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MILITARY SPECIFICATION

POWER UNITS; AIRCRAFT AUXILIARY, GAS-TURBINE-TYPE, GENERAL SPECIFICATION FOR

This specification has been approved by the Department of the Air Force and by the Navy Bureau of Aeronautics.

1. SCOPE

1.1 Scope.- This specification covers the general requirements for gas-turbine-type aircraft auxiliary power units.

1.2 Classification.- Auxiliary power units shall be of the following types and model, as specified in the model specification (see 6.2):

Type I	- Primarily used as a power takeoff unit (source of mechanical power).
Type II	- Primarily used as a source of compressed air bled from the compressor.
Type III	- Primarily used as a source of compressed air bled from the compressor and mixed with combustion products.
Type IV	- Used as a combination power and compressed air source.
Model	- The model designation will be established by the procuring activity.

2. APPLICABLE DOCUMENTS

2.1 The following specifications, standards, drawings, and publications, of the issue in effect on date of invitation for proposals, form a part of this specification to the extent specified herein:

SPECIFICATIONS

Federal

QQ-M-151	Metals; General Specification for Inspection of
QQ-P-416	Plating, Cadmium (Electrodeposited)

Military

MIL-A-8625	Anodic Coatings, for Aluminum and Aluminum Alloys
MIL-C-5544	Thread Compound; Anti-Seize, Graphite-Petrolatum
MIL-C-8554	Cable; Ignition, High-Tension, Aircraft Quality
MIL-C-9282	Container, Shipping, Metal, Reusable 5 Cu. Ft.-50 Cu. Ft. Volume
MIL-D-5028	Drawings and Data Lists: Preparation of Manufacturers' (for Production Aircraft, Guided Missiles, Engines, Accessories, and Other Auxiliary Equipment)

MIL-E-5557	Enamel; Heat-Resisting, Glyceryl-Phthalate, Black
MIL-E-5607	Engine, Gas Turbine, Preparation for Storage and Shipment of, Process for
MIL-F-5161	Fuel, Referee, Aircraft Turbine and Jet Engine
MIL-F-5572	Fuel, Aircraft Reciprocating Engine Grades 80, 91/96, 100/130, 115/145
MIL-F-5624	Fuel, Aircraft Turbine and Jet Engine Grades JP-3, JP-4, and JP-5
MIL-F-7024	Fluids, Calibrating, for Aircraft Fuel System Components
MIL-H-3136	Hydrocarbon-Fluid, Standard Test
MIL-I-6181	Interference Limits, Tests and Design Requirements, Aircraft Electrical and Electronic Equipment
MIL-I-6865	Inspection, Radiographic
MIL-I-6866	Inspection, Penetrant Method of
MIL-I-6868	Inspection Process, Magnetic Particle
MIL-M-3171	Magnesium Alloy; Process for Corrosion Protection of
MIL-O-6081	Oil, Lubricating, Jet Engine
MIL-P-6889	Primer; Zinc-Chromate, for Aircraft Use
MIL-S-7742	Screw Threads, Standard, Aeronautical
MIL-X-6141	X-Ray Laboratories, Procedure for the Certification of (for Inspection of Aircraft Components)
JAN-A-699	Anti-Seize Compound, White Lead Base, General Purpose (for Threaded Fittings)

STANDARDS

Military

MIL-STD-129	Marking for Shipment and Storage
MS28741	Hose Assembly, Detachable End Fitting, Medium Pressure

DRAWINGS

Air Force-Navy Aeronautical Standard Drawings

AND10060	Tubing End - Hose Connection, Standard Dimensions for
AND10398	Metals - Definition of Dissimilar
AND20006	Drive - Type XVI Engine Accessory

PUBLICATIONS

Air Force-Navy Aeronautical Bulletins

No. 182	Material Changes and Substitutions; Aircraft Engine Parts (Production Contracts)
No. 343	Specifications and Standards Applicable to Aircraft Engines and Propellers, Use of
No. 391	Changes; Engineering, to Aircraft Engines, Propellers, and Aeronautical Equipment in Production and Service
No. 410	Age-Controls Fuel System Synthetic Rubber Part

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

2.2 Other publications.- The following documents form a part of this specification. Unless otherwise indicated, the issue in effect on date of invitation for bids, shall apply.

National Advisory Committee for Aeronautics

NACA TN 3182	Manual of the ICAO Standard Atmosphere Calculations by the NACA

(Application for copies of the NACA publication should be addressed to the National Advisory Committee for Aeronautics, 1512 H St., N.W., Washington 25, D. C.)

American Society of Mechanical Engineers

ASME PTC 19.5; 4-1949 Power Test Codes

(Application for copies of the ASME publication should be addressed to the American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y.)

Society of Automotive Engineers (Aeronautical Material Specifications)

AMS2640	Magnetic Particle Inspection
AMS2645	Fluorescent Penetrant Inspection

(Application for copies of AMS specifications should be addressed to the American Society of Automotive Engineers, 29 West 39th St., New York 18, N. Y.)

3. REQUIREMENTS

3.1 Materials.-

3.1.1 Critical materials.- The use of critical materials, as listed in the model specification, shall be held to a minimum. The estimated weight of each critical material required in the construction of the gas-turbine-type auxiliary power unit shall be specified in the model specification.

3.1.2 Dissimilar metals.- The use of dissimilar metals in contact, as defined on Drawing AND10398, shall be avoided wherever practicable.

3.1.3 Synthetic rubber parts.-

3.1.3.1 Marking.- All synthetic rubber parts, such as diaphragms, excepting "O" rings and parts with no suitable surface, shall have printed, stamped with ink, or otherwise noted on the part, the year and month of the curing date of the part.

3.1.3.2 Serviceability.- All synthetic rubber parts shall be readily replaceable with a minimum replacement of attaching parts.

3.1.3.3 Uniformity.- For components which include parts fabricated of synthetic material in contact with fuel, manufacturers shall control subsequent batches to provide for uniformity.

3.1.3.4 Age controls.- Age controls for synthetic rubber parts shall comply with the requirements of ANA Bulletin No. 410.

3.1.4 Materials, processes, and products.- Materials, processes, and products used in the manufacture of auxiliary power units shall be of high quality, suitable for the purpose, and shall conform to applicable specifications selected in accordance with ANA Bulletin No. 343. Where contractor's specifications are used for materials and

processes which affect performance or durability of the finished product, such specifications shall be subject to release by the procuring activity. The use of nongovernmental specifications shall not constitute waiver of Government inspection.

3.1.4.1 Standard parts.- Standard parts (MS, AN, or JAN) shall be used wherever they are suitable for the purpose, and shall be identified on the drawing by their part numbers. In the event there is no suitable corresponding standard part in effect on date of invitation for bids, commercial parts may be used provided they conform to all requirements of this specification.

3.2 Design standards.- MS and AND Design Standards shall be used wherever applicable.

3.3 Model specification.- A model specification conforming to Appendix III of this specification shall be submitted by the contractor for approval. Unless otherwise specified by the procuring activity, a revision of the model specification and drawings forming a part thereof, shall be submitted to the procuring activity after approval of the unit.

3.4 Preproduction and acceptance.-

3.4.1 Preproduction.- The approval of any complete gas-turbine-type auxiliary power unit as a service type or model shall be predicated on the satisfactory completion of a Preproduction test in accordance with the requirements of Appendix I of this specification

3.4.2 Acceptance requirements.- An Acceptance test shall be conducted on each production unit and shall consist only of those requirements specified in Appendix II of this specification.

3.5 Performance characteristics.- The performance characteristics shall be as specified in the model specification. These performance characteristics shall be determined, using Specification MIL-F-5161 fuel and the type and grade of oil specified in the model specification. These performance characteristics shall be determined under the sole control of the automatic control system furnished on the unit.

3.5.1 The unit shall function satisfactorily throughout its operating range with fuel conforming to Specification MIL-F-5624, and shall also function satisfactorily throughout its operating range with fuel conforming to Specification MIL-F-5572. External control adjustments shall be allowed to meet this requirement. In particular, the operating limits specified in the engine model specification shall not be exceeded when fuel having any of the variations in characteristics permitted by Specification MIL-F-5624 is used.

3.5.2 Fuel contamination.- The unit shall function satisfactorily when using fuel contaminated to the extent of 80 grams of foreign matter per 1,000 gallons of fuel. Contaminant shall be considered to consist of not less than 68 percent SiO_2 and shall have a particle-size analysis as follows:

Particle size microns	Percent of total
0 to 5	39 ±2 by weight
5 to 10	18 ±3 by weight
10 to 20	16 ±3 by weight
20 to 40	18 ±3 by weight
Over 40	9 ±3 by weight
Through a 200-mesh screen	100 by weight

Demonstration of the foregoing requirement on the complete unit by the contractor shall not be required unless so specified in the model specification. If a filter is required, it shall be a part of the unit, and the filter element shall be of sufficient capacity to permit a minimum of 30 hours continuous operation at normal rated output without being cleaned.

3.5.3 Lubrication.- No change in lubricants shall be required for operation throughout the complete ground temperature range.

3.5.4 Ratings.- The performance ratings shall be as specified in the model specification. The specified ratings shall be predicated on the minus tolerance of the control system variation.

3.5.5 Estimates.-. The estimated performance shall be as specified in the model specification.

3.5.6 Oil consumption.- The oil consumption shall not exceed the amount specified in the model specification.

3.5.7 Altitude-temperature limits for starting and operating.- The unit starting and operating altitude and temperature limits shall be defined in the model specification.

3.5.8 Attitude conditions.- The unit shall function satisfactorily under any one of the following attitude conditions:

(a) Normal horizontal level position.

(b) 0 to 45 degrees positive displacement to either side with up to 10 degrees positive and negative displacement of the fore and aft axis.

(c) 0 to 45 degrees negative displacement of the fore and aft axis with up to 10 degrees inclination on either side.

(d) 0 to 45 degrees positive displacement of the fore and aft axis with up to 10 degrees inclination on either side.

(e) 10 seconds during negative "g" conditions.

3.5.9 Ambient temperature conditions.- The complete auxiliary power unit shall perform satisfactorily under sea level static conditions from no load to maximum output.

3.5.9.1 The unit shall suffer no detrimental effects, and shall start and operate successfully after being subjected to:

(a) A soaking period of 8 hours at an ambient temperature of 160°F when supplied with fuel at 135°F and inlet air at 130°F.

(b) A soaking period of 72 hours at an ambient temperature of -65°F when supplied with fuel at -65°F and air at -65°F.

3.5.10 Reduced-speed, idle operation.- Means or provisions for reduced-speed idle operation shall be as specified in the model specification. Operation under load at reduced speed is not required by this specification.

3.5.11 Stability.- Under steady-state conditions, within the operational range defined in the model specification, power output oscillation shall not exceed ±0.5 percent of the maximum power output available at a given loading condition, or when the primary use of the unit is to provide compressor bleed air, then, under steady-state conditions, within the operational range defined in the model specification, bleed output pressure oscillation shall not exceed ±0.5 percent of the bleed output absolute pressure at a given loading condition.

3.5.12 Gas temperature limits.- Gas temperature limits shall be automatically controlled to prevent the maximum allowable temperature from being exceeded under any condition of operation specified.

3.5.12.1 Measurement.- Provision shall be made for the measurement or determining of gas temperature. The location of the temperature probe or probes shall be specified by the contractor. Temperature sensing and indicating devices shall not be furnished with the unit.

3.5.13 Starting.- The turbine shall make consistent successful starts when used in conjunction with a starter which meets the starter requirements specified in the model specification. A successful start shall be defined as a complete start and acceleration from starter torque initiation to stabilized idle speed within the times specified in figure 1, curve A, without exceeding allowable limits when following the technique specified in the model specification. When so specified in the model specification a curve similar to figure 1 showing a different required curve such as curve B, shall apply in lieu of curve A, figure 1.

3.5.13.1 Starter.- Unless otherwise specified in the model specification, the unit shall be equipped with a direct-current electric starter capable of starting the unit in not more than 60 seconds at +60°F, and not more than 100 seconds at -65°F. Unless otherwise specified in the model specification, the starter shall be suitable for operation over a voltage range of 14 to 30 volts, dc. Starting with the driven equipment loaded is not required by this specification. The starting performance listed above shall be achieved at all static conditions specified herein from sea level to 6,000 feet.

3.5.13.2 Starting power.- The starting power shall be specified in the model specification.

3.5.13.3 Automatic starting.- The starting system shall be suitable for complete automatic starting from a remote location. Components required for automatic starting and not furnished with the unit shall be specified on the contractor's specification control drawings.

3.5.13.3.1 Starting cycle.- The automatic starting cycle shall be so arranged that the unit will be purged of residual fuel mixture and the ignitor will operate a sufficient time prior to introduction of fuel, to preclude an explosion.

3.5.13.4 Special starting fuel.- Unless specifically approved by the procuring activity, special fuel for starting at low temperatures shall not be used.

3.5.13.5 Restart time.- The minimum allowable time between starting attempts as determined by the gas-turbine auxiliary power unit limitations shall be as specified in the model specification.

3.5.14 Maximum rotor speed.- The maximum permissible rotor speed of the auxiliary power unit shall be as specified in the model specification.

3.5.15 Section protection.- The design shall be such that failure of a major section will not result in damage to either of the other sections.

