR)	6.2.1.22.2	102
Mean Time Between Failure (MTBF) - Chargeable	6.2.1.41.5	106
Mean Time Between Failures (MTBF) - Observed	6.2.1.41.4	105
Measured Exhaust Gas Temperature	6.2.1.27	103
Metallic Inserts	3.3.1.2.1	26
Microelectronic Modular Assemblies	20.3.3.1.2	127
Miscellaneous Data	4.3.5.7	51
Miscellaneous Data	4.7.4.5	96
Miscellaneous Environment	20.4.6.5	131
Mission	6.2.1.28	103
Mission Mix	6.2.1.29	103
Mission Profile	6.2.1.30	103
Mock-up	3.1.2.2	7

Paragraph Title	Paragraph Number	Page Number
Model Specification Preparation	6.5	110
Modular Concept	3.5.1.1	34
Modules	20.3.3.1.3	127
Moments of Inertia	3.1.2.4	7
Mounting	20.3.1.3	122
MTBUMA and DMMH/FH	20.4.9.2	133
MTTR	20.4.9.1	133
Nameplate and Product Marking	3.3.3	27
Nameplates and Product Marking	20.3.3.3	128
No Electrical Load	6.2.1.31	103
Noise Survey	4.6.4.10	87
Non-Concurrent Downtime Rate (NCDR)	6.2.1.22.8	103
Non-Nuclear	3.3.6.6.2	29
Nonoperating Envelope Temperatures	3.2.5.1.2	23
Normal Governed Rotor Speed	6.2.1.32	104
Normal Governed Rotor Speed Adjustment	3.7.2.3.1	36
NOTES	6	99
Nuclear Hardening Test	4.6.4.12	87
Nuclear Safety and Hardening	3.3.6.6.1	29
Numerical Requirements	3.2.4.1	21
O-Ring Seals and Packings	3.3.1.1.2	26
Oil Consumption Limits	3.2.1.4.9	19
Oil Cooler	3.7.7.4.5	44
Oil Drain	3.7.7.4.2	44
Oil Filter	3.7.7.4.3	44
Oil Flow and Heat Rejection	3.1.2.8.3	9
Oil Flow and Heat Rejection	3.7.7.3.1	43
Oil Flow Interruption Test	4.4.2	54
Oil Flow Interruption Test Report	6.3.2.30	110
Oil Interruption	3.7.7.3.3	43
Oil Pressure and Temperature Limits	3.2.1.4.8	19
Oil Pressure Pump	3.7.7.4.7	45
Oil Pressure Sensor	3.7.7.4.8	45
Oil Reservoir	3.7.7.4.1	43
Oil Reservoir	4.6.2.4.1	78
Oil Reservoir Capacity	3.7.7.4.1.1	43
Oil Reservoir External Features	3.7.7.4.1.2	43
Oil Reservoir Pressure Test	4.5.2.4	61
Oil Servicing	4.3.4.1	49
Oil Servicing	4.7.2.1.1	94
Oil System Installation and Servicing	3.7.7.1.1	42
Oil Wetted Surfaces	3.7.7.3.4	43
Operating and Nonoperation Envelope	3.2.1.4.1	18

Paragraph Title	Paragraph No.	Page No.
Operating Attitude and Storage Limits	3.2.1.5.1	19
Operating Characteristics	3.2.1.5	19
Operating Characteristics	10.2.2.2	118
Operating Envelope Temperatures	3.2.5.1.1	22
Operating Life	20.3.2.4.1.1	126
Operating Limits	3.2.1.4	18
Operating Mode	10.2.2.2.1	118
Operation and Control	20.3.1.6.1	123
Operational Environments	20.3.2.5.2.1	126
Ordering Data	6.3	107
Other Government Documents	2.1.2	5
Other Publication	2.2	5
Overspeed	4.5.4.2.1	63
Overspeed	4.6.6.4.1	90
Overspeed Control Test	4.5.1.1.3	56
Overspeed Control Test	4.6.1.1.3	64
Overspeed Control Test	4.7.2.5	94
Overspeed Switch Actuation Speed	6.2.1.33	104
Overtemperature	4.5.4.2.2	63
Overtemperature	4.6.6.4.2	90
Overtemperature Switch Actuation Temperature	6.2.1.34	104
Packing List	6.3.2.35	110
Pads and Drives	3.1.2.7	8
Part Number Marking	3.3.3.3	28
Parts List	3.3.9.2	32
Parts, Materials, Processes and Standards	20.3.3.1	127
Penalty Run	4.7.5.1.2	97
Performance Characteristics	3.2.1	13
Performance Characteristics	10.2.2.1	117
Performance Characteristics	20.3.2.1	123
Performance Characteristics	30.2.3	138
Performance Curves	3.2.1.2.2	17
Performance Presentation Digital Computer Program	6.3.2.4	108
Performance Presentation Digital Computer Program	3.2.1.2.1	14
Performance Presentation Steady-State	3.2.1.2	14
Performance Ratings	3.2.1.1	13
Performance Verification	3.2.1.3	17
Permanent Magnet Generator	3.7.4.1.1	39
Personnel and Training	3.6	35
Personnel and Training	20.3.6	129
Physical Characteristics	3.2.2	20
Physical Characteristics	10.2.2.3	118
Physical Characteristics	20.3.2.2	125

Paragraph Title	Paragraph Number	Page Number
Plating	20.3.3.1.1	127
PMG Test	4.6.2.4.2	79
Power Section	6.2.1.35	104
Precedence	3.8	47
Preliminary Data	4.3.5.2	50
Preliminary Data	4.7.4.1	96
Preliminary Flight Rating Test (PFRT)	3.9.2	47
Preliminary Flight Rating Test (PFRT)	4.5	56
Preliminary Flight Rating Test (PFRT)	6.2.1.36	104
Preparation for Delivery	20.5.1	134
PREPARATION FOR DELIVERY	5	99
PREPARATION FOR DELIVERY	20.5	134
Preparation for Storage and Shipment	5.1	99
Pressure Connections	3.7.6.2	40
Pressure System	30.2.2.1	137
Pretest Data	4.3.5.1	50
Pretest Data	6.3.2.25	109
Pretest Verification	4.5.1.1	56
Pretest Verification	4.6.1.1	64
Previous Component Approval	4.5.2.1	60
Previous Component Approval	4.6.2.1	68
Primary Fuel	3.7.3.2.1	37
Procurement Requirements	6.3.1	107
Procuring Service	6.2.1.37	104
Protection Against Long Lines	20.3.2.1.8	125
Protective Treatments	6.3.2.11	108
Purging of Combustible Fluids	3.3.6.4	28
QUALITY ASSURANCE PROVISIONS	4	48
QUALITY ASSURANCE PROVISIONS	20.4	129
Quality Conformance Inspections	4.2	48
Quality Verification	3.9	47
Radar Cross Section	3.1.2.12	12
Radar Cross Section (RCS)	4.6.5.2	89
Radar Cross Section Report	6.3.2.3	108
Rated Load	6.2.1.38	104
Rated Measured Exhaust Gas Temperature	6.2.1.39	104
Rating	6.2.1.40	104
Recalibration	4.6.2.2.10	76
Recalibration (PFRT)	4.5.1.4	58
Recalibrations (VT)	4.6.1.4	66
Rejection and Retest	4.7.5.3	97
Rejection and Retest of Components	20.4.3.1	129
Relative Humidity Data	4.3.5.10	52

Paragraph Title	Paragraph No.	Page No.
Reliability	3.2.3	20
Reliability	20.3.2.3	126
Reliability Analysis Report	6.3.2.8	108
Reliability Assurance Program	20.4.8	132
Reliability Definitions	6.2.1.41	104
Reliability Values	3.2.3.1	21
Repair Procedure and Wear Limits	3.5.1.5	34
Repair Procedures and Wear Limits	6.3.2.21	109
Reports	4.3.6	52
REQUIREMENT	10.2	117
REQUIREMENT	30.2	137
REQUIREMENTS	3	6
REQUIREMENTS	20.3	122
Responsibility for Inspection	4.1.1	48
Responsibility for Inspection	20.4.1.1	129
Restart Time	3.7.9.2.1	45
Return System	30.2.2.2	138
Revisions	6.5.4	112
Room Temperature	4.6.2.2.7	73
Rotor Integrity	3.3.8.9.2	30
Rotor Integrity Report	6.3.2.17	109
Rotor Speed Limits	3.2.1.4.6	18
Rotor Structural Integrity	4.5.4.2	63
Rotor Structural Integrity	4.6.6.4	90
S-3A AIRCRAFT APU HYDRAULIC START SYSTEM	30	137
S-3A GENERATOR	10	117
Safety	3.3.6	28
Safety	20.3.3.6	128
Safety Override	20.3.2.1.6	124
Safety Provisions	20.3.2.1.5	124
Safety Shutdown	20.3.2.1.9	125
Safety Wire	6.3.2.19	109
Salt Water	4.6.2.2.5	72
Sampling Instructions	20.4.4	130
Sampling Tests	3.9.5	47
Sampling Tests	4.7.7	99
Sampling Tests	6.2.1.42	106
Sand and Dust	4.6.2.3.4	77
Sand Ingestion	3.2.5.6.4	24
Sand Ingestion Test	4.6.4.7	86
Satisfactorily	6.2.1.43	106
Scheduled Preventative Maintenance	6.2.1.22.6	102
Scope	1.1	1
Scope	10.1.1	117

