MILITARY SPECIFICATION

POWER UNIT
AIRCRAFT, AUXILIARY, GAS TURBINE
GENERAL 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). 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 APUs. 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 APUs covered by this specification for purposes of PFRT, VT, or AT; the manufacturer/contractor 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 contractor for the preparation of the model specification.

1.2 Components. The APU defined in this specification shall include, but not be limited to, the following components furnished as part of and qualified

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with the APU: Intake shroud, power section, load compressor, gearbox, control system, fuel system, ignition system, oil system, starter motor and exhaust duct.

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-T-5544	Thread Compound, Antiseize, Graphite-petrolatum
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-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-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-C-38373	Cap, Fluid Tank Filler
MIL-H-46855	Human Engineering Requirements for Military Systems, Equipment and Facilities
MIL-W-81381	Wire, Electric, Polyimide-insulated, Copper and Copper Alloy
MIL-T-83133	Turbine Fuel, Aviation Kerosene Type, Grade JP-8

STANDARDS

MILITARY

DOD-STD-100	Engineering Drawing Practices
MIL-STD-130	Identification Marking of U.S. Military Property
MIL-STD-210	Climatic Extremes for 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-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-1390	Level of Repair
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 14169	Circular Spline & Adapter Details, Engine Driven Accessories
MS 14184	Nonmetallic Shaft-Coupling Details, Engine Driven Accessories
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 33537	Insert screw Thread, Helical Coil, Coarse and Fine Thread, Standard Dimensions for
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 33666	Packing, Preformed - Aeronautical, Elastomeric, Range of Sizes
MS 33668	Packing, Preformed, Elastomeric, Tube Fitting, Range of Sizes

PUBLICATIONS

NAVPERS 18068	Navy Enlisted Manpower and Personnel Classifications and Occupational Standards
OPNAVINST 4790.2	The Naval Aviation Maintenance Program
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 addressed to: Commanding Officer, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120.)

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

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 publications. The following documents form 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.

AMERICAN NATIONAL STANDARDS INSTITUTE

ANSI N2.1	Radiation Symbol

(Copies may be obtained by writing to the American National Standards Institute, 1430 Broadway, New York, NY 10018.)

SOCIETY OF AUTOMOTIVE ENGINEERS

AEROSPACE STANDARDS

AS 681	Gas Turbine Engine Steady-State Performance Presentation for Digital Computer Programs
AS 1055	Fire Testing of Flexible Hose, Tube Assemblies, Coils, Fittings and Similar System Components

AEROSPACE RECOMMENDED PRACTICES

ARP 492	Aircraft Engine Fuel Pump Cavitation Endurance Test
ARP 755	Turbine Engine Performance Station Identification and Nomenclature
ARP 1179	Aircraft Gas Turbine Engine Exhaust Smoke Measurement
ARP 1256	Procedure for the Continuous Sampling and Measurement of Gaseous Emissions from Aircraft Turbine Engines

(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.)

2.3 Order of precedence. In the event of a conflict between the text of this specification and the references cited herein, the text of this specification shall take precedence.

3. REQUIREMENTS

3.1 Item definition. A model specification shall be prepared by the contractor in accordance with 6.4. 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; control system; gearbox provisions; type of lubrication and scavenge system; start motor; starting and ignition systems; number and location of main bearings; 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 for the fuel, ignition, lubrication and control systems, gas flow path (see 3.2.1.2), basic assembly and other systems as required by the Using Service. Item diagrams shall be attached to the model specification in the form of figures.

3.1.2 Interface definition. The interface requirements include all physical installation and performance requirements necessary for installation of the APU. All interface definitions shall require approval of the Using Service prior to incorporation into the APU design. In addition, all interfaces shall be as shown on the APU configuration and envelope drawing 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 the center of gravity of the dry APU. 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. Electrical installation connection figure. This drawing shall show and identify all external electrical circuit requirements and installation interface connection details.

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 installation interfaces shall be established in the model specification. Changes (additions, deletions or modifications) shall be submitted to the Using Service for approval only after coordination between the interfacing contractors as required by the applicable contract.

3.1.2.4 Mass moment of inertia. 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 shall be specified in the model specification. The maximum effective mass moment of inertia (slug-ft^2) about the resultant rotational axis, together with the direction of rotation when viewed looking forward from the exhaust, shall also be specified.

3.1.2.5 Externally applied forces. The APU, mounted in the mounting provisions of 3.1.2.6, shall function satisfactorily under the conditions of figure 1 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 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 accessories and operating fluids. When airframe components are supported by the APU, the weight of these components shall be included in the weight factor. A report shall be submitted containing a detailed structural analysis of the entire APU with regard to its capability to withstand the loads specified in this paragraph and 3.1.2.5.1 (see 4.5.4.3 and 4.6.6.5).

3.1.2.5.1 Gyroscopic moments. At all speeds up to at least maximum allowable steady-state rotor speed, the APU shall operate satisfactorily when a gyroscope moment is imposed under the following (see 4.6.6.7):

a. 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. Controlled flight. A steady angular velocity of 1.4 radians per second in any axis in a plane perpendicular to the rotor axis, and the maximum load factor shown in figure 1, for infinite cyclic life.

3.1.2.6 APU mounts. The number, type, location, interface dimensions, and the maximum allowable load limits at each individual attachment point shall be shown on the APU configuration and envelope figure (see 4.5.4.3 and 4.6.6.5).

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 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. If adapters are necessary, these will be designed and provided by the manufacturer. The APU shall incorporate means for lifting or hoisting and 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 APU components and aircraft accessories shall be in accordance with the basic configuration and rating requirements specified in the model specification and presented as shown in table IV. The 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. If drive splines are lubricated, they shall either be positively lubricated with APU oil, or incorporate provisions for non-metallic shaft-couplings as described in MS 14169 or MS 14184, depending upon the interface of the shaft coupling to the drive. 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. (see 4.4.1)

3.1.2.8.1 Limiting temperatures. The maximum operating surface temperature of the APU and of all its components and accessories external to the APU, shall be specified in the model specification. These temperatures shall not be exceeded when surrounded by compartment air under the following conditions:

a. Continuous operation at rated loads with the compartment air either at 250°F (121°C) or at the maximum sea level hot atmosphere temperature 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 the 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 condition. 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 temperatures 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 Component cooling. If required, the APU shall supply sufficient cooling fluid to selected component to maintain their temperatures within specified limits. The rate and temperature of the cooling fluid shall be specified in the model specification.

3.1.2.8.5 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 and submitted. The report shall be presented for table I and II APU operating conditions.

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. 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 air inlet flange shall be specified in the model specification. The maximum allowable loads at the air inlet flange for the maximum allowable combined maneuver and air loads shall also be specified. The maximum allowable maneuver loads are defined in figure 1.

3.1.2.10.3 Air inlet distortion limits. Not less than five sets of inlet 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 manufacturer. For each set of inlet 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 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 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 (see 4.6.3.2).

3.1.2.10.4 Air 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 0.25 inch diameter. The effects of the inlet screen on APU performance shall be included in the performance of 3.2.1 (see 4.6.4.4 and 4.6.4.6).

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 ten percent of the total APU mass airflow or up to two lbm/sec, whichever is greater. The effects of ingesting steam and/or steam condensate on APU performance shall be specified in the model specification (see 4.6.4.13).

3.1.2.10.6 Armament gas ingestion. The APU shall be capable of recovering from armament gas ingestion within five seconds after the cessation of the armament gas and shall operate satisfactorily thereafter. Any provisions incorporated into the APU for prevention of armament gas induced malfunctions shall be specified in the model specification. The APU shall ingest armament gas at an altitude of 7,500 feet, 0.7 Mach number when using one of two propellant types. The first propellant type is a non-aluminized double-base, the second an aluminized double-base. The air inlet shall be 15 feet in front of the rocket exhaust when the APU is installed in a simulated aircraft installation. The rocket mass flow rate shall be 25 percent of the APUs and shall be of at least a 0.1 second duration (see 4.6.4.9).

3.1.2.11 Compressed air. Compressed air shall be supplied to the aircraft as specified in the model specification. The location and interface dimensions shall be shown on the APU configuration and envelope figure. The pressure and temperature of the compressed air at all operating conditions for all operating altitudes, air inlet temperatures and flight speeds, and the effects on APU performance, shall be included in the performance computer program of 3.2.1.2.1. The maximum compressed air pressure and temperature shall be specified in the model specification. The compressed air port shall be sized to prevent APU failure in the event of a failure on the aircraft side. Bleed ducts with external surface temperatures exceeding 500°F (260°C) shall be insulated to prevent hazards from combustible fluid leakage. The bleed port internal pickup points shall be located at positions which have the least susceptibility to pickup of sand and dust, oil, moisture, or other foreign materials contained in the air which would enter the bleed air.

3.1.2.11.1 Compressed air connection. The compressed air connection shall be of the quick-disconnect type. 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 1.

3.1.2.11.2 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 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 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 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 (see 4.5.1.2.3.1, 4.5.3.1, 4.6.1.2.3.1 and 4.6.3.1).

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 five mg/cubic metre (3.12×10^{-7} lbm/cubic foot) of APU generated submicron particles.

3.1.2.11.4 Surge control bleed 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.

3.1.2.12 Radar cross section (RCS). A report shall be submitted detailing the RCS of the inlet and exhaust systems. The RCS shall be defined in terms of square metres over the frequency range from two to 18 GHz and in intervals of ten degrees. Median values of RCS shall be specified. The ten degree intervals over which the median values are obtained shall extend, as a minimum, over the angular range of ±60 degrees in both azimuth and elevation, as measured from the APU centerline at the inlet for the forward hemisphere and at the APU centerline at the exhaust for the aft hemisphere. Any special provisions for reducing RCS shall be described in the model specification (see 4.6.5.1).

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. No Government furnished property is to be incorporated in the APU design.

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 performance characteristics defined by the contractor in the model specification shall be for the poorest performing APU that the contractor would expect to submit to the Using Service for acceptance. Unless otherwise specified, the 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 (geopotential altitude).

c. No inlet air distortion.

d. An inlet pressure recovery of 100 percent.

e. 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.

f. Hot and cold atmosphere extremes (geopotential altitude) as defined on figure 2.

g. The static pressure outside of the APU compartment shall be equal to the free stream static pressure at the air inlet for fans that pass air into or out of the compartment.

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.

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 symbols, subscripts and abbreviations used in the model specification and computer program shall be listed in section 6. The model specification shall also include a diagrammatic figure defining the station identifications. The symbols and station identifications shall be in accordance with the provisions of ARP 755.

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 VAX 11/780 computer located at Naval Air Propulsion Center, Trenton, NJ 08628 shall be the computer upon which the program will be installed to obtain the official APU performance data. Compilation and 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 practices of AS 681 to the extent specified in table V, part A and as modified herein.

a. Program requirements. The performance program shall be a thermodynamic 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. The computer program shall be submitted in source language compatible with the specified computer. Nomenclature both internal and external to the program shall be in accordance with the provisions of ARP 755.

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 inches of mercury absolute. Compilation shall not be necessary for each different run. Capability for determination of installation effects shall be included in the computer program. Effects of distortion, relative humidity, ram recovery, parasitic flows, windmilling and variable geometry shall be included as applicable for the APU.

c. Documentation requirements. A user's manual and source program card image tape shall be provided.

(1) User's manual. In addition to those items specified in AS 681, the user's manual shall contain a general description of the simulation techniques, general overall model flow chart and a clear explanation of the calculation process and related assumptions for all APU components. The user's manual shall include a tabulation of all parameter limits and reference to all APU limits described in the model specification; e.g., measured temperature, speed. Additionally, the user's manual shall include graphs of all empirical functions used, reference values for normalized parameters, an index of subroutines including their inputs, outputs and functions and a listing of all test case program inputs and the corresponding required outputs.

(2) Source program. A source program card image tape and program listing shall be provided. These shall include all program subroutines with comment card images to identify subroutines and their functions. Sufficient comment card images shall appear in the program code to elucidate the calculation process. The first card images on the tape shall be comment cards indicating the contractor, APU type designation, program number and date. The format of the card image tape shall be compatible with the designated computer. The source program shall include the main program and the input and output subroutines.

d. Inputs/outputs. The program output listing shall be so organized that the input data shall print separately from the output. The program output listing shall show the APU designation, deck number and date. On classified decks, provision shall be made in the program for a line on the output sheet which can print declassification and authority by means of a Hollerith data input card. Program inputs shall be by namelist. Namelist nomenclature shall be in accordance with the provisions of ARP 755.

All program inputs must be independently variable and the programs shall be capable of sequentially accepting multiple numerical changes to the computer inputs. The program shall provide for inputs and outputs listed on table V,

part B. All aerothermodynamic cycle parameters used in component performance determination and cycle calculations shall be available, for information only, and will not be considered specification data.

e. Rating codes. The rating codes shall include, but not be limited to, the following:

Rating Code	Definition
55	Maximum Load
45	Maximum Continuous Load
15	No Load

The program shall be capable of calculating all required output parameters with input options of compressed airflow rate and power output, 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, 20,000, and 30,000 feet. The method for interpolation shall be specified, shall include any discontinuities in the curves, and shall be consistent with the computer program. These curves shall be drawn in accordance with the format of figure 3. In addition, the droop characteristic and combined load information shall be provided in the format of figure 4. 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 3.2.1.2.1 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 (see 4.5.1, 4.5.3, 4.6.1, 4.6.3 and others).

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. The operating limits are the limiting conditions within which the APU

shall meet all specified steady-state and transient performance characteristics.

3.2.1.4.1 Operating and non-operating envelope. The APU operating and nonoperating limits, as defined by aerothermodynamics and mechanical limitations for standard day and the hot and cold atmosphere extremes of figure 2 shall be specified in the model specification in the format of figure 5. The APU shall be capable of withstanding exposure to the nonoperating envelope without incurring irreversible damage or being rendered nonfunctional in the operating envelope (see 4.5.3 and 4.6.3).

3.2.1.4.2 Sea level operating limits. APU Mach number limits for standard day and the hot and cold atmosphere extremes of figure 2 shall be specified in the model specification on figure 5 (see 4.5.3 and 4.6.3).

3.2.1.4.3 Maximum operating altitude. The maximum operating altitude of the APU and the range of Mach numbers applicable at standard day conditions shall be specified in the model specification on figure 5 (see 4.5.3 and 4.6.3).

3.2.1.4.4 Starting limits. The starting and operating limits shall be specified in the model specification in the format of figure 5. The APU shall start under no-ram conditions from sea level up to at least 15,000 feet. After starting, the APU shall be capable of operating within the hot and cold atmosphere extremes of figure 2. 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 an APU in which a start is attempted within ten seconds after a flameout or shutdown (see 4.4.5, 4.5.3, 4.6.3 and 4.6.4.1).

3.2.1.4.5 Temperature limits. (see 4.5.1 and 4.6.1)

a. First stage turbine rotor blade metal temperature.

(1) The maximum allowable steady-state metal temperature at the first stage turbine blade, for the highest temperature blade, shall be specified in the model specification. The maximum allowable transient metal temperature during starting and acceleration shall also be specified.

(2) The temperature margin shall be specified in the model specification. Temperature margin is defined as the difference between the maximum allowable metal temperature specified above and the highest first stage turbine rotor blade metal temperature that can occur anywhere within the operating envelope in a minimum performing APU as defined by the computer program of 3.2.1.2.1. The APU operating condition (including the compressor inlet temperature and pressure) where this highest metal temperature can occur shall also be specified in the model specification.

b. Measurement plane temperature. If a direct measuring metal temperature sensing system is not provided for service use then:

(1) The maximum allowable steady-state gas temperature averaged over the gas path area at the measuring plane and corresponding to the above specified maximum allowable steady-state metal temperature, shall be specified in the model specification along with the location of the measurement plane (including station identification number).

(2) The maximum allowable measured temperature at the measurement plane (based on the signal indication after the thermocouple electrical harness plug) shall also be specified.

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.

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 (see 4.5.1 and 4.6.1).

3.2.1.4.7 Fuel flow limits. The maximum and minimum APU fuel flow shall be specified in the model specification (see 4.5.1 and 4.6.1).

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 all lubrication and cooling requirements. The maximum and minimum oil pressures during starting and initial operation at the sea level cold atmosphere extreme of figure 2, predicated on a 20,000 centistoke oil viscosity, 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 (see 4.5.1, 4.6.1 and 4.6.4.1).

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 (see 4.5.1 and 4.6.1).

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 shall be specified in the model specification. The overall velocity limit specified for each transducer shall be applicable up to a frequency of ten kHz (see 4.4.4).

3.2.1.5 Operating characteristics.

3.2.1.5.1 Operating attitude and conditions. The APU shall be capable of continuous satisfactory operation in the clear area and at least 30 seconds operation in the shaded areas shown on figure 6. The APU shall function satisfactorily for at least 60 seconds under conditions of negative "g" and for at least 30 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 clear area on figure 6. APU attitude stowage capabilities outside of the figure 6 clear area shall be specified in the model specification (see 4.5.4.4).

3.2.1.5.2 Starting. See 3.7.8.

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 (see 4.5.1.1.4 and 4.6.1.1.4).

3.2.1.5.4 Stability. Under steady-state operating conditions, throughout the complete environmental conditions and operating envelope, the APU output and rotor speed fluctuations shall be within one percent of the maximum continuous value, between no load and maximum load. When a droop characteristic is provided, the speed droop range from no load to the maximum load shall not exceed four percent of the no load rotor speed. In addition, the compressed air pressure fluctuations shall be within one percent of the maximum continuous value, between no load and maximum load (see 4.5.3.1 and 4.6.3.1).

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 three 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 (see 4.5.1.2.3, 4.5.3.1, 4.6.1.2.3 and 4.6.3.1).

3.2.1.5.6 Windmilling. The APU shall be capable of at least five hours of continuous windmilling operation throughout the complete operating envelope without damage to the APU and without excessive loss of lubricating oil (see 4.6.3.2).

3.2.2 Physical characteristics.

3.2.2.1 Dry weight. The dry weight of the complete APU shall not exceed the value specified in the model specification. The weight of components not mounted on the APU shall be specified and included in the dry weight (see 4.5.1.1.1 and 4.6.1.1.1).

3.2.2.2 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 in a report submitted to the Using Service (see 4.5.1.1.1 and 4.6.1.1.1).

3.2.3 Reliability. An APU failure mode and effect analysis, in accordance with Task 101 of MIL-STD-1629, shall be submitted. After completion of all verification testing, the contractor shall prepare a reliability report based on the total development and verification effort and based on data gathered through the contractor reliability programs. The contractor shall submit a reliability program plan in accordance with MIL-STD-785. The reliability values specified herein shall be demonstrated in the VT endurance test. The reliability values are subject to the failure definitions and exclusions specified in section 6 (see 4.6.1).

3.2.3.1 Mean-time-between-failures (MTBF) - chargeable. The APU shall have an MTBF - chargeable of 1000 hours.

3.2.3.2 Start reliability. The probability of a successful start on the first attempt shall be 0.995 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 defined in OPNAVINST 4790.2, and when using only the tools approved by the Using Service for support of the APU. The contractor shall submit a maintainability plan in accordance with MIL-STD-470 (see 4.4.7).

3.2.4.1 Quantitative requirements.

3.2.4.1.1 Direct-maintenance-manhours/operating hour (DMMH/OH). The APU shall be designed such that the DMMH/OH measured at the end of full scale development (FSD) shall not exceed 0.024 DMMH/OH (scheduled and unscheduled organizational and intermediate level of maintenance). The DMMH/OH shall include those tasks identified in 3.2.4.1.3.1, 3.2.4.1.3.2, and 3.2.4.1.4.

3.2.4.1.2 Mean-time-between-unscheduled-maintenance-actions (MTBUMA). The APU shall be designed such that the MTBUMA measured in the FSD program shall be not less than 300 operating hours. MTBUMA is defined as the number of unscheduled maintenance actions occurring in a time interval divided into the total operating hours in the same time interval. Maintenance action consists of all tasks resulting from a malfunction required to return the APU to operating condition.