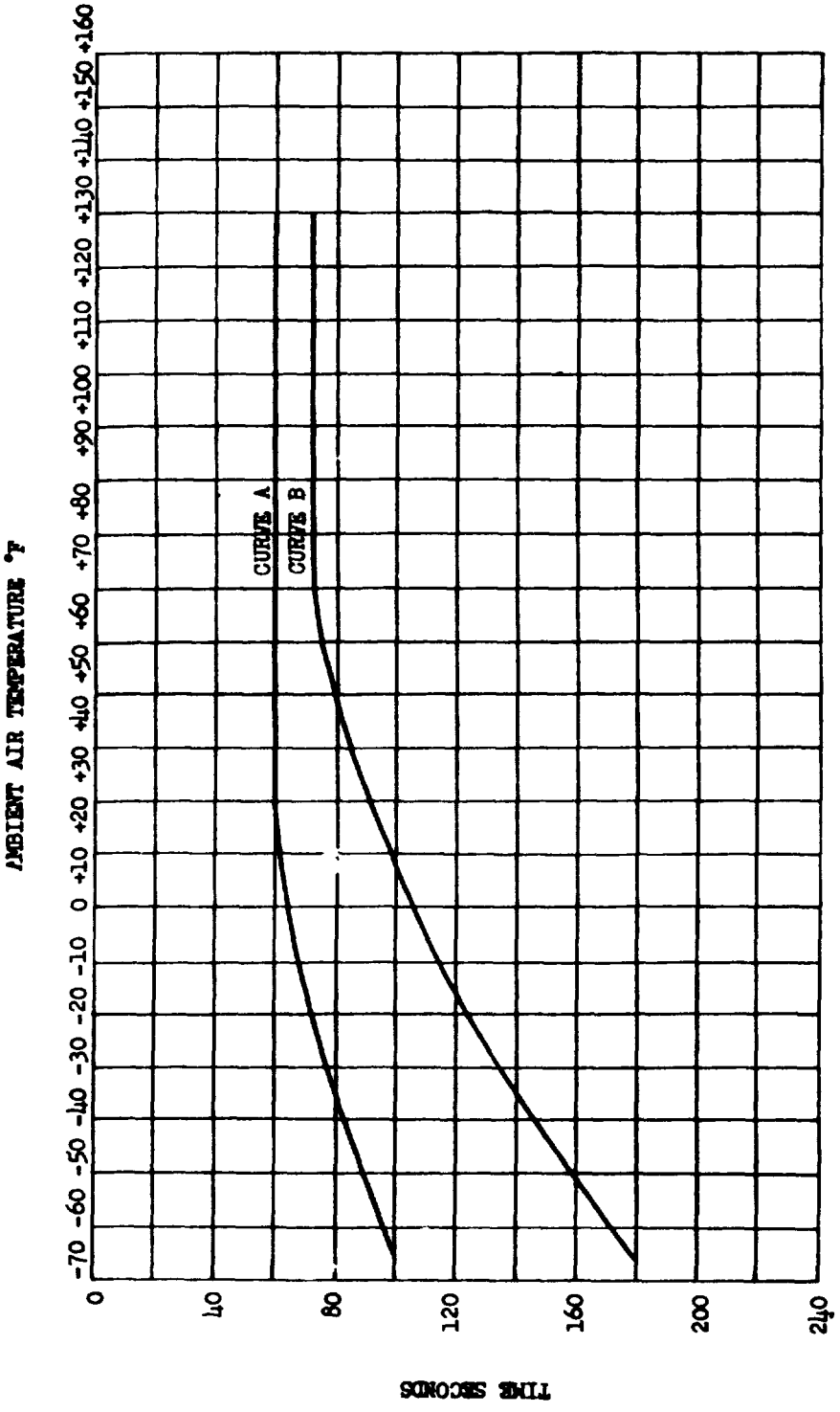


FIGURE 1. Required turbine starting time versus ambient air temperature

3.6 Drawings and data.- As soon as practicable after the award of the service-type or model contract, but in any case before delivery of units has begun, the contractor shall furnish to the procuring activity drawings showing the information listed below and the photographs listed below. The drawings shall be submitted in duplicate, one set reproducible, and one set of prints made therefrom. Photographs shall be submitted in duplicate.

(a) Gas-turbine-type auxiliary power unit assembly (complete except for components not furnished with the unit).

(b) Gas-turbine-type auxiliary power unit installation (including removal clearance for maintenance changes).

(c) Fuel-system diagram.

(d) Ignition-system diagram.

(e) Lubrication-system diagram.

(f) Gas-flow diagram.

(g) Control-system diagram.

(h) Photographs showing front, rear, top, bottom, and both sides.

3.6.1 Complete detail drawings, including assemblies and subassemblies, shall be furnished to the procuring activity before one-half of the units on contract have been delivered, unless the latest revision of these drawings have been previously submitted. These drawings shall be submitted in duplicate, one set reproducible, and one set of prints made therefrom.

3.6.2 Microfilm drawings.- As soon as practicable after the award of a contract, the contractor shall submit to the procuring activity microfilm of all drawings and photographs covered by 3.6, including complete detail drawings.

3.7 Design and construction changes.-

3.7.1 Material substitutions.- Temporary material substitutions shall be made in accordance with ANA Bulletin No. 182.

3.7.2 Changes in design.- No changes shall be made in the design or materials of parts listed in an approved gas-turbine auxiliary power unit parts list, except where such changes are approved in accordance with the provisions of ANA Bulletin No. 391.

3.7.2.1 Class 1 changes.- Class 1 changes are of a nature affecting contract requirements covering weight, performance, cost, interchangeability, or affecting durability of either parts or complete gas-turbine auxiliary power units.

3.7.2.2 Class 2 changes.- All other changes shall be classified as class 2 changes.

3.7.2.3 Approval of changes.- Approval of changes does not relieve the contractor from full responsibility for the results of such changes on any of the auxiliary power unit characteristics.

3.7.3 Service bulletin.- When specified by the procuring activity at the time of approval of a change, the contractor shall submit a service bulletin, in order to permit procuring activities to incorporate the change in units previously delivered.

3.7.4 Parts list.- The parts list for the unit which successfully completes the Preproduction tests shall constitute the approved parts list for subsequent units of the same model. Changes to the approved gas-turbine auxiliary power unit parts list shall be governed by the requirements specified in 3.7.2.

3.8 Interchangeability.- Insofar as practicable, all parts having the same contractor's part number shall be directly and completely interchangeable with each other with respect to installation and performance. Matched parts or selective fits will be permitted where required. Changes in contractor's part numbers shall be governed by the drawing requirements of Specification MIL-D-5028.

3.9 Installation.- To facilitate installation and removal of the unit from its installation, service connections (such as fuel line(s), hydraulic line(s), fire extinguisher line(s), electrical lead(s), and other connections where furnished for load control and reduced speed), shall be contained on a readily accessible connection panel. The connection panel shall be permanently marked to identify all connections grouped on the panel. Air inlet, cooling air outlet(s), turbine exhaust, and bleed air ports, oil fill, and all drain and mounting provisions may be located separately, and if practicable, shall be permanently marked or identified. Similar fluid connections located in close proximity shall be made physically noninterchangeable.

3.10 Accessibility.- Insofar as practicable, parts of the unit requiring routine service checking, adjustment, or replacement, shall be made readily accessible for servicing without teardown of the unit and removal of any major part, component, or accessory, other than removal of access provisions and locking devices. Particular attention shall be paid to access for the removal of replacement of such items as fuel nozzles, replaceable parts of the ignition system, oil pressure relief valve oil vent, oil filter, control system, air intake screens, drain plugs, and in addition, sufficient clearance shall be provided for connecting and removing any separately supplied external fittings and lines.

3.11 Disassembly with tools.- Wherever practicable, nuts and screws shall be removable with standard tools. In any case, the design shall be such as to permit disassembly and assembly of the unit without undue difficulty. A minimum of bolt sizes shall be used. If practicable, not more than three sizes shall be used for external assembly.

3.12 Environmental conditions.- The unit shall not suffer any detrimental effects when inoperative and exposed to the temperature range of -100°F to +275°F. The design of the unit shall provide satisfactory operation during and after exposure to any combination of the following conditions in worldwide operation: Humidity, fungus, sunshine, rain, snow, sleet, hail, ice fog, fog, mildew, salt spray, ice, ozone, smoke, wind, sand, and dust.

3.13 Electrical components.-

3.13.1 Explosion-proof.- If practicable, electrical components shall be explosion-proof, in order not to ignite any explosive mixture surrounding the electrical components.

3.13.2 Electrical interference.- Electrical components shall not cause electrical interference beyond the limits specified in Specification MIL-I-6181.

3.13.3 Voltage range.- Unless otherwise specified by the procuring activity, all components using electrical power from a source external to the unit shall operate satisfactorily with input voltage at the unit connection panel in the range from 14 to 30 volts, dc.

3.13.4 Electrical power.- The electrical power which must be supplied from sources external to the unit shall be as specified in the model specification. Malfunction protection features shall be incorporated in the power unit, to protect it during any condition of operation, in the event of external electric power failure.

3.13.5 Connectors and cable.- At a temperature of -65°F, it shall be possible to connect or disconnect electrical connectors and to flex electrical conductors, as necessary for routine maintenance without damage to these items.

3.14 Dry weight.- The dry weight of the unit shall not exceed that specified in the model specification.

3.14.1 Weights of additional equipment.- The estimated weights of items which are not components of the auxiliary power unit but which are furnished with it shall be listed in the model specification. These items shall not be included in the dry weight of the unit.

3.15 Over-all dimensions.- The over-all dimensions of the complete unit, and allowance for expansion, shall not exceed those specified in the model specification.

3.16 Mounting provisions.- The number, type, and location of the mounting provisions shall be clearly shown on the unit outline drawing.

3.16.1 Handling supports.- The unit shall incorporate provisions for hoisting, and for resting on level ground. These provisions shall be shown on the unit outline drawing.

3.17 Flight maneuver forces.- The unit and its mounting provisions shall withstand without permanent deformation or failure the conditions specified in figure 2. When applicable, type I and type IV units shall have installed a generator or other driven accessory of the maximum weight and overhung moment specified in the model specification.

3.17.1 Simulated flight maneuver loads.- The unit and its mounting provisions shall not fail when subjected to static loads equivalent to 1-1/2 times the values specified in 3.17 and 3.17.3.

3.17.2 Ditching loads.- The unit and its mounting provisions shall be designed not to disintegrate, but may undergo permanent deformation, when subjected to any one of the following acceleration loads. When applicable, type I and type IV units shall have installed a generator or other driven accessory of the maximum weight and overhung moment specified in the model specification.

(a) 15g in the vertical plane.

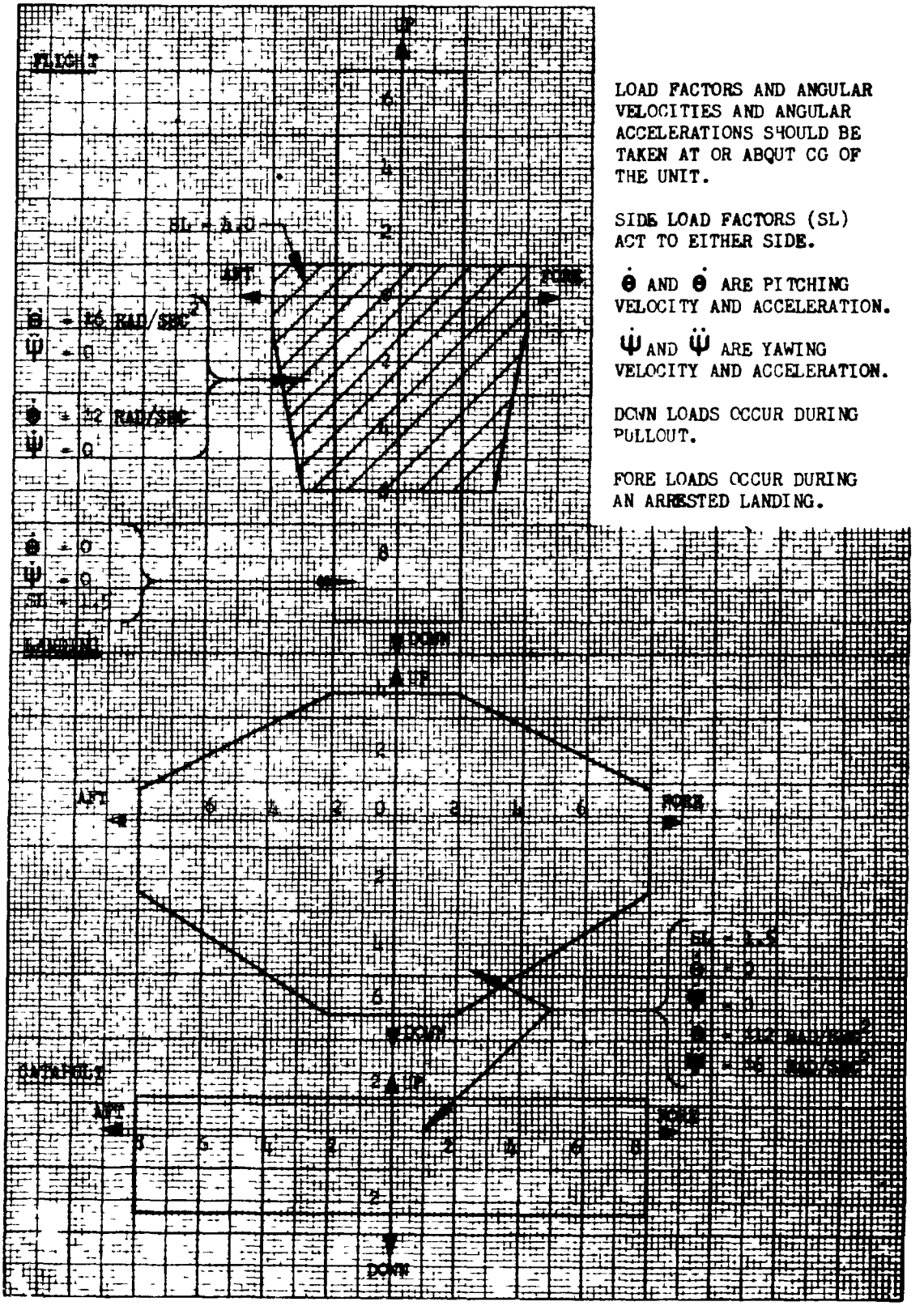
(b) 20g in the horizontal plane.