Paragraph Title	Paragraph Number	Page Number
Scope	20.1.1	122
Scope	30.1.1	137
SCOPE	1	1
SCOPE	10.1	117
SCOPE	20.1	122
SCOPE	30.1	137
Sea Level Operating Limits	3.2.1.4.2	18
Service and Accessibility	3.5.1.3	34
Servicing	4.7.2.1	93
Servicing Indicators	3.7.6.9	42
Shutdown	20.3.2.1.4	124
Shutdown of the Second Engine	10.2.2.2.4	118
Shutdown Conditions	3.7.2.2.1	36
Simulated Operational Component Tests	4.6.2.2	68
Specification Dates	6.5.3	111
Specifications and Standards	2.1.1	2
Speed Indication	3.7.6.7	41
Speed Signal	20.4.5.1.1	131
Stability	3.2.1.5.4	20
Stall	6.2.1.44	106
Standard Condition	6.2.1.45	106
Standard Conditions	20.3.2.5.1	126
Standard Parts	3.3.9.1.2	32
Standard Tools	20.3.5.1.2	129
Standardization	3.3.9.1	32
Start and Acceleration Bleed Air	3.1.2.11.2.1	11
Start of the Second Engine	10.2.2.2.3	118
Start Reliability	3.2.3.2	21
Start Time	6.2.1.46	106
Starter Interface	3.7.9.1	45
Starting	3.2.1.5.2	19
Starting	4.3.3.4	49
Starting	4.4.5	55
Starting	4.7.1.4	93
Starting Data	4.3.5.6	51
Starting Data	4.7.4.4	96
Starting Demonstration Procedure	6.3.2.33	110
Starting Limits	3.2.1.4.4	18
Starting Sequence	20.3.2.1.3	123
Starting Torque	4.6.5.1	89
Starts	4.5.1.3.3	58
Starts	4.6.1.3.3	66
Steady-State Data	4.3.5.4	51
Steady-State Data	4.7.4.2	96
Steam Ingestion	3.1.2.10.5	11

Paragraph Title	Paragraph No.	Page No.
Steam Ingestion Test	4.6.4.13	87
Stoppage	4.7.5.3.3	98
Stopping	3.2.1.5.3	19
Stopping	4.5.1.1.4	56
Stopping	4.6.1.1.4	64
Stopping	4.7.2.6	94
Storage Temperature Range	3.2.5.1.3	23
Straight 60° Screw Threads	3.3.1.2.2	27
Strength and Life Analysis	3.3.8.6	30
Strength and Life Analysis	6.3.2.15	109
Structural Life	3.3.8.1	29
Structural Load Analysis Report	6.3.2.1	107
Structural Performance	3.3.8	29
Structural Tests	4.5.4	62
Structural Tests	4.6.6	89
Summary Reports	4.3.6.2	53
Summary Reports	6.3.2.28	110
Supply	3.5.2	34
Supply	20.3.5.2	129
Surge	6.2.1.47	106
Surge Margin	6.2.1.48	106
Survivability and Vulnerability	3.3.6.6	29
Sustained Acceleration	4.6.2.3.5	78
Symbols, Subscripts, and Abbreviations	6.2.2	107
System Description	30.2.2	137
System Power Capability	10.2.2.1.2	117
System Rating	10.2.2.1.1	117
System Start-Up with External or APU Generator Power	10.2.2.2.2	118
Tapered Pipe Threads	3.3.1.2.3	27
Temperature Sensing System Calibration	4.5.1.2.1	56
Temperature Sensing System Calibration	4.6.1.2.1	64
Temperature Sensing System Recalibration	4.5.1.4.2	58
Temperature Sensing System Recalibration	4.6.1.4.2	66
Temperature Sensing Systems	3.7.6.4	41
Test Apparatus	4.3.3	49
Test Apparatus	4.7.1	93
Test Article Configuration	4.3.2	48
Test APUs	4.3.2.1	48
Test Cell and Test Equipment	4.7.1.3	93
Test Completion	4.7.6	98
Test Condition	4.3.4	49
Test Conditions	4.7.2	93
Test Conditions	20.4.5.1	131

Paragraph Title	Paragraph Number	Page Number
Test Data	4.7.4	96
Test Notes	4.3.5.8	51
Test Procedure	4.7.5	97
Test Procedures	20.4.3	129
Test Records	4.7.3	95
Test Reports	4.3.6.1	52
Test Reports	6.3.2.27	110
Test Stand Dynamic Characteristics	4.3.3.3	49
Test Surveillance	4.3.1	48
Time Between Overhaul (TBO)	6.2.1.22.9	103
Tools	3.5.1.4	34
Transient Conditions	3.2.1.5.5	20
Transient Data	4.3.5.5	51
Transient Data	4.7.4.3	96
Transportability	3.2.6	25
Transportability	20.3.2.6	127
Type of Anti-Icing	3.7.1.2	35
Underspeed Protection	10.2.2.2.5	118
Unscheduled Maintenance	6.2.1.22.7	102
Unusable Oil	6.2.1.50	106
Using Service	6.2.1.49	106
Verification of Performance	6.3.2.5	108
Verification Table	6.5.5	112
Verification Test	3.9.3	47
Verification Test (VT)	4.6	64
Verification Test (VT)	6.2.1.51	107
Vibration	3.3.8.10	31
Vibration	4.6.4.17	88
Vibration	20.4.6.4	131
Vibration and Stress Analysis	3.3.8.10.2	31
Vibration and Stress Report	6.3.2.18	109
Vibration and Stress Test	4.6.6.6	91
Vibration Limits	3.2.1.4.10	19
Vibration Measuring Equipment and Response Characteristics	4.3.3.2	49
Vibration Measuring Equipment and Response Characteristics	4.7.1.2	93
Vibration Transducer Provisions	3.7.6.5	41
Voltage	20.3.1.5.1	122
Voltage Rating	20.3.3.1.6.1	127
Wash Procedure	3.7.11	47
Wash Procedure and Washing Medium	6.3.2.24	109

Paragraph Title	Paragraph No.	Page No.
Water Fouling	4.6.2.3.6.2	78
Wear Rate Analysis	3.7.7.4.6	45
Wear Rate Analysis Reports	6.3.2.23	109
Weight	20.3.2.2.1	125
Weight of Additional Equipment	3.2.2.2	20
Weight of Fluids	3.2.2.3	20
Weight of Operating Fluids	6.2.1.52	107
Weight of Operating Fluids	6.3.2.6	108
Windmilling	6.2.1.53	107
Workmanship	3.3.4	28
Workmanship	20.3.3.4	128

NUMERICAL INDEX OF FIGURES

Figure Number	Figure Title	Page Number
1	Interface Control Drawing, S-3A APU	183/184
2	Externally Applied Forces	185
3	Ambient Temperature Extremes	186
4	Uninstalled APU performance	188
5	Droop Characteristic and Combined Loads	189
6	APU Starting, Operating and Nonoperating Envelopes	190
7	Operating Attitude and Storage Limits	191
8	Continuous Maximum Icing Conditions	192
9	Intermittent Maximum Icing Conditions	193
10	APU Test Points and Altitude Ranges	194
	APPENDIX I	
1	S-3A Generator Heat Rejection	119
2	Generator Input Shaft Power vs Output KW	120
3	Power Transfer System	121
	APPENDIX II	
1	Interface Control Drawing, S-3A ECU	135
2	Electrical Interface, S-3A ECU	136
	APPENDIX III	
1	S-3A Modified Hydraulic APU Starting System	140
2	Start Valve Characteristics - Valve Opening Rate	141

NUMERICAL INDEX OF TABLES AND APPENDICES

Number	Title	Page Number
	TABLES	
I	Minimum Uninstalled Sea Level Static Performance	195
II	Minimum Uninstalled Altitude Performance	196
III	APU Characteristics Summary	197
IV	Gearbox Pads and Drives	198
V	Sea Level Anti-Icing Conditions	199
VI	Mission, Mission Mix and Component Life	200
VII	Fuel Contaminants	202
VIII	Data Recording	203
IX	Corrosion Susceptibility 48 Hour Test Cycle Schedule	204
	APPENDICES	
I	S-3A Generator	117
II	Electronic Control Unit, APU, Requirements for	122
III	S-3A Aircraft APU Hydraulic Start System	137
IV	Analysis and Test Summary	142

Preparing Activity
NAVY - AS
(Project No. 2840-N613)