3.2.4.1.3 Unscheduled mean-time-to-repair (MTTR).

3.2.4.1.3.1 Organizational level maintenance. The MTTR for organizational level maintenance shall not exceed 0.75 elapsed hours, and the maximum time to repair (90th percentile) shall not exceed 1.50 elapsed hours, excluding aircraft access, utilizing a crew of two of skill level specified in 3.2.4.3. Repair at this level shall include trouble shooting, fault isolation and functional checkout. Organizational level maintenance shall be acccmplished without the use of peculiar ground support equipment (PGSE). Equipment design shall be such that fault isolation of 95 percent of all failures can be accomplished in five minutes elapsed time, and fault isolation of 100 percent of all failures can be accomplished in ten minutes elapsed time.

3.2.4.1.3.2 Intermediate level maintenance. The MTTR for this level of maintenance shall not exceed 2.60 elapsed hours utilizing a crew of one of skill level specified in 3.2.4.3. The mean corrective maintenance time shall include: Connect and disconnect ground support equipment (GSE), bench check, disassembly and assembly, removal and replacement of components in accordance with approved maintenance plans, calibration if required, and functional checkout for repair verification.

3.2.4.1.3.3 Depot level maintenance. Depot level maintenance shall be justified by the contractor by a level of repair analysis (LORA) in accordance with MIL-STD-1390.

3.2.4.1.4 Scheduled maintenance. The "On Condition" maintenance concept shall apply to scheduled maintenance. Deviation from this concept shall be supported by a level of repair analysis/life cycle cost (LORA/LCC) determination and is subject to approval of the Using Service.

3.2.4.2 Qualitative requirements.

3.2.4.2.1 Preventive maintenance. The APU shall be designed to eliminate requirements for scheduled maintenance. In the event this cannot be fully achieved, proposed requirements shall be justified by the contractor, and will be subject to Using Service approval. Scheduled replacement shall not be allowed for any parts unless the contractor establishes that such parts have a wearout or fatigue characteristic which results in a determinable life span with non-random life distribution characteristics. Wearout of parts caused by mechanical operation is a typical example which may justify a scheduled maintenance action. As opposed to this, items which possess random failure distribution characteristics do not justify a scheduled maintenance action.

3.2.4.3 Maintenance personnel skill level. Organizational level maintenance shall not require a skill level greater than AD3, and intermediate level maintenance shall not require a skill level greater than AD2, as defined in NAVPERS 18068.

3.2.5 Environmental conditions.

3.2.5.1 Ambient temperature conditions.

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 thereafter, throughout the Mach number and altitude conditions specified on figure 5 (see 4.6.4.1).

a. Under no ram conditions at surface (ground) elevations from sea level to the maximum altitude specified on figure 5 and with the APU rotor at rest, the APU shall:

(1) Start after a hot soak period of six hours at the hot ground soak temperature as shown on figure 2 and when supplied with inlet air and fuel both at the hot atmosphere extreme shown on figure 2.

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

b. Under no ram conditions at surface (ground) elevations from sea level to the maximum altitude specified on figure 5 and with the APU rotor at rest, the APU shall:

(1) Start after a cold soak period of six hours when the ambient air temperature, supplied inlet air and MIL-T-5624, grade JP-4 fuel are all at the cold atmosphere extreme shown on figure 2.

(2) Start after a cold soak period of six hours when the ambient air temperature, supplied inlet air and MIL-T-5624, grade JP-5 fuel are all at the cold atmosphere extreme shown on figure 2 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 5 when supplied with inlet air and MIL-T-5624 fuel at any temperature between the hot and cold atmosphere extremes shown on figure 2 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 five-hour period of nonoperation within the nonoperating envelope of figure 5, the APU shall start at any condition within the starting envelope of figure 5 when supplied with inlet air and fuel at the temperature conditions specified in 3.2.5.1.1c (see 4.6.3.2).

3.2.5.1.3 Storage temperature range. During storage, the complete APU shall be capable of withstanding exposure to ambient temperatures from -70°F (-57°C) to 160°F (71°C) for periods of 24 and 48 hours, respectively, without incurring irreversible damage or being rendered nonfunctional in the operating envelope. The APU shall withstand the storage temperature extremes at surface (ground) elevations from sea level to the maximum (no-ram) altitude specified on figure 5 or 15,000 feet altitude, whichever is less.

3.2.5.1.4 Altitude changes. The APU shall start and operate satisfactorily after: (1) the APU has reached its maximum operating temperature when supplied with inlet air at the sea level hot atmosphere extreme of figure 2; (2) subsequently shutdown and (3) restarted within one minute at the minimum ambient starting temperature and Mach number, and at the maximum starting altitude. 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 (see 4.6.3.2).

3.2.5.2 Icing conditions. The APU shall operate satisfactorily under the meteorological conditions shown in figures 7 and 8, and table VI, with not more than five percent total loss in available load and five 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 (see 4.6.4.2).

3.2.5.3 Fungus conditions. APU components shall be resistant to fungus as determined by selection of non-nutrient materials which are resistant to fungus and by satisfactory completion of fungus test (see 4.6.2.3.4).

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 humidity test (see 4.6.2.3.3).

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. Upon completion of the corrosion susceptibility test, the APU shall be capable of operating with not greater than a five percent loss of available load and not greater than a five 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 (see 4.6.4.3).

3.2.5.6 Environmental ingestion capability.

3.2.5.6.1 Bird ingestion. The APU shall be capable of ingesting birds weighing two to four ounces at a bird velocity equal to the cruise flight

speed and with the APU at maximum load. The APU need not operate thereafter; however, no APU failure shall occur which would result in damage to the aircraft. The number of birds to be ingested shall be based on the inlet area directly exposed to the free stream and shall be one two-to-four ounce bird for each 50 square inches or for each fraction larger than 50 percent thereof (see 4.6.4.4).

3.2.5.6.2 Foreign object damage (FOD). The APU shall operate for at least 12 hours, in accordance with the PFRT endurance cycle, after ingesting foreign objects which produce a minimum stress concentration factor (K_t) of three to compressor blades and stators (see 4.6.4.5).

3.2.5.6.3 Ice ingestion. The APU shall be capable of ingesting hail and sheet ice (2.0 inches x 4.0 inches x 0.25 inch) without flameout, lengthy power recovery, sustained power loss exceeding ten percent of the power at the operating condition or major structural damage which would cause the APU to fail. The time for power recovery shall be specified in the model specification (see 4.6.4.6).

3.2.5.6.4 Sand and dust ingestion. The APU 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 and dust per pound of air. The APU shall be operated for ten hours in accordance with the VT endurance test schedule while ingesting the specified concentration of sand and dust. The APU performance degradation, while ingesting sand and dust, shall not exceed five percent and the capability to execute power transients shall not be impaired. The specified sand and dust contaminant shall consist of crushed quartz with the total particle size distribution as follows (see 4.6.4.7):

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 ingestion. The APU shall operate satisfactorily throughout the complete operating envelope from no load to the maximum load with up to five 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 (see 4.6.4.8).

3.2.5.7 Acoustic noise environment. The noise level of a bare APU during operation shall not exceed 95 dB(A) at a distance of 12 feet (see 4.6.4.10).

3.2.5.8 Exhaust gas contamination.

3.2.5.8.1 Exhaust smoke emission. The APU shall not emit visible exhaust smoke at any load condition throughout the environmental conditions and operating envelope of the APU when using any primary fuel specified for the APU. The maximum allowable smoke emission level shall not exceed a smoke number of 65 as determined by ARP 1179 and when using MIL-T-5624, grade JP-5 fuel with a minimum aromatic content of 17 percent by volume. Toluene may be added to the fuel to attain the required aromatic content (see 4.6.4.11.1).

3.2.5.8.2 Invisible exhaust mass emissions. The quantity in lb/1000 lb fuel of hydrocarbon, carbon monoxide and oxides of nitrogen emissions at maximum load, part load and no load conditions shall be specified in the model specification. The procedure for measuring the amount of exhaust constituents emitted by the APU shall be as specified in ARP 1256. The hydrocarbons shall be specified on the basis of methane and the oxides of nitrogen shall be specified on the basis of nitrogen dioxide. MIL-T-5624, grade JP-5 fuel with a minimum aromatic content of 17 percent by volume shall be used. Toluene may be added to the fuel to attain the required aromatic content (see 4.6.4.11.2).

3.2.5.9 Vibration-induced. The APU shall be capable of operating satisfactorily during and after exposure to the induced vibrational levels of 4.6.4.14 without a loss in output or transient performance.

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 manufacturer's documents are used for materials and processes, such documents shall be subject to review by the Using Service and unless specifically disapproved, will be considered released upon approval of the PFRT and VT. The use of non-governmental specifications shall not constitute waiver of government inspection. The Using Service

reserves the right to inspect any and all processes of the manufacturer. 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. 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 elastomeric materials 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. Materials selected for O-ring seals and packings shall be compatible with the conveyed fluid and shall not be subject to age controls insofar as possible.

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 manufacturer shall identify and submit a list of all protective treatments.

3.3.1.1.4 Exterior fluid lines. Exterior fluid lines 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 exterior lines shall be supported to avoid the detrimental effect of vibration and shall comply with the flammable fluid system requirements of 3.3.6.1. Tube fittings shall conform to MS 33514 or MS 33656.

3.3.1.2 Fasteners.

3.3.1.2.1 Metallic inserts. 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 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 defined in paragraph 19.2.1 of MIL-STD-461. The contractor shall conduct a system analysis to verify the need for those tests in MIL-STD-461, for Class A1b equipment which are marked "T" and "Y_L" (Limited Applicability). The analysis shall be submitted to the Using Service for approval. 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. An EMI control plan and an EMI test plan as required by MIL-STD-461 shall be submitted (see 4.5.1.1.2 and 4.6.1.1.2).

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. Components containing a radioactive substance shall have a decal, in accordance with ANSI N2.1, affixed to the exterior of the component.

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 ten 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.

3.3.6 Safety. The safety criteria and considerations set forth in MIL-STD-882 shall be used in establishing APU safety design features. A safety assessment report shall be submitted to the Using Service.

3.3.6.1 Flammable fluid systems. All exterior lines, fittings, and components which convey flammable fluids shall be fire resistant (five 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 throughout the environmental conditions and operating envelope of the APU (see 4.5.2.5 and 4.6.2.4.4).

3.3.6.2 Explosion-proof. All electrical components (except igniter plug electrodes) shall not ignite any explosive mixture surrounding the equipment (see 4.5.2.2 and 4.6.2.3.3).

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. The quantity of fluid leakage from all drains, except for the purging system, shall not exceed five millilitres per minute (see 4.5.1.2.3 and 4.6.1.2.3).

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 (see 4.5.1.2.3 and 4.6.1.2.3).

3.3.6.5 Ground safety. Warning notices shall be provided, where applicable, for high voltage electrical sources, noise, and explosive devices. (see 4.6.4.12)

3.3.6.6 Survivability/vulnerability. (see 4.6.4.12)

3.3.6.6.1 Nuclear safety and hardening. The APU 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 as prescribed in MIL-H-46855 and shall be applied to the design of the APU.

3.3.8 Structural performance.

3.3.8.1 Structural life. The APU shall be designed for a structural life, with and without repair, consistent with 3.3.8.1.1 and 3.3.8.1.2. In table VII the contractor shall list the predicted structural lives, both with and without repair, of all major life limiting components. Table VII shall specify the APU operating hours before which not more than 0.1 percent (B0.1

life), ten percent (B10 life) and 50 percent (B50 life) of all articles in service will fail when subjected to the missions and mission mix specified in table VII and to the ambient temperature distribution of figure 9. The contractor shall also include in table VII the scheduled replacement lives in operating hours for expendable parts, and as ignitor plugs, filter elements, gaskets, seals and O-rings. Notation shall be made in table VII of all failure modes which are critical (i.e. - resulting in parts penetrating the APU case).

3.3.8.1.1 Hot parts structural life. Based on operation of the complete APU in accordance with the missions and mission mix of table VII and the ambient temperature distribution of figure 9, the APU hot parts shall be capable of operating for at least 1,000 hours without parts replacement or repair. The APU hot parts shall include all parts exposed to a vitiated air stream such as the combustor, turbine vanes and blades and exhaust duct.

3.3.8.1.2 Cold parts structural life. Based on operation of the complete APU in accordance with the missions and mission mix of table VII and the ambient temperature distribution of figure 9, the APU cold parts shall not require repair or replacement of parts for at least 2,000 hours. The intended service life of the APU shall be 4,000 hours.

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 environmental conditions and operating envelope of the APU. For materials which do not have a discrete endurance limit knee on the stress versus cycles to failure curve, the contractor 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 contractor in table VII. LCF life requirements apply to all parts of the APU and include both pressure and temperature cyclic effects (see 4.6.6.2).

3.3.8.4 Pressure balance. The 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 VII. 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 (see 4.4.6).

3.3.8.5 Pressure vessel/case design. Each case and each gas pressure loaded component of the APU shall withstand at least two times its maximum operating pressure without rupture (see 4.5.4.1 and 4.6.6.1).

3.3.8.6 Strength and life analysis. A strength and life analysis shall be performed and a report submitted, for information only. Stress analysis shall include items such as APU cases, discs, vanes, blades, mounts, combustion liners, bearing supports, gears, brackets, and tubing. The report shall contain a study to establish the LCF test duty cycle and total cycles required for one LCF life equivalent consistent with table VII requirements (see 4.6.6.6).

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 VII. Creep also shall not affect disassembly and reassembly of the APU. A report shall be submitted stating the rate of part growth (for all parts which are potentially creep limited) 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 Containment. The APU shall completely contain a compressor or turbine blade failure at the blade airfoil section in the fillet above the platform at maximum allowable transient rotor speeds. In addition, the APU shall contain all parts damaged and released by the failure of a single blade. The APU shall incorporate a fail safe design to eliminate catastrophic failure including the following (see 4.6.6.3):

a. Compressor and turbine discs shall be protected by having blades fail first during overspeed and overtemperature malfunctions.

b. A main rotor shaft bearing or lubrication system failure shall not cause parting or decoupling of the shaft(s).

c. In the event of shaft decoupling, the turbine blading shall contact the vanes to arrest the rotor to preclude an overspeed condition.

d. In the event of a rotor bearing failure, the structures supporting the rotating masses shall be designed to minimize the probability of gross misalignment of the rotating parts.

3.3.8.9.2 Rotor integrity. To provide the 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 five minutes (see 4.5.4.2.1 and 4.6.6.4.1).

b. Measured gas temperature at least 80°F (44°C) in excess of the maximum allowable measured gas temperature and at maximum allowable steady-state rotor speed for five minutes (see 4.5.4.2.2 and 4.6.6.4.2).

3.3.8.9.3 Disc burst speeds. Disc burst speeds shall be not 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 (see 4.5.4.2.3 and 4.6.6.4.3).

3.3.8.10 Vibration. The APU shall be free of destructive vibration at all rotor 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 as 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 50 percent of the maximum load rotor speed in all modes of vibration which can be excited by the residual rotor unbalances. Acceleration spectrograms shall be obtained at the highest vibrational level in the operating envelope (which shall be identified) and at designated 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 shall be identified on each spectrogram. Each spectrogram shall cover the frequency range of five Hz to ten kHz and present acceleration data in peak g's (see 4.4.4).

3.3.8.10.1 Critical speeds. For designs with a fundamental critical speed above the normal governed rotor speed, a minimum of 20 percent margin shall exist between the normal governed 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 (see 4.4.4).

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, 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 (see 4.6.6.6).

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 contractor 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.

3.3.9.1.2 Standard parts. The military standard parts developed specifically for use in aircraft engines, such as those listed in 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 in critical or high strength application, 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 manufacturer part numbers and all previous identification marks shall be removed.

3.3.9.2 Parts list. The parts list for the APU which successfully completes either the PFRT and/or the VT shall constitute the approved parts list for any subsequent APUs of the same model to be delivered to the Using Service. The contractor 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 to reflect incorporation of approved engineering changes. The item configuration control number shall be

used to identify the APUs to be delivered. The approved parts list shall be prepared in accordance with Chapter 600 of DOD-STD-100 and shall show the latest drawing revision letter or number used to manufacture the parts 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 as approved by the Using Service.

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 contractor 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 shall be defined and submitted to the Using Service. The fabrication source and process of selected vendor components shall 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 contractor 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. In addition, the contractor 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 supplied to the Using Service shall be in accordance with 6.2.2.

3.5 Logistics.

3.5.1 Maintenance.

3.5.1.1 Modular concept. The APU shall be designed for replacement of major components by incorporating the modular concept. The separate modules and parameters which indicate when each specific module requires replacement and the module replacement limits shall be specified in the model specification.

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. Provisions for 360 degree inspection of the installed APU by borescope shall be made for the compressor, combustor and turbine sections of the APU. The borescope access port size shall be a minimum diameter of 0.40 inch. The location of access parts shall, at a minimum, permit borescope inspection at the following locations:

a. Compressor inlet guide vane leading edge.

b. Compressor inlet guide vane trailing edge and compressor first stage rotor leading edge.

c. Compressor last stage rotor trailing edge and combustor inlet.

d. Combustor lines, and fuel nozzle faces.

e. Combustor outlet and turbine first stage vane leading edge.

f. First stage turbine vane trailing edge and first stage rotor leading edge.

g. Last state turbine rotor trailing edge and power turbine first stage vane leading edge.

h. First stage power turbine vane leading edge and first stage rotor leading edge.

Radiographic inspection capability shall be provided for the completely assembled APU. The extent of inspection coverage by the above techniques shall be staged in the model specification. Location of the inspection provisions shall assure port access and radiographic access for the installed APU. A positive means of slowly rotating the rotor system shall be provided to facilitate borescope inspection. Inspection provisions, including access envelopes, shall be shown on the APU configuration and envelope figure.

3.5.1.3 Service and accessibility. Parts of the APU requiring routine service, checking, adjustment or frequent replacement shall be made readily accessible without removal of other parts or components, and without disassembly of the APU.

3.5.1.4 Tools. The APU shall be designed to make maximum use of standard tools and equipment for servicing, adjustment, assembly and disassembly. The requirement for new special tools, fixtures and test equipment shall be held to a minimum. If special tools are required, justification must be presented to the Using Service for approval. 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 contractor shall establish after-run wear tolerances, standards and repair procedures for submittal to the Using Service.

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 anti-icing system, if required, shall prevent the accumulation of ice on any part of the air inlet while operating under the icing conditions specified in 3.2.5.2. The total loss in performance of five 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 (see 4.6.4.2).

3.7.1.1 Anti-icing system actuation. The anti-icing system shall be actuated automatically by an ice detector supplied by the manufacturer. The signal requirements for actuation of the anti-icing system and a description of the ice detector shall be specified in the model specification.

3.7.1.2 Type of anti-icing. A description of the anti-icing 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, such as the fuel control, sequence unit, safety unit, and any other control units required for proper and complete automatic control of the APU. The control system shall be completely self-sufficient and require no external power from the airframe electrical system. In the event of an APU electrical power failure the control system shall safely shut down the APU. Each unit and function of the control system shall be listed and described in the model specification.

3.7.2.1 Fuel control. The fuel control shall provide control of the thermodynamic and output functions to obtain the steady-state and transient performance specified in the model specification. The fuel control shall automatically prevent the APU from exceeding any of its mechanical or critical temperature limits and shall provide the proper relationship between the load conditions and the controlled APU variables throughout the environmental conditions and operating envelope of the APU.

3.7.2.1.1 Fuel control adjustments. External adjustments to the controls, if required, shall be limited to adjustments which can be made correctly with the APU assembled and installed and with reference only to the operating characteristics of the APU on the ground. The adjustments shall be clearly marked, accessible and adjustable with the APU running. 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.

a. Normal governed rotor speed. The normal governed rotor speed shall be adjustable within five percent of the no load rotor speed.

b. Acceleration fuel flow. The acceleration fuel flow shall be adjustable to maintain the starting limits specified in 3.2.1.4.4 and load recovery limits specified in 3.2.1.5.5.

c. Bleed air. The bleed air shall be adjustable to maintain the variables within the limits specified in the model specification.

3.7.2.2 Sequence and safety unit(s). The sequence and safety unit(s) shall provide for the overall control and safety of the APU.