Operation of the unit during or after exposure to these loads shall not be required.

3.17.3 Gyroscopic moments.- At maximum rated speed, the unit shall withstand a gyroscopic moment imposed by a steady angular acceleration of 3.5 radians per second in yaw of the unit for a period of 30 seconds.

3.17.4 Demonstration of loads.- Demonstration of any of the loads specified in 3.17, or any of its subparagraphs, shall not be required unless so specified in the contract.

3.17.5 Identification of forces.- The forces, loads, and accelerations quoted herein are defined on figure 2, and shall be identified by axes (see table I) indicated on the contractor's outline drawing.



LOAD FACTORS AND ANGULAR VELOCITIES AND ANGULAR ACCELERATIONS SHOULD BE TAKEN AT OR ABOUT CG OF THE UNIT.

SIDE LOAD FACTORS (SL) ACT TO EITHER SIDE.

$\dot{\theta}$ AND $\ddot{\theta}$ ARE PITCHING VELOCITY AND ACCELERATION.

$\dot{\psi}$ AND $\ddot{\psi}$ ARE YAWING VELOCITY AND ACCELERATION.

DOWN LOADS OCCUR DURING PULLOUT.

FORE LOADS OCCUR DURING AN ARRESTED LANDING.

FIGURE 2. Design limit load factors for turbine power unit

TABLE I

Force axes

Force acting	Direction	Axis
Horizontal	Longitudinal	x
Horizontal	Transverse	y
Downward or upward	Vertical	z

3.18 Polar moment of inertia of compressor-turbine system.- The polar moment of inertia of the complete rotor about the rotor axis shall be as specified in the model specification.

3.19 Output drives (type I and type IV units).- One AND20006, type XVI-B engine accessory drive shall be furnished as the output drive of the auxiliary powerplant. This drive shall transmit the torque specified by the AND drawing. It shall carry an accessory having the maximum weight and overhung moment specified on the drawing under the loads specified in 3.17 herein and subparagraphs thereto. The speed of the drive shall be held to 6,000 rpm ±5 percent from no load to maximum output under steady-state and transient conditions.

3.19.1 Adapter gearbox.- When so specified in the model specification an adapter gearbox, lubricated from the basic powerplant, shall be provided to furnish additional accessory drives. The speed, torque, and other characteristics of these additional drives shall be as specified in the model specification.

3.19.2 Generator cooling air.- Cooling air to provide cooling for a generator that may be mounted on the output drive shall be furnished by the auxiliary powerplant. The characteristics of this cooling air shall be shown in the model specification as curves of quantity, temperature, and pressure vs altitude from sea level to guaranteed-operational altitude.

3.19.2.1 Generator cooling air connection.- The generator cooling air connection shall consist of a 3-inch-outside-diameter tube, beaded in accordance with Drawing AND10060, type A.

3.20 Compressed air product (type II, type III, and type IV units).-

3.20.1 Compressor bleed.- The type II, type III, and type IV units shall provide for extraction of compressed air from the compressor only in the quantity, pressure, and temperature specified in the model specification.

3.20.2 Mixed bleed.- The type III units shall also incorporate provisions for the mixing of compressor bleed and combustion chamber products to raise the temperature of the bleed air to that value specified in the model specification.

3.20.3 Bleed air connection.- The bleed air connection shall be of the quick-disconnect type and shall be shown on the unit outline drawing. The maximum permissible shear load, axial load, and overhung moment for the bleed air connection shall be as specified in the model specification.

3.21 Limiting zone temperature.- All external zones of the unit and all unit components mounted on the unit shall be capable of continuous operation when surrounded by air at an ambient temperature of 200°F, or 130°F plus the ram temperature rise of air, at the maximum ram ratio specified for unit operation, whichever is greater. The estimated maximum permissible continuous operating temperature of all external zones and appropriate components of the unit shall be specified in the model specification. Cooling air shall be provided by the unit, if necessary, to meet the foregoing requirement.

3.21.1 Cooling after shutdown.- No auxiliary power unit component or zone shall require special cooling (e.g., forced convection, refrigeration, or rotation of rotor(s)) after shutdown of the unit.

3.21.2 Fire-detecting and extinguishing systems.- The unit shall include mounting provisions for a fire-detecting device, and the connection panel shall include mounting provisions for the fire-detecting device electrical receptacle. The connection panel shall also include a fitting suitable for connection to a CO_2 fire-suppressant system. The suppressant system, fire-detecting device, wiring, receptacle, and nozzle for dispersion of the CO_2 shall not be furnished with the unit.

3.22 Air intake.- The air intake size and location(s) shall be shown on the gas-turbine power-unit outline drawing which shall be a part of the model specification.

3.22.1 Air intake screen.- Unless otherwise specified in the model specification, a screen shall be provided at the air inlet to prevent the entrance of foreign objects of dimensions equal to, or greater than, a 0.125-inch sphere.

3.22.2 Duct attachment.- Provisions for intake duct attachments shall be as shown on the unit outline drawing. The maximum permissible shear load, axial load, and overhung moment for the attachment provisions shall be as specified in the model specification.

3.22.3 Inlet air pressure drop.- The maximum allowable inlet air pressure drop which will permit operation of the unit without adverse effects shall be specified in the model specification.

3.23 Exhaust system.-

3.23.1 Turbine exhaust.- Provisions for quick-disconnect-type attachments shall be furnished for the turbine exhaust system to permit ready removal of the unit from its installation. These provisions shall be shown on the outline drawing. The maximum allowable shear load, axial load, and overhung moment shall be specified in the model specification.

3.23.1.1 Turbine exhaust pressure drop.- The maximum allowable exhaust pressure drop which will permit operation of the unit without adverse effects shall be specified in the model specification.

3.23.2 Cooling air discharge.- Provisions for quick-disconnect-type attachments shall be furnished at the cooling air outlet port(s) if an air outlet port(s) is provided. These provisions shall be shown on the outline drawing. The maximum allowable shear load, axial load, and overhung moment shall be specified in the model specification.

3.23.2.1 Cooling air discharge pressure drop.- The maximum allowable cooling air pressure drop which will permit operation of the unit without adverse effects shall be specified in the model specification.

3.24 Lubricating system.- The lubricating system shall adequately lubricate the auxiliary power unit throughout its operating range.

3.24.1 Lubrication points.- All points in the unit requiring pressure lubrication shall be lubricated from the unit lubricating system. No lubricating from an external source shall be required.

3.24.2 Oil interruption.- The unit shall be capable of operating continuously, with no detrimental effects during and after operation, when air only is supplied to the inlet of the oil pump for a period of 10 seconds.

3.24.3 Oil drainage.- Provisions shall be made to prevent oil drainage into the turbine.

3.24.4 Oil filter.- A suitable AN-type oil filter element shall be provided as a component of the unit. The filter element shall be of sufficient capacity to operate satisfactorily between oil changes as specified in the model specification.

3.24.5 Scavenging system.- If a scavenging system is used, it shall adequately scavenge the basic gas turbine and compressor for extended periods of time, under the operating conditions specified herein, including negative "g" operation for a period of 10 seconds. The scavenge pump shall operate satisfactorily during the low-temperature starts specified.

3.24.6 Oil pressure.-

3.24.6.1 Oil pressure pump.- The oil pressure pump shall maintain not less than the specified oil pressure for all operating speeds and all altitudes up to and including the absolute altitude specified in the model specification.

3.24.6.2 Oil pressure measurement.- Provisions shall be made for the measurement of oil pressure. The connection for this measurement shall be shown on the unit outline drawing. The oil pressure indicator shall not be furnished with the unit.

3.24.6.3 Pressure adjustment.- The lubricating system shall be arranged to provide oil pressure without adjustment throughout the operating range specified in the model specification. If oil pressure adjustment is required during normal maintenance, it shall be readily adjustable without parts change.

3.24.6.4 Pump relief valve.- The oil-pump relief valve shall be so designed that it will be unnecessary to change adjustment of the valve when operating under any condition specified in the model specification.

3.24.6.5 Oil bypass.- The lubricating system shall be so arranged that oil bypassed from the pressure pump shall not be returned to the oil tank by a separate line.

3.24.7 Oil drain.- The unit shall be provided with an oil drain at the lowest point(s) in the system, in order that the installation may be adequately drained with the unit in a horizontal position and in any position within 15 degrees from the horizontal position.

3.24.7.1 Insofar as practicable, all oil drainage shall be collected at the single point shown on the unit installation drawing.

3.24.8 Oil tank.- Unless otherwise specified in the model specification, the oil tank shall be a component part of the unit. Satisfactory functioning of the unit shall be provided under any of the attitude conditions specified in 3.5.8 when the oil level in the tank contains 20 percent of its usable quantity as defined in 3.24.8.2

3.24.8.1 Cleaning.- The oil tank design shall be such that internal contours will permit ease of cleaning by means of flushing methods. Provisions shall be made for flushing or for cleaning the interior of the tank.

3.24.8.2 Capacity.- The oil tank capacity shall provide for the following:

(a) A quantity equal to the residual capacity of the basic auxiliary power unit system exclusive of the oil tank.

(b) A quantity of usable oil sufficient for a minimum of 10 hours of continuous operation under any condition specified herein. The quantity of oil shall be determined from the contractor's specified oil consumption.

(c) A minimum expansion space, between the maximum level to which the tank can be filled and the total oil tank volume, which shall be 15 percent of the oil tank capacity.

3.24.8.3 Filler cap.- A filler cap and adapter shall be provided, and shall close and seal the oil tank. It shall be possible to install and remove the cap by hand without the use of tools. The cap and adapter shall be such that water cannot collect and drain into the tank, and shall be so located that the tank can be filled without the use of special funnels and that the oil tank expansion space cannot be filled. The cap shall be fully seated and locked by turning the cap not more than 90 degrees. The cap shall be fastened to the adapter by means of a chain, or its equivalent. The outside of the cap shall be painted black with a fuel- and oil-resistant paint, and marked in yellow with the following information: "Oil Cap _____JS Gal" (which shall be filled in with the oil tank capacity).

3.24.8.4 Oil tank filler opening.- The oil tank filler opening and location shall be such that under normal conditions the entire tank can be filled in one operation in not more than 1 minute. The filler opening shall be so located and sealed that liquids from the opening shall not spill on the unit or spill on any of the unit accessories. If necessary, filler spill basins with adequate drains shall be provided to accomplish the foregoing.

3.24.8.5 Sump.- A removable sump shall be provided in the bottom of the oil tank at the oil tank drain. The sump shall be of sufficient capacity to collect normal accumulations of condensate and sediment likely to be encountered during operation under the conditions specified, and shall incorporate a standpipe which shall be the oil outlet. A 1/4-inch straight-thread self-locking drain valve shall be provided in the sump to drain the condensate and sediment.

3.24.8.6 Vents.- If oil tank vent lines are provided, they shall be installed in such manner that no liquid trap exists. Provisions shall be made for efficient separation of entrained oil from the air, if required.

3.24.8.7 Oil level gage.- The oil tank shall be provided with a level cock, dipstick, or other means acceptable to the procuring activity for determining the normal oil level in the tank when the unit is in the horizontal attitude defined by the contractor's drawings. The gage shall be in such a position that it is readily discernible or readily accessible on the unit, depending on the type.

3.24.9 Oil cooler.- An oil cooler shall be furnished as a component of the lubricating system where provisions for cooling of the oil are required. The oil cooler may be integral with the oil tank.

3.24.9.1 Type.- The oil cooler may be of the air-cooled type.

3.24.9.2 Design conditions.- If a fuel-cooled oil system is used, the following oil cooler design conditions shall apply:

(a) For cooling, the hot fuel temperature of 135° ±5°F shall apply.

(b) For low temperature and oil congealing consideration, a cold fuel temperature of -65°F shall apply.

(c) Fuel used for cooling shall not be returned to the fuel tank.

(d) If an automatic oil temperature control is provided, it shall include fuel or oil bypass provisions for both oil cooling and anticongealing. Where applicable, surge protection shall be provided for the oil cooler.