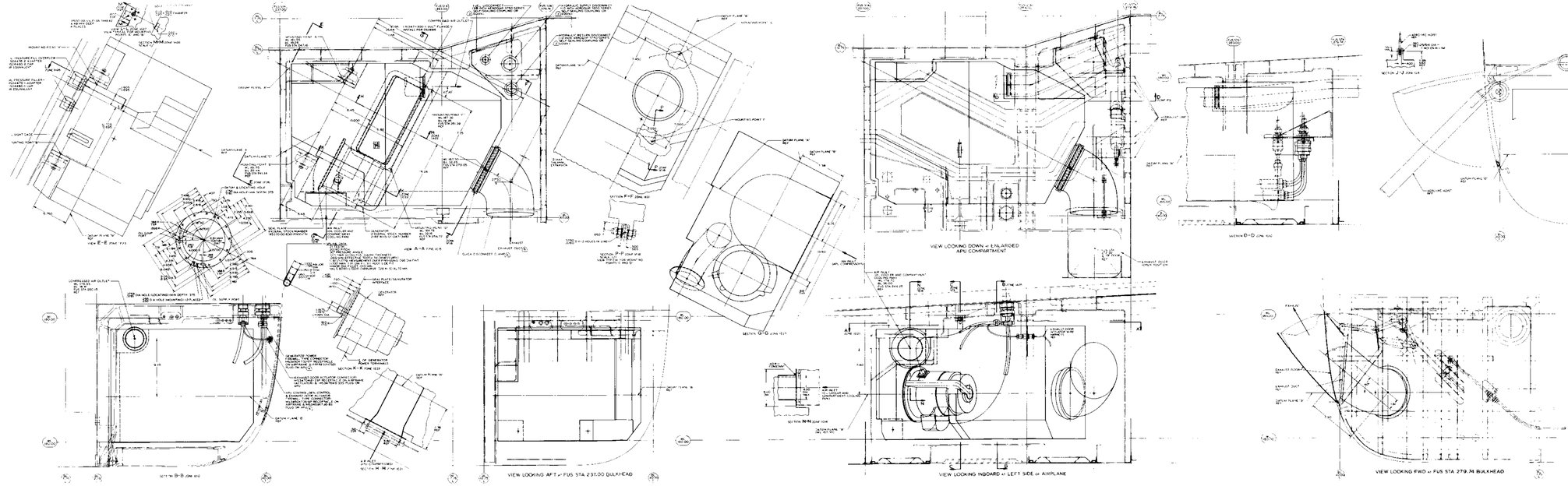
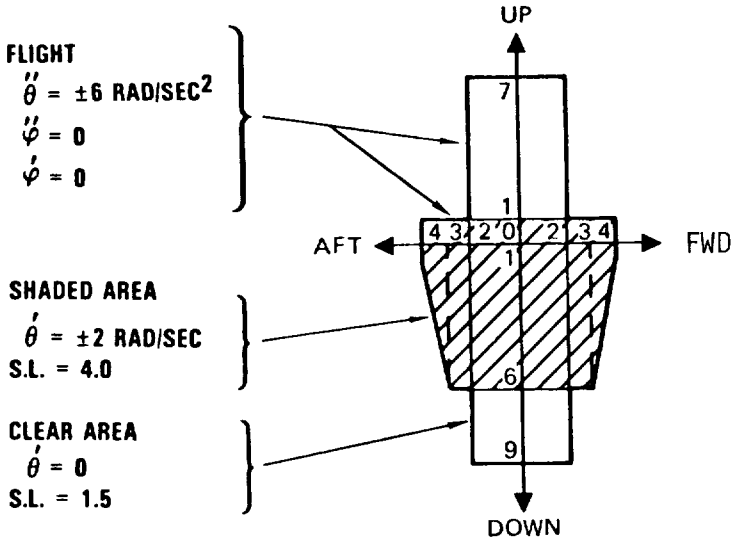
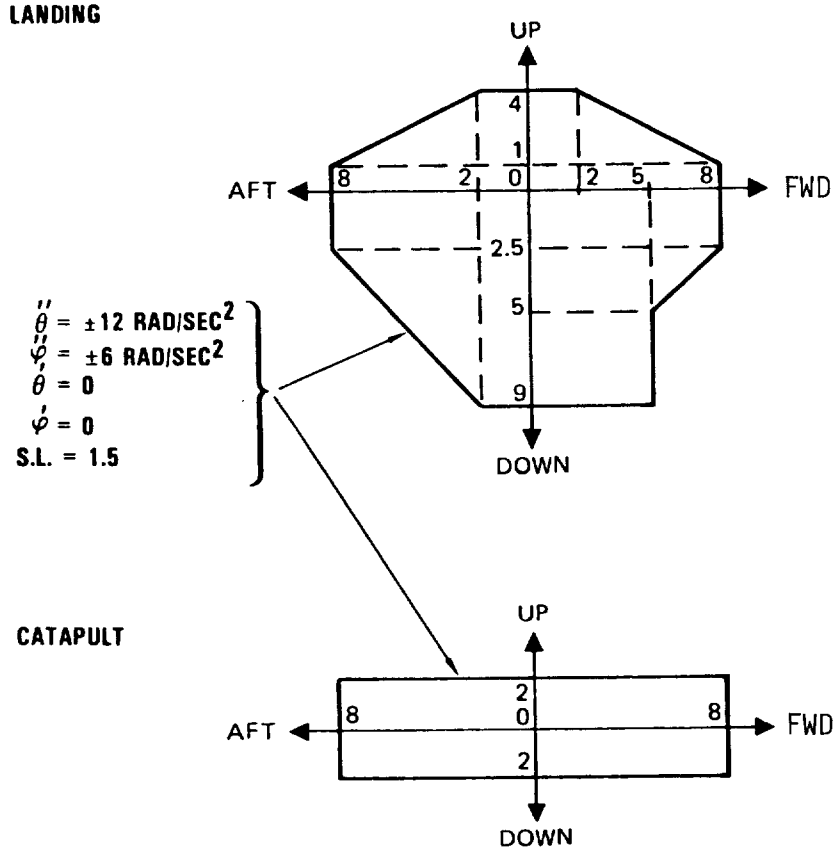


FIGURE 1. Interface Control Drawing, S-3A APU
REF. - 1.3, 3.1.2, 3.1.4, 3.1.2.10.1, 3.1.2.11.1, 3.7.3.1.1, 3.7.6.3, 3.7.7.4.1.2, 3.7.7.4.1, 3.7.9.1, 3.7.10.1.1



NOTES:

1. LOAD FACTORS AND ANGULAR VELOCITIES AND ANGULAR ACCELERATIONS SHOULD BE TAKEN AT OR ABOUT CG OF THE UNIT WITH GENERATOR INSTALLED.
2. SIDE LOAD FACTORS (SL) ACT TO EITHER SIDE.
3. $\dot{\theta}$ AND $\ddot{\theta}$ ARE PITCHING VELOCITY AND ACCELERATION.
4. $\dot{\varphi}$ AND $\ddot{\varphi}$ ARE YAWING VELOCITY AND ACCELERATION
5. DOWN LOADS OCCUR DURING PULLOUT.
6. FWD LOADS OCCUR DURING AN ARRESTED LANDING.



LANDING CONDITION I

n_x	= +2.5 FWD
n_y	= ±3.0
n_z	= −4.5 DOWN

LANDING CONDITION II

n_x	= + 5 FWD
n_y	= ± 1.5
n_z	= − 9 DOWN

FIGURE 2. Externally applied forces.

Ref. - 3.1.2.5, 3.1.2.10.2, 3.1.2.11.1, 3.7.3.1.2, 3.7.10.1.2

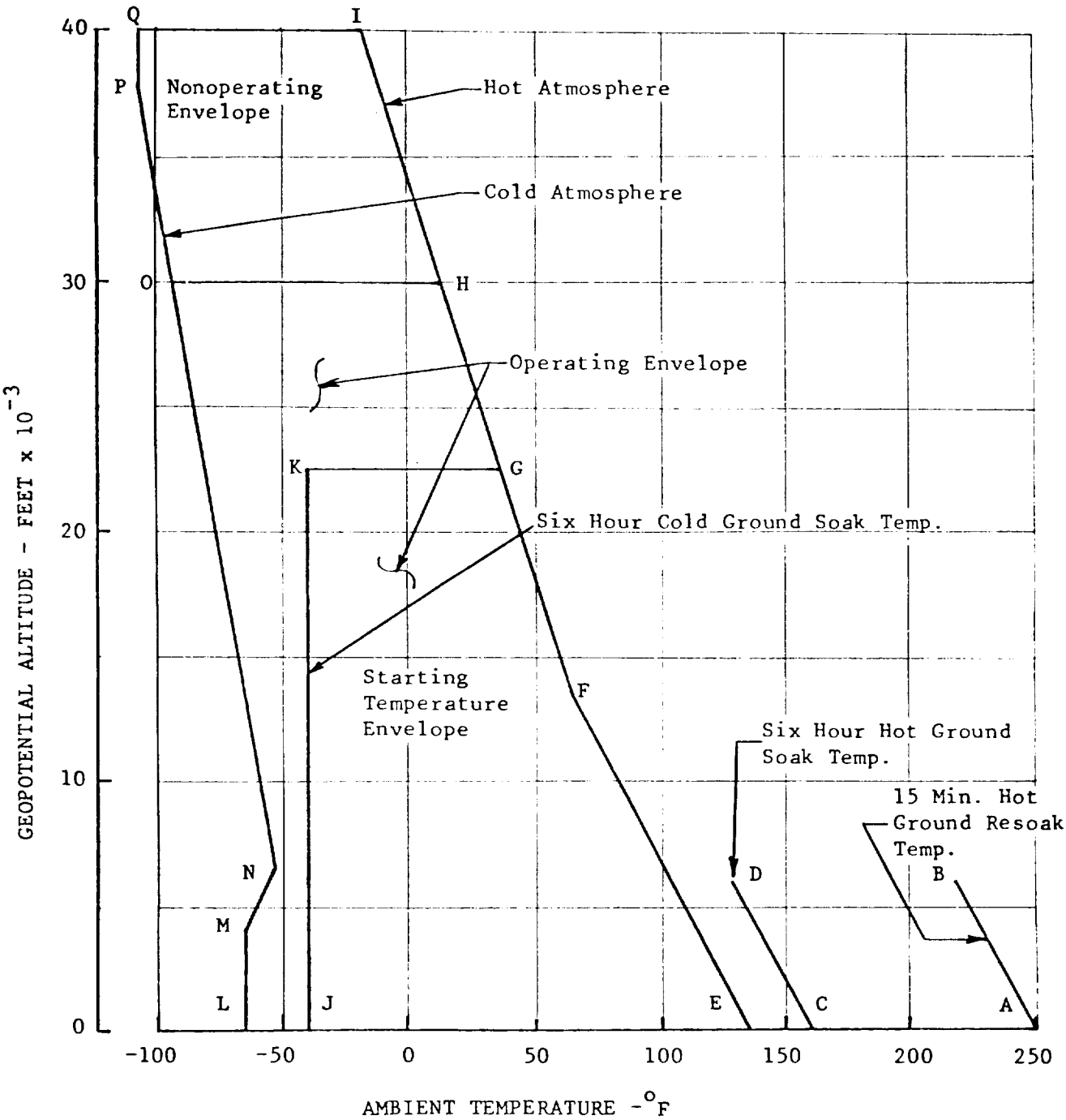


FIGURE 3. Ambient temperature extremes.