3.7.2.2.1 Sequence unit. The sequence unit shall automatically schedule the starting, shutdown and override functions of the APU after being armed. These functions shall include, but not be limited to: assuring that the inlet and exhaust doors are open, and energizing/de-energizing the fuel solenoid, starter and ignition. The sequence unit shall provide a ready-to-load signal and a signal for the condition monitoring panel of 3.7.6.1.3, when the rotor speed has reached a specified value during the starting sequence. Following a

shut down for any cause, the sequence unit shall purge the APU of combustible fluids in accordance with 3.3.6.4.

3.7.2.2.2 Safety unit. The safety unit shall monitor critical safety parameters and shutdown the APU in the event any of these parameters are exceeded. At the option of the Using Service certain parameters may be overridden. The critical safety parameters shall at least include the oil pressure, turbine temperature and rotor speed. The APU shall not be shutdown for low oil pressure during initial portion of the starting sequence. The safety unit shall provide a signal to the condition monitoring panel and the cockpit indicating the exceeded parameter. The maximum parameter values shall be specified in the model specification (see 4.5.1.1.3 and 4.6.1.1.3).

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 APU fuel inlet connections 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 1.

3.7.3.1.3 Fuel inlet pressure and temperature. The maximum and minimum fuel inlet pressure shall be specified in the model specification. The maximum fuel inlet temperature allowed for continuous operation shall not be less than 200°F (93°C) and shall be specified in the model specification. Minimum fuel inlet temperature shall be in accordance with 3.2.5.1.

3.7.3.2 Fuels.

3.7.3.2.1 Primary fuel. The APU shall start and operate satisfactorily throughout its complete 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 and MIL-T-83133, grade JP-8.

3.7.3.2.2 Alternate fuel. The APU shall also start and operate when using commercial Jet A, A1 and B, and other fuels specified by the Using Service. The operating limits, power outputs and power transients specified in the model specification shall not be adversely affected when using an alternate fuel. The effects on the APU performance characteristics, changes in specific fuel consumption (SFC), changes in starting and stopping time and effects on the aircraft mission(s) when using alternate fuels, shall be specified. There shall be no effect on the established overhaul time for the APU from that

specified in 3.2.4.2. Those external adjustments permitted in 3.7.2.1.1 shall be allowed in order to meet this requirement. The APU shall function satisfactorily with an alternate fuel containing anti-icing additive conforming to MIL-I-27686 and added in a concentration up to 0.15 percent by volume (see 4.6.5.3).

3.7.3.2.3 Emergency fuel. The APU shall also start and operate when using the emergency fuels specified by the Using Service. The APU shall function satisfactorily for at least six hours from sea level to 20,000 feet, over an operating range from no load to maximum continuous load and at no greater than 120 percent of the specified or estimated SFC. Those external adjustments permitted in 3.7.2.1.1 shall be allowed in order to meet this requirement. If applicable, operating limitations, special inspection or maintenance actions required as a result of using an emergency fuel, shall be specified in the model specification (see 4.6.5.4).

3.7.3.3 Fuel system performance.

3.7.3.3.1 Fuel system calibration limits. Fuel system calibration limits shall be determined when using MIL-C-7024, Type II test fluid. 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 VIII.

3.7.3.3.3 Fuel system performance with external assistance. The APU fuel system shall supply the required amount of fuel at the required pressures for operation throughout the environmental conditions and operating envelope of the APU including starting with the following conditions at the fuel inlet connection:

a. Fuel temperature. From the sea level cold atmosphere extreme shown on figure 2 (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 or MIL-T-83133 grade JP-8 fuel) to the maximum compartment temperature specified in 3.1.2.8.2 for the volume of fuel between the fuel inlet connection and the compartment wall; thereafter, not less than 200°F (93°C). The maximum sustained fuel temperature shall be specified in the model specification.

b. Fuel pressure. From a minimum of five 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 Fuel system performance with no external assistance. The APU fuel system shall supply the required amount of fuel, at the required pressures for APU operation, from sea level up to the maximum operating altitude and ground

and air starts up to the maximum starting altitude under the following conditions at the fuel inlet connection:

a. Air inlet. As defined by the standard day operating envelope up to the maximum operating altitude.

b. Fuel temperature. Up to at least a minimum of 200°F (93°C) when using MIL-T-5624 grade JP-5 or MIL-T-83133, grade JP-8 fuel, or 110°F (43°C) for MIL-T-5624 grade JP-4 fuel.

c. Vapor/liquid ratio. From zero to 0.45.

3.7.3.3.4.1 Fuel pump priming. The fuel pump shall prime itself when subject to a dry lift of one foot at a pressure of 4.4 psia at the fuel pump inlet with a Reid vapor pressure not exceeding three psi and a fuel temperature of at least 110°F (43°C) for MIL-T-5624 grade JP-4 fuel. The requirements of this paragraph need not apply to operation with emergency fuel (see 4.5.2.3).

3.7.3.3.5 Fuel system performance under conditions of excessive fuel vapor. Under the conditions of vapor/liquid ratio greater than 0.45 at the fuel inlet, it shall not be necessary for the fuel system to supply the amount of fuel required for APU operation. However, it shall be possible to accomplish normal starts after the conditions specified in 3.7.3.3.4 have been re-established. Excessive fuel vapor 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, without servicing, to permit a cumulative fuel flow equivalent to a minimum of 12 hours of continuous operation at the sea level maximum load with fuel contamination as specified in 3.7.3.3.2. The filter assembly shall incorporate a pressure relief bypass and shall be of a design which shall prevent the discharge of filter contaminant through the bypass. The filter assembly shall provide a signal to the condition monitoring panel of 3.7.6.1.2 of an impending filter bypass. The filter system shall be described in the model specification.

3.7.4 Electrical system.

3.7.4.1 Electrical power. The electrical power for ignition and control system operation during starting and operating throughout the complete environmental conditions and operating envelope of the APU shall be supplied by the APU electrical system.

3.7.4.1.1 Generator/alternator. If a generator/alternator is used, it shall provide the required electrical power from the specified minimum firing speed to maximum allowable transient rotor speed. The generator/alternator shall not be adversely affected by continuous operation at a generator/alternator speed equivalent to 106 percent maximum allowable rotor speed under full electrical load, and shall withstand five minutes of operation at overspeeds equivalent to 135 percent maximum allowable transient rotor speed without electrical load (see 4.6.2.4.2).

3.7.4.2 Electrical power failure. The APU shall safely shutdown in the event of an APU electrical power failure (see 4.4.3).

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 the sea level cold atmosphere extreme of figure 2, it shall be possible to flex electrical cable and conductors and to connect or disconnect electrical connectors during routine maintenance procedures without damage to these items (see 4.6.4.1).

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 delivery under this contract. 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.

3.7.5.1 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, and shall function satisfactorily 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 the 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 (see 4.5.3.2 and 4.6.3.2).

3.7.5.2 Ignition lead assembly. The ignition lead assembly shall be as short as practicable and its capacitance shall not exceed ten percent of the storage capacitor within the exciter unit. It shall be possible to install or remove the ignitor(s) from the unit at the sea level cold atmosphere extreme of figure 2 without mechanical or electrical failure of the ignition lead

assembly. The ignition lead assembly shall also be detachable from the ignition power source (see 4.6.4.1).

3.7.5.3 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 Instrumentation interface.

3.7.6.1.1 Condition indication. The APU shall incorporate sensors (pressure, temperature, quantity, warning, etc.) which are required to provide information to permit safe APU operation and operation within the established limits. The instrument range, system accuracy, time response, and electrical characteristics for each parameter shall be presented in tabular form in the model specification.

3.7.6.1.2 Condition monitoring panel. A condition monitoring panel shall be mounted on the APU in such a manner as to be easily viewed by ground maintenance crews through an access door. The panel shall include, but not be limited to, the following indicators and services:

a. Elapsed time indicator and start counter, per 3.7.6.3.

b. Impending bypass of the fuel or oil filters, per 3.7.3.4 and 3.7.7.4.3, respectively.

c. Oil quantity, per 3.7.7.4.1.2b.

d. Contaminated oil, per 3.7.7.4.4.

e. Life counter, per 3.7.6.6.

f. Exceeded parameter causing an emergency shutdown, per 3.7.2.2.

g. Oil filler openings and overflow provisions, per 3.7.7.4.1.2a.

h. Ground support equipment (GSE) connection and cap for trouble shooting.

The condition indicators of b through f shall, when activated, remain in the indiating position until manually reset. The condition monitoring panel shall be shown on the APU configuration and envelope figure.

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 on the condition monitoring panel of 3.7.6.1.2. 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 be accurate to within five percent and shall count each and every time the ready-to-load rotor speed signal is received from the control system. The location and attachment of the elapsed time indicator shall be shown on the APU configuration and envelope figure (see 4.5.1.3.1 and 4.6.1.3.1).

3.7.6.4 Temperature sensing systems. The temperature sensing system, if one is required to control the thermodynamic cycle, shall provide a signal for safety unit monitoring 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 Life counter. The life counter shall have provisions for counting the significant low cycle fatigue events and other events which provide an indication of the usage of APU life. The counter shall be located for convenient readout by ground maintenance personnel. A brief description of the counter and the system and means by which the counter is activated shall be presented in the model specification.

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

3.7.7 Lubricating system. The lubricating system shall satisfactorily lubricate the APU throughout its operating envelope without a change in lubricant. The complete lubricating system, including oil cooler(s) and oil reservoir, shall be furnished as part of the APU. If required, the oil system shall provide oil for lubrication and cooling of a component. Degradation of the component oil system shall not be detrimental to the APU oil system. The lubrication system shall be designed to prevent contamination of the oil by seepage of fuel or other fluids into the oil system. The lubrication system shall also be designed to permit oil servicing when the APU is installed.

3.7.7.1 Lubricating system interface. 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.

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 (see 4.5.4.4).

3.7.7.3.1 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.

3.7.7.3.2 Oil interruption. The APU shall operate at maximum load for a period of 30 seconds during which no oil is supplied to the 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 operation (see 4.4.2).

3.7.7.3.3 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, vibration, and cyclic stresses imposed by variations in pressure and temperature. The oil reservoir shall withstand a differential pressure of 15 psi positive and negative or twice the maximum reservoir operating differential pressure within the operating envelope of the APU, whichever is greater, 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 (see 4.5.2.4 and 4.6.2.4.1).

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 through the condition monitoring panel of 3.7.6.1.2. 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 minute. It shall not be possible to overfill the oil tank or fill the expansion space provided. The pressure fill and overflow connections shall be in accordance with MS 24476-2. The reservoir shall also have a 1.5-inch manual oil cap in accordance with MIL-C-38373. The following information shall be painted in black on the outside of the cap to indicate the capacity of the oil reservoir:

OIL CAP____US PINTS

b. An oil quantity device on or in the oil reservoir shall be mounted on the condition monitoring panel or viewed through the panel. 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 oil while the APU is in any attitude within 15 degrees from the horizontal. 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 tube shall be in accordance with the installation drawing. A readily accessible self-closing drain valve with a port in accordance with MS 33649-6, 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 (see 4.5.1.3.1 and 4.6.1.3.1).

3.7.7.4.3 Oil filter. A disposable oil filter shall be provided in the 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 shall be removable and replaceable on an installed APU without draining the oil system. 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 a signal to the condition monitoring panel of an impending filter bypass.

3.7.7.4.4 Chip detectors. Magnetic chip detectors, of a self-closing design and with features permitting electrical continuity checkout, 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 electrical characteristics of the chip detectors shall be described in the model specification. The chip detectors shall be readily accessible on an installed APU and shall be removable with minimum loss of oil (see 4.5.1.3.1 and 4.6.1.3.1).

3.7.7.4.5 Oil coolers. The type and number of oil coolers used in the oil system shall be specified in the model specification. Oil coolers shall incorporate a pressure relief bypass valve and features which will permit disassembly of the cooler for cleaning and inspection.

3.7.7.4.6 Wear rate analysis. A report shall be submitted to the Using Service which contains guidelines and trend analysis data on spectrometric oil analysis for the chemical elements in the particular model APU. 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 sensor. A continuous indication of the oil pressure at the location where the limits of 3.2.1.4.8 are determined, is required for the safety unit of 3.7.2.2.2.

3.7.8 Starting system.

3.7.8.1 Starter energy source interface. The interface between the starter and its energy source shall be shown on the APU configuration and envelope figure.

3.7.8.2 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 power from the power source of 3.7.8.3. A satisfactory start shall be a start during which the rotor is accelerated to the ready-to-load rotor speed from either rest or windmilling speed provided that (see 4.4.5, 4.5.1.3.3, 4.5.3.2, 4.6.1.3.3 and 4.6.3.2):

a. The APU stays within operating limits.

b. The total starting time for starts made with no ram, from sea level to 15,000 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 the ready-to-load rotor speed 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 the stabilized uncorrected ready-to-load rotor speed.

3.7.8.2.1 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.

3.7.8.3 Starter energy source. The type of energy source used to start the APU shall require approval of the Using Service and shall be described in the model specification. The minimum energy needed to start the APU throughout the environmental conditions and operating envelope of the APU, shall also be specified.

3.7.9 Exhaust duct system.

3.7.9.1 Exhaust duct attachment.

3.7.9.1.1 Exhaust duct design and dimensions. Provisions shall be made for a quick-disconnect flange between the exhaust duct and the aircraft. Interface dimensions for the exhaust duct shall be shown on the APU configuration and envelope figure.

3.7.9.1.2 Allowable exhaust duct connection loads. 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 1.

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

3.7.9.2.1 Exhaust wake diagrams. Exhaust wake diagrams showing temperature and velocity profiles in the exhaust wake at sea level static standard day conditions for maximum load and no load shall be presented in the model specification.

3.7.9.3 Infrared radiation (IR). The contractor shall perform an IR signature analysis to define the maximum IR levels for the following azimuth, elevation, bandpass, altitude and load conditions. A report shall be submitted to the Using Service (see 4.6.5.2).

a. Azimuth angles: 0°; 5°; 10°; 15°; 20°; 30°; 40°; 60°; 90°; 135°; and 180°. (An extension of the centerline aft of the APU shall define the 0° azimuth and 0° elevation position. The 0° azimuth angle, 0° elevation angle and centerline are defined as being in a plane parallel to a level ground plane. If the radiation pattern is symmetrical about the centerline, a polar plot with a notation indicating symmetry may be used.)

b. Elevation angles: 0°; 5°; 10°; 15°; 20°; 30°; 40°; 60°; and 90° (Above and below horizontal).

c. IR bandpass conditions: 1-3 microns, 3-5 microns, 8-10 microns, 10-12 microns and 12-14 microns.

d. Altitudes: Sea level, 15,000 feet and the maximum operating altitude.

e. APU load conditions: Maximum load and maximum continuous load.

Both the measurement equipment and the standard source used for its calibration shall be specified.

3.7.9.3.1 Infrared suppression system. When an infrared suppression system is required by the Using Service a description of the system shall be provided in the model specification.

3.7.10 Wash procedure. The required pressure, flow and composition of the washing medium and the wash procedure for field service use, shall be specified in the model 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 contractor is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract, the contractor 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 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. 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 is not allowable. All parts shall be considered as having zero time at the start of a test. While all parts do not have to be new, any part which fails during the test shall be cause for rejection of that test article. The parts list for the APU which successfully completes the PFRT or VT tests shall constitute the approved parts list for the respective APU model.

4.3.2.1 Test APUs. The particular APU intended for a specific test or demonstration shall be officially designated by the contractor 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 transducers. The vibration measurement and analysis equipment shall operate over a frequency band of at least five Hz to ten 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 be within three dB from the known sinusoidal input at frequencies from five Hz to ten 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 three 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.

4.3.3.3 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 50 percent of the maximum load rotor speed in all modes of motion which can be excited by residual rotor unbalances.

4.3.3.4 Starting. During the PFRT and VT, the APU shall be supplied with the minimum starting energy of 3.7.8.3.

4.3.4 Test conditions.

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

4.3.4.3 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.

4.3.4.4 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. 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.

c. A list of components not requiring calibration.

4.3.5.2 Preliminary data. Prior to the PFRT and VT endurance test, 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	
Torque	±1.0 percent of the value obtained at maximum continuous load.
Rotor speed(s)	±0.2 percent of the value obtained at no load.
Fuel flow	±1.0 percent of the value obtained at maximum continuous load.
Airflow	±1.5 percent of the value being measured.
Temperature	±2.0°F up to 400°F (±1.0°C up to 200°C). ±5.0°F above 400°F (±3.0°C above 200°C). ±70°F above 750°F (±4.0°C above 800°C).
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 maximum continuous 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 IX.

4.3.5.5 Transient data. For each transient performed during the transient operations, the data shall be recorded as specified in table IX.

4.3.5.6 Starting data. During each start, the data shall be recorded as specified in table IX.

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.

4.3.6 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. The following tests shall be conducted on APUs having substantially the same parts list and configuration as the PFRT endurance test APU.

4.4.1 Heat rejection and cooling test. Heat rejection and cooling requirements data, including the oil system, shall be obtained from an APU 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 of the APU. 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 shall be subjected to an oil flow interruption test to demonstrate compliance with 3.7.7.3.2. The APU shall be operated at maximum 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.

4.4.3 Electrical power failure test. The APU electrical system shall be inactivated to verify the electrical power failure requirements of 3.7.4.2.

4.4.4 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. 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 five Hz to ten 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. The test stand shall be consistent with the requirements of 4.3.3.3.

4.4.5 Starting test. Prior to start of PFRT, an APU shall be tested to demonstrate compliance with the starting requirements of 3.7.8.2. The APU shall be started and operated for one minute and shutdown. This procedure shall be repeated until the APU has started, satisfactorily, ten consecutive times.

4.4.6 Pressure balance verification. Tests shall be conducted to verify the pressure balance analysis specified in 3.3.8.4.

4.4.7 Maintainability/maintenance demonstration. A maintainability/maintenance demonstration shall be performed by the contractor on an APU 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.

4.5 Preliminary flight rating test (PFRT).

4.5.1 Endurance test (PFRT).

4.5.1.1 Pretest verification (PFRT).

4.5.1.1.1 Weight verification (PFRT). 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. In addition, the operating and residual fluid weights, in accordance with 3.2.2.2, shall be verified.

4.5.1.1.2 Electromagnetic interference and susceptibility tests (PFRT). 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 the electromagnetic interference test plan. The tests shall be conducted in accordance with the methods, procedures and techniques of MIL-STD-462.

4.5.1.1.3 Overspeed test (PFRT). With the normal speed governing system rendered inoperative, the APU shall be oversped at no load until the safety unit shuts down the APU. The test shall be repeated until ten consecutive shutdowns have been completed and the limiting rotor speed of 3.7.2.2.2 has been sufficiently demonstrated.

4.5.1.1.4 Stopping (PFRT). Tests shall be performed to demonstrate the stopping requirements of 3.2.1.5.3.

4.5.1.2 Calibration (PFRT).

4.5.1.2.1 Temperature sensing system calibration (PFRT). The 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 operating conditions. The performance shall meet the tolerance and thermal response characteristics of 3.7.6.4.

4.5.1.2.2 Control system calibration (PFRT). Prior to the initiation of the APU calibration specified in 4.5.1.2.3, all fuel nozzles, and the components of the 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 (PFRT). 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 may be cleaned using the wash procedure of 3.7.10. The APU controls shall be adjusted and shall not be readjusted throughout the calibration. The 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 and purging system requirements of 3.3.6.3 and 3.3.6.4, respectively, shall be demonstrated. The following shall be obtained:

a. Data required to establish compliance with sea level performance ratings in table I.

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

4.5.1.2.3.1 Compressed air analysis (PFRT). Compressed air shall be sampled from the compressed air outlet during a maximum load run. A sample of air entering the 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 test report.

4.5.1.3 Endurance test procedure (PFRT).

4.5.1.3.1 Endurance test requirements (PFRT).

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 three cycles. Oil drained for analysis shall not be charged to 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. At the completion of the endurance runs, the 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.

e. If the APU is equipped with an anti-icing system it shall be operated every tenth cycle.

f. During the endurance test, the accuracy of the start counter and the operation of the elapsed time indicator shall be verified in accordance with the requirements of 3.7.6.3.