3.24.10 Breather.- If a single breather is provided, the breather system shall be so designed that oil in liquid form will not be lost through the breather when operating the unit in any attitude or condition specified herein. The size and location of the outlet connection shall be as shown on the unit installation drawing.

3.25 Fuel system.-

3.25.1 Performance.- The auxiliary power unit fuel system shall perform satisfactorily and shall be capable of supplying the required amount of fuel at the required pressure under all conditions specified in the model specification, with fuel temperatures throughout the range of 0°to 80°F above the ambient temperature but not in excess of 135°F, when the fuel pressure at the unit fuel inlet connection at the panel is from a minimum of 5 psi above the Reid vapor pressure up to a maximum of 40 psi gage.

3.25.2 Valves.- Valves, where furnished with the unit, shall close completely without visible dripping from the minimum operating fuel pressure to 110 percent of maximum operating fuel pressure.

3.25.3 Pressure protection.- A means shall be provided to limit the fuel pump discharge pressure.

3.25.4 Fuel pressure connection.- A fuel pressure connection for use with a fuel pressure indicator shall be provided as specified in the model specification. The fuel pressure indicator shall not be furnished with the unit.

3.25.5 Filtering provisions.- Filtering provisions, if required, shall be as specified in 3.5.2.

3.25.6 Fuel drains.- Provisions shall be made for automatically clearing the combustion chambers after shutdown with the unit in a level position, 15 degrees positive displacement from the level position, and 20 degrees negative displacement from the level position. Where practicable, all fuel drainage shall be collected at a single common point on the unit as shown on the unit installation drawing.

3.25.7 Lines and fittings.- The fuel lines shall be as short as practicable and shall contain no water-collecting traps. Fuel lines external to the basic gas turbine which convey fuel shall be flexible or adequately supported to eliminate the effects of destructive vibration. External hose assemblies shall conform to Standard MS28741 or equal assemblies, or shall be of stainless steel.

3.25.8 Fuel resistance.- All materials used in components of the auxiliary power unit fuel system shall be sufficiently resistant to fuels conforming to Specifications MIL-F-5624 and MIL-F-5572 to assure satisfactory operation as herein defined. If testing is required by the model specification, fluids conforming to Specification MIL-H-3136, type I and type III, shall represent the extremes for test purposes.

3.26 Ignition system.- The ignition system, excluding the electrical power source, shall be mounted entirely on the unit. The system shall provide for satisfactory ignition during starting and restarting under all of the operating conditions specified. The ignition system shall meet the foregoing requirements when the voltage supply to the unit at the connection panel is as low as 14 volts, dc, or as high as 30 volts, dc. At least two igniters shall be provided if the unit is of a multiple combustion-chamber type. Multiple combustion-chamber units may include crossfire tubes. Continuous ignition is not mandatory where combustion can be self-maintained after accomplishment of a successful start.

3.26.1 High-tension ignition cable.- High-tension ignition cable, when used, shall conform to Specification MIL-C-8554.

3.26.2 Lead assembly.- If high-tension ignition is used, the lead assembly shall be equipped with AN-type high-altitude-type terminals where a disconnect is necessary. Other types, if used, shall be approved by the procuring activity. It shall be practicable to install or remove igniter(s) on the unit at -65°F without mechanical or electrical failure of the ignition lead assembly. The lead assembly shall be rewirable.

3.26.3 Connections.- The ignition-system connections shall be as specified in the model specification.

3.27 Control systems.-

3.27.1 Primary controls.- The auxiliary power unit primary controls shall provide for complete automatic control of the unit, including remote automatic starting when manually initiated, and for bleed control for compressor bleed or mixed bleed, by controlling such variables as are necessary to insure satisfactory operation of the unit. Means for reduced-speed idle control shall be provided. Reduced speed shall be as specified in the model specification. Load control shall be furnished if specified in the model specification.

3.27.2 Emergency controls.- The unit shall incorporate such malfunction-protection emergency controls as necessary to prevent failure of the unit in the event that accidental overtemperature, flame-out, fuel supply failure, electrical failure, etc, are encountered. The emergency controls shall be specified in the model specification.

3.27.3 Control adjustments.-

3.27.3.1 Bleed air operational controls.- Where compressor bleed, or combinations of compressor bleed and mixed bleed are provided, adjustment shall be provided to maintain variables within the limits established in the model specification.

3.28 Accessory drives.- When specified in the model specification, special purpose drives for such accessories as generators, tachometer-generator, cooling fans, etc, shall be provided.

3.29 Counting devices.- An hour meter, or similar device, for indicating the total elapsed operating time shall be furnished with the unit.

3.30 Cover plates.- Cover plates for covering all accessory drive openings where the accessory is not mounted for auxiliary power unit shipment shall be supplied with each unit. Suitable provision for covering or plugging all other connection openings shall be made for shipment and storage.

3.31 Screw threads.-

3.31.1 Straight screw threads.- All conventional straight screw threads shall conform to the requirements of Specification MIL-S-7742.

3.31.2 Tapered pipe threads.- Tapered pipe threads may be employed only for permanently plugging drilled or cored openings.

3.31.3 Coating threaded parts.- When aluminum or aluminum-alloy threaded parts are treated at the time of assembly with antiseize compound, the compound shall conform to Specification MIL-C-5544 or JAN-A-669.

3.31.4 Inserts.- Threads in aluminum or magnesium alloys for fittings having a thread major diameter of less than 3/4 inch and subject to removal for routing maintenance purposes shall be provided with inserts.

3.32 Identification of product.-

3.32.1 Gas-turbine power-unit data plate.- A data plate shall be attached to the unit and shall include only the following information:

POWER UNIT; AIRCRAFT AUXILIARY, GAS-TURBINE-TYPE (insert I, II, III or IV, as applicable)
Model No.
Manufacturer's Serial No.
Contract or Order No.
Manufacturer's name or trade-mark
US

The data plate, or any other plates, attached to the unit shall be secured in a manner that minimizes corrosion in the presence of a salt atmosphere. The data plate, or plates, shall be so located on the unit that it can be readily seen and that if detached it will not cause failure of the unit.

3.33 Protective treatments, coatings, and paint finishes.- Protective treatments, coatings, and paint finishes shall be in accordance with applicable specifications listed in ANA Bulletin No. 343.

3.33.1 Protective treatment and coatings.-

3.33.1.1 Steel parts.- With the exception of the parts listed below, all exterior steel parts, and other steel parts subject to corrosion and not in contact with oil, shall be treated to resist corrosion by cadmium plating in accordance with Specification QQ-P-416, or by a process approved by the procuring activity.

(a) Corrosion-resistant steel parts.

(b) Cable.

(c) Tin-coated wire.

(d) Members or portions of members which act as bearings or journals.

3.33.1.2 Aluminum parts.- With the exception of the parts listed below, all exposed aluminum-alloy parts shall be treated to resist corrosion by anodizing in accordance with Specification MIL-A-8625, where practicable, or by a process acceptable to the procuring activity. Other parts may be excepted where application of treatment is considered impractical or unnecessary.

(a) Metal-sprayed surfaces.

(b) Surfaces in contact with oil.

(c) Accessory pads and port covers.

(d) Unalloyed aluminum and aluminum-clad aluminum alloy.

(e) Parts fabricated from 2S, 3S, 52S, and 61S aluminum alloys (when painted).

3.33.1.3 Magnesium parts.- All magnesium-alloy parts shall be surface treated to resist corrosion in accordance with Specification MIL-M-3171, where practicable, or by a process approved by the procuring activity.

3.33.2 Paint finishes.- With the exception of the parts listed below, all exposed metal surfaces shall be painted with one coat of primer and a minimum of two full wet finish coats, applied in such manner that no pinholing, holidays, sags, or runs are encountered; and with the further exception that magnesium-alloy parts shall receive two coats of primer and a minimum of two finish coats as described above. Additional parts may be excepted where application of paint finishes on any part thereof is considered impractical or unnecessary.

(a) Metal-sprayed surfaces.

(b) Corrosion-resistant steel, brass, copper, or bronze parts.

(c) Cable.

(d) Working surfaces.

(e) Threads.

(f) Oil holes.

(g) Cadmium-plated parts (or equivalent treatment).

(h) Unalloyed aluminum and aluminum-clad aluminum alloy.

(i) Parts fabricated from 2S, 3S, 52S, and 61S aluminum alloy.

(j) Surfaces of casting or forging identification pads when treated to resist corrosion by other means.

3.33.2.1 Primer coat.- The primer coat shall be in accordance with Specification MIL-P-6889, and shall be applied as soon as practicable after prior surface treatments or coatings. The primer coat shall be thoroughly dried prior to application of the finish coat(s), in order to prevent any consolidation of the primer or finish coats. When the primer coat is soiled or damaged by intervening operations between priming and finish coats, it shall be thoroughly cleaned and other light coat of primer added before the finish coat is applied.

3.33.2.2 Finish coat.- The finish coat for the unit and components shall be in accordance with Specification MIL-E-5557, or shall be aluminum-pigmented varnish.

3.34 Workmanship.- The workmanship and finish on all parts shall be in accordance with high-grade aircraft practice for equipment of this type.

4. QUALITY ASSURANCE PROVISIONS

4.1 Classification of tests.- The inspection and testing of power units shall be classified as follows:

(a) Preproduction tests: Preproduction tests are those tests accomplished on samples representative of the power unit, to determine that the production power unit meets all the requirements of this specification.

(b) Acceptance tests: Acceptance tests are those tests on power units manufactured and submitted under contract.

4.1.1 Preproduction and Acceptance tests.- Auxiliary power units shall be subjected to the Preproduction and Acceptance tests specified in Section 3 and described in Appendixes I and II.

4.2 General.- Auxiliary power units, components, and all material entering into the construction thereof shall be subject to inspection during course of manufacture and upon completion by authorized Government Inspectors who shall be given reasonable facilities to determine conformance to this specification.

4.3 Tests and test methods.-

4.3.1 Material tests.- Samples of all materials used in the auxiliary power unit and components shall be selected in the manner and quantity specified in the material specification, and subjected to the required tests.

4.3.2 Magnetic inspection.- The following parts shall be subject to magnetic particle inspection in accordance with Specification MIL-I-6868 or AMS2640 if made of magnetic materials:

(a) All magnetic parts constituting the compressor-turbine rotor assembly, including threaded fastenings.

(b) Other highly stressed magnetic parts.

(c) All accessory drive and vibration or friction dampener springs.

(d) Starter jaw.

(e) All gears.

(f) All quill and accessory drive shafts.

4.3.3 Fluorescent penetrant inspection.- The following nonmagnetic parts shall be subject to fluorescent penetrant inspection in accordance with Specification MIL-I-6866 or AMS2645:

(a) Turbine disk.

(b) Turbine blades.

(c) Turbine nozzle vanes and assemblies.

(d) All other highly stressed parts.

4.3.3.1 Hydrostatic testing.- Very bulky and intricately shaped parts may be hydrostatically tested by the contractor's approved method in lieu of fluorescent testing when specifically approved by the procuring activity.

4.3.4 Excepted parts.-

4.3.4.1 Commerical and AN standard parts.- Commerical and AN standard parts, such as cotter pins, washers, and similar low-stressed parts are not required to be inspected by the magnetic or fluorescent methods.

4.3.4.2 Antifriction bearings.- Assembled ball or roller bearings shall not be inspected by the magnetic or fluorescent methods.

4.3.4.3 Additional parts.- In the case of special units or where service experience of the procuring activity warrants, the list of parts specified above may be extended or supplemented to include additional parts.

4.3.5 Radiographic or ultrasonic inspection.- The following parts shall be subject to radiographic or ultrasonic inspection for defects or soundness to a degree of inspection on each article as agreed between the contractor and the procuring activity:

(a) The compressor impeller or rotor(s), if it is nonmagnetic.

(b) The turbine rotor(s), if it is nonmagnetic.

(c) Highly stressed magnesium and aluminum castings.

4.3.5.1 Radiographic inspection.- Radiographic inspection of materials shall be in accordance with Specification MIL-I-6865. Laboratories performing radiographic inspection shall be certified in accordance with Specification MIL-X-6141.

4.3.6 Control tests.- All production acceptance bench testing of components of the fuel system shall be accomplished with calibrating fluid meeting the requirements of Specification MIL-F-7024.

5. PREPARATION FOR DELIVERY

5.1 Application.- The requirements of Section 5 apply only to direct purchases by or direct shipments to the Government.

5.2 Preservation, packaging, and packing.-

5.2.1 Preservation.- The auxiliary power unit, components, and accessories shall be packaged and preserved in accordance with Specification MIL-E-5607.

5.2.2 Shipping container.- The auxiliary power unit, components, and accessories shall be packaged and packed in contractor-furnished reusable metal shipping containers in accordance with the requirements of Specification MIL-C-9282.

5.2.3 Packing list.- The contractor shall furnish a packing list with each unit. All parts, accessories, components, and tools, which are not installed on the unit, but which are shipped with the unit, shall be included on the packing list.

5.3 Marking of shipments.- Identification marking shall conform to the requirements of Specification MIL-E-5607. Interior packages and exterior shipping containers shall be marked in accordance with Standard MIL-STD-129. The identification shall be composed of the following information listed in the order shown:

Stock No. or other identification number as specified in the purchase document*
POWER UNITS; AIRCRAFT AUXILIARY, GAS-TURBINE
TYPE (insert I, II, III, IV, as applicable)
Specification (insert symbol and number)
Manufacturer's Serial No.
Contract or Order No.
Manufacturer's name or trade-mark

*NOTE: The contractor shall enter the Federal Stock No. specified in the purchase document or as furnished by the procuring activity. When the Federal Stock No. is not provided or available from the procuring activity, leave space therefor and enter the Stock No. or other identification as provided by the procuring activity.