Ref. - 3.1.2.8.2, 3.2.1, 3.2.1.4.1, 3.2.1.4.2, 3.2.1.4.4, 3.2.1.4.8, 3.2.5.1, 3.2.5.1.1, 3.2.5.1.4, 3.7.3.3.4, 4.6.4.1

POINT	ALTITUDE FEET	TEMPERATURE °F(°C)
A	0	250(121)
B	6000	218(104)
C	0	160(71)
D	6000	128(54)
E	0	135(57)
F	13,500	64(18)
G	22,500	44(7)
H	30,000	14(-10)
I	40,000	-17(-27)
J	0	-40(-40)
K	22,500	-40(-40)
L	0	-65(-54)
M	4000	-65(-54)
N	6600	-53(-47)
O	30,000	-94(-70)
P	37,800	-108(-78)
Q	40,000	-108(-78)

FIGURE 3. Ambient temperature extremes - continued.

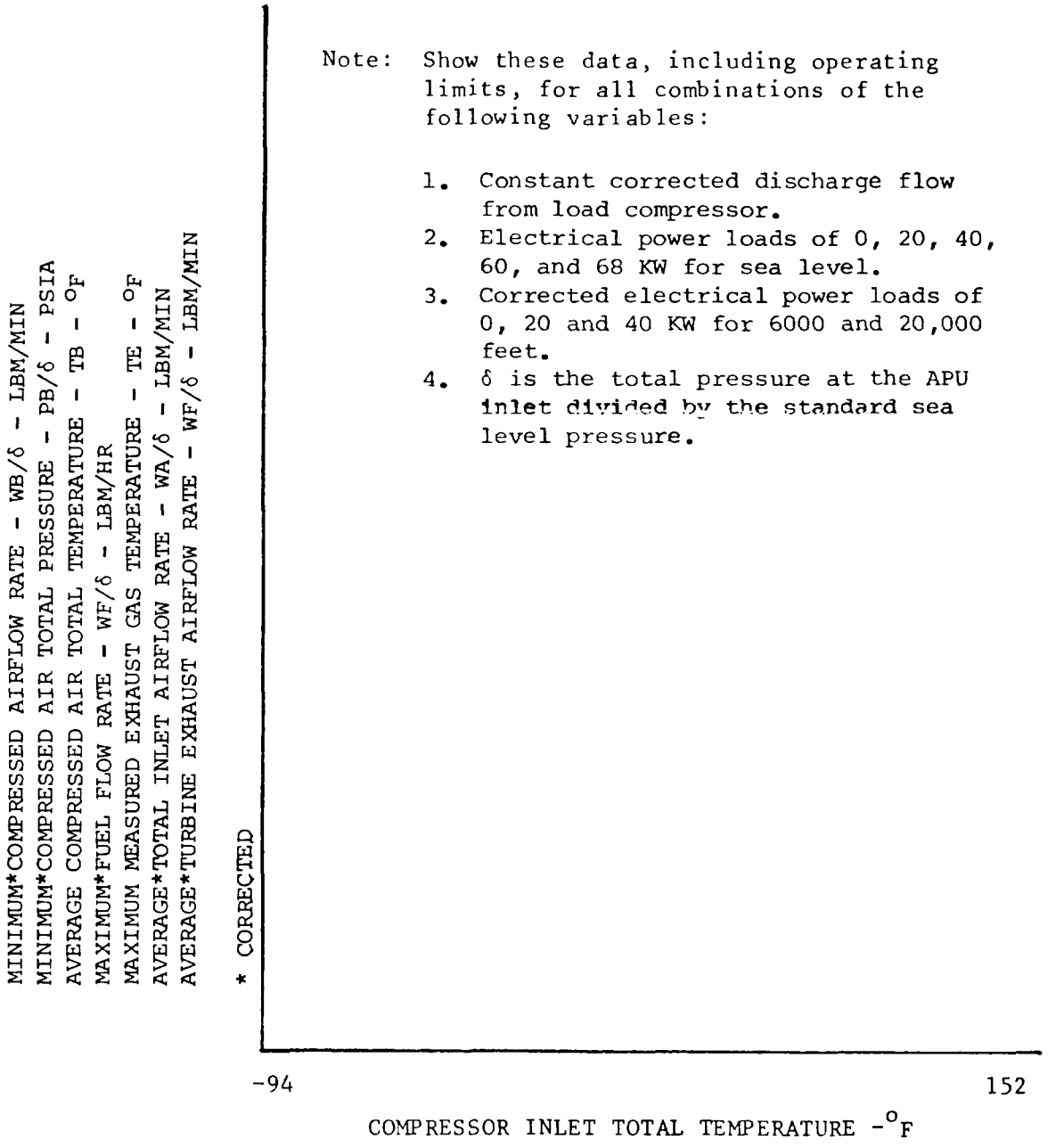


FIGURE 4. Uninstalled APU performance.