4.5.1.3.2 Endurance test schedule (PFRT). The APU shall be subjected to a 300-hour endurance test consisting of 50 six-hour cycles, each in accordance with the schedule listed below, when using MIL-L-23699 oil and MIL-T-5624 grade JP-5 fuel. Each PFRT cycle shall be preceded by at least a two-hour shutdown. The APU shall be shutdown for at least five minutes at the completion of each shutdown run. 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. When the time limit at a load condition is exceeded by the endurance schedule, the APU shall be run to the full time limit and the remaining time shall be run at the next lowest load condition. The test runs in each cycle shall be conducted in the order given.

a. Maximum-no load run. This run shall consist of six successive periods of ten minutes each. Each period shall include five minutes at maximum load followed by five minutes at no load.

b. Incremental run. This run shall consist of 96 minutes of:

(1) Eight minutes at maximum load.

(2) Eight minutes at maximum continuous load.

(3) Eight minutes at 90 percent maximum continuous load.

(4) Eight minutes at 80 percent maximum continuous load.

(5) Eight minutes at 70 percent maximum continuous load.

(6) Eight minutes at 60 percent maximum continuous load.

(7) Eight minutes at 50 percent maximum continuous load.

(8) Eight minutes at 40 percent maximum continuous load.

(9) Eight minutes at 30 percent maximum continuous load.

(10) Eight minutes at 20 percent maximum continuous load.

(11) Eight minutes at 10 percent maximum continuous load.

(12) Eight minutes at no load.

c. Slow transient run. This run shall consist of 20 minutes of APU operation as follows:

(1) Operate at no load for five minutes.

(2) Gradually increase the APU output over a period of five minutes until maximum load is reached.

(3) Remain at maximum load for five minutes.

(4) Gradually decrease the APU output over a period of five minutes until no load is reached.

d. Start-stop run. This run shall consist of 20 minutes of APU operation as follows:

(1) Run at maximum continuous load for five minutes, then shutdown for five minutes.

(2) Start the APU and shutdown within ten seconds, after starter cut-out. Reinitiate the starting sequence 30 seconds after shutdown, run at maximum continuous load for ten minutes, then shutdown for a maximum of five minutes.

(3) Start the APU, operate at maximum continuous load for five minutes and then shutdown for five minutes.

e. Random transient run. This run shall consist of 82 two-minute periods for a total of 164 minutes of APU operating time. Each period shall be run at the following load conditions. At the completion of the eight periods indicated by an asterisk (*), the APU shall be shutdown from that load condition, cool for at least five minutes after coast-down, restarted and immediately accelerated to the next load condition. This run shall start with the load condition in the upper left column, proceed down the column and continue with the remaining columns in sequence.

80	NL	20	MC*	NL	90	50*
30	10	70	90	70	20	MC
90	60	10*	50	NL	ML	10
30	MC	ML	10	70	NL*	80
MC	NL	80	70	90	30	60
70	50*	60	30	70	ML	30
ML	70	30	90	MC*	NL	MC
60	80	MC	80	60	10	NL
80*	ML	NL	MC	50	20	50
90	MC	90	ML*	70	MC	70
ML	60	50	70	MC	ML	
60	80	40	50	70	80	

NL - No Load

MC - Maximum Continuous Load

ML - Maximum Load

4.5.1.3.3 Starts (PFRT). A minimum of 800 starts shall be made on the endurance test APU. In addition to the 800 endurance test starts, there shall be ten 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 from shutdown). During these starts, immediately after the APU has reached no load, an acceleration to maximum continuous load shall be accomplished in not more than 0.5 second. The APU shall be held at maximum continuous load for one minute and immediately shutdown. The shutdown time between the 20 restarts shall be of durations of five, ten and 15 minutes and increasing by five-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 (PFRT). 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 3.7.10 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 (PFRT). After completion of the APU recalibration, the 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 Control system recalibration (PFRT). After completion of the APU recalibration, all components, including fuel nozzles, of the 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 control adjustments shall be established at their pretest bench calibration physical settings.

4.5.1.5 Disassembly and inspection (PFRT). The APU completing the endurance test shall be completely disassembled for examination of all parts. Prior to cleaning, the 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. Part measurements shall be taken as necessary to inspect for excessive wear and distortion. These measurements shall be compared with the 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 contractor 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 (PFRT). 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 output is not less than 97.5 percent of the initial calibration value and the specific fuel consumption and measured exhaust gas temperature 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 shall 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 Component tests (PFRT). The following tests shall be conducted on components conforming to the same parts list and configuration used on the PFRT endurance test APU.

4.5.2.1 Previous component approval (PFRT). 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 (PFRT). 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 ten 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 contracts. Power supply transients 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 ten 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 fuel system from the APU fuel inlet to the 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 five hours at flow and pressure conditions corresponding to those required by design maximum APU performance at the maximum operating altitude conditions. The fuel shall be in accordance with MIL-T-5624, grade JP-4. The fuel pump shall be operated with the pressure on the fuel tank maintained at the ambient pressure at the maximum operating altitude and an APU fuel inlet temperature of 110°F (43°C). The fuel vapor/liquid ratio at the APU fuel inlet shall be maintained at not less than 0.45. Except as stated above, the test procedure shall be in accordance with ARP 492. 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 (PFRT). 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 AS 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 (PFRT). 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 of 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 distortion on performance and stability. Data to be taken and recorded during the test shall be as specified in table IX. 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 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 calibration (PFRT). 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 (PFRT). 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 load conditions shall be selected for each specified altitude test point to establish operating and performance characteristics at the rated condition. The time elapsed versus rotor speed, output parameters (electrical power, compressed air, etc.), measured exhaust gas temperature and fuel flow shall be obtained for stability verification with load conditions of no load, maximum continuous and maximum loads and other load conditions as specified by the Using Service. The time period for stability verification shall be a minumum of five 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 on transient performance of varying each output parameter singularly and in combination with other output parameters 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. The effects of inlet distortion on transient operation and steady-state performance shall be determined.

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

4.5.3.3 Altitude test completion (PFRT). 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 performance is at least that specified in the steady-state performance computer program and the ratio of measured performance at altitude to measured performance at sea level is within five percent of the ratio of specified altitude performance to specified performance at sea level.

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 rating points, altitude starting data or transient data.

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

4.5.4 Structural tests (PFRT). 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 Pressure vessel/case test (PFRT). Each pressure vessel/case and all gas pressure loaded components subjected to compressor discharge pressure, shall be tested to two times the maximum operating pressure 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 (PFRT).

4.5.4.2.1 Overspeed rotor test (PFRT). The turbine and compressor rotors shall be subjected to APU operation for a stabilized period of at least five minutes duration, at maximum allowable measured 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.

4.5.4.2.2 Overtemperature test (PFRT). Upon successful completion of the overspeed test of 4.5.4.2.1, the same APU shall be operated at a measured gas temperature of at least 80°F (44°C) in excess of the maximum allowable measured gas temperature at no less than maximum allowable steady-state rotor 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.

4.5.4.2.3 Disc burst test (PFRT). Spin pit testing shall be conducted on all critical rotating disc components of the APU. Components shall be operated to a minimum of 122 percent of maximum allowable steady-state rotor speed with the bore metal at maximum design bore metal temperature without failure or evidence of imminent failure.

4.5.4.3 Static load test (PFRT). 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 operated at maximum load for at least 30 minutes at each of the test points shown in the clear area of figure 6. The APU shall also be operated at maximum load for at least 30 seconds at each of the test points shown in the shaded area of figure 6. 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 (VT).

4.6.1.1 Pretest verification (VT).

4.6.1.1.1 Weight verification (VT). 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. In addition, the operating and residual fluid weights, in accordance with 3.2.2.2, shall be verified.

4.6.1.1.2 Electromagnetic interference and susceptibility tests (VT). 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 the electromagnetic test plan. The tests shall be conducted in accordance with the methods, procedures, and techniques of MIL-STD-462.

4.6.1.1.3 Overspeed test (VT). With the normal speed governing system rendered inoperative, the APU shall be oversped at no load until the safety unit shuts down the APU. The test shall be repeated until ten consecutive shutdowns have been completed and the limiting rotor speed of 3.7.2.2.2 has been sufficiently demonstrated.

4.6.1.1.4 Stopping (VT). Tests shall be performed to demonstrate the stopping requirements of 3.2.1.5.3.

4.6.1.2 Calibrations (VT).

4.6.1.2.1 Temperature sensing system calibration (VT). The 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 operating conditions. The performance shall meet the tolerance and thermal response characteristics specified in 3.7.6.4.

4.6.1.2.2 Control system calibration (VT). Prior to the initiation of the APU calibration specified in 4.6.1.2.3 all fuel nozzles, and the components of the 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 (VT). 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 may be cleaned using the wash procedure of 3.7.10. The controls shall be adjusted and shall not be readjusted throughout the calibration. The 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 4.6.1.3. Data indicated for calibration in 4.3.5.4 and 4.3.5.5 shall be recorded. During calibration, conformance with the leakage and purging system requirements of 3.3.6.3 and 3.3.6.4, respectively, shall be demonstrated. The following shall be obtained:

a. Data required to establish compliance with the sea level performance ratings in table I.

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

4.6.1.2.3.1 Compressed air analysis (VT) Compressed air shall be sampled from the compressed air outlet during a maximum load run. A sample of air entering the 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 test report.

4.6.1.3 Endurance test procedure (VT).

4.6.1.3.1 Endurance test requirements (VT).

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 three cycles. Oil drained for analysis shall not be charged to 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. 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.

e. If the APU is equipped with an anti-icing system it shall be operated every fifth cycle.

f. During the endurance test, the accuracy of the start counter and the operation of the elapsed time indicator shall be verified in accordance with the requirements of 3.7.6.3.

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

h. Fuel inlet pressure shall be maintained at no more than the minimum specified in 3.7.3.1.3 throughout the test. Fuel inlet temperature shall be maintained at no less than the maximum fuel inlet temperature specified in 3.7.3.1.3 for at least 20 percent of the duration of the endurance test.

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

j. Upon completion of each mission cycle or run, the APU shall be shutdown prior to the start of a subsequent cycle or run. During the shutdown period the APU shall be motored or windmilled until the first stage turbine rotor blade metal temperature stabilizes below 212°F (100°C) when the APU is not rotating.

k. A number of starts, in addition to those required at the beginning of each mission or run, shall be performed to represent starts for maintenance purposes in service. The Using Service shall specify the minimum number of additional starts required.

4.6.1.3.2 Endurance test schedule (VT). The endurance test shall consist of at least 1,000 hours operation on each of three APUs in accordance with the mission cycles of table VII, randomly mixed, or with 167 six-hour cycles of 4.5.1.3.2. Each APU shall be operated with one of the following oil/fuel

combinations: (1) MIL-L-23699/MIL-T-5624 grade JP-5, (2) MIL-L-23699/MIL-T-83133 grade JP-8 and (3) MIL-L-7808/MIL-T-5624 grade JP-4. Each six-hour cycle or equivalent mission cycle duration shall be preceded by at least a two-hour shutdown. The APU shall be shut down for at least five minutes at the completion of each run or mission cycle. The time for changing load conditions shall be charged to the duration of the lower load. Change in load condition shall be accomplished in not more than 0.5 second. When the time limit at a load condition is exceeded by the endurance schedule, the APU shall be run to the full time limit and the remaining time shall be run at the next lowest load condition. The test runs in each cycle of 4.5.1.3.2 shall be conducted in the order given.

4.6.1.3.3 Starts (VT). A minimum of 2,672 starts shall be made on the endurance test APU. In addition to the 2,672 endurance test starts, there shall be ten 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 from shutdown). During these starts, immediately after the APU has reached no load, an acceleration to maximum continuous load shall be accomplished in not more than 0.5 seconds. The APU shall be held at maximum continuous load for one minute and immediately shutdown. The shutdown time between the 20 restarts shall be of durations of five, ten and 15 minutes and increasing by five 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 (VT). 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 3.7.10 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 (VT). After completion of the APU recalibration, the 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 Control system recalibration (VT). After completion of the APU recalibration, all components, including fuel nozzles, of the control system shall undergo a bench recalibration to determine conformance with allowable service limits specified by the applicable design specifications. For this recalibration, external control adjustments shall be established at their pretest bench calibration physical settings.

4.6.1.5 Disassembly and inspection (VT). Each APU completing the endurance test shall be completely disassembled for examination of all parts. Prior to cleaning, the 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 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 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 contractor 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 (VT). The endurance test shall be considered to be satisfactorily completed when the APU has completed the endurance test of 4.6.1 and during the APU recalibration, the output is not less than 97.5 percent of the initial calibration values and the specific fuel consumptions 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 shall not be judged to have passed the endurance test until they have successfully completed the entire 1000 hours of the endurance test.

4.6.2 Component tests (VT). 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 VT endurance test APUs.

4.6.2.1 Previous component approval (VT). 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.

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 control system 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 contractor shall provide a list of the components not requiring calibration to the Using Service in the pretest data. 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 contractor, 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 components excluding the fuel pump, control system, and ignition system shall have a test cycle defined by the contractor 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. Safety unit components, 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 shall be measured at the entrance to the fuel pump. Fuel pressure shall 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.

a. For fixed displacement pumps, the cycle shall be as defined below for any point within the APU operating envelope. 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 zero to 60 percent of the maximum speed and/or flow in 40-50 seconds and hold at this point for two minutes.

(2) Linearly increase speed and/or flow from 60 to 100 percent of the maximum speed and/or flow in 20-30 seconds and hold at this point for two minutes.

(3) Hold this speed and/or flow for one minute.

(4) Linearly decrease speed and/or flow from 100 to 90 percent of the maximum speed and/or flow in 5-15 seconds and hold at this point for one minute.

(5) Linearly decrease speed and/or flow from 90 to 60 percent of the maximum speed and/or flow in 5-15 seconds and hold at this point for two minutes.

(6) Linearly decrease speed and/or flow from 60 to zero percent of the maximum speed and/or flow within 40-50 seconds and remain shut down for a minimum of two minutes.

b. For variable flow or displacement fuel pumps, a test cycle with ten minutes of accreditable running time shall be defined in the pre-test data by the contractor 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 Control system test cycle. The 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 control system shall be included in the test. The contractor shall define a ten 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 ten 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 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 four-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 contractor 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 95-100 percent relative humidity, during the high temperature test. Each cycle shall consist of the following (in minutes):

	Voltage	ON	OFF
(1)	Minimum	2	3
(2)	Minimum	2	23
(3)	Maximum	2	3
(4)	Maximum	2	23

(5) Repeat for a total of four 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 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, one pint of salt water conforming to the requirements of Note 4 on table X 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 ten 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. Components (excluding fuel pump, 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 five 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. Control system. The 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 4.6.2.2.3.3 and at the maximum component limiting temperature given in 3.1.2.8.1. A two-hour shutdown shall follow each cycle at the temperature conditions corresponding to the requirements of 3.1.2.8.1c. 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 fuel system, shall be serviced as recommended by the manufacturer, but at intervals representing a cumulative fuel flow equivalent to not less than that obtained in ten hours of 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 four 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 x 10^{-4} pounds of quartz per pound of air.

Microns	Percent
0-5	37 - 41
5-10	15 - 21
10-20	13 - 19
20-40	15 - 21
40-80	6 - 12

a. Component (excluding fuel pump, 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 five psi plus the true vapor pressure of the fuel.

c. Control system. The 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 control system shall be subjected to 90-100 percent relative humidity and temperature of 130-150°F (56-64°C) for 120 hours before cyclic endurance.

(2) Operate the 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 60-80°F (17-25°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 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 at the sea level cold atmosphere extreme of figure 2 for a minimum period of ten hours. At the end of the ten-hour soak, the temperature shall be maintained at the cold atmosphere extreme 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 the cold atmosphere extreme. 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 the cold atmosphere extreme.

a. Component (excluding fuel pump, 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 ten 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 ten separate runs with the cycle sequence of operation in each run as defined in 4.6.2.2.3.1.

c. Control system. The 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 ten 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 the cold atmosphere extreme. The system shall be operated for 12 hours of cycling in accordance with 4.6.2.2.3.3 followed by a ten-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 fuel system from the APU fuel inlet to the 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 two 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 by the APU at sea level standard altitude conditions and a ram pressure ratio of 1.15. Pressure on the fuel tank shall be maintained at 20 inches of mercury 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 fluid/vapor ratio at the APU fuel inlet shall be maintained at not less than 0.45 and the full temperature shall be at least 110°F (43°C). Except as stated above the test procedure shall be in accordance with ARP 492.

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 component tests. The following tests apply to electrical components or sub-components, including electrical connectors and electrical and electronic portions of the 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 or 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 contractor shall provide a list of components not requiring calibration to the Using Service in the pretest data. 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 ten 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 five times 10^{-5} second and a spike voltage of $\pm$600 volts for 10^{-5} second each to be applied five 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 Humidity. Components shall be subjected to a humidity test in accordance with MIL-STD-810, Method 507, Procedure I. During steps six and seven 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 the test, the component shall be disassembled to show that there is no corrosion or other defects that affect the function or structural strength.

4.6.2.3.4 Fungus. Components 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.

4.6.2.3.5 Explosion-proof (VT). 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 ten 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.

4.6.2.3.6 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.

4.6.2.3.7 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.

4.6.2.3.8 Impact. Components 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. Components shall be subject to pre- and post-test calibrations or functional checks as applicable, but need not be operated during the test. Post-test inspection procedures shall be in accordance with MIL-STD-810, method 516.

4.6.2.3.9 Vibration. Components 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. Components may be tested in test assemblies or as individual units. During the test the component shall be subjected to its maximum limiting component temperature specified in the model specification.

4.6.2.3.10 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 shall 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.

4.6.2.3.10.1 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.

4.6.2.3.10.2 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 test. 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. The oil tank shall be cycled between the minimum and maximum differential pressure limits of 3.7.7.4.1 at a rate no more than four times per minute for a minimum of 10,000 cycles. The differential pressure to be used in the cyclic fatigue test shall be stated in the pretest data. For the purpose of this test, the differential pressure shall mean the absolute value of the difference between external and internal pressure of the oil tank. During the first 5,000 cycles the oil reservoir shall be kept at the nominal operating temperature and during the last 5,000 cycles the

reservoir temperature shall be kept at the maximum oil operating temperature. Throughout this cycling, no leakage or permanent deformation of the oil reservoir, filler cap or fittings shall occur.

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 ten minutes with the wall temperature of the oil reservoir at the maximum oil operating temperature. The contractor 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 contractor shall specify in the pretest data the procedure to be used.

4.6.2.4.2 Generator/Alternator test. The following tests, in addition to the environmental tests, shall be conducted on each generator/alternator:

a. Overspeed. The generator/alternator shall be operated at a speed which corresponds to 135 percent of maximum allowable rotor speed for five minutes. At the completion of the test, there shall be no evidence of mechanical or electrical damage or failure.

b. Load test. The generator/alternator shall be operated at a speed corresponding to 106 percent of maximum allowable rotor speed under full rated electrical load for one hour. During this test, the generator/alternator 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 generator/alternator 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 generator/alternator 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 two successive times and held two 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 two successive times and held two 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 (VT). 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 AS 1055 while conveying fluids at the lowest flow rate, highest system pressure and highest fluid temperature expected over the environmental conditions and 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. The above test may be waived for identical components which have successfully completed the test of 4.5.2.5.

4.6.3 Altitude tests (VT). 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 APU operating envelope and at least those given in the model specification as shown in figure 10. The test points shall include the effects of inlet recovery, windmilling, and inlet distortion on APU performance and stability. Data to be taken and recorded during the test shall be as specified in table IX. Control system adjustments shall not be made without approval of the Government representative. The altitude tests shall be accomplished using the following oil/fuel combinations: (1) MIL-L-23699/MIL-T-5624 grade JP-5, (2) MIL-L-23699/MIL-T-83133 grade JP-8 and (3) MIL-L-7808/MIL-T-5624 grade JP-4. 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 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 calibration (VT). 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 (VT). 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 load conditions shall be selected for each specified altitude test point to establish operating and performance characteristics at rated condition. The time elapsed versus rotor speed, output parameters (electrical power, compressed air, etc.), measured exhaust gas temperature and fuel flow shall be obtained for stability verification with load conditions of no load, maximum continuous load, maximum load and other load conditions as specified by the Using Service. The time period for stability verification shall be a minimum of five 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 on transient performance of varying each output parameter singularly, and in combination with other output parameters, 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. Effects of inlet distortion on transient operation and steady-state performance shall be determined.