6. NOTES

6.1 Intended use.- The auxiliary power units covered by this specification are intended to be used as a power source for the driving of generators, hydraulic pumps, and other aircraft accessories, or to provide compressed air for aircraft engine pneumatic starting systems.

6.2 Ordering data.- Requisitions, contracts, and orders should state the type and model, and whether overseas packing is desired (see 1.2).

6.3 Preproduction tests.- It is expected that the contract or purchase order will specify that a minimum of two power units will be required as preproduction samples. The contract or purchase order should specify the point of inspection for these tests. Requests for information pertaining to the Preproduction tests should be addressed to the Commander, Wright Air Development Center, Directorate of Laboratories, Wright-Patterson Air Force Base, Ohio, or the Bureau of Aeronautics, Navy Department, Washington 25, D. C.

6.4 Definitions.-

6.4.1 Government.- The term "Government" as used in this specification should be interpreted to mean the procuring activity.

PATENT NOTICE: When Government drawings, specifications, or other data are used for any purpose other than in connection with a definitely related Government procurement operation, the United States Government thereby incurs no responsibility nor any obligation whatsoever; and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

Custodians:
Navy - Bureau of Aeronautics
Air Force

APPENDIX I

POWER UNITS; AIRCRAFT AUXILIARY, GAS-TURBINE-TYPE, PREPRODUCTION TESTS FOR

10. QUALITY ASSURANCE PROVISIONS

10.1 General.- Auxiliary power units, components, and test apparatus shall be subject to inspection by authorized Government Inspectors who shall be given reasonable facilities to determine conformance with this appendix. Calibration and endurance tests conducted at the contractor's plant shall be subject to witnessing by authorized representatives of the procuring activity.

10.1.1 Sampling instructions.- Unless otherwise specified, each Preproduction test sample for a new type or model shall consist of two gas-turbine power units of each manufacturer's part number upon which approval is desired. The units shall be accompanied by one complete set of manufacturer's drawings, the manufacturer's model specification, a parts list, two spare parts kits, containing all spare parts which the contractor considers necessary for maintenance during the Preproduction tests, tool kit, containing all special tools required for complete disassembly of the unit, one maintenance and operation manual, and a complete test report showing the results of the manufacturer's tests. Samples, identified as required, shall be forwarded to the testing activity specified in the contract or purchase order (see 6.3).

10.1.2 Accuracy of data.- All instruments and equipment shall be calibrated often enough to insure that reported data shall have a static accuracy within 2.0 percent of the value obtained at the maximum output of the unit, except for rpm, which shall be accurate within 0.5 percent of the value obtained at the maximum output of the unit.

10.1.3 Temperature measurements.- The points of application for all temperature-measuring devices shall be as defined in an outline to be submitted by the contractor and approved by the procuring activity. Gas temperatures shall be measured with chromel alumel thermocouples or iron-constantan thermocouples where temperatures are in a suitable range, unless otherwise specified by the contractor and approved by the procuring activity. Other temperatures may be measured by calibrated mercury thermometers, or calibrated electrical-resistance-type thermometers. All temperature measurements shall be recorded in degrees Fahrenheit.

10.2 Gas-turbine power unit Preproduction tests.-

10.2.1 Test apparatus.-

10.2.1.1 Airflow.- Airflow measurements shall be made in accordance with the procedures outlined in ASME Power Test Code PTC 19.5; 4-1949, Part 5, Chapter 4, or by a method acceptable to the procuring activity.

10.2.1.2 Unit speed.- The unit speed for performance check runs during those periods when readings are being taken shall be determined by means of a positive counter which will actually count the revolutions for a period of not less than 1 minute; by an indicating tachometer and matching stroboscope disk energized by a controlled frequency source, or by other means acceptable to the procuring activity. At all other times, speed may be measured by means of an indicating tachometer.

10.2.1.3 Fuel flow.- Fuel flow measurements shall be made by either the volume or weight method. The quantity selected for the volume or weight method shall be such that each reading will cover an elapsed time of at least 1 minute. Flowmeter readings may be used for calculations of specific fuel consumption when the flowmeter has been calibrated by the volume or weight method in accordance with 10.1.2 of this appendix.

10.2.2 Test methods.-

10.2.2.1 Test units.- Two identical units, "A" and "B," shall be used for the Preproduction tests. Unit "A" shall be used for preliminary runs, Unit calibration, 200-Hour endurance test, and Recalibration. Unit "B" shall be used for the miscellaneous tests described in 10.2.2.6.1, 10.2.2.6.2, and 10.2.2.6.3 of this appendix.

10.2.2.2 Weight and other data.- The unit weight, if not previously obtained, photographs, and other pertinent data shall be obtained preferably at the time the unit is being prepared for test.

10.2.2.3 Unit calibration.- The order of conducting calibration of unit "A" shall be at the option of the contractor. The procedure shall be such as to establish the performance characteristics of the complete unit prior to the test specified in 10.2.2.4. Performance shall meet the values specified in the model specification. Operating time during this test shall be limited to the minimum practicable. Calibration shall be conducted to obtain the data required in item 10 of report form (figure 1).

10.2.2.4 200-Hour endurance test.- Following the Unit calibration test specified in 10.2.2.3, the unit shall be subjected to a 200-Hour endurance test consisting of 20 periods of 10 hours each. The test runs in each period shall be conducted in the order given unless otherwise specified by the procuring activity. The time for changing output shall not be deducted from the duration time at maximum output.

10.2.2.4.1 Sequence.- Each period of the 200-Hour endurance test shall be conducted as follows:

(a) 5 minutes at maximum output plus 5 minutes at no load plus 1 hour at normal output.

(b) 5 minutes at maximum output plus 5 minutes at no load plus 1 hour at 75 percent normal output.

(c) 5 minutes at maximum output plus 5 minutes at no load plus 1 hour at normal output.

(d) 5 minutes at maximum output plus 5 minutes at no load plus 1 hour at 50 percent normal output.

(e) 5 minutes at maximum output plus 5 minutes at no load plus 1 hour at normal output.

(f) 5 minutes at maximum output plus 5 minutes at no load plus 1 hour at 25 percent normal output.

(g) 3 hours consisting of 12 cycles at 10 minutes at no load (idle) and 5 minutes at maximum output.

10.2.2.4.2 Starts.- A minimum of 100 starts shall be made during the Preproduction test. There shall be at least 30 starts each preceded by a minimum of 2 hours shutdown. All starts accumulated during testing of the unit, including preliminary runs, may be credited to the total required. If necessary, additional starts required to bring the total to 100 may be made at the end of the endurance test.

Contents

1. Title
2. Index
3. Object
4. Summary
5. Conclusions and recommendations
6. Description (Under this heading shall be prepared a brief general description of this unit and components, and a detailed description of all features which differ from a previous model.)
7. Method of test (General description of test equipment and methods used in conducting the test.)
8. Record of test (Chronological history of all events in connection with all of the testing.)
9. Analysis of results (A complete discussion of all phases of the test, such as probable reasons for failure and unusual wear, comparison in performance with previous models, and analysis of general operation.)

10. Calibration and recalibration data The following information, as applicable, and all recorded data shall be shown by suitable curves. Recorded data, as applicable, shall include as a minimum the readings specified in item 11 below.

(a) Power output (horsepower) versus turbine outlet temperature.
(b) Bleed airflow (weight flow) versus turbine outlet temperature.
(c) Bleed air pressure versus turbine outlet temperature.
(d) Bleed air temperature versus turbine outlet temperature.
(e) Bleed airpower versus turbine outlet temperature.
(f) Unit fuel consumption versus turbine outlet temperature.

11. Data. Sufficient readings shall be recorded during the 200-Hour endurance test to obtain the data required for the tabulated data, where applicable.

(a) Power output (horsepower).
(b) Bleed airflow (lb per min).
(c) Bleed air total pressure (in. Hg abs).
(d) Bleed air total temperature (°F).
(e) Compressor inlet total pressure (in. Hg abs).
(f) Compressor inlet total temperature (°F).
(g) Turbine outlet static pressure (in. Hg abs).
(h) Turbine outlet total temperature (°F).
(i) Fuel flow (lb per hr).
(j) Fuel inlet pressure (psig).
(k) Fuel pump discharge pressure (psig).
(l) Oil consumption (lb per hr).
(m) Oil pressure (psig).
(n) Oil tank temperature (°F).
(o) Turbine speed (rpm).
(p) Barometer (in. Hg abs).

FIGURE 1. Form of report

10.2.2.5 Recalibration.- After completion of the 200-Hour endurance test specified in 10.2.2.4, a calibration check run in accordance with 10.2.2.3 of this appendix shall be made on unit "A" during which running time shall not exceed 1 hour at or above 90 percent of normal output. During this run, the output shall be not less than 95 percent of the values obtained during calibration, and fuel consumption shall not exceed 105 percent of the values obtained during calibration. The unit shall meet all other specified performance requirements which can be checked by the calibration procedure. This check run may be preceded by a run-in period during which the cleaning and adjustment procedure recommended by the contractor for field use may be applied.

10.2.2.6 Miscellaneous tests.- The following miscellaneous tests shall be conducted. Tests on unit "B" may be conducted at a Government laboratory under the supervision of the procuring activity if no other facilities are available.

10.2.2.6.1 Extreme temperature tests.-

10.2.2.6.1.1 High-temperature test.- Unit "B" shall be exposed to an ambient temperature of 160° ±5°F for a period of not less than 4 hours. It shall then be started and operated for 1 hour at maximum allowable turbine inlet temperature. During this operation period, the unit shall be supplied with air at a temperature of 130° ±5°F, and fuel at a temperature of 135° ±5°F. The fuel shall be supplied at the unit connection panel at a minimum pressure of 5 psi above the Reid vapor pressure of the fuel at that temperature.

10.2.2.6.1.2 Low-temperature test.- Unit "B" shall be exposed to an ambient temperature of -65°F for a period of not less than 72 hours. It shall then be started and operated for 1 hour at maximum allowable turbine inlet temperature. During this operation period, the unit shall be supplied with air and fuel at a temperature of -65°F.

10.2.2.6.2 Test of overspeed control.- With the normal speed governing system rendered inoperative, unit "B" shall be overspeeded at no load until the overspeed control functions. This test shall be repeated until the overspeed control has demonstrated, on 10 consecutive trials, ability to limit the unit speed to the maximum permissible value shown in the model specification.

10.2.2.6.3 Alternate fuel test.- Unit "B" shall be subjected to an alternate fuel test, using fuel conforming to Specification MIL-F-5572 of the grade having the specified maximum lead content. This Alternate fuel test schedule shall be as specified in 10.2.2.4, 10.2.2.4.1, and 10.2.2.4.2 of this appendix, except that the times of running at each condition shall be proportionately reduced, in order that the total duration of the Alternate fuel test is 50 hours and the number of starts required is 25; with 10 starts each preceded by a 2-hour shutdown. Performance ratings shall not apply to operation on fuel conforming to Specification MIL-F-5572.

10.2.2.6.4 Lubrication check.- Unless otherwise specified by the procuring activity, observations of unit oil pressures shall be made to determine conformance with applicable requirements of the specifications under which the unit was built.

10.2.2.6.5 Oil drainage.- After completion of the 200-Hour endurance test specified in 10.2.2.4 on unit "A," conformance with the oil drainage requirements of 3.24.7 shall be determined.

10.2.2.7 Test operating conditions.-

10.2.2.7.1 Except as specified herein, tests shall be run at prevailing ambient laboratory conditions. The fuel and oil used, the conditions of loading, and the rated loads shall be as specified for the unit ratings in the model specification.

10.2.2.7.2 The oil system shall be drained and filled with new oil at the start of the 200-Hour endurance test specified in 10.2.2.4, and thereafter shall be maintained in accordance with the requirements of the contractor as approved by the procuring activity.

10.2.2.7.3 Intervals of endurance test operation of less than 1/2-hour duration terminated by any unit failure shall not be credited to the required test time. Endurance test time shall not be credited by increments shorter than 30 minutes, except when shorter periods are a test requirement.

10.2.2.7.4 Wet and dry bulb air temperature readings shall be taken at intervals not exceeding 3 hours.

10.2.2.7.5 The room barometer shall be read and recorded at intervals not exceeding 3 hours.

10.2.2.7.6 The date, operating schedule, unit model designation, and serial number shall be recorded on each log sheet.

10.2.2.7.7 Notes shall be placed on the log sheets of all incidents of the run, such as leaks, vibration, and any other irregular functioning of the unit or the equipment, and corrective measures taken.

10.2.2.7.8 Correction.- Readings of airflow, fuel flow, gas pressures, and gas temperatures shall be corrected to NACA standard sea level atmospheric conditions, as defined in NACA TN 3182 by the method specified in the model specification.

10.2.2.7.8.1 The barometer shall be corrected for temperature.

10.3 Components tests.- The following Components tests shall be conducted. Approval of the Components tests shall be obtained prior to the acceptance of the gas-turbine compressor or auxiliary powerplant as a service type or model. All components shall be substantially identical with those used on the 200-Hour endurance test specified in 10.2.2.4.