Ref. - 3.2.1.2.2

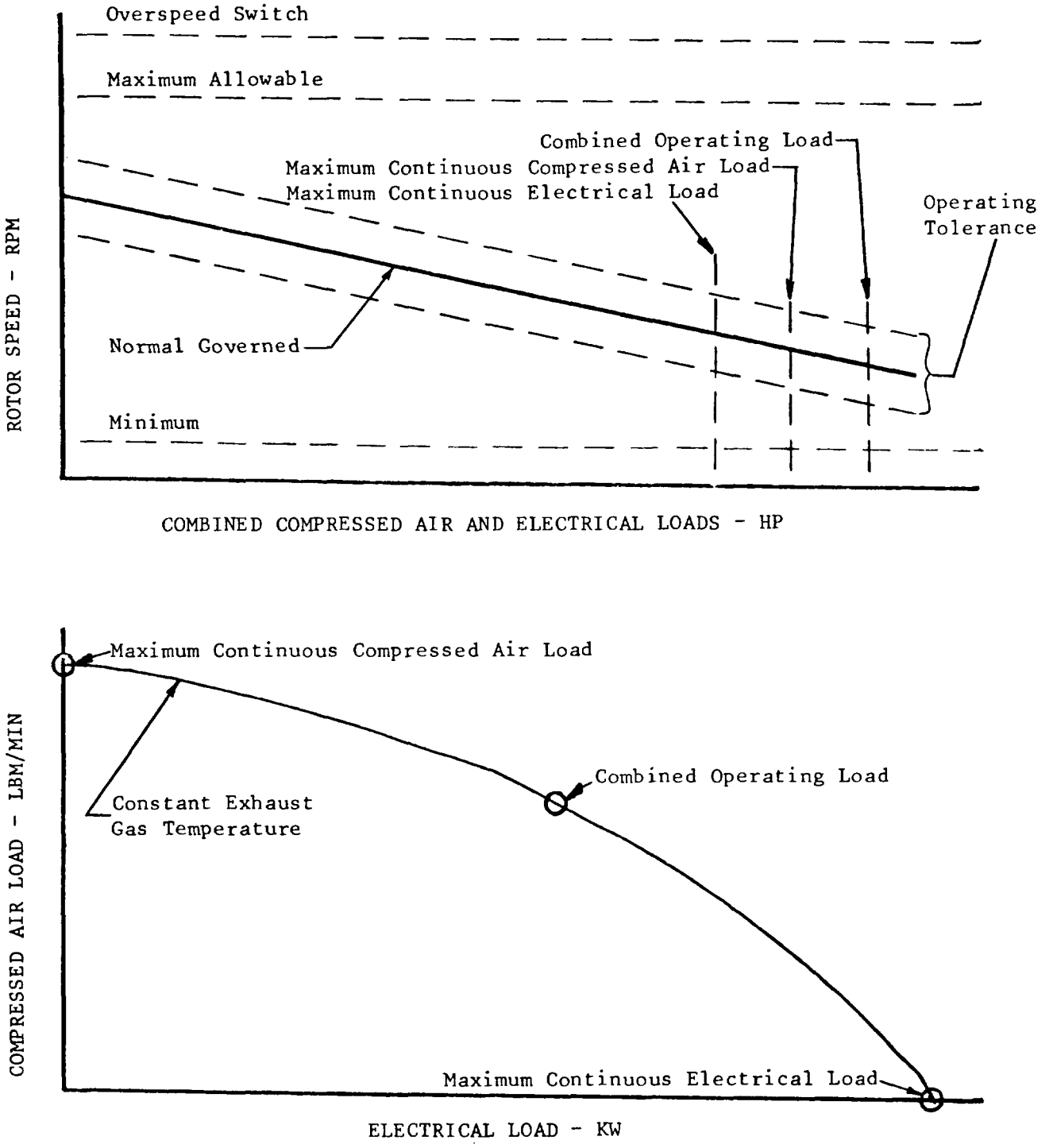
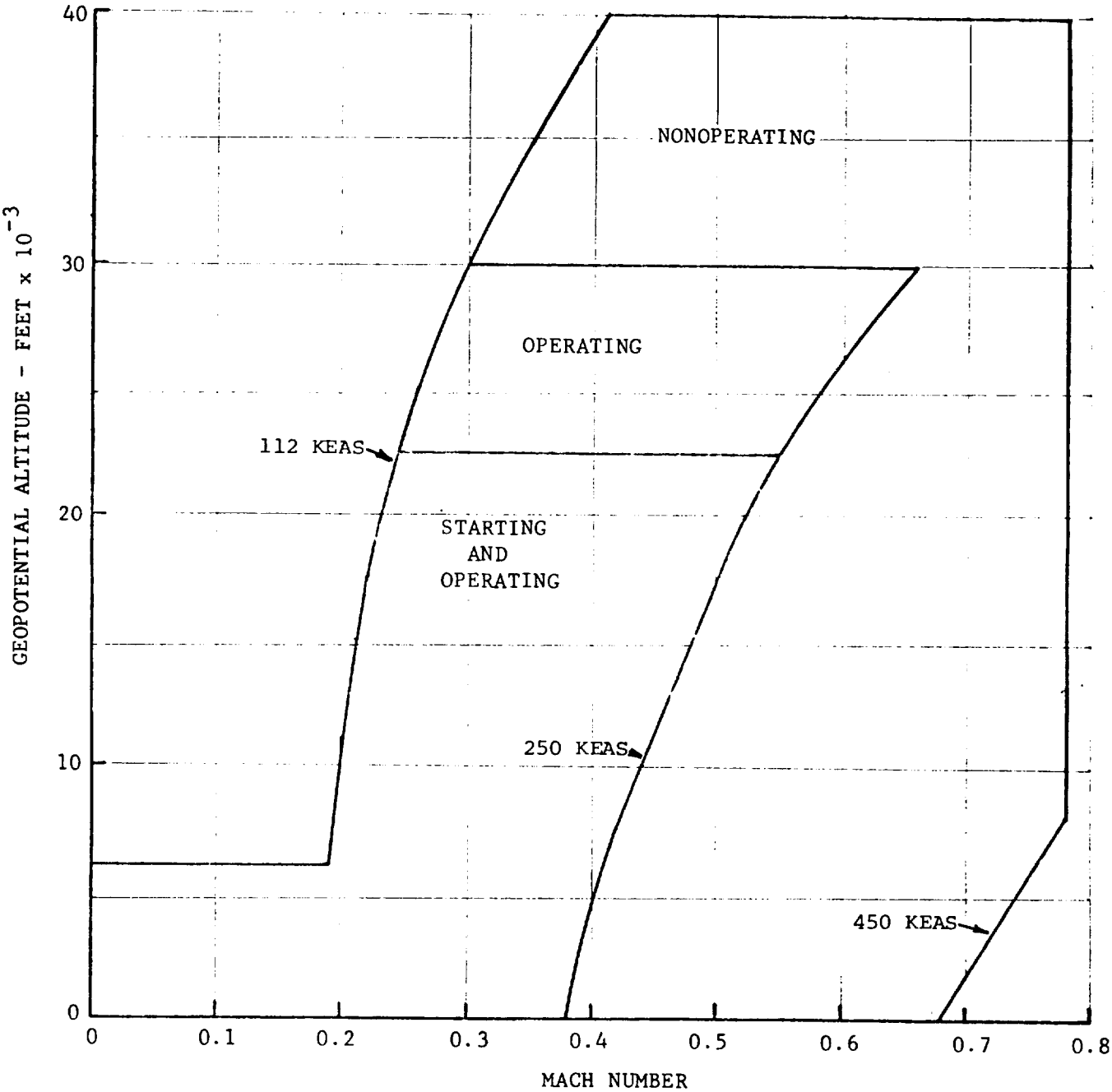


FIGURE 5. Droop characteristic and combined loads.

Ref. - 3.2.1.2.2

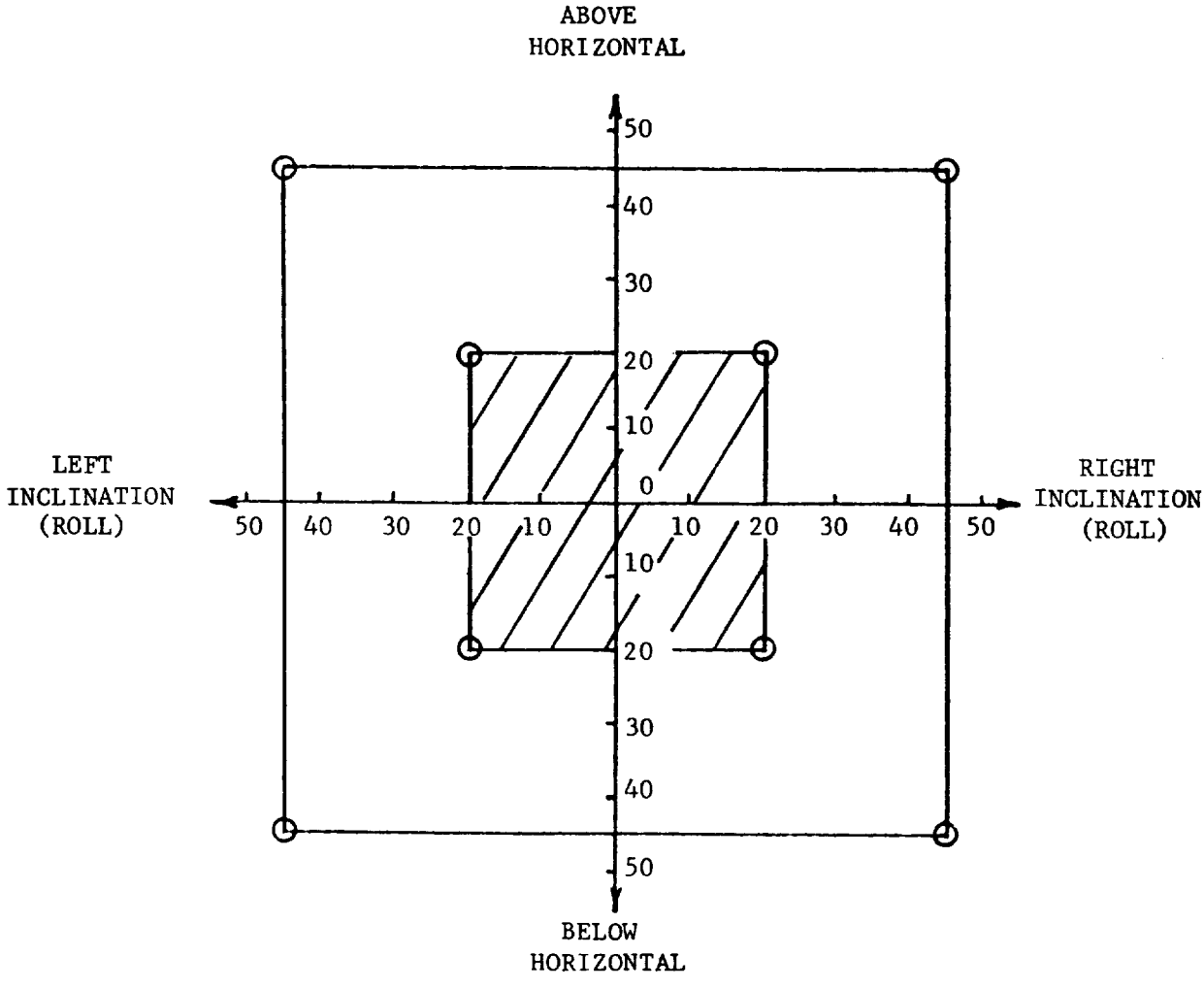


This figure is applicable for:

1. U.S. Standard Atmosphere 1976
2. Environmental conditions of figure 3
3. Inlet recovery as defined in 3.2.1d

FIGURE 6. APU starting, operating and nonoperating envelopes.

Ref. - 3.2.1.4.1, 3.2.1.4.2, 3.2.1.4.4, 3.2.5.1.1, 3.2.5.1.2



NOTES:

1. For the purpose of defining the direction of the acceleration vector from the APU CG, the figure assumes no acceleration other than gravity; however, the APU shall be capable of operating at all acceleration conditions of figure 2.
2. Referenced to ground, and values in degrees.
3. APU centerline perpendicular to plane of paper and looking forward from rear of APU. (See 6.2.1.51 for axes definition.)
4. Continuous operation in the shaded area and at least 30 seconds operation outside the shaded area but within the larger box.
5. Symbol "O" indicates test points.
6. Indefinite storage capability in shaded area.

FIGURE 7. Operating attitude and storage limits.