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

f. Changes in altitude. To demonstrate the requirements of 3.2.5.1.4, the APU shall be operated for at least 15 minutes at maximum load and ram extremes and at the sea level hot atmosphere extreme of figure 2. The APU shall be then shut down, the inlet condition changed to the minimum ambient starting temperature and Mach number at the maximum starting altitude within five minutes, and restrated within one minute. Following this demonstration the APU shall be operated at maximum load while the inlet conditions are changed at a rate of 600 feet/second, standard day temperatures at each of 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.

4.6.3.3 Altitude test completion (VT). 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 performance is at least that specified in the steady-state performance computer program and the ratio of measured performance at altitude to measured performance at sea level is within five percent of the ratio of specified altitude performance to specified performance at sea level.

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 rating points, 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 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 the starter energy source in accordance with 3.7.8.3. 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 3.7.8.2. All data required in 4.3.5.6 shall be recorded during each start. Recalibration shall not be required. The point within the APU where temperature shall be measured for determining the 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 six hours duration at the sea level cold atmosphere extreme of figure 2. The six-hour soaking period shall be started after the point specified in the model specification has reached the cold atmosphere extreme. 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 starter energy source at the cold atmosphere extreme, the APU shall be started. Immediately after the APU has reached no load, the APU shall be accelerated to maximum load for one minute and returned to no load. The cycle shall be repeated once. 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 and 3.7.7.3, respectively. The test will be considered to be satisfactorily completed when, in the judgment of the Using Service, the above three 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 six hours duration at the hot ground soak temperature shown on figure 2. The six-hour soaking period shall be started after the point specified in the model specification has reached the hot ground soak temperature shown on figure 2. After the soak period and when supplied with fuel, inlet air and starter power source at the hot atmosphere extreme shown on figure 2, the APU shall be started. Immediately after the APU has reached no load, the APU shall be accelerated to maximum load for one minute and returned to no load. The cycle shall be repeated. 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 VI. 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 VI. This meteorological data shall be recorded at suitable intervals during each test run. The method and procedure for collecting and determining the water droplet size and liquid content shall be specified in the pretest data. During the testing, output power, 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 VI with air between 80 and 100 percent relative humidity and zero liquid water content. The output power and specific fuel consumption losses shall be determined by comparison of the performance when operating at the icing conditions defined in table VI 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 ot two runs at each of several load conditions under each of the conditions of table VI. The load conditions shall include: no load, maximum load, and other load conditions as specified by the Using Service. At each icing condition and at each load condition, the APU shall be operated for a period of not less than ten minutes. During each period, at intervals after ice buildup, the APU shall be rapidly accelerated to demonstrate the acceleration response. If the APU incorporates an anti-icing system, the above test shall be performed using the anti-icing system to demonstrate the requirements of 3.2.5.2 and 3.7.1. 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 X requirements and includes 480 hours total duration, of which 60 hours are APU operating time. 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 ten cycles of 48 hours each in accordance with table X. The APU shall be washed if, during the test, the APU performance deteriorates five 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 third 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. 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 five percent total loss in output performance values obtained during the initial calibration, (2) the APU exhibits not more than a five percent increase in specific 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. The test APU shall be subjected to a bird ingestion test conducted in such a manner as to verify the requirements of 3.2.5.6.1. The birds shall be ingested in a random sequence and dispersed over the inlet area to simulate an encounter with a flock. If approved by the Using Service, synthetic "birds" may be used for testing. The contractor shall specify in the pretest data the critical target areas for each bird size and the procedure to be used for bird ingestion. High speed photographic coverage of the inlet is required during the ingestion test. The test will be considered to be satisfactorily completed when, in the judgment of the Using

Service, the performance criteria of 3.2.5.6.1 have been met and there is no evidence of major structural damage which could cause the APU to fail.

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 load rotor speed. The damage applied shall produce at least a stress concentration factor (K_t) of three. Following the foreign object damage application, the APU, with damaged blades installed, shall be subjected to a six-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 test 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. One two-inch diameter hailstone and two one-inch diameter hailstones of 0.80 to 0.90 specific gravity for each 400 square inches, or fraction thereof, of APU inlet area, shall be introduced into the APU inlet at maximum load condition.

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 contractor shall specify in the pretest data the procedures to be used for introduction of ice at the inlet and the load conditions at which the ice is to be ingested. The time for 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 and dust ingestion test. The test APU shall be subjected to a ten-hour run in accordance with the VT endurance test schedule while ingesting contaminated air in the concentration and distribution of 3.2.5.6.4. Changes in load condition shall be accomplished in not more than 0.5 second. If an anti-icing system is provided, the system shall be operating during the maximum-no load run. The compressed air shall be continually filtered, the total deposits measured and results reported. Following the ten-hour run and post test performance check, the APU shall be disassembled as necessary to

inspect for the extent of sand and dust erosion and the degree to which sand may have entered critical areas in the 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 maximum load, two, 3.5 and five 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 five minutes. The above procedure shall be repeated with the APU operating at no load. 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. The test APU shall be subjected to an armament gas ingestion test to demonstrate compliance with 3.1.2.10.6. Unless otherwise specified in the model specification, the APU operating conditions and armament gas conditions and characteristics shall be in accordance with 3.1.2.10.6. No recalibration shall be required after this test. This test will be considered satisfactorily completed when, in the judgment of the Using Service, the requirements of 3.1.2.10.6 have been met.

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 ten 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 95 dB(A) at 12 feet.

4.6.4.11 Exhaust gas emission tests.

4.6.4.11.1 Exhaust smoke emission test. The APU shall be subjected to an exhaust smoke emission test to demonstrate compliance with the requirements of 3.2.5.8.1. APU exhaust smoke measurements shall be taken using the equipment, instrumentation and test procedures set forth in ARP 1179. Smoke level will be determined at two load conditions: maximum load and no load. Prior to sampling at a particular load condition, a ten-minute stabilization run shall be made at that load condition. A performance check need not be made after this test.

4.6.4.11.2 Invisible exhaust mass emissions test. During the test of 4.6.4.11.1, the APU exhaust gases shall be analyzed for non-visible contamination using the equipment, instrumentation and procedures set forth in ARP 1256. The tests shall be conducted at maximum load and no load conditions to demonstrate the levels of invisible exhaust mass emissions specified in 3.2.5.8.2. A performance check need not be made after this test.

4.6.4.12 Survivability/vulnerability test. The APU shall undergo tests to determine its ability to meet the nuclear and non-nuclear survivability/vulnerability requirements specified in 3.3.6.6. 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 no load or maximum 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 five 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 Vibration test. 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. Prior to the test the APU shall be operated at maximum load for ten minutes. During the test the APU shall be operated in accordance with the load schedule of 4.5.1.3.2e. At the completion of the test the APU shall be operated to demonstrate compliance with table I and the transient performance of 3.2.1.5.5.

4.6.5 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 Radar cross section (RCS) test. The RCS shall be calculated to provide data specified in 3.1.2.12 of the model specification by taking radar reflectivity measurements of a full-scale model of the APU inlet and exhaust systems. The radar reflectivity determinations shall be conducted at an outdoor test site.

4.6.5.2 Infrared radiation test. Peak APU infrared radiation and radiation patterns shall be determined to substantiate the requirements of 3.7.9.3. The IR signature shall be measured as total (hot parts + reflection + plume) effective radiation for the uninstalled APU. The infrared intensity and spectral response of the IR instruments shall be determined by calibration before and after infrared test measurement and these data shall be recorded. The measurement instruments shall be calibrated with a field standard IR source to determine their effective response to infrared radiation during the IR test. The standard source used as a reference for both the radiation patterns and the measurement equipment shall be specified. Atmospheric conditions (temperature, humidity, precipitation, cloud formation, meteorological range, sun location and test location) shall be recorded to aid in the calculation of the field standard and APU effective IR radiation. The measurement technique shall be such that extraneous radiation from the background is minimized. The APU shall be set up in an outdoor test facility and operated at the load conditions specified in 3.7.9.3. Each load condition shall be maintained until exhaust system component temperature is stabilized before taking IR readings. Infrared radiation measurements shall be taken at angles specified in 3.7.9.3 in the increments required to determine the peak radiation and overall emission patterns. Total IR signature shall be verified by band with radiometers, sensitive in the 1-3, 3-5, 8-10, 10-12 and 12-14 micron wave lengths. In addition, spectral measurements shall be made with a spectrometer having a resolution of at least 0.05 microns at each aspect angle from zero to 180 degrees to identify the exhaust gas "plume" contributions. For APUs incorporating special IR suppression system features, the above tests shall be accomplished with the APU running both in and out of the suppression mode. Specification MIL-T-5624, grade JP-5 fuel shall be used for the test.

4.6.5.3 Alternate fuel test. The test APU shall be subjected to a 300-hour test run in accordance with the schedule of 4.5.1.3.2 when using any of the alternate fuels specified in 3.7.3.2.2. 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 may be performed as a segment of the VT endurance test.

4.6.5.4 Emergency fuel test. The APU shall be subject to five six-hour cycles in accordance with the schedule of 4.5.1.3.2 when using any of the emergency fuels specified in 3.7.3.2.3. Changes in performance due to the use of emergency fuel shall be determined by calibrations with primary and emergency fuel prior to the test and recalibrations with both fuels after the test. Calibrations shall be made to the extent required to establish performance levels and as defined in the pre-test data. 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 3.7.3.2.3 and results of the hot section inspection do not reveal abnormal hot section distress.

4.6.6 Structural tests (VT). 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 Pressure vessel/case test (VT). Each pressure vessel/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 tests.

4.6.6.2.1 Low cycle fatigue component tests. The parts shall be subjected to testing to comply with the requirements of 3.3.8.3 and shall be subjected to damaging cycles equivalent to at least twice the LCF cyclic life values consistent with the missions and mission mix in table VII. The specific test procedures shall be as specified in the pretest data. During these tests, no repair shall be permitted for the first equivalent life time. Permissible component repair intervals after the first equivalent life time shall be specified in the model specification. Except for the tests conducted on the combustor, these tests shall be performed either with high temperature and loads appropriate for simulating APU and maneuver load conditions, or with loads adjusted for materials properties at the test temperature. The combustor shall be tested only at high temperature conditions.

4.6.6.2.2 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 VII 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 (in seconds) as specified by the contractor.

Total Time	Scheduled Time	Event
____	____	Start APU.
____	____	Run at no load.
____	____	Accelerate to maximum load and maintain as specified,
____	____	Decelerate from maximum load to no load and hold as specified.
____	____	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 (VT).

4.6.6.4.1 Overspeed rotor test (VT). 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 test (VT). 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 80°F (44°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 Disc burst test (VT). Spin pit testing shall be conducted on all critical rotating disc 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 Static load test (VT). 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 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 contractor, 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 the locations 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 incremental steps of 0.5 rad/sec from 0.5 rad/sec up to and including 3.5 rad/sec. At each step, the APU shall be operated as follows:

a. No load for one minute.

b. Gradually increase the APU output from no load to the maximum load in 30 seconds.

c. Dwell at maximum load for ten seconds or sufficient time to record data.

d. Gradually decrease the APU output from the maximum load to no 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.

4.7 Acceptance test (AT). An acceptance test, as specified herein, shall be conducted on each APU submitted for delivery. The contractor 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 five Hz to ten 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 be within three dB of the known sinusoidal input at frequencies from five Hz to ten 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 three 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. The test cell and test equipment shall be acceptable to the Using Service. The natural frequencies of the test stand with the APU installed shall be no higher than 50 percent of the maximum load rotor speed in all modes of motion which can be excited by residual rotor unbalances.

4.7.1.4 Starter energy source. Power to start the APU shall be supplied per 3.7.8.3.

4.7.2 Test conditions.

4.7.2.1 Servicing.

4.7.2.1.1 Oil servicing (AT). 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 Electromagnetic interference and susceptibility tests (AT). 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. If a change is made which, in the judgment of the Using Service, might affect the electromagnetic interference level, then the 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 electromagnetic 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 Control system calibration (AT). 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 Temperature sensing system calibration (AT). The temperature sensing system shall be checked to establish its functioning in accordance with 3.7.6.4. The actual thermal responses of the system shall be reported on the acceptance log sheets.

4.7.2.5 Overspeed test (AT). With the normal speed governing system rendered inoperative, the APU shall be oversped at no load until the safety unit shuts down the APU. The test shall be repeated until three consecutive shutdowns have been completed.

4.7.2.6 Stopping (AT). 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 an electronic part, shall be subject to the following burn-in procedure. Temperature sensors shall be located on the part of the component which is the last to stabilize

in temperature. The capacity of the chamber shall be such that all temperature changes can be accomplished within one hour. The time required for temperature stabilization shall be within one percent of the average value for like components. The component shall be operated throughout the test while being subjected to the vibration of 4.6.2.3.9. The component shall be continuously tested until three consecutive failure-free cycles have been completed.

a. The temperature of the chamber shall be reduced to and maintained at -71 to -63°F (-57 to -53°C) until the temperature at all locations in the component are below -49°F (-45°C).

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 154 - 162°F (68 - 72°C) until the temperature at all locations in the component are above 140°F (60°C).

d. The temperature of the chamber shall be maintained at 154 - 162°F (68 - 72°C) for four hours.

4.7.3 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 serial number and area, square inches

f. Exhaust duct serial number and area, square inches

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 (maximum recorded in 4.7.4)

l. All data required in 4.7.4, except 4.7.4.3.

The contractor shall retain copies of acceptance test log sheets for each APU for two years. Copies of log sheets shall be shipped with each APU.

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 3.2.2.2 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 IX.

4.7.4.3 Transient data. For each transient performed during the maximum-no load and the slow transient runs, the parameters of measured exhaust gas temperature, rotor speed, fuel flow and power output shall be continuously recorded versus time.

4.7.4.4 Starting data. During each start performed, the time required from start initiation to: ignition, starter cutout and ready-to-load and stabilized no load with rotor speeds shall be recorded.

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.

4.7.5.1 Initial run. The APU shall be subjected to a 100-minute initial run in accordance with the following schedule. The steady-state load times may be increased at the option of the contractor if needed to obtain stable performance data required to verify sea level static rated performance. All load changes shall be accomplished in 0.5 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 contractor.

a. Maximum-no load run. This run shall consist of 20 minutes of:

(1) Start APU.

(2) Five minutes at maximum load.

(3) Five minutes at no load.

(4) Five minutes at maximum load.

(5) Five minutes at no load.

(6) Shutdown APU.

b. Performance run. This run shall consist of 29 minutes of verifying the Table I ratings.

c. Slow transient run. This run shall consist of 15 minutes of:

(1) Start APU.

(2) Gradually increase the APU output over a period of five minutes until maximum load is reached.

(3) Remain at maximum load for five minutes.

(4) Gradually decrease APU output over a period of five minutes until no load is reached.

(5) Shutdown APU.

d. Random transient run. This run shall consist of 18 two-minute periods for a total of 36 minutes of APU operating time. Each period shall be run at the following load conditions. This run shall start with the load condition in the upper left column, proceed down the column and continue with the remaining columns in sequence.

80	ML	NL	ML - Maximum load
30	60	10	
90	80	60	MC - Maximum continuous load
30	SS	MC	
MC	90	NL	NL - No load
70	ML	50	
	60		SS - Shutdown/start

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 contractor, 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.

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 or any of its components, this shall be considered a rejection of the APU. At the option of the Government representative, a complete re-run or a repetition of the portion of the test prior to encountering the difficulty shall be made.

4.7.5.3.1 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 a 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 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.

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. 3.2.1.1 - Performance ratings

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 limits

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. 3.7.8.2 - Starting requirements

4.7.7 Sampling tests. When required, an individual APU shall be selected by the cognizant Government inspector and tested at a Government facility.

5. PREPARATION FOR DELIVERY

5.1 Preparation for storage and shipment. The APU 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 and the furnishing of the APU historical records shall be in accordance with contract requirements. A packing list shall be furnished with each APU and shall include all components and tools which are not installed, but which are shipped with the APU.

6. NOTES

6.1 Intended use. The APUs covered by this specification are intended for use onboard an aircraft. The APUs will be used to supply compressed air for aircraft engine pneumatic starting systems and environmental cooling systems, and as a power source to drive hydraulic pumps, generators and other aircraft accessories.

6.2 Ordering data.

6.2.1 Acquisition requirements. Acquisition documents, as a minimum, shall specify the following:

a. Title, number and date of this specification.

b. Interface requirements (see 3.1.2).

c. Mock-up required (see 3.1.2.2).

d. Weight of aircraft accessories supported by the APU (see 3.1.2.5).

e. Armament gas ingestion required (see 3.1.2.10.6).

f. Performance ratings (see 3.2.1.1).

g. Minimum operating and non-operating envelopes (see 3.2.1.4.1).

h. Minimum air starting altitude (see 3.2.1.4.4).

i. Weight limitations (see 3.2.2.1).

j. Reliability requirement modifications (see 3.2.3).

k. Maintainability requirement modifications (see 3.2.4).

l. Workmanship (see 3.3.4).

m. Survivability/vulnerability requirements (see 3.3.6.6).

n. Human engineering principles, criteria and procedures (see 3.3.7).

o. Personnel and training requirements (see 3.6).

p. Override parameters (see 3.7.2.2.2).

q. Primary, alternate and emergency fuels (see 3.7.3.2).

r. Elapsed time/start indicators or life counter (see 3.7.6.3 and 3.7.6.6) required.

s. Oil(s) to be used (see 3.7.7.2.1).

t. Starter energy source requirements (see 3.7.8.3).

u. Infrared suppression system required (see 3.7.9.3.1).

v. Responsibility for inspection (see 4.1.1).

w. Sampling test requirements (see 4.7.7).

x. Preservation, shipping container and historical records (see 5.1).

y. Mission, mission mix and component life (see table VII).

6.2.2 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 contractor in accordance with the contract requirements. Deliverable data required by this specification is cited in the following paragraphs:

Paragraph no.	Data requirement title	Applicable DID no.	Option
3.1	Model specification	DI-A-5026	
3.1.2.5	Structural load analysis report	UDI-S-23272	
3.1.2.8.5	Heat rejection and cooling report	UDI-S-23272	
3.1.2.11.3	Non-specified compressed air contaminants	UDI-S-23272	
3.1.2.12	Radar cross section report	UDI-S-23272	
3.2.1.2	Performance presentation digital computer program and user's manual	DI-S-7032	

3.2.1.3	Substantiating performance data and analysis report	UDI-S-23272
3.2.2.2	Residual and operating fluid report	UDI-S-23272
3.2.3	Failure mode and effect analysis	DI-R-7085
3.2.3	Reliability report	UDI-S-23272
3.2.3	Reliability program plan	DI-R-7079
3.2.4	Maintainability plan	DI-R-2127
3.2.4.1.3.3	Level of repair analysis report	DI-L-2085
3.2.4.1.4	LORA/LCC report	UDI-S-23272
3.2.4.2	Non-scheduled maintenance requirements	UDI-S-23272
3.3.1.1	Materials and process documents	DI-E-30136
3.3.1.1.3	Protective treatments	UDI-S-23272
3.3.2	Electromagnetic interference system analysis	UDI-S-23272
3.3.2	Electromagnetic interference control plan	DI-R-7061
3.3.2	Electromagnetic interference test plan	DI-R-7063
3.3.5	Matched or selected fit parts list	UDI-S-23272
3.3.6	Safety assessment report	DI-H-7049
3.3.8.4	Pressure balance report	UDI-S-23272
3.3.8.6	Strength and life analysis	UDI-S-23272
3.3.8.8	Parts growth report	UDI-S-23272
3.3.8.10.2	Vibration and stress report	UDI-S-23272
3.3.9.1.1	Safety wire locations	UDI-S-23272

3.3.9.2	Parts list	UDI-T-20458
3.3.9.4.2	Changes in vendors or fabrication process	UDI-S-23272
3.5.1.4	Special tool requirements	UDI-S-23272
3.5.1.5	Repair procedures and wear limits	UDI-S-23272
3.7.7.4.6	Wear rate analysis	UDI-S-23272
4.3.5.1	Pretest data	UDI-T-21347
4.3.5.2	Preliminary data	UDI-T-21347
4.3.6.1	Test reports	DI-E-3718
4.3.6.2	Summary reports	DI-E-3718
4.7	Acceptance test procedure	DI-T-3714
4.7.2.2	Rejection report	DI-T-5299
4.7.3	Acceptance log sheets	DI-T-3721
5.1	Packing list	UDI-L-20500

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

6.3.1 Definitions.

6.3.1.1 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.