10.3.1 Previous component approval.- All gas-turbine compressor or auxiliary-powerplant components requiring testing as specified herein may have these requirements waived at the option of the procuring activity, if the component has been previously approved for service use on another unit. All such components shall be substantially identical with the components previously approved, with the exception of the mounting provisions. If such a waiver is granted, information on the components for which previous approval was obtained shall be provided in the Preproduction test report prior to approval of the gas-turbine power unit.

10.3.2 Simulated operational tests.- The following tests pertain only to fuel system, all controls, and ignition-system components, except that tests of additional components shall be conducted when specified in the contract.

10.3.2.1 Test conditions.- All components shall be cleaned of oil, grease, or other corrosion-preventative compound prior to the start of any testing. Insofar as practicable, components shall be mounted in their normal positions as mounted on the gas-turbine compressor or auxiliary powerplant. Test assemblies or components shall be subjected to operating loads simulating those encountered on the gas-turbine compressor or auxiliary powerplant. 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.

10.3.2.1.1 All components shall be supplied with such fluids as they normally handle or contact, except that components normally in contact with fuel shall be supplied with the test fluids specified below. There shall be no traces of external fluid leakage from any component.

10.3.2.1.2 Test cycles.- Unless otherwise specified, appropriate test cycles, consistent with the following requirements, shall be used for these tests.

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

(b) Components in test assemblies shall function in approximately their normal sequence of operation.

(c) Cycling shall be controlled by varying simulated inputs to the test assembly or component. Gas-turbine compressor or auxiliary powerplant-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 variable.

(e) Components designed to prevent the gas-turbine compressor or auxiliary powerplant from exceeding its operating limits, but which are not actuated by simulated normal operation, shall be actuated at least once during each cycle by causing their input variables to reach the necessary range of values.

10.3.2.2 Component calibration.- Prior to the initiation of the Simulated operational tests specified in 10.3.2, each component for which the establishment of input-output relationships is a function of the component shall be subject to a calibration. The calibration shall be extensive enough to cover the entire steady-state and dynamic ranges of operation of the component on the gas-turbine compressor or auxiliary powerplant, and shall indicate conformance with the design-tolerance range of the component. Components not subject to calibration shall be operated under normal operating conditions to demonstrate satisfactory functioning. Each calibration shall be recorded. Calibrations shall be conducted using test fluid in accordance with Specification MIL-F-7024.

10.3.2.3 Procedures.- All Simulated operational tests specified in 10.3.2 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 gas-turbine compressor or auxiliary powerplant, except where otherwise specified. However, subassemblies or components of a system may be tested separately at the contractor's option if such separation does not prevent simulation of the complete function of the components or subassemblies. At the option of the contractor and with the approval of the procuring activity, alternate testing of components or subassemblies may be conducted on gas-turbine compressors or auxiliary powerplants substantially like the 200-Hour endurance test compressor or powerplant in lieu of all or part of the tests specified hereunder.

10.3.2.3.1 Accelerated aging.- Upon completion of the component calibrations, all nonmetallic components shall be placed dry, in an air oven, and maintained in an ambient temperature of not less than 160°F for a minimum period of 168 hours. Components are not required to be aged in test assemblies.

10.3.2.3.2 Salt water.- Upon completion of the Accelerated aging test specified in 10.3.2.3.1, necessary test assemblies shall be assembled. Each fuel- and control-system test assembly shall undergo functional cycling for 30 minutes while supplied with test fluid conforming to Specification MIL-H-3136, type III. At the end of this period, 1 pint of salt water conforming to the requirements of the paragraph entitled "Salt Solution" of Specification QQ-M-151 shall be introduced into the inlet of each test assembly. After the introduction of salt water, the supply of test fluid shall be

resumed 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 72 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.

10.3.2.3.3 High temperature.- Upon completion of the Salt water test specified in 10.3.2.3.2, each test assembly or component shall be maintained in an ambient temperature above 200°F or 105 percent of the maximum Fahrenheit ambient temperature which it will encounter in normal service use, whichever is higher. After reaching and remaining at this temperature for at least 1 hour, each test assembly or component shall be operated as specified below.

10.3.2.3.3.1 Fuel and control systems.- Each fuel- and control-system test assembly or component shall be operated according to an appropriate test cycle for a minimum period of 50 hours and 3,000 cycles. Components normally in contact with fuel shall be supplied with fluid conforming to Specification MIL-H-3136, type III, at a temperature of 135° ±5°F. Other fluids, as required, shall be maintained at a temperature of 135° ±5°F.

10.3.2.3.3.2 Ignition system.- Ignition-system test assemblies shall be operated in accordance with the following schedule until a total of 300 hours of such operation has been accumulated. During the first 150 hours of the test, the input voltage to the system shall be 29 volts, dc. For the second 150 hours of the test, the input voltage shall be 14 volts, dc.

(a) 23 hours in periods of 30 minutes each. Each period shall be divided as follows:

2 minutes - ignition on.
3 minutes - ignition off.
2 minutes - ignition on.
23 minutes - ignition off.

(b) 2 hours of alternate periods during which the ignition system shall be on for 5 minutes and off for 55 minutes.

10.3.2.3.4 Room temperature endurance.- Upon completion of the High-temperature test specified in 10.3.2.3.3, each fuel-system and control-system test assembly shall undergo functional cycling for at least 400 hours, or 24,000 cycles, whichever shall represent the longer period. Test assemblies containing components normally in contact with fuel shall be supplied with fluid conforming to Specification MIL-H-3136, type I. After 250 hours of cycling, the fluid entering the system shall be contaminated with at least 8 grams per 1,000 gallons of fluid for 150 hours, except that the last 2 hours shall be performed with fluid containing 80 grams per 1,000 gallons. The fluid contaminant shall be considered to consist of not less than 68 percent SiO_2 and shall have a particle-size analysis as specified in 3.5.2. During the testing covered by this paragraph, the fuel filter shall be cleaned as recommended by the gas-turbine compressor or auxiliary-powerplant manufacturer, but at intervals representing a cumulative fuel flow equivalent to not less than that obtained in 10 hours operation at normal output. Control of ambient or fluid temperatures shall not be required during this test. During this test, the inlet fuel pressure at the pump in each test assembly shall not exceed 15 psi absolute. Following the test period, the pumps shall be operated at the maximum flow and discharge pressure required by the gas-turbine compressor or auxiliary powerplant until 400 hours at these conditions has been accumulated, including the time during the cycling period. The time accumulated on pumps at the specified conditions during cycling may be included in the total test time required for the pumps. By the end of this test, all pumps shall have been exposed to fluid conforming to Specification MIL-H-3136, type I, for at least 400 hours.

10.3.2.3.5 Low temperature.- Upon completion of the Room temperature endurance test specified in 10.3.2.3.4, each test assembly or component shall be soaked in ambient temperature of lower than -65°F for a period of 72 hours. Upon completion of soaking, this temperature shall be maintained while each assembly or component is operated as detailed below. During the entire Low-temperature test, fluid conforming to Specification MIL-H-3136, type I, shall be present in each test assembly or component containing parts normally in contact with fuel.

10.3.2.3.5.1 Fuel and control systems.- At least 10 simulated gas-turbine compressor or auxiliary-powerplant starts shall be performed. Each start shall be preceded by a soaking period sufficient to reduce the fluid temperature below -65°F. Each start shall be followed by a maximum of 2 hours of functional cycling or 120 cycles, whichever represents the longer period. During each cycling period, the test fluid inlet temperature may gradually rise until it reaches -30°F. If -30°F is reached before completion of the cycling period, the cycling shall be stopped and a start shall be made when the fluid temperature has been returned to below -65°F. The cycling time of the test shall total 20 hours or 1,200 cycles, whichever represents the longer period.

10.3.2.3.5.2 Ignition system.- While at a temperature of below -65°F each ignition system test assembly shall successfully start and operate at least six consecutive times. Each start shall be preceded by a minimum 3-hour soaking period followed by 3 minutes of continuous operation. Half of the starts shall be made when the system is supplied with 14 volts, dc and the remainder when the system is supplied with 29 volts, dc.

10.3.2.3.6 Cavitation - fuel pump.- The fuel system from the inlet of the gas-turbine compressor or auxiliary powerplant to the pump shall be simulated in the test assembly. This assembly will include lines, fittings, filter, and any other pumps that are part of the gas-turbine compressor or auxiliary-powerplant fuel system. The filter shall have had fluid passed through it at normal compressor or powerplant fuel flow for 2 hours. This fluid shall have been contaminated with at least 80 grams of foreign matter as defined in 3.5.2 per 1,000 gallons of fuel for fuel contamination. Clean fluid may be used to conduct the test. Test fluid shall be high vapor pressure fuel. The pumps shall be operated for 50 hours at maximum output and at the maximum flow and discharge pressure required by the gas-turbine compressor or auxiliary powerplant. The fluid-to-vapor ratio at the compressor or powerplant inlet shall be maintained at not less than 0.45, and the fluid temperature shall be at least 100°F. At the beginning of the test and after each 10 hours of testing, a sample shall be taken from the test fluid to insure that the vapor liquid ratio does not fall below the value specified above.

10.3.2.3.7 Recalibration.- Upon completion of the Low-temperature test specified in 10.3.2.3.5, component calibrations shall be repeated, and shall indicate that no component has changed its calibration beyond allowable service limits. Components not subject to calibration shall be operated under normal operating conditions to demonstrate satisfactory functioning. During recalibration, the same fluids shall be used as in the calibration. All components shall then be disassembled. All parts shall show no indication of failure or of unusual wear. Each calibration shall be recorded.

10.3.3 Electrical interference test.- The electrical system shall be tested as outlined below for conformance to the interference limitations of Specification MIL-I-6181.

(a) The radiated interference level shall be tested at frequencies up to 150 megacycles.

(b) The test antenna shall be located at the maximum radiated interference level at a distance of 6 feet from the unit.

(c) Radiated and conducted interference tests shall not be conducted during the starting cycle.

10.4 Teardown inspection.- After completion of the recalibration run specified in 10.2.2.5 on unit "A," and after the Alternate fuel test specified in 10.2.2.6.3 on unit "B," the unit and components shall be completely disassembled for examination of parts, and for measurements as necessary to disclose excessively worn, distorted, or weakened parts.

10.4.1 Oil tank.- If an external oil tank is furnished as a component part of the unit, the tank with filler cap installed shall be subjected to a positive, minimum internal air pressure of 15 psig, or twice the tank operating pressure, whichever is greater, for 10 minutes. No signs of leakage shall appear when the tank is submerged in water, with the internal air pressure as above.

10.5 General inspection.- At convenient times prior to the tests and during teardown inspections, the unit and components shall be examined to determine if they conform to all requirements of the contract and specifications under which they were built. At no time during the test shall any part of the unit be removed, disassembled for examination, or adjusted without prior approval of the witnessing representative of the procuring activity.

10.6 Parts failures.- If, during the Preproduction tests, a part fails, a new Preproduction test may be started on a new unit with a redesigned part or one of different material, or the witnessing representative of the procuring activity may authorize the installation of a new part of original design and material for one which failed owing to faulty material or workmanship. The Preproduction tests on each unit shall be considered complete when every major part of the unit has been subjected to the complete test. At the discretion of the procuring activity, redesign and retesting may be required of any part which fails, or indicates weakness after completing its Preproduction tests.

10.6.1 Components.- The above procedure shall apply in the event of parts failure during approval of components except that, at the discretion of the procuring activity, a rerun of the component Preproduction tests or the unit Preproduction tests, or any portion thereof, may be waived.

10.7 Additional tests.- The Government reserves the right to conduct such additional tests as may be considered necessary to determine conformance with applicable requirements.

APPENDIX II

POWER UNITS; AIRCRAFT AUXILIARY, GAS-TURBINE-TYPE, ACCEPTANCE TESTS FOR

20. QUALITY ASSURANCE PROVISIONS

20.1 General.- Auxiliary power units, components, and test apparatus, and the material entering into the manufacture thereof shall be subject to inspection by authorized Government Inspectors who shall be given reasonable facilities to determine conformance with this appendix. All instructions for the testing of units shall be submitted to the Inspector for his information and guidance. Previous acceptance or approval of material, or release of any design by the procuring activity, shall in no case be construed as a guaranty of the acceptance of the finished product.

20.2 Test conditions.-

20.2.1 Test apparatus.-

20.2.1.1 Unit speed.- The unit speed for performance check runs at normal and maximum ratings shall be determined by means of a positive counter which will actually count the revolutions for a period of not less than 1 minute, by an indicating tachometer and matching stroboscope disk energized by a controlled frequency source, or by other means acceptable to the procuring activity. At all other times, speed may be measured by means of an indicating tachometer.

20.2.1.2 Fuel flow.- Fuel flow measurements shall be made by either the volume or weight method. The quantity selected for the volume or weight method shall be such that each reading will cover an elapsed time of at least 1 minute. Flowmeter readings may be used for calculations of specific fuel consumption when the flowmeter has been calibrated by the volume or weight method in accordance with 20.2.3 of this appendix. Fuel flow quantities shall be reported on the weight basis. The specific gravity of the fuel shall be noted on the Acceptance Test Log Sheet (see 20.10 of this appendix).