Ref. 3.2.1.5.1, 4.5.4.4

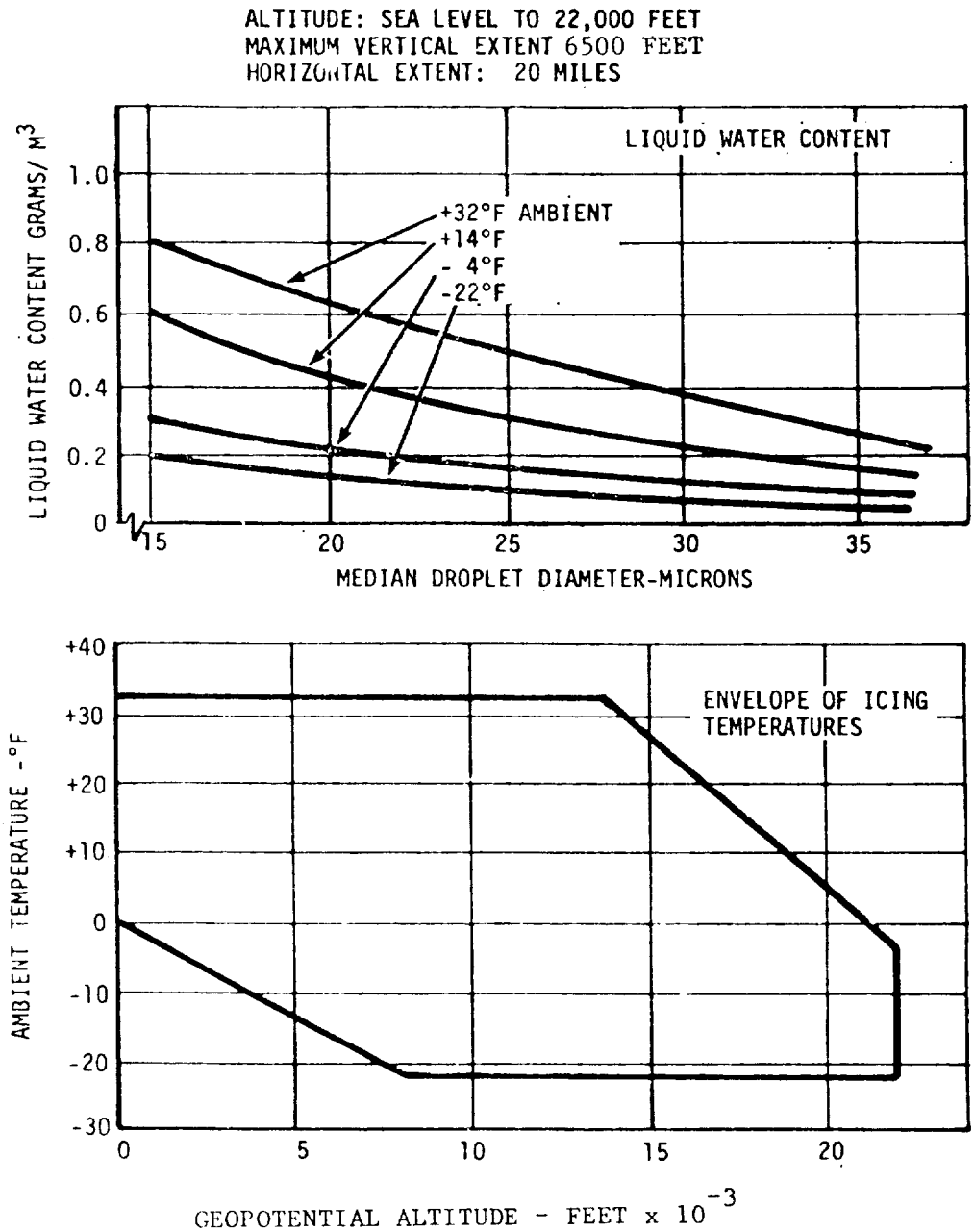


FIGURE 8. Continuous maximum icing conditions.

Ref. - 3.2.5.2

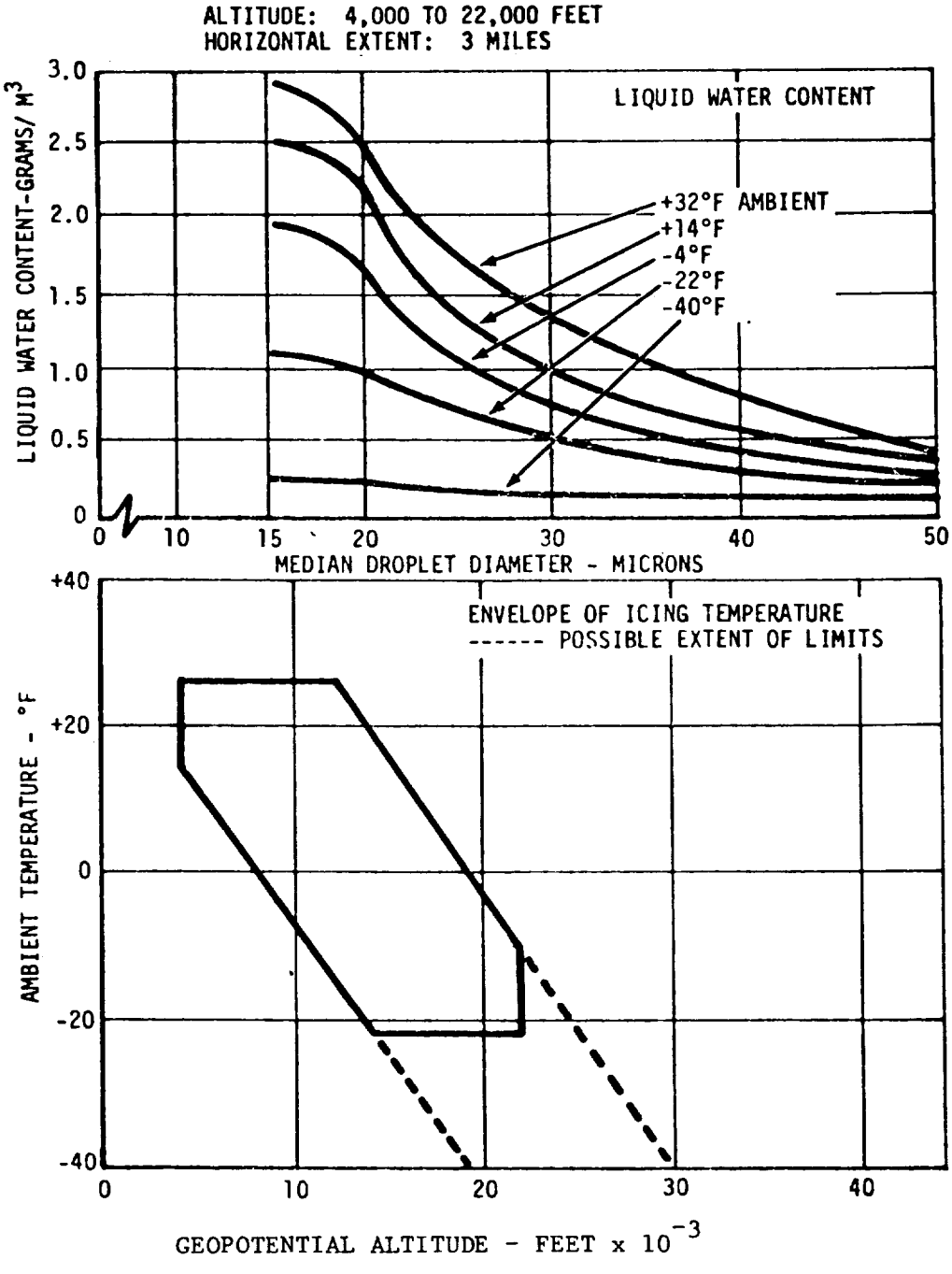


FIGURE 9. Intermittent maximum icing conditions.