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

6.3.1.3 Acquiring service. The acquiring service is the service which negotiates the APU contract.

6.3.1.4 Air inlet area. The air 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.

6.3.1.5 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.

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

6.3.1.7 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.

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

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

6.3.1.10 Catastrophic failure. A catastrophic 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.

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

6.3.1.12 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.

6.3.1.13 Components. 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, control system, variable guide vane

actuators, anti-icing valves and the temperature sensing system are included in this category.

6.3.1.14 Dry weight. The dry weight is the combined physical weight of the APU with no liquids in the system. It does not include the weight of accessories.

6.3.1.15 Duty cycle. The duty cycle is a composite cycle derived from the mission profiles and mission mix.

6.3.1.16 Environmental conditions and operating envelope. The environmental conditions and operating envelope of the APU including all 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.

6.3.1.17 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 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.

6.3.1.18 Maintainability definitions.

6.3.1.18.1 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.

6.3.1.18.2 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.

6.3.1.18.3 Maintainability index (MI). The MI is the ratio of direct maintenance man-hours (6.3.1.18.1) for APU and APU-caused maintenance to operating hours (6.3.1.18.6).

6.3.1.18.4 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).

6.3.1.18.5 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).

6.3.1.18.6 Operating hours (OH). OH is defined as the total number of operating hours accumulated by all the APUs in the sample.

6.3.1.18.7 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 VII, at an interval not less than the frequencies in table VII.

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

6.3.1.18.8 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).

6.3.1.18.9 Unscheduled maintenance. Unscheduled maintenance is any maintenance other than scheduled preventive maintenance (6.3.1.18.7) (e.g., corrective maintenance required as a result of a problem uncovered during scheduled preventive maintenance or during APU operation.).

6.3.1.19 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.

6.3.1.20 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.

6.3.1.21 Maximum continuous load. Maximum continuous load is an operating condition at which the APU is capable of operating continuously.

6.3.1.22 Maximum load. Maximum load is an operating condition at which the APU is capable of operating for a specified time.

6.3.1.23 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.

6.3.1.24 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.

6.3.1.25 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.

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

6.3.1.27 Mission profile. A mission profile is a representation of a specific mission in terms of inlet conditions and load conditions.

6.3.1.28 No load. No load is an operating condition at which the normal governed rotor speed is maintained and there is no load on the APU.

6.3.1.29 Normal governed rotor speed. The normal governed rotor speed is the average rotor speed at which the fuel control system maintains the APU and should be less than the maximum rotor speed shown on tables I and II.

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

6.3.1.31 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.

6.3.1.32 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.

6.3.1.33 Rating. A rating is a characteristic value of performance specified in table I or II of the model specification when the APU is operating at the normal governed rotor speed for that condition, and the rated measured exhaust gas temperature and the specific fuel consumption have not been exceeded.

6.3.1.34 Reliability definitions.

6.3.1.34.1 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 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.

6.3.1.34.2 Failures - chargeable. Failures-chargeable shall consist of all failures-observed (6.3.1.34.3) less the excluded failures (6.3.1.34.1).

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

6.3.1.34.4 Mean-time-between-failures (MTBF) - chargeable. The MTBF-chargeable shall be generated by using failures-chargeable (6.3.1.34.2) 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.

6.3.1.34.5 Mean-time-between-failures (MTBF) - observed. The MTBF-observed is the ratio of operating hours (6.3.1.18.6) to the number of failures-observed (6.3.1.34.3).

6.3.1.35 Sampling tests. The sampling test is conducted on a randomly selected APU and 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.

6.3.1.36 Satisfactorily. The words "satisfactorily" or "satisfactory" as used in this specification in conjunction with words or terms relating to operation or performance of the 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.

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

6.3.1.38 Standard condition. Standard conditions are the values of air temperature and pressure given in the US Standard Atmosphere. 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.

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

6.3.1.40 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.

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

6.3.1.42 Unusable oil. Unusable oil is the maximum quantity of oil in the 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.

6.3.1.43 Verification test (VT). The verification test is the sum of test, demonstration and analysis activities accomplished on APUs and components submitted for verification to demonstrate the suitability of an APU model for production and service use.

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

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

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

6.4 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.

6.4.1 Instructions for preparation. The model specification shall be prepared as follows:

a. The cover or first page shall show the name and address of the manufacturer, the APU model designation and the date and number of the specification.

b. The specification number and date shall be shown on the upper outside corner of each page.

c. The APU model designation and specification number shall be displayed on the spline of the document.

d. Identifying dividers shall be placed between major sections and indices to provide easy access and reference.

e. All parameters appearing in the specification shall be presented in U. S. Customary units. Temperature shall be presented in degrees Fahrenheit and degrees Celsius. Degrees Fahrenheit shall be primary and shall be followed parenthetically by degrees Celsius.

f. The headings, numbering of sections, paragraphs, tables and figures shall correspond to those of this specification.

g. 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.

h. 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.

i. Paragraphs requiring modification to define a particular design shall be modified only to the extent necessary to describe the characteristics of that particular APU model and shall be identified by placing an identifying mark or symbol in the margin.

j. New requirements or additions shall be added as additional subparagraphs or as new paragraphs in logical sequence and location.

k. 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.

l. All curves shall be presented on graph paper having an adequate number of subdivisions to permit necessary interpolations.

m. Section 2 of the 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.

6.4.2 Approval status. The cover or first page 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".

6.4.3 Revisions. When revisions are made, they shall be designated by use of a suffix letter following the specification number with a revision date, which shall be shown on the cover or first page. 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.

6.4.4 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.

6.4.5 Instructions for preparation of APU summary. Instructions for preparation of APU summary (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 CONTRACTOR'S DESIGNATION - Show the contractor's designation and popular name for the APU. If not applicable, insert "None".

BLOCK 4 SPECIFICATION DATA - Insert contractor'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..... _____Percent
(Equals compressed air divided by total maximum 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. Measured Exhaust Gas Temperature - Shutdown..... _____°F(_____°C)

k. Max Allowable Rotor Speeds (Steady-State)
LP Rotor..... _____rpm
HP Rotor ..... _____rpm

l. Rotor Speed - Shutdown..... _____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 - Shutdown..... _____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, Mounts (nearest lbf).....____lbf

BLOCK 13 UTILIZATION - Indicate the vehicle application by both nickname and military designation. Include number of APUs per application, and indicate the Using Service for each vehicle.

BLOCK 14 DATE - Add date indicating currency of summary.

TABLE I. Minimum uninstalled performance at standard sea level static conditions.

REF. - 3.1, 3.1.2.8.5, 3.2.1.1, 3.2.1.2, 4.5.1.2.3, 4.6.1.2.3, 4.6.4.14, 6.3.1.29, 6.3.1.32, 6.3.1.33, 6.4.1

APU RATING (1)	OUT-PUT MIN HP	COMPRESSED AIR			SFC (2) MAX L/H/HP	EGT MAX F/C	ROTOR SPEED MAX RPM	INLET (3) AIRFLOW AVG L/M
		AIR MIN L/M	PRES MIN PSIA	TEMP MIN F/C				
Max								
Max Cont								
80% MC								
60% MC								
No Load								

F - Degrees Fahrenheit
C - Degrees Celsius
L - Pound Mass
HP - Horsepower
M - Minute
H - Hour

NOTES: (1) Additional ratings and columns shall be added as required by the Using Service.
(2) The SFC shall be calculated on the total energy expended: output plus compressed air.
(3) Total inlet airflow.

TABLE II. Minimum uninstalled altitude performance.

REF. - 3.1, 3.1.2.8.5, 3.2.1.1, 3.2.1.2, 4.5.3.2, 4.6.3.2, 6.3.1.29, 6.3.1.32, 6.3.1.33, 6.4.1

APU RATING (1)	ALT FT	AMB TEMP F/C	IN-LET MACH NO	OUT-PUT MIN HP	COMPRESSED AIR			SFC (2) MAX L/H/HP	EGT MAX F/C	ROTOR SPEED MAX RPM	INLET (3) AIRFLOW AVG L/M
					AIR MIN L/M	PRES MIN PSIA	TEMP MIN F/C				
Max											
Max Cont											
80% MC											
60% MC											
No Load											

F - Degrees Fahrenheit
C - Degrees Celsius
L - Pound Mass
HP - Horsepower
M - Minute
H - Hour

NOTES: (1) Additional ratings and columns shall be added as required by the Using Service.
(2) The SFC shall be calculated on the total energy expended: output plus compressed air.
(3) Total inlet airflow.

TABLE III. APU characteristics summary.

REF. - 3.1, 6.4.5

1

APU CHARACTERISTICS SUMMARY		
	APU 2	
3		4
	5	6
GENERAL DESCRIPTION		
7		
AVAILABILITY		PROCUREMENT
8		9
STATUS		
10		
GENERAL		
11		
SIZE & WEIGHT		UTILIZATION
12		13

14 1 2

TABLE IV. Pads and drives.

REF. - 3.1.2.7

APU COM-PONENT	TYPE OF DRIVE (1)	RATIO PAD TO ROTOR RPM(2)	ROTATION DIRECTION FACING PAD	TORQUE lbf-in			OVERHUNG MOMENT lbf-in	MAXIMUM SPLINE MISALIGN-MENT - in
				MAX CONT	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 _____ RPM.
(3) Specify duration and frequency of overload.

TABLE V. Computer program requirements.

REF. - 3.2.1.2.1

PART A - APPLICABLE PARAGRAPHS OF AS 681

2.2	Program Operation
2.3	User's Manual
2.4	Program Scope
3.1	Computer Capabilities
3.2	Program Language
3.3	Precision
3.7	Standard Thermodynamics
3.8	Programming Standards
4.1.1	Inlet Mode
4.1.2	Ram Pressure Recovery
4.4	Parasitic Flows
4.5	Engine Anti-Icing
4.7	Windmilling
4.9	Variable Geometry
4.10	Engine Stability
5.5	Numerical Status Indicators
6	Program Identification
7	Program Checkout
8	Program Revisions
10	Reference Documents

PART B - INPUT/OUTPUT PARAMETERS

The following input/output parameters shall be used in lieu of the parameters listed in paragraph 5 of AS 681. The parameters are in accordance with ARP 755.

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

TABLE V. Computer program requirements. - Continued

12	ZPAMB	Ambient pressure
13	ZXM	Mach number at the APU inlet
14	SIM	Inlet mode selection SIM = 1 - Selects altitude and Mach altitude 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 a 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 vane 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 fuel heating value
24	ZWB	Load compressor discharge airflow
25	ZPWSD	Power output (HP)
Output Parameters:		
1	CLASS	APU program security classification, Format (A6)
2	IDENT	APU program title, 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*

TABLE V. Computer program requirements. - Continued

20	WB	Load compressor discharge airflow*
21	TB	Load compressor discharge temperature
22	PB	Load compressor discharge pressure
23	PWSD	Power output (HP)*
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	Output rotor speed
35	FHV	Fuel lower heating value*
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.

TABLE VI. Sea level anti-icing conditions.

REF. - 3.2.5.2, 4.6.4.2

APU Inlet Total Temperature	-5 to -3°F -21 to -19°C	22 to 24°F -6 to -4°C
Velocity	0 to 60 kts	0 to 60 kts
Altitude	0 to 500 ft	0 to 500 ft
Mean Effective Drop Diameter	15 to 25 microns	15 to 25 microns
Liquid Water Content (Continuous)	0.75 to 1.25 g/m^3	1.75 to 2.25 g/m^3

TABLE VII. Mission, mission mix and component life.

REF. - 3.3.8.1, 3.3.8.1.1, 3.3.8.1.2, 3.3.8.3, 3.3.8.4, 3.3.8.6, 3.3.8.8, 4.6.1.3.2, 4.6.6.2.1, 4.6.6.2.2, 6.2.1, 6.3.1.18.7

PART A - MISSION AND MISSION MIX

Mission Number:_____

Time (Min)	Load Condition	Altitude (feet)	Mach No.

_____ - Total Time

Missions/1,000 hours: _______ number
Total Time/1,000 hours: _______ hours

Mission Number:_____

Time (Min)	Load Condition	Altitude (feet)	Mach No.

_____ - Total Time

Missions/1,000 hours: _______ number
Total Time/1,000 hours: _______ hours

Mission Number:_____

Time (Min)	Load Condition	Altitude (feet)	Mach No.

_____ - Total Time

Missions/1,000 hours: _______ number
Total Time/1,000 hours: _______ hours

TABLE VII. Mission, mission mix and component life
(Continued)

PART B - COMPONENT LIFE			
Item	*Predicted Minimum Structural Life - With and W/O Repair (Operating Hours)		
	0.1 Percent	10 Percent	50 Percent
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 VIII. Fuel contaminants.

REF. - 3.7.3.3.2

CONTAMINANT	PARTICLE SIZE	QUANTITY
FERROSO-FERRIC Iron Oxide (Fe_3O_4) Magnetite (Black)	0 - 5 microns	1.5 gm/1000 gal
FERRIC Iron Oxide (Fe_2O_3) Hematite	0 - 5 microns	27.0 gm/1000 gal
FERRIC Iron Oxide (Fe_2O_3) Hematite	5 - 10 microns	1.5 gm/1000 gal
Crushed Quartz	1000 - 1500 microns	0.25 gm/1000 gal
Crushed Quartz	420 - 1000 microns	1.75 gm/1000 gal
Crushed Quartz	300 - 420 microns	1.0 gm/1000 gal
Crushed Quartz	150 - 300 microns	1.0 gm/1000 gal
Prepared dirt conforming to AC Spark Plug Co. Part No. 1543637 (coarse Arizona road dust)	Mixture as follows: 0 - 5 microns (12%) 5 - 10 microns (12%) 10 - 20 microns (14%) 20 - 40 microns (23%) 40 - 80 microns (30%) 80 - 200 microns (9%)	8.0 gm/1000 gal
Cotton Linters	Below 7 staple (U. S. Depart. of Agriculture Grading Standards SRA-AMS 180 and 251)	0.1 gm/1000 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

TABLE IX. 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

	TITLE	Starting	Once/30 min or one/cycle steady-state	Continuously during transients	Calibration/recalibration	PFRT/VT	AT
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 starter cutout rpm	X	-	-	-	-	-
7	Rotor speed(s), stabilized at no load	X	-	-	-	-	-
8	Power output	-	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	Air inlet total pressure psia	-	X	-	X	X	X
12	Air 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	Max. 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 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 stabilized normal oil pressure sec	X	-	-	-	-	-
39	Additional data required by the Using Service	X	X	X	X	X	X

TABLE X. Corrosion susceptibility 48-hour test cycle schedule.

REF. - 4.6.2.2.5, 4.6.4.3

Phase No. Note 3	Phase Duration Hours	Test APU Operation	Measured Salt Ingested (PPB)	APU Ambient Air	
				Temperature	Relative Humidity
1	3 Notes 1&5	Operating	200 Note 4	50°F Min. (10°C Min.)	73 percent Minimum
2	2	Not Operating	0	Atmospheric	Atmospheric
3	7	Not Operating	200 Notes 2 & 4	50°F Min. (10°C Min.)	73 percent Minimum
4	12	Not Operating	0	100 to 120°F (38 to 49°C)	90 percent Minimum
5	3 Notes 1&6	Operating	200 Note 4	50°F Min. (10°C Min.)	73 percent Minimum
6	2	Not Operating	0	Atmospheric	Atmospheric
7	7	Not Operating	200 Notes 2 & 4	50°F Min. (10°C Min.)	73 percent Minimum
8	12	Not Operating	0	100 to 120°F (38 to 49°C)	90 percent Minimun

See the following pages for an explanation of the Notes.

TABLE X. Corrosion susceptibility 48-hour test cycle schedule.

Continued

NOTES FOR TABLE X

1. During shutdown, while the APU is decelerating 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. 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 inlet. 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 - three hours)

   (1) Four ten-minute cycles, each consisting of five minutes at maximum continuous load followed by five minutes at no load.

   (2) 110 minutes at maximum load.

   (3) Three ten-minute cycles, each consisting of five minutes at maximum continuous load followed by five minutes at no load.

6. Phase 5 - APU Operating Cycle (total accumulative time - three hours).

   (1) Ten minutes at maximum load.

   (2) Three ten-minute cycles, each consisting of five minutes at maximum continuous load followed by five minutes at no load.

TABLE X. Corrosion susceptibility 48-hour test cycle schedule.

Continued

NOTES FOR TABLE X - Continued

(3) Five 25-minute cycles, each consisting of five minutes at maximum continuous load, maximum load, maximum continuous load, maximum load and no load.

(4) Fifteen minutes at maximum load.

7. The basic salt formulation shall be composed of the following materials dissolved with sufficient distilled water to make one litre of salt solution.