20.2.1.3 Airflow.- Airflow measurements shall be made in accordance with the procedures outlined in ASME Power Test Code PTC 19.5; 4-1949, Part 5, Chapter 4, or by a method acceptable to the procuring activity.

20.2.1.4 Temperature and pressure measurements.- All temperature measurements shall be recorded in degrees Fahrenheit. Gas temperature measurements shall be accomplished using the type, number, and location of temperature-sensing elements as specified in the model specification. All oil and fuel pressures shall be recorded in psi gage. All air or gas pressures shall be recorded in in. Hg abs or psi gage, whichever is applicable.

20.2.2 Fuel and oil.- Fuel and oil used for all testing, including preliminary runs, shall be as specified in the model specification.

20.2.3 Accuracy of data.- All instruments and equipment shall be calibrated often enough to insure that reported data shall have a static accuracy within 3 percent of the value obtained at the maximum output of the unit.

20.3 Preliminary runs.- The nature and extent of the running-in prior to the Acceptance tests shall be determined by the contractor.

20.4 Acceptance tests.- The Acceptance tests shall be conducted on each production unit and shall consist of tests specified under Schedule "A" or "B." All production units shall be acceptance tested under Schedule "A" until such time as the penalty run and parts replacement record warrants the use of Schedule "B," as determined by the procuring activity. Units to be tested by either schedule shall be selected by the Government Inspector.

20.4.1 Schedule "A." - Schedule "A" shall consist of the following requirements.

20.4.1.1 Initial run.- The unit shall be subjected to a 1-1/2 hour initial run in accordance with the following schedule:

(a) Start and accelerate to governed speed.

(b) 15 minutes at no load.

(c) 15 minutes at normal rated output.

(d) 15 minutes at 25 percent of normal rated output.

(e) 5 minutes at maximum rated output.

(f) 15 minutes at 50 percent of normal rated output.

(g) 15 minutes at 75 percent of normal rated output.

(h) 10 minutes at normal rated output.

20.4.1.1.1 Initial run test data.- For each run at the loadings specified for the initial run, instrumentation shall be provided, readings shall be taken, and the necessary calculations shall be made to obtain the following data, as applicable. These data shall be corrected for the effects of ambient conditions to NACA standard sea level day performance by the method specified in the model specification. The corrected data shall be recorded on the Acceptance test report.

(a) Output torque lb - ft.

(b) Output horsepower.

(c) Bleed airflow - lb per min.

(d) Bleed air total pressure - in. Hg abs.

(e) Bleed air total temperature - °F.

(f) Bleed airpower - ft lb per min.

(g) Fuel consumption - lb per hr.

(h) Maximum oil temperature during run °F.

(i) Duration of turbine inlet temperature in excess of maximum permissible value specified in the model specification - sec.

(j) Maximum and minimum oil pressure during run - psig.

(k) Compressor inlet air total temperature - °F.

(l) Barometric pressure - in. Hg abs.

(m) Unit speed - rpm.

20.4.1.2 Additional runs.- Any special units not covered above shall be subjected to additional runs as may be required by the procuring activity. Such runs shall be for the purpose of testing special features and will not mutually increase the duration of the Acceptance tests of the basic unit as outlined in this specification. Any additional runs required by the procuring activity shall be specified in the model specification.

20.4.1.3 Inspection after initial runs.- After completion of the initial and additional runs, the unit shall be disassembled sufficiently to allow a detailed inspection of working parts. The extent of disassembly shall be the option of the Government Inspector. If any part is found to be defective, an approved part shall be supplied to replace it and, at the discretion of the Inspector, a penalty run of suitable duration shall be made.

20.4.1.4 Penalty run.- The maximum penalty run shall be double the initial run, and any failure during this run shall cause the unit to be rejected. Additional run-in prior to the penalty run may, at the option of the contractor, be performed for the accommodation of replaced parts.

20.4.1.5 Inspection after penalty run.- Upon completion of the penalty run, the unit shall, at the discretion of the Inspector, be disassembled to allow for inspection of replaced parts.

20.4.1.6 Final run.- The final run shall be a complete repetition of the "initial run" and "additional runs," if any. Performance checks on automatic starting, overspeed control, radio interference, and turbine inlet temperatures shall be made and recorded during this run, and shall conform to the values specified in the model specification.

20.4.2 Overspeed test.- With the normal speed governing system rendered inoperative, the unit shall be overspeeded at no load until the overspeed control functions. This test shall be repeated until the overspeed control has demonstrated, on five consecutive trials, the ability to limit the unit speed to the maximum permissible value shown in the model specification.

20.4.3 Radio interference level.- All first production units shall be subjected to a Radio interference level test as outlined below to demonstrate compliance with the interference limitations of Specification MIL-I-6181, until 10 consecutive units have passed the test without reworking. Thereafter, the Inspector shall select one unit from each lot and subject it to the test. A lot shall consist of 10 consecutive units of the same model or models, provided identical electrical systems are used on each model in the lot.

20.4.3.1 When a unit modification is made which might affect the radio interference level, all units incorporating the modification shall be tested as outlined below until 10 consecutive units have passed the test without reworking. Thereafter, the Inspector shall select one unit from each lot and subject it to the test.

20.4.3.2 The following test conditions shall apply to the Radio interference level tests:

(a) The radiated interference level shall be tested at frequencies up to 150 megacycles.

(b) The test antenna shall be located at the maximum rated interference level at a distance of 6 feet from the unit.

(c) Radiated and conducted interference tests shall not be conducted during the starting cycle.

20.4.4 Automatic start test.- Each unit shall demonstrate satisfactory functional operation of automatic start controls by five consecutive successful automatic starts at no load. These starts may be accomplished during the initial run.

20.5 Schedule "B." - Schedule "B" shall consist of the requirements specified in 20.4.1.1, followed by an inspection as detailed in the model specification.

20.6 Stoppages.- Stoppage from any cause may, at the option of the Inspector, require a repetition of the particular period during which the stoppage occurred. Fuel and oil leaks will be considered as stoppages. If on close inspection at the completion of the final run fuel or oil leaks are discovered, a check run or a complete final run shall be made after the leak is sealed if deemed necessary by the Inspector.

20.7 Criteria for acceptance.- A production unit shall have passed the Acceptance tests if the following requirements have been met.

20.7.1 Initial run performance.- The corrected performance data shall demonstrate that the unit meets the performance ratings specified in the model specification. In addition, the operating gas temperatures, oil temperatures, oil pressures, and unit speed shall be within the permissible limits specified in the model specification.

20.7.2 Overspeed test.- At no time during the Overspeed test shall the unit speed exceed the maximum allowable value specified in the model specification.

20.7.3 Radio interference tests.- The radiated and conducted interference levels of the unit, when tested as specified above, shall not exceed the permissible limits specified in Specification MIL-I-6181.

20.7.4 Automatic start tests.- A successful start shall be defined as continuous acceleration from actuation of the start switch to idling speed within the times specified in the model specification.

20.7.5 Inlet temperature.- The maximum turbine inlet temperature shall not exceed the maximum permissible transient and steady-state values specified in the model specification.

20.8 Additional tests.- Satisfactory performance in any additional tests shall be defined as demonstration of conformance with the requirements for that component or control specified in the model specification..

20.9 Rejection and retest.-

20.9.1 Retest.- Whenever, in the opinion of the Inspector, there is evidence of insufficient output or other malfunctioning of the unit, the difficulty shall be investigated and its cause corrected to the satisfaction of the Inspector before the test is continued. If such investigation requires disassembly involving any internal moving part of the unit proper, the portion of the test in which the difficulty was encountered shall, at the option of the Inspector, be repeated.

20.9.2 When any unit fails to pass the Radio interference level test, all subsequent units shall be tested until 10 consecutive units have passed the test without reworking. Units which have been rejected may be reworked to correct the defects and resubmitted for testing. Before resubmitting, full particulars concerning previous rejection and action to correct the original defects shall be furnished the Inspector.

20.9.3 Maximum hours of running.- If any unit, other than an experimental unit, requires more than 15 hours of running under its own power at 50 percent of normal-rated output or above, in connection with its test under this appendix, including preliminary runs or running-in when performed, it shall stand rejected. Parts and components from these rejected units may be used in other units being built, provided these parts and components are not worn or defective to an extent which will prevent their being reconditioned sufficiently to enable them to pass the detailed inspection required for similar unused parts or components. Parts and components from rejected units shall not be resubmitted for inspection without full particulars being given to the Inspector concerning previous rejection of the unit.

20.10 Acceptance test log.- The contractor shall prepare Acceptance Test Log Sheets for each unit, two copies of which shall be supplied to the procuring activity.

APPENDIX III

POWER UNITS; AIRCRAFT AUXILIARY, GAS-TURBINE-TYPE
MODEL SPECIFICATION FOR
(OUTLINE AND INSTRUCTIONS FOR PREPARATION)

30. SCOPE

30.1 This appendix establishes the form to be used by manufacturers in the preparation of gas-turbine auxiliary power unit model specifications.

40. APPLICABLE DOCUMENTS

40.1 The following specification, of the issue in effect on date of invitation for proposals, forms a part of this appendix to the extent specified herein:

SPECIFICATIONS

MIL-P-8686 Power Units; Aircraft Auxiliary, Gas-Turbine-Type, General Specification for

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

50. APPLICATION

50.1 A complete gas-turbine auxiliary power unit model specification in accordance with the outline and instruction for preparation as specified herein, shall be prepared for each specific model. New power unit model designations will be assigned by the Government. When a new model designation is assigned, a new power unit model specification shall normally be prepared with a new specification number assigned thereto by the unit manufacturer. It is desired that no new power unit model designation be implemented by appendixes, or variants to an existing model specification, and in no case shall amendments be used for this purpose. No changes to a power unit model specification shall be submitted to the procuring activity by means of amendments or revision pages prior to the time when the power unit model specification is approved and becomes a part of a contract. Revisions, by amendment form, to an approved power unit model specification which has been released and forming a part of a contract will be acceptable to the procuring activity. Each amendment shall be approved, and shall include and supersede the previous amendment.

50.2 The headings and numbering of sections and paragraphs herein correspond to those of the basic specification for the specific data needed only in the model specification. Omission of reference in the model specification to a particular requirement of the basic specification shall be interpreted as compliance therewith. When departures are necessary from the requirements of this appendix and of the basic specification, the details of such departures shall be stated as specific requirements bearing the same section and paragraph heading and numbering as in the basic specification.

50.3 Parenthetical sentences, phrases, and words are included herein for the guidance of the auxiliary power unit manufacturer for insertion of proper information and data related thereto, in connection with the preparation of the model specification. Parenthetical statements shall not be copied verbatim in the model specification.

50.4 The specification number shall be the number assigned by the powerplant manufacturer. When revisions are made, they shall be designated by the use of a dash and a letter following the number, with a revision date therefor, which shall be shown on page 1 only. Only the specification number, and the revision suffix letter if applicable, shall be shown on the subsequent pages.

50.5 For purposes of permitting preliminary evaluation of a proposed gas-turbine auxiliary power unit design, or for release of approved auxiliary power unit performance characteristics in connection with an aircraft or aircraft equipment design competition, the power unit manufacturer may submit a preliminary model specification to serve until superseded by a complete coordinated model specification which will be required for a production contract.

50.5.1 The preliminary model specification shall be prepared in accordance with the requirements stipulated herein, except that, at the option of the manufacturer, the information requested in paragraph numbers preceded by an asterisk (*) may be omitted.

60. MODEL SPECIFICATION

60.1 The form and description of the Model specification follow.

(Number and title.- The number and title shall be as follows:)

(Spec No.) _____
(Date) _____
(a) Revised _____ (Date)
(b) Revised _____ (Date)

MODEL SPECIFICATION

POWER UNIT; AIRCRAFT AUXILIARY, GAS-TURBINE-TYPE

(Insert Service type and model designation if assigned)

(NAME OF CONTRACTOR)

1. SCOPE

1.1 Scope.- This specification covers the standard requirements for the _____ (insert the Service type and model designation) gas-turbine auxiliary power unit hereinafter described as the unit(s).

1.2 Classification.- The _____ (insert type and model) gas-turbine auxiliary power unit is a _____ (insert briefly the description of the salient features of this model.)

2. APPLICABLE DOCUMENTS

2.1 The following specification, of the issue in effect on date of invitation for proposals, forms a part of this specification to the extent specified herein:

SPECIFICATIONS

Military

MIL-P-8686 Power Units; Aircraft Auxiliary, Gas-Turbine-Type, General Specification for)

(List all additional Government publications not covered in this specification which are applicable to the unit.)

3. REQUIREMENTS

3.1.1 Critical materials.- The estimated weight of the following critical materials based on the finished parts plus manufacturing scrap losses, but excluding mill and melt losses required in the construction of the gas-turbine power unit is as follows:

Chromium	----- lb
Cobalt	----- lb
Columbium	----- lb
Molybdenum	----- lb
Natural rubber	----- lb
Nickel	----- lb
Tungsten	----- lb

3.5 Performance characteristics.- The ratings and curves shown are based on the terms and standard conditions defined herein.