Ref. - 3.2.5.2

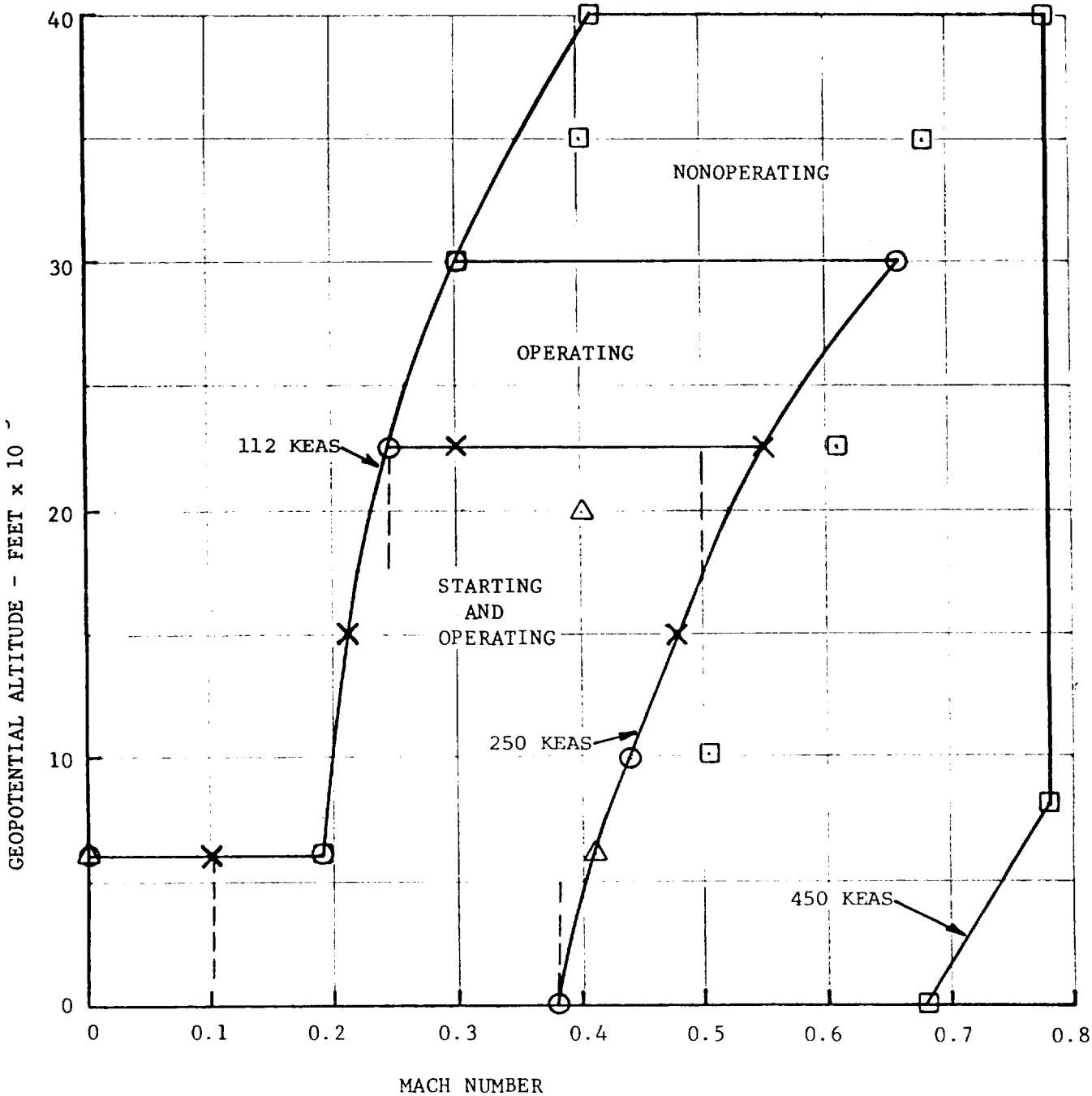


FIGURE 10. APU test points and altitude ranges.

Ref. - 4.5.3, 4.5.3.2, 4.6.3, 4.6.3.2

TABLE I. Minimum uninstalled sea level static performance.

Ref. - 3.1, 3.1.2.8.5, 3.1.2.11, 3.2.1.1, 3.2.1.2, 4.5.1.2.3, 4.6.1.2.3, 4.6.4.16, 4.6.4.17, 6.2.1.32, 6.2.1.39, 6.2.1.40, 6.5.1

APU RATING	AMBIENT TEMP °F(°C)	GEN LOAD MIN KW	COMPRESSED AIR (1) AIRFLOW MIN LBM/MIN	COMPRESSED AIR (1) PRESSURE MIN PSIA (2)	COMPRESSED AIR (1) TEMP AVG (3) °F(°C)	FUEL FLOW MAX LBM/HR	EXHAUST TEMP MAX °F(°C)	ROTOR SPEED AVG (3) RPM	INLET (4) AIRFLOW AVG (3) LBM/MIN
COL ↓ (5)	-65(-54)	40	(6)	(6)	(6)	(6)	(6)	(6)	(6)
	0(-18)		↓	↓	↓	↓	↓	↓	↓
	59(15)								
	103(39)		80.2	53.8	439(226)				
	135(57)		(6)	(6)	(6)				
MCCAL ↓	-65(-54)	0	(6)	(6)	(6)				
	0(-18)	↓	↓	↓	↓				
	59(15)								
	135(57)								
MCEL ↓	-65(-54)	43							
	0(-18)	↓							
	59(15)								
	135(57)								

NOTES (1) Compressed air is for a system demanding a corrected airflow of 28.9 lbm/min.
(2) Total pressure.
(3) Tolerances are to be specified by the APU manufacturer.
(4) Total inlet airflow.
(5) Aircraft systems design point.
(6) The performance values are to be listed by the APU manufacturer.

ABBREVIATIONS

COL - Combined Operating Load
MCCAL - Maximum Continuous Compressed Air Load
MCEL - Maximum Continuous Electrical Load
MIN - Minimum or Minute
AVG - Average
GEN - Generator

TABLE II. Minimum uninstalled altitude performance.

Ref. - 3.1, 3.1.2.8.5, 3.1.2.11, 3.2.1.1, 3.2.1.2, 4.5.3.2, 4.6.3.2, 6.2.1.32, 6.2.1.39, 6.2.1.40, 6.5.1

APU RATING	ALTITUDE FEET	AMBIENT TEMP °F(°C)	INLET MACH NO.	GEN LOAD MIN KW	COMPRESSED AIR (1)			FUEL FLOW MAX LBM/HR	EXHAUST TEMP MAX °F(°C)	ROTOR SPEED AVG (3) RMP	INLET (4) AIRFLOW AVG (3) LBM/MIN
					AIRFLOW MIN LBS/MIN	PRESSURE MIN PSIA (2)	TEMP AVG (3) °F(°C)				
COL	6000	-55(-49)	0	40	(5)	(5)	(5)	(5)	(5)	(5)	(5)
MCCAL	↓	↓	↓	0	↓	↓	↓	↓	↓	↓	↓
MCEL	↓	↓	↓	43	↓	↓	↓	↓	↓	↓	↓
COL	↓	103(40)	.41	30	↓	↓	↓	↓	↓	↓	↓
MCCAL	↓	↓	↓	0	↓	↓	↓	↓	↓	↓	↓
MCEL	↓	↓	↓	43	↓	↓	↓	↓	↓	↓	↓
COL	20,000	-12(-25)	.40	27	↓	↓	↓	↓	↓	↓	↓
MCCAL	↓	↓	↓	0	↓	↓	↓	↓	↓	↓	↓
MCEL	↓	↓	↓	43	↓	↓	↓	↓	↓	↓	↓

NOTES (1) Compressed air is for a system demanding a corrected airflow of 28.9 lbm/min.
(2) Total pressure.
(3) Tolerances are to be specified by the APU manufacturer.
(4) Total inlet airflow.
(5) The performance values are to be listed by the APU manufacturer.

ABBREVIATIONS

COL - Combined Operating Load
MCCAL - Maximum Continuous Compressed Air Load
MCEL - Maximum Continuous Electrical Load
MIN - Minimum or Minute
AVG - Average
GEN - Generator

TABLE III. APU characteristics summary.

Ref 3.1, 6.6

(1) APU CHARACTERISTICS SUMMARY	
APU (2)	
(3)	(4)
(5)	(6)
GENERAL DESCRIPTION (7)	
AVAILABILITY (8)	PROCUREMENT (9)
STATUS (10)	
GENERAL (11)	
SIZE & WEIGHT (12)	UTILIZATION (13)
(14)	(1) (2)

TABLE IV. Gearbox pads and drives.

Ref. - 3.1.2.7

NAME OF APU COMPONENT	TYPE OF DRIVE (1)	RATIO OF PAD TO ROTOR SPEED (2)	DIRECTION OF ROTATION (FACING PAD)	TORQUE (lbf-in)			OVERHUNG MOMENT (lbf-in)
				MAXIMUM CONTINUOUS	OVERLOAD (3)	STATIC	

NOTES: (1) Give the type of drive including AND or MS number and type.
(2) Ratio of speeds based on 100 percent rotor speed of 62,594 r.p.m.
(3) Specify duration and frequency of overload.

TABLE V. Sea level anti-icing conditions.

Ref. - 3.2.5.2, 4.6.4.2

APU Inlet Total Temperature	$-4 \pm 1^{\circ}F$ ($-20 \pm .6^{\circ}C$)	$+23 \pm 1^{\circ}F$ ($-5 \pm .6^{\circ}C$)
Velocity	0 to 60 kts	0 to 60 kts
Altitude	0 to 500 ft	0 to 500 ft
Mean Effective Drop Diameter	20 ± 5 microns	20 ± 5 microns
Liquid Water Content (Continuous)	$1 \pm .25$ g/m^3	$2 \pm .25$ g/m^3

TABLE VI. Mission, mission mix and component life.

Ref. - 3.3.8.3, 3.3.8.4, 3.3.8.6, 3.3.8.8, 4.5.1.3.2, 4.6.1.3.2, 4.6.6.2.1, 4.6.6.2.2, 6.2.1.22.6

MISSION DESCRIPTION	APU FUNCTION	APU LOADING BLEED PERCENT	APU LOADING ELEC KW	TIME(SEC) STARTS/HOUR 2	TIME(SEC) STARTS/HOUR 10
I Main Engine Start (MES) and Takeoff 20 Minutes/ Flight Avg.	APU Start	-	-	-	-
	Stand-By	*	*	10	12
	Cool Down	100	40	240	48
	MES	100	20	48	48
	Takeoff	*	*	300	60
	Shutdown	-	-	-	-
II In-Flight Emergency 0.6 Minutes/Flight Average					
A.MES	APU Start	-	-	-	-
	Stand-By	*	*	10	12
	MES	100	20	48	48
	Stand-By	*	*	18	18
	Shutdown	-	-	-	-
B.Emergency Power	APU Start	-	-	-	-
	Emergency Power	100	43	96	96
	Shutdown	-	-	-	-
III Maintenance 198.4 Minutes/Flight Average					
A.Landing	APU Start	-	-	-	-
	Stand-By	*	*	10	12
	Landing	*	*	300	60
	Parking	*	43	300	60
	Maintenance:			8 Times	Total
	Excursion	100	40	300	60
	Excursion	*	43	240	60
	Excursion	*	55	180	60
	Excursion	*	68	5	5
	Excursion	100	20	300	60
	Shutdown	-	-	-	-
B.Verification-Calibration	APU Start			2 Times	Total
	Stand-By	*	*	10	13
	Verify/ Calibrate	100	40	150	30
	Excursion	*	43	150	30
	Excursion	*	55	150	30
	Excursion	100	20	150	30
	Shutdown	-	-	-	-

*The bleed air is normally at 100 percent but will decrease on hot ambient days to maintain the EGT limit and will also decrease when high electrical loads are demanded. In the stand-by function the bleed air is dumped overboard through the surge control system and the generator absorbs 3.5 SHP.