Chemical Designation	Quantity per litre of spray solution
NaCl (c.p.)	23 grams
$Na_2SO_4 \cdot 10H_2O$	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 stock solution
KCl (c.p.)	10 grams
KBr	45 grams
$MgCl_2 \cdot 6H_2O$ (c.p.)	550 grams
$CaCl_2 \cdot 6H_2O$ (c.p.)	110 grams

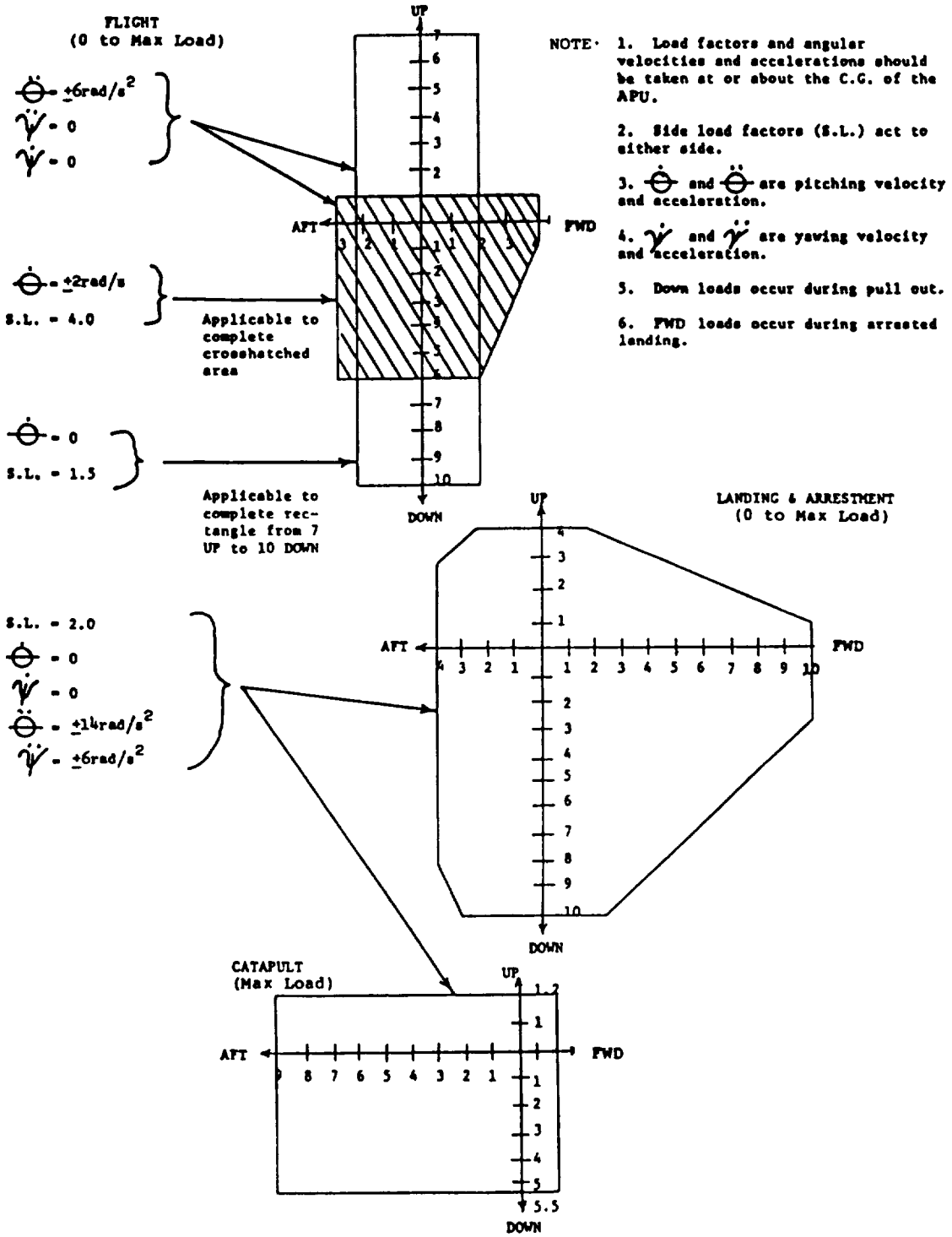
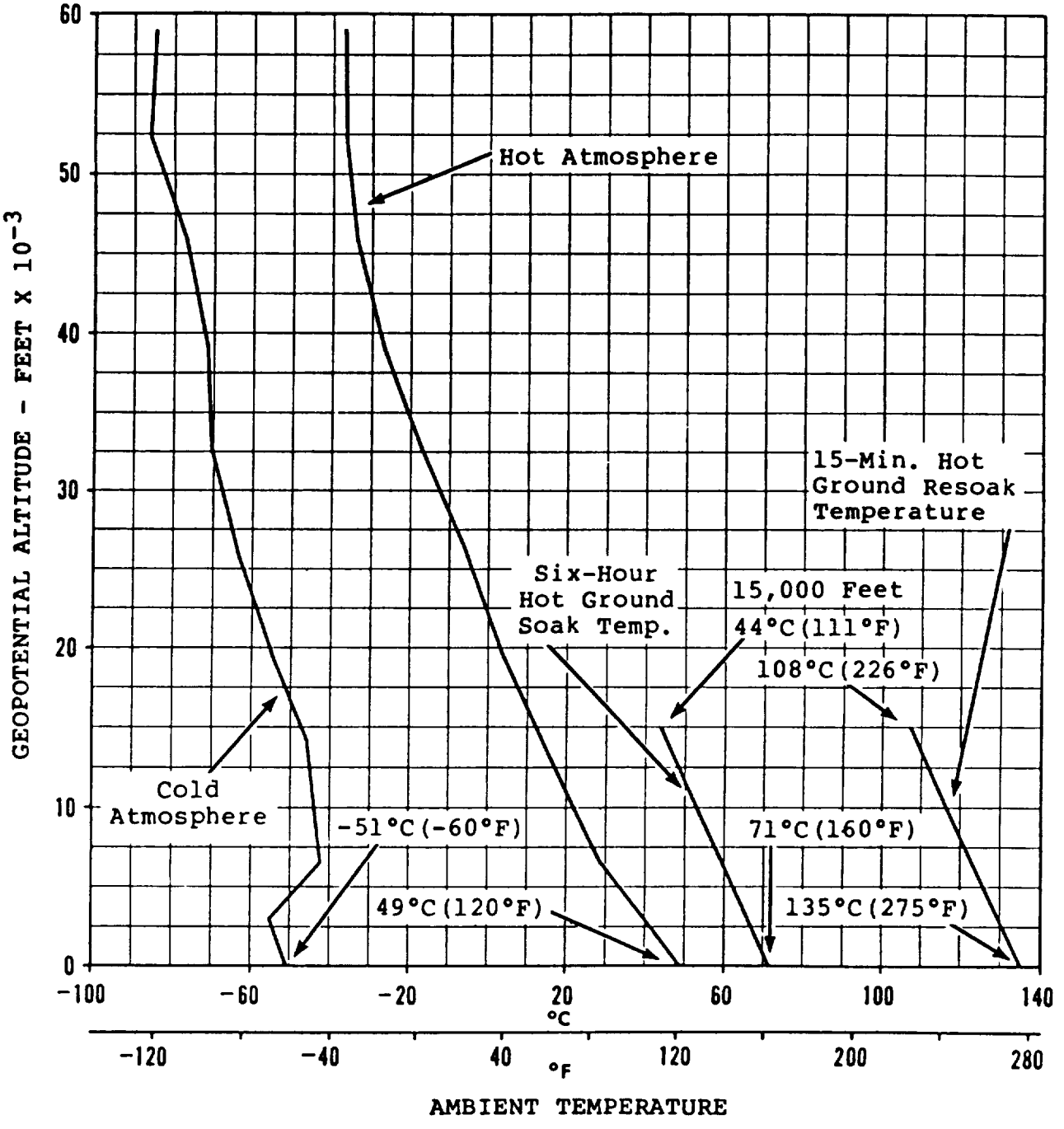


FIGURE 1. Externally applied forces.

REF. - 3.1.2.5, 3.1.2.5.1, 3.1.2.10.2, 3.1.2.11.1, 3.7.3.1.2, 3.7.9.1.2



NOTE:
1. Hot and cold atmospheres, except sea level, consistent with one percent risk of MIL-STD-210 World-Wide Air Environment.
2. Sea level hot and cold atmosphere temperatures consistent with one percent risk and 20 percent risk, respectively, of MIL-STD-210 Ground Environment.
3. Ambient static pressure variation shall be as defined in U.S. Standard Atmosphere for geopotential altitude.

FIGURE 2. Ambient temperature extremes.

REF. - 3.2.1, 3.2.1.4.1, 3.2.1.4.2, 3.2.1.4.4, 3.2.1.4.8, 3,2.5.1.1, 3.2.5.1.4, 3.7.3.3.3, 3.7.4.3.1, 3.7.5.2, 4.6.2.2.8, 4.6.3.2, 4.6.4.1

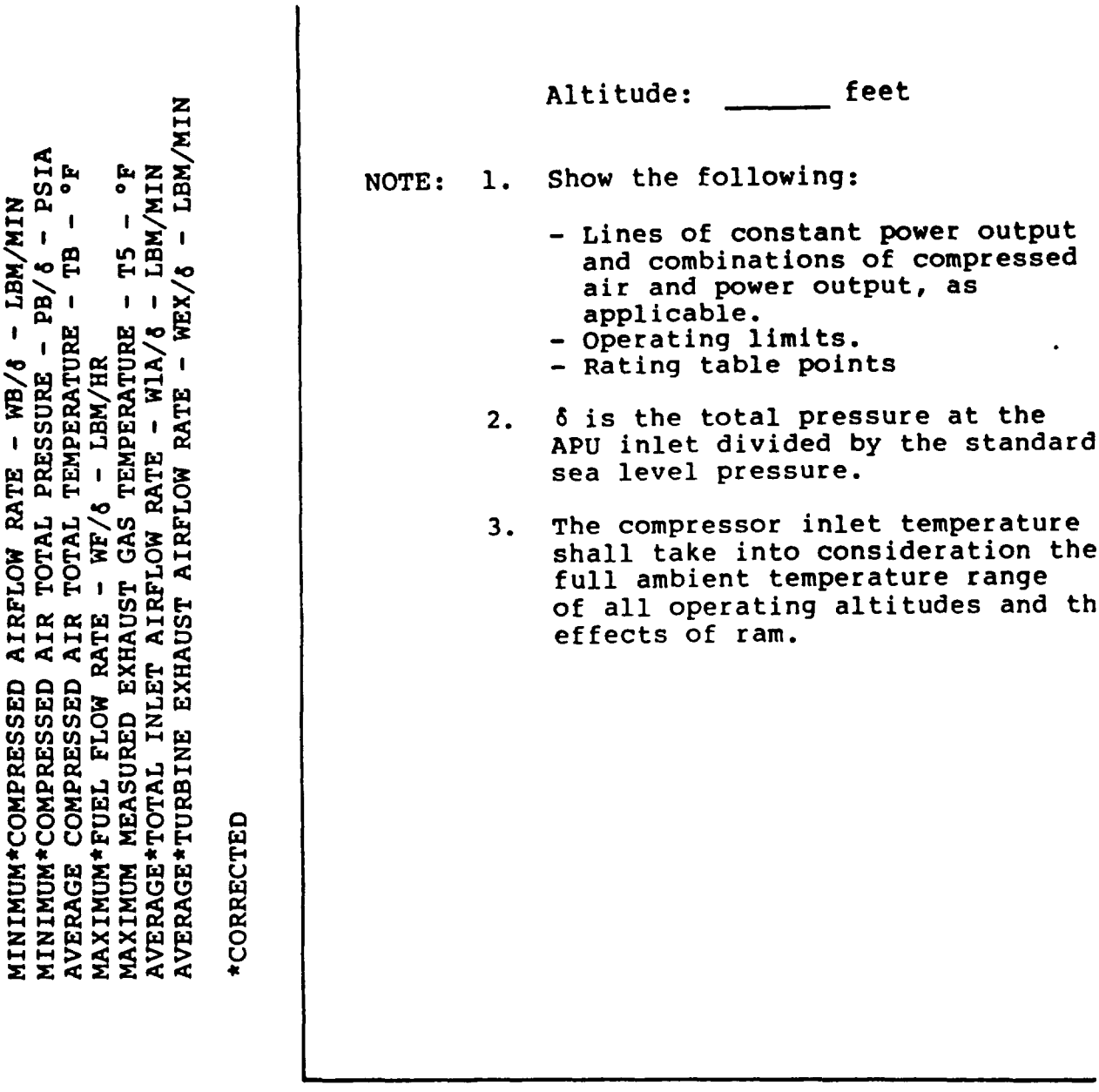
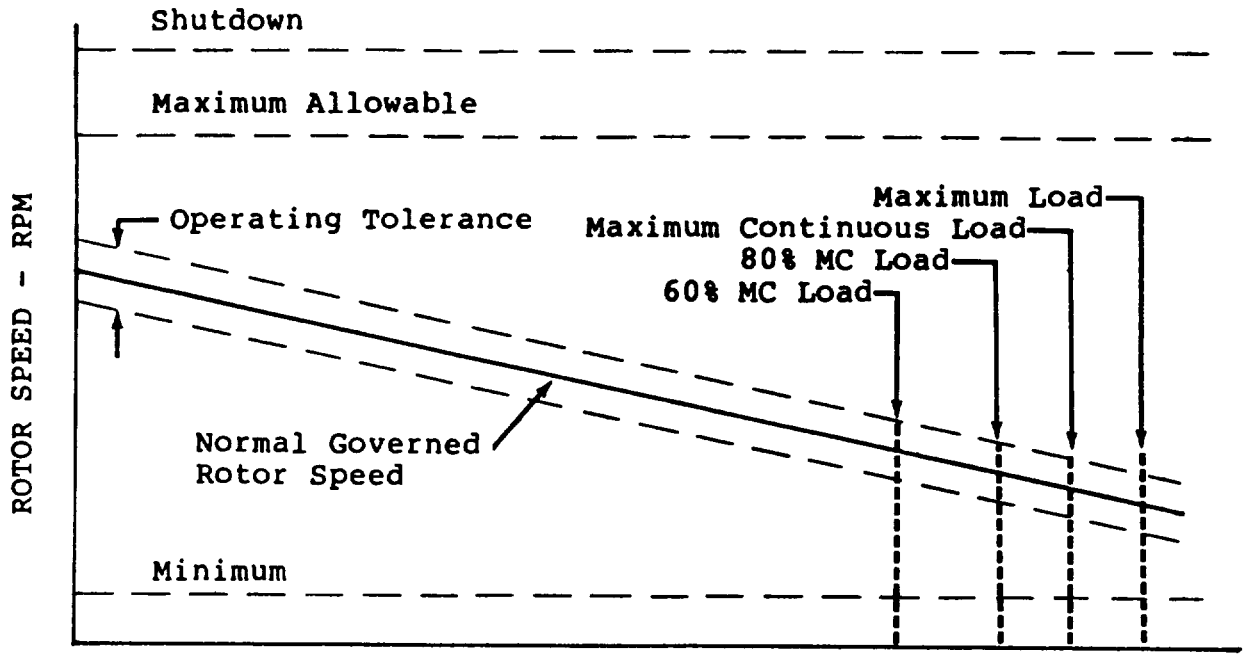


FIGURE 3. Uninstalled APU performance.

REF. - 3.2.1.2.2



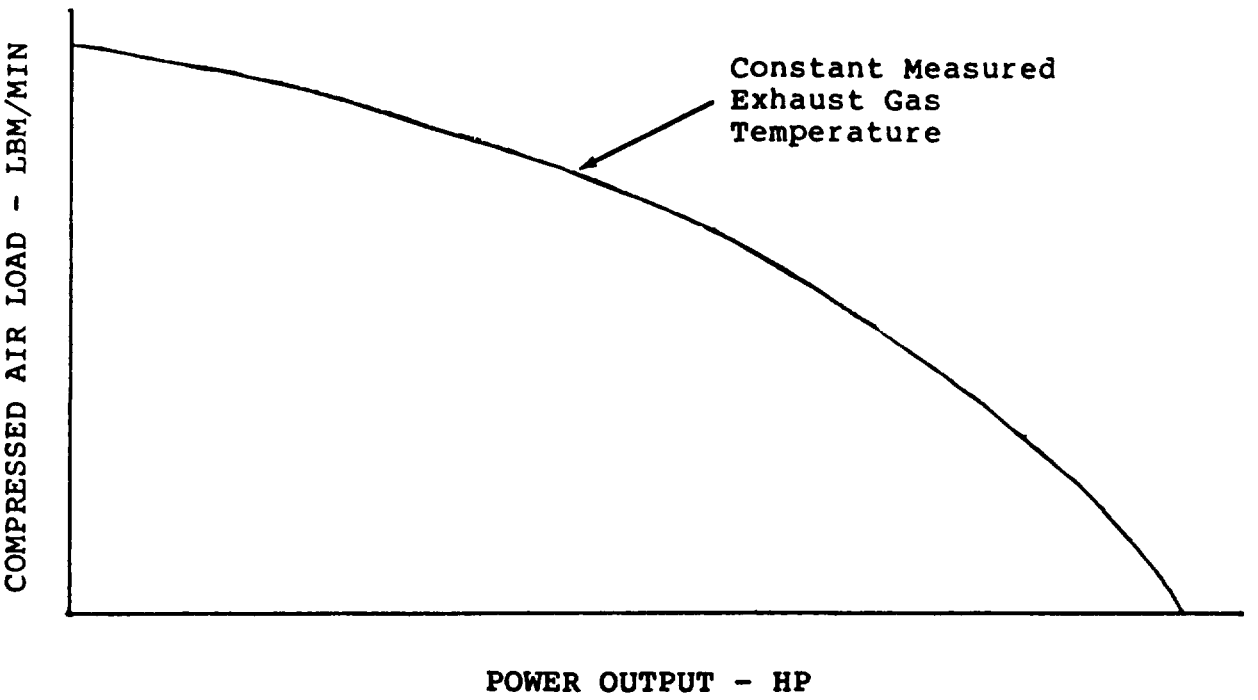
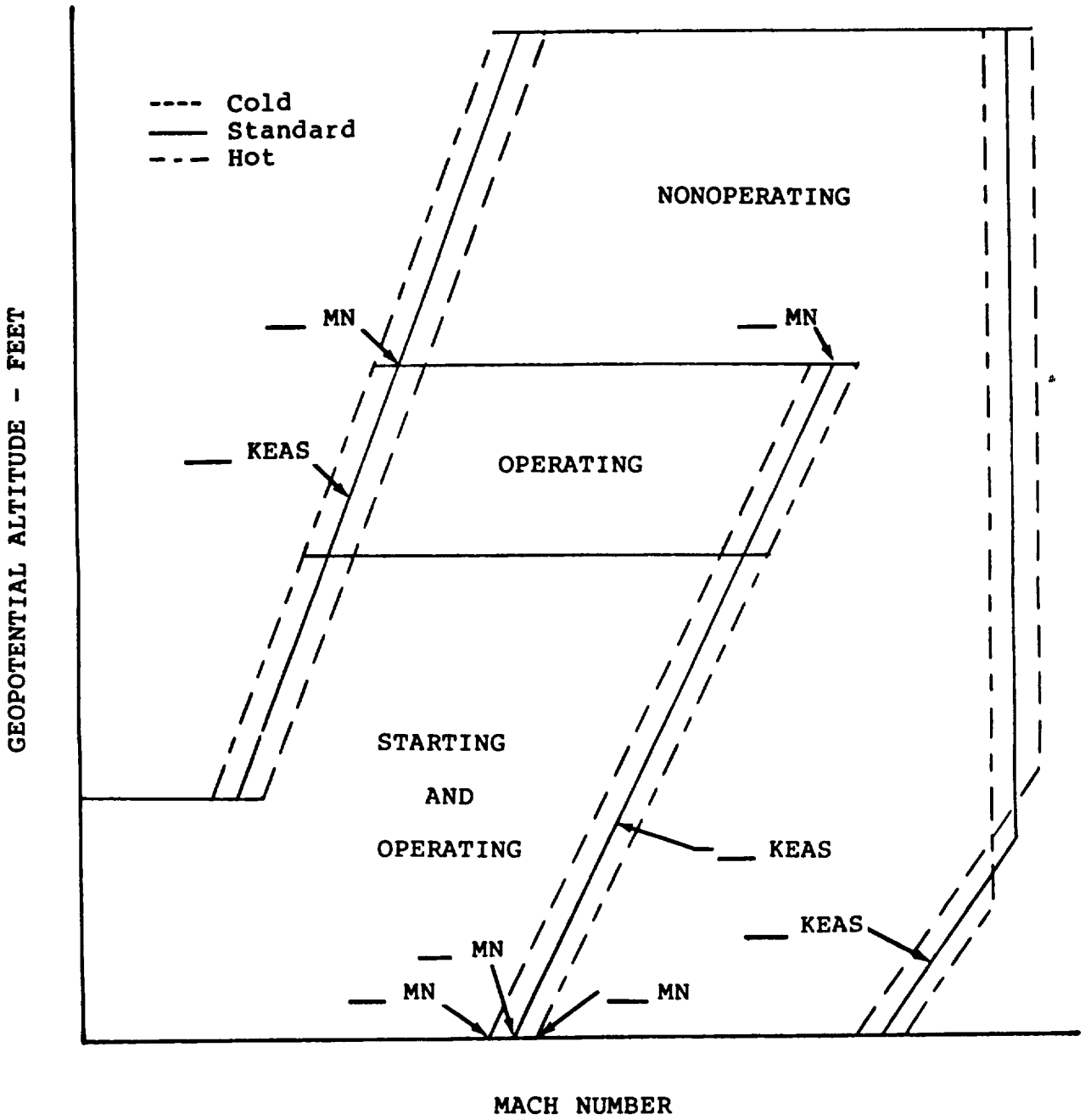