3.5.4 Ratings.- The performance ratings shall be as listed in table I (use applicable column headings). These data are based on the use of fuel conforming to Specification MIL-F-5161 and oil conforming to Specification (MIL-O-6081) grade (1010). (If other fuels or oils have been approved by the procuring activity, the approved fuels and oils shall be specified.) These data contemplate no restriction of the air inlet and outlet, and exhaust, and no loading of the accessory drives, or generator, if such is installed. Rated performance shall be obtained at normal governed speed under the sole control of the automatic control system.

TABLE I

Performance ratings

Output	Power output hp	Bleed airflow lb/min	Fuel consumption lb/hr (nominal)	Bleed air press. ratio	Output shaft speed rpm (nominal)	Bleed air temp °F	Turbine out temp °F
Maximum							
Normal							
75 percent normal							
50 percent normal							
No load							

3.5.5 Estimates.- Estimated performance curves shown in figures 1 to ____ (insert applicable number) inclusive, shall constitute part of this specification. These curves indicate estimated performance attained under standard conditions and under operating conditions as specified in 3.5.4 entitled "Ratings." (The following estimated performance curves shall illustrate the performance obtainable and shall be consistent with the rated performance. Points of rated performance shall be indicated on the sea level curves.) (For examples of figures, see figures 1 to 8.)

3.5.5.1 Estimated performance curves.- (Curves showing the estimated performance of the unit at various altitudes from sea level up to the maximum altitude specified herein, shall be furnished, if applicable.)

NOMINAL GOVERNED SPEED
STANDARD SEA LEVEL PRESSURE
FUEL LOWER HEATING VALUE -
BTU/LB TRANSPOSE FUEL CURVE
ACCORDING TO THE LOWER
HEATING VALUE OF THE FUEL
USED.

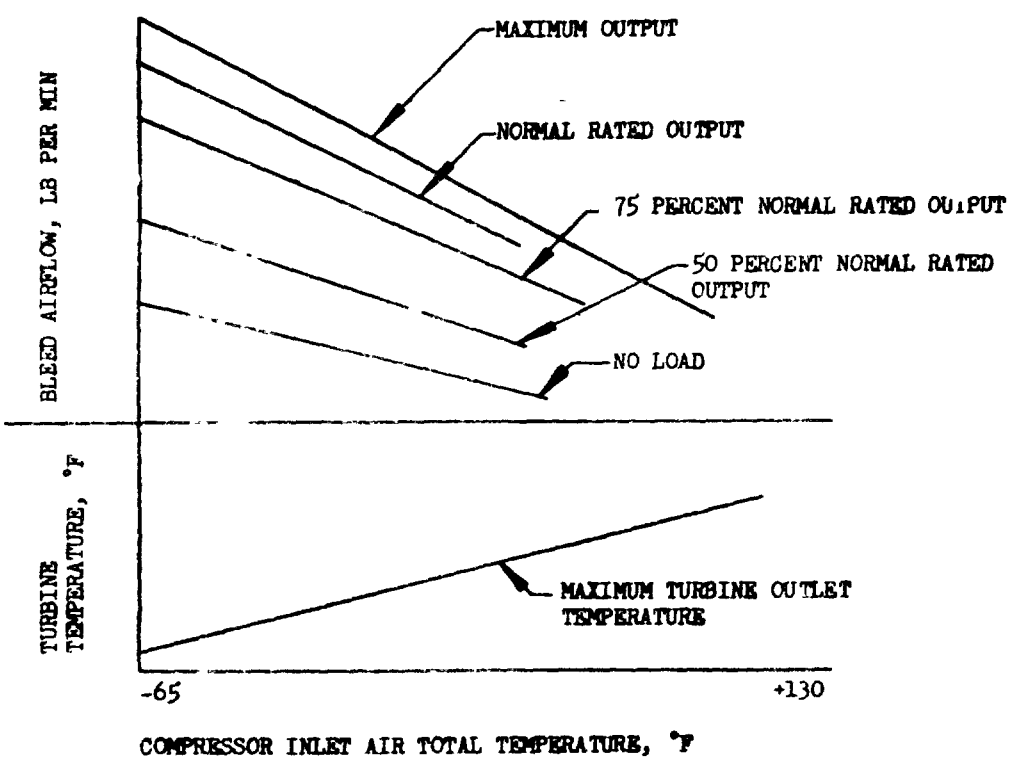


FIGURE 1. Performance characteristics for types II, III, and IV

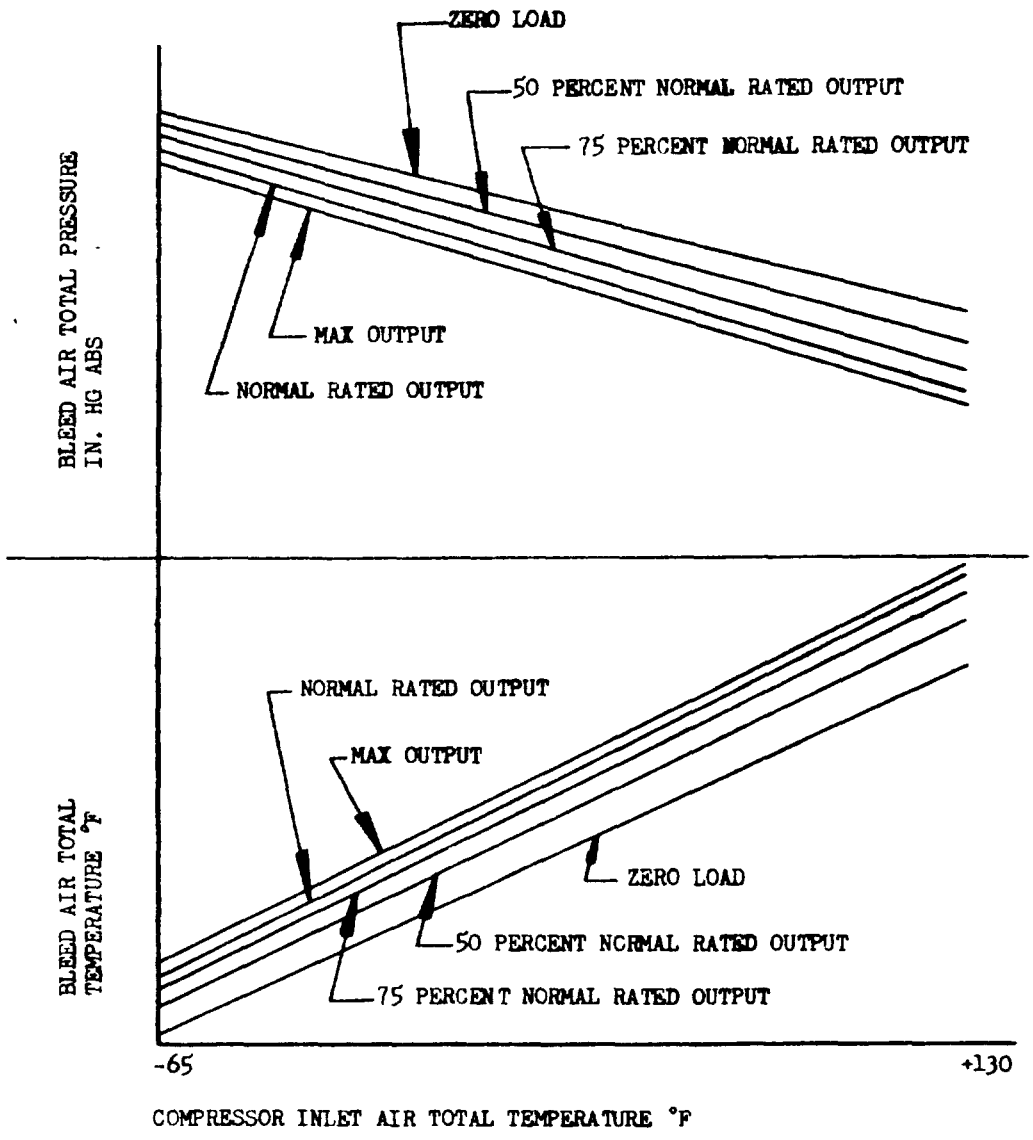


FIGURE 2. Bleed air characteristics for types II, III, and IV

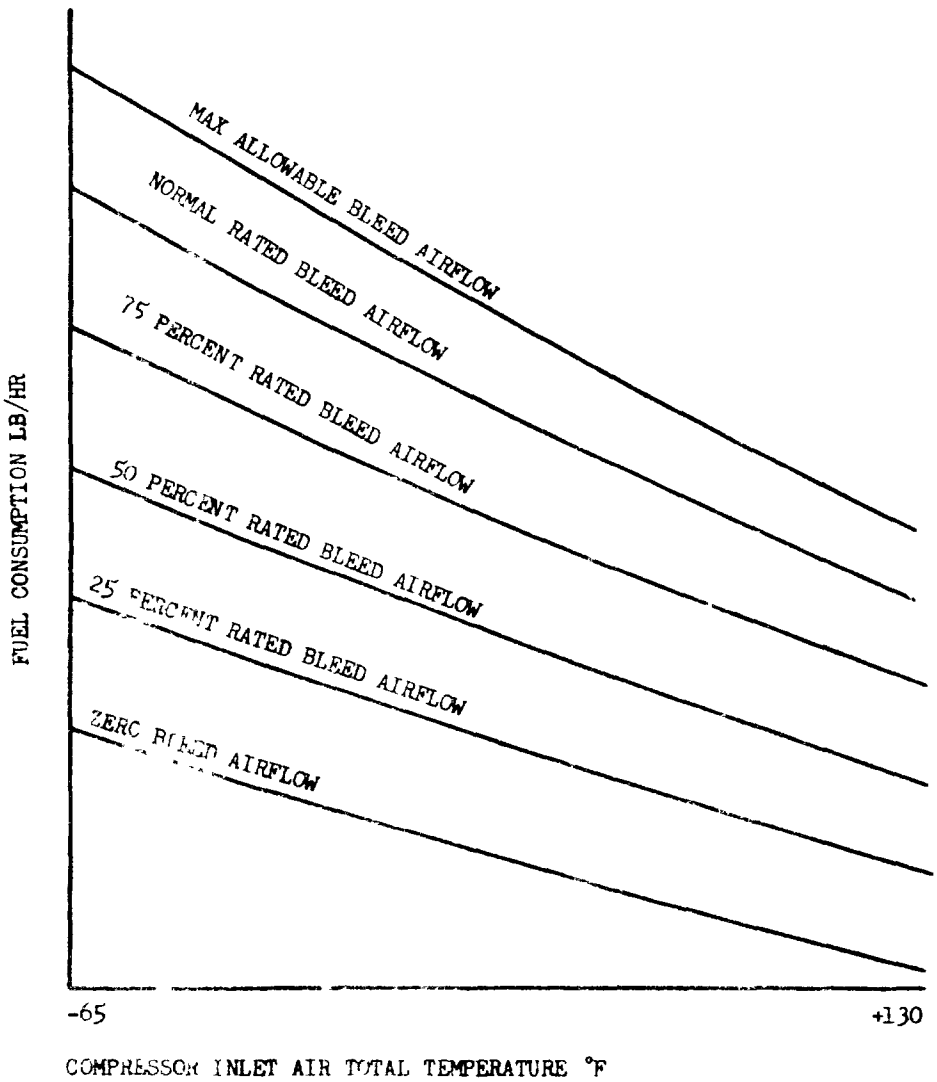


FIGURE 3. Fuel consumption for types II, III, AND IV

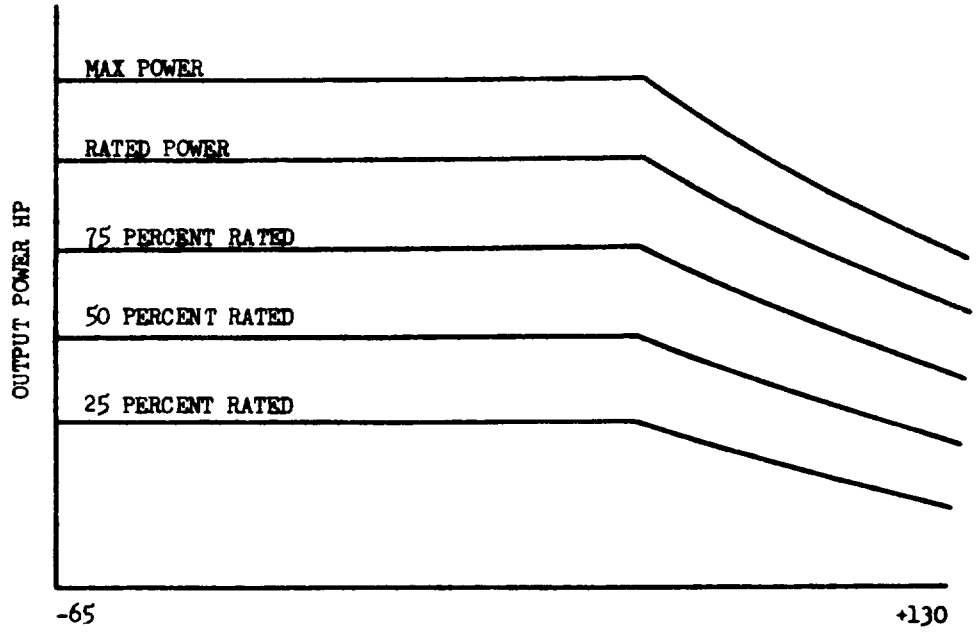


FIGURE 4. Nominal performance types I and IV