TABLE VI. Mission, mission mix and component life - continued.

Item	**Predicted Minimum Structural Life - Without Repair (Operating Hours)
Power Section Gearbox APU Components	
Expendable Parts	Estimated Minimum Life (Operating Hours)
Oil Filter Fuel Filter Seals Ignitor	

**The predicted minimum structural life shall be based on the above missions and mission mix. In addition, the failure mechanisms of LCF, HCF, creep, stress rupture and thermal fatigue shall be taken into consideration.

TABLE VII. Fuel contaminants.

Ref. - 3.7.3.3.2

CONTAMINANT	PARTICLE SIZE	QUANTITY
Ferroso-Ferric Iron Oxide (Fe_3O_4, (Black color) Magnetite)	0 - 5 microns	1.5 gm/1,000 gal.
Ferric Iron Oxide (Fe_2O_3, Hematite)	0 - 5 microns	27.0 gm/1,000 gal.
Ferric Iron Oxide (Fe_2O_3, Hematite)	5 - 10 microns	1.5 gm/1,000 gal.
Crushed Quartz	1000 - 1500 microns	.25 gm/1,000 gal.
Crushed Quartz	420 - 1000 microns	1.75 gm/1,000 gal.
Crushed Quartz	300 - 420 microns	1.0 gm/1,000 gal.
Crushed Quartz	150 - 300 microns	1.0 gm/1,000 gal.
Prepared dirt conforming to A.C. Spark Plug Co. Part No. 1543637 (coarse Arizona road dust)	Mixture as follows: 0 - 5 microns (12 percent) 5 - 10 microns (12 percent) 10 - 20 microns (14 percent) 20 - 40 microns (23 percent) 40 - 80 microns (30 percent) 80 - 200 microns (9 percent)	8.0 gm/1,000 gal.
Cotton Linters	Below 7 staple (U.S. Department of Agriculture Grading Standards-SRA-AMS 180 and 251)	0.1 gm/1,000 gal.
Crude Napthenic Acid		0.03 percent by volume
Salt water prepared by dissolving salt in distilled water or other water containing not more than 200 parts per million of total solids	4 parts by weight of NaCl 96 parts by weight of H_2O	0.01 percent by volume entrained

TABLE VIII. Data recording.

Ref. - 4.3.5.4, 4.3.5.5, 4.3.5.6, 4.5.3, 4.6.3, 4.7.4.2, 4.7.4.3, 4.7.4.4

	TITLE	*A	*B	*C	*D	*E	*F
1.	Date and time of day	X	X		X	X	X
2.	Total endurance or running time	X	X		X	X	X
3.	Variable geometry position		X		X		
4.	Rotor speed(s) rpm	X	X	X	X	X	X
5.	Rotor speed(s) at ignition rpm	X					
6.	Rotor speed(s) at start cutout rpm	X					
7.	Rotor speed(s), stabilized at no load	X					
8.	Electrical power KW		X	X	X	X	X
9.	Fuel consumption lbm/hr		X	X	X	X	X
10.	Data for determining airflow		X	X	X	X	X
11.	Inlet total pressure psia		X		X	X	X
12.	Inlet total temperature °F(°C)	X	X		X	X	X
13.	Compressed air total pressure psia		X		X	X	X
14.	Compressed air total temperature °F(°C)		X		X	X	X
15.	Compressed airflow lbm/min		X	X	X	X	X
16.	Exhaust static pressure psia		X		X	X	X
17.	Oil pump inlet pressure psia	X	X		X	X	
18.	Oil pump inlet temperature °F(°C)	X	X		X	X	
19.	Oil pump outlet pressure psia	X	X		X	X	
20.	Oil pump outlet temperature °F(°C)	X	X		X	X	
21.	Oil consumption		X			X	X
22.	Fuel system inlet pressure psia	X	X		X	X	X
23.	Fuel system inlet temperature °F(°C)	X	X		X	X	
24.	Fuel system pressure at a point shown on the installation drawing psia	X	X		X	X	X
25.	Measured exhaust gas temperature °F(°C)		X	X	X	X	X
26.	Maximum measured exhaust gas temperature °F(°C)	X					
27.	Accessory compartment temperature °F(°C)		X	X	X	X	X
28.	Vibration at points shown on the APU configuration and envelope figure in/sec	X	X	X	X	X	X
29.	Test cell static pressure psia	X	X		X	X	X
30.	Ignition source voltage and current	X	X		X		
31.	Oil leakage at accessory pads		X		X	X	X
32.	Start number	X			X		
33.	Time to ignition actuation sec	X					
34.	Time to light-off sec	X					
35.	Time to starter cutout sec	X					
36.	Time to stabilized no load rpm sec	X					
37.	Time to oil pressure indication sec	X					
38.	Time to stabilize to normal oil pressure sec	X					
39.	Additional data required by the Using Service	X	X	X	X	X	X

*Column	Title
A	Starting
B	Once/30 min or one/cycle steady-state
C	Continuously during transients
D	Calibration/recalibration
E	PFRT/VT
F	AT

TABLE IX. Corrosion susceptibility 48 hour test cycle schedule.
(see following pages for explanation of Notes 1 to 8)

Ref. - 4.6.2.2.5, 4.6.4.3

Phase No. (Note 3)	Phase Duration Hours	Test APU Operation	Measured Salt Ingested-Parts per Billion (PPB)	APU Ambient Air	
				Temperature	Relative Humidity
1	3 (Notes 1 & 5)	Operating	200 (Note 4)	50°F (10°C) Min.	73% Min.
2	2	Not Operating	0	Atmospheric	Atmospheric
3	7	Not Operating	200 (Notes 2 & 4)	50°F (10°C) Min.	73% Min.
4	12	Not Operating	0	110±10°F (43±5°C)	90% Min.
5	3 (Notes 1 & 6)	Operating	200 (Note 4)	50°F (10°C) Min.	73% Min.
6	2	Not Operating	0	Atmospheric	Atmospheric
7	7	Not Operating	200 (Notes 2 & 4)	50°F (10°C) Min.	73% Min.
8	12	Not Operating	0	110±10°F (43±5°C)	90% Min.

NOTES FOR TABLE IX

1. During shutdown, while the APU is decelerating from no load, the salt solution shall continue to be sprayed into the APU until the rotor has come to rest.

2. The test facility blower system shall provide the flow of salt-laden air through the APU gas flowpath(s) and over the external surfaces of the APU.

3. APU inlet and exhaust openings shall remain open for all phases of the test cycle.

4. Salt solution ingested by the APU shall conform to that specified in Note 7 below, and shall be regulated to provide a constant concentration of 200 ppb by weight of salt in air during those phases of each cycle which require salt ingestion. A salt sampling system shall be employed to determine the concentration level during each cycle of operation.

5. Phase 1 - APU Operating Cycle (total accumulative time - 3 hours).

   (1) Four 10-minute cycles, each consisting of five minutes at maximum continuous electrical load followed by five minutes at no electrical load.

   (2) 110 minutes at combined operating load.

   (3) Three 10-minute cycles, each consisting of five minutes at maximum continuous compressed air load followed by five minutes at no electrical load.

6. Phase 5 - APU Operating Cycle (total accumulative - 3 hours).

   (1) Ten minutes at combined operating load.

   (2) Three 10-minute cycles, each consisting of five minutes at maximum continuous compressed air load followed by five minutes at no electrical load.

   (3) Five 25-minute cycles, each consisting of five minutes at maximum continuous electrical load, combined operating load, maximum continuous compressed air load, combined operating load and no electrical load.

   (4) Fifteen minutes at combined operating load.

NOTES FOR TABLE IX (Cont'd)

7. The basic salt formulation shall be composed of the following materials dissolved with sufficient distilled water to make one litre of salt solution. Additional distilled water may be added to the salt solution, as required, to provide a uniform salt aerosol profile across the face of the APU.

Chemical Designation	Quantity per litre of spray solution
NaCl (c.p.)	23 grams
$Na_2 SO_4 . 10H_2O$	8 grams
Stock solution (see Note 8)	20 millilitres

8. The stock solution shall be composed of the following materials dissolved with sufficient distilled water to make one litre of stock solution:

Chemical Designation	Quantity per litre of spray solution
KCl (c.p.)	10 grams
KBr	45 grams
$MgCl_2 . 6H_2O$ (c.p.)	550 grams
$CaCl_2 . 6H_2O$ (c.p.)	110 grams

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SUBMITTED BY *(Printed or typed name and address — Optional)*

TELEPHONE NO.

DATE

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