FIGURE 4. Droop characteristic and load combinations

REF. - 3.2.1.2.2

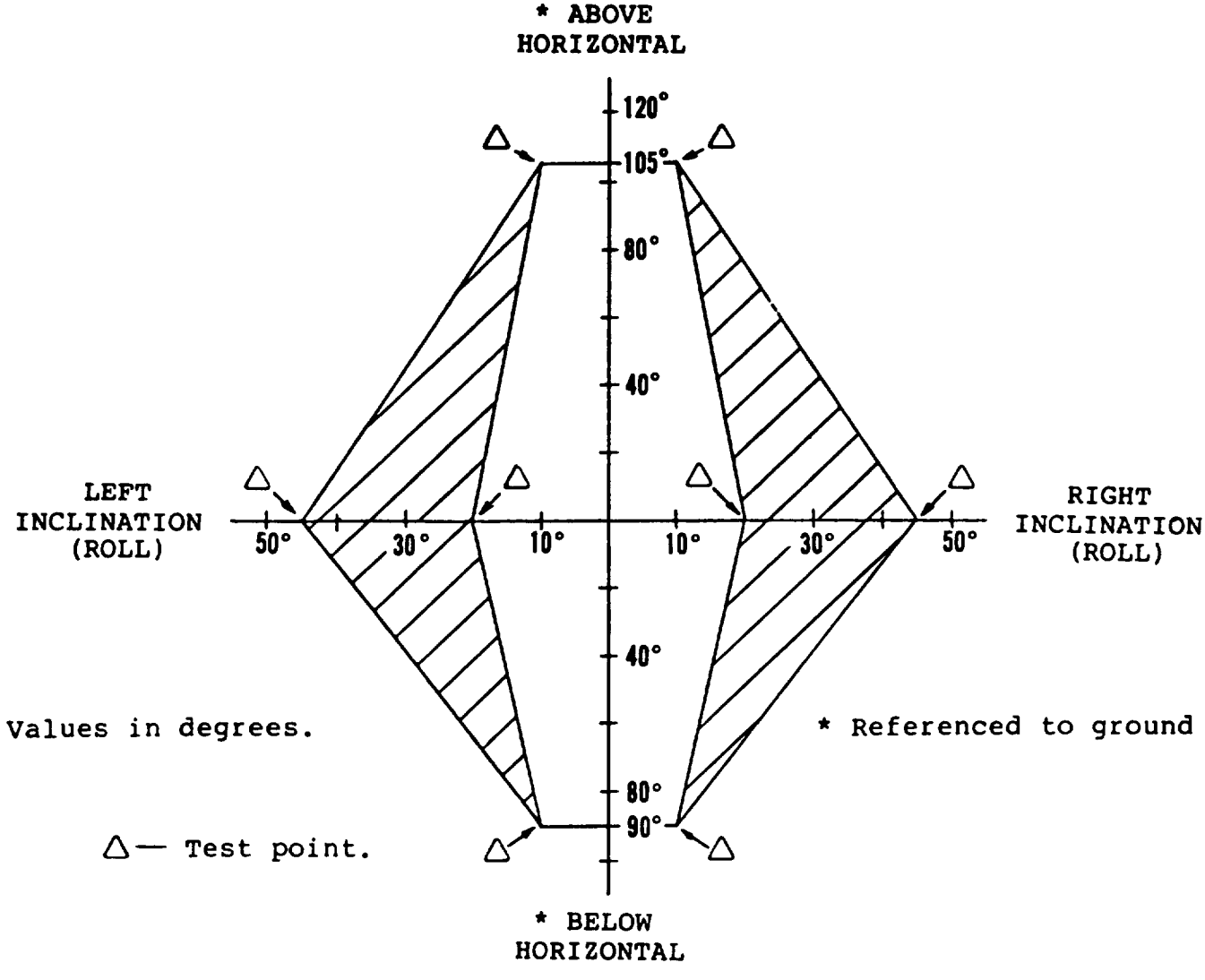


This figure is applicable for:

1. U.S. Standard Atmosphere
2. Environmental conditions of figure 2
3. Inlet recovery of 100 percent

FIGURE 5. APU starting, operating and nonoperating envelopes.

REF. - 3.2.1.4.1, 3.2.1.4.2, 3.2.1.4.3, 3.2.1.4.4, 3.2.5.1.1, 3.2.5.1.2, 3.2.5.1.3



NOTE: 1. This figure defines the attitude limits under static ground test stand (gravity) conditions. The forces generated during maneuvering flight may have a combined or resultant effect that permits pitch and roll attitudes that exceed the limits of this figure without encountering an APU limiting condition.
2. The APU centerline is perpendicular to the plane of the page and looking forward from the rear of the APU.

FIGURE 6. Operating attitude and storage limits.

REF. - 3.2.1.5.1, 4.5.4.4

ALTITUDE: SEA LEVEL TO 22,000 FEET
MAXIMUM VERTICAL EXTENT: 6500 FEET
HORIZONTAL EXTENT: 20 MILES

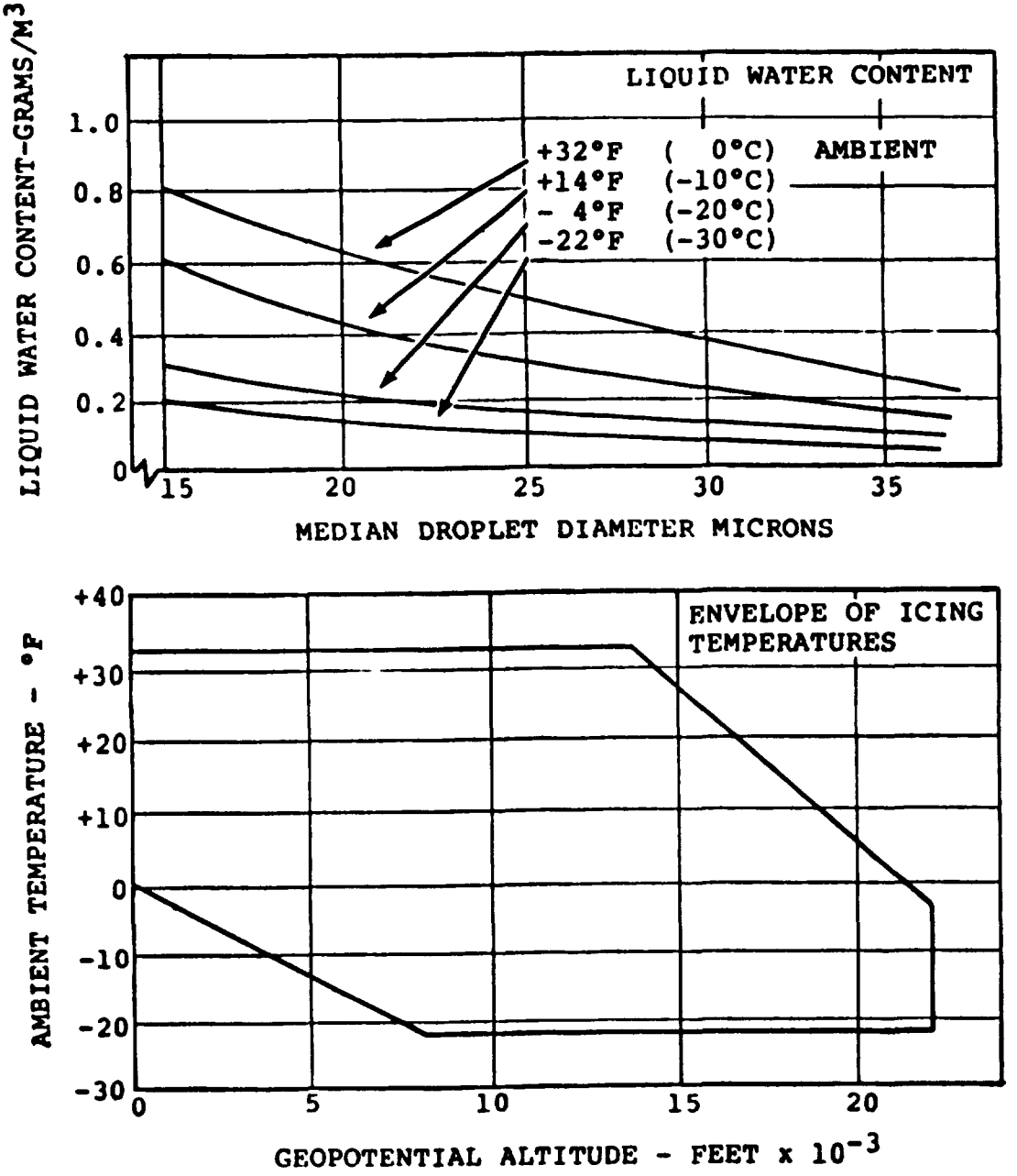


FIGURE 7. Continuous maximum icing conditions.

REF. - 3.2.5.2

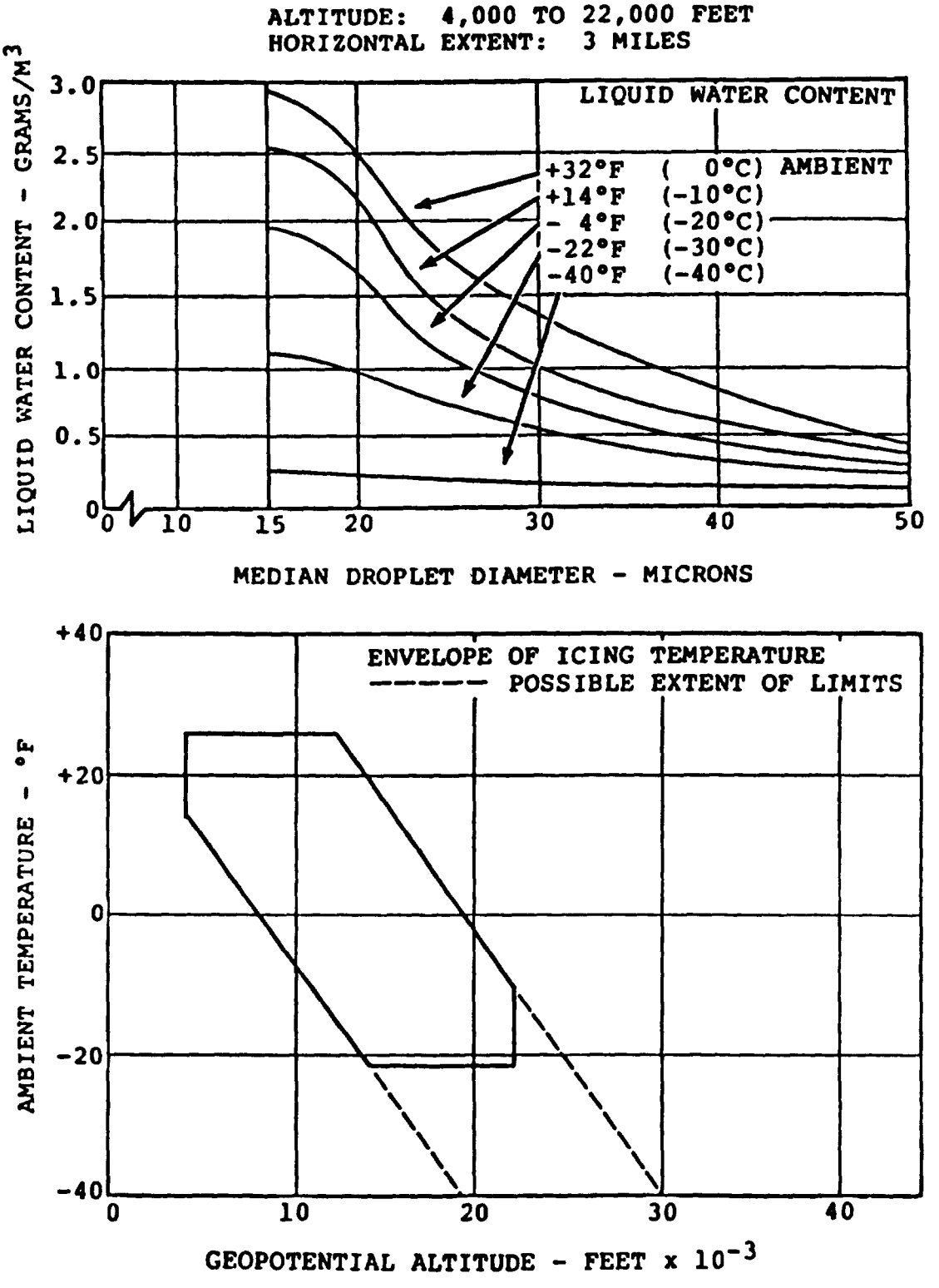
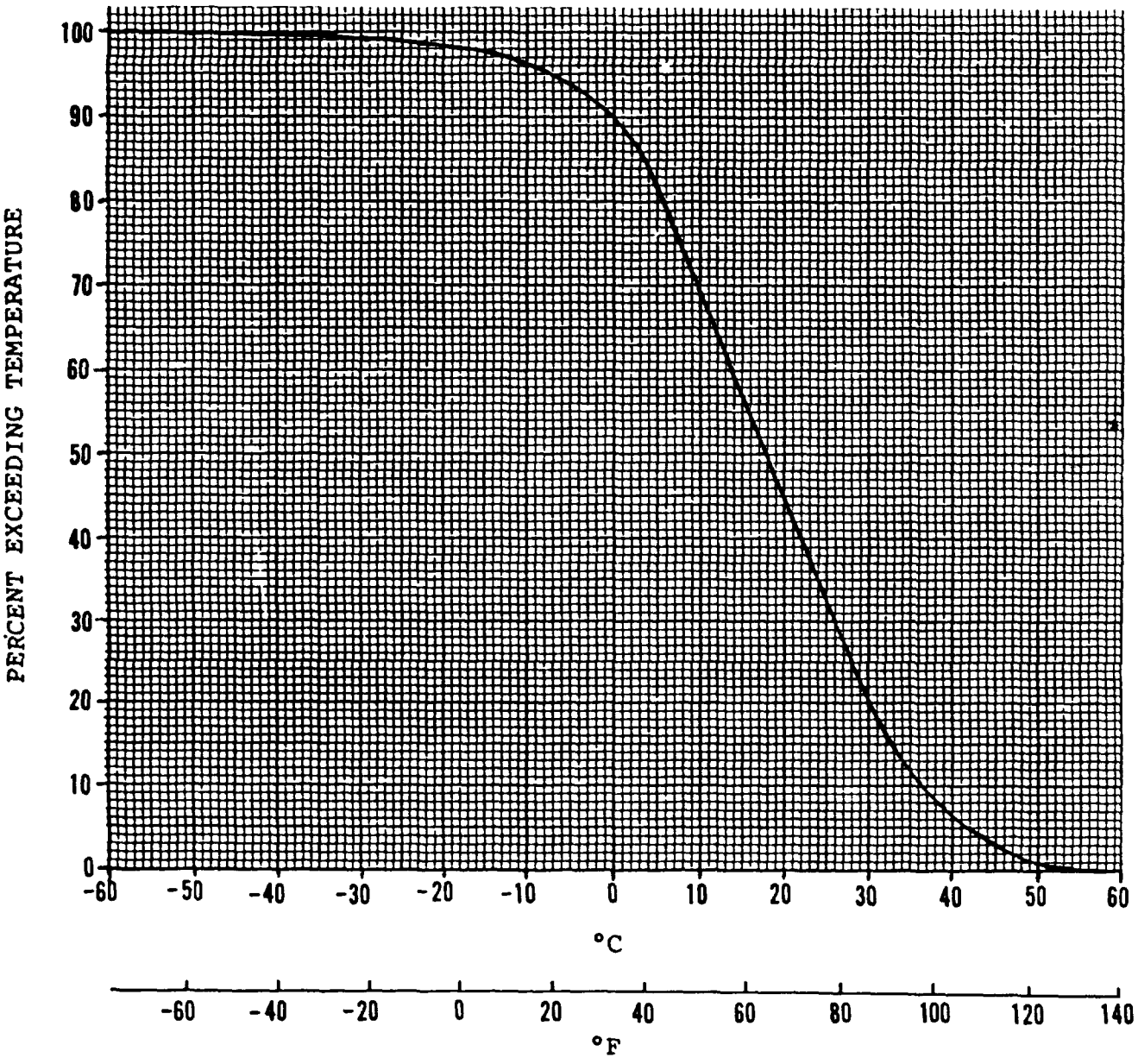


FIGURE 8. Intermediate maximum icing conditions.

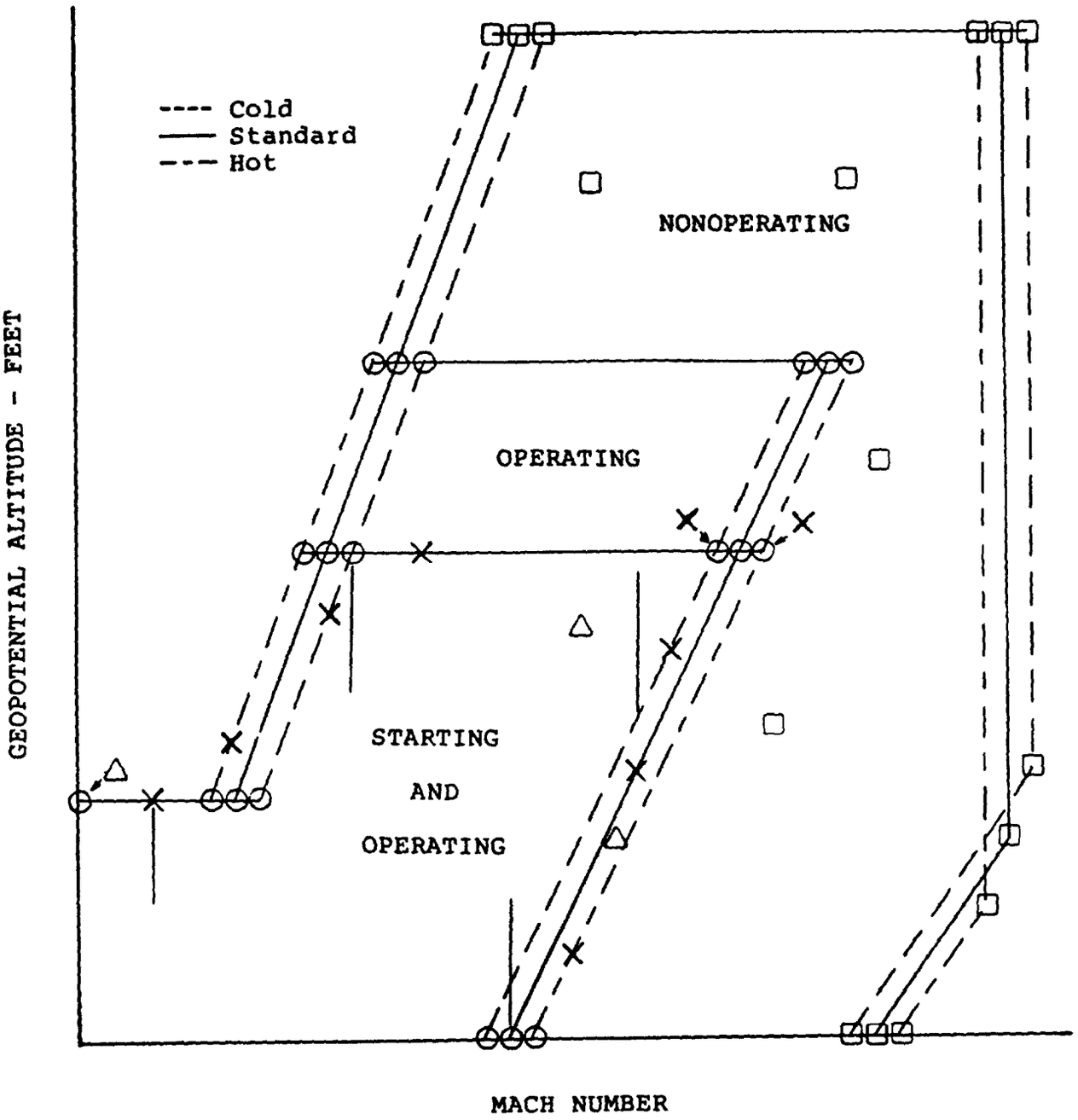
REF. - 3.2.5.2



NOTE: 1. Applicable to sea level static conditions
2. For altitudes above sea level; shift the temperature range on the abscissa such that the mean temperature (50 percent exceeding temperature) has a value equal to the air temperature defined in U.S. Standard Atmosphere.

FIGURE 9. Ambient temperature distribution.

REF. - 3.3.8.1, 3.3.8.1.1, 3.3.8.1.2



△ Altitude Rating Point

× Starting Test Point

○ Functional Test Point

□ Windmilling and Nonwindmilling Test Point

| Altitude Range

FIGURE 10. APU test points and altitude ranges.

REF. - 4.5.3, 4.5.3.2, 4.6.3, 4.6.3.2

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ALPHABETICAL INDEX

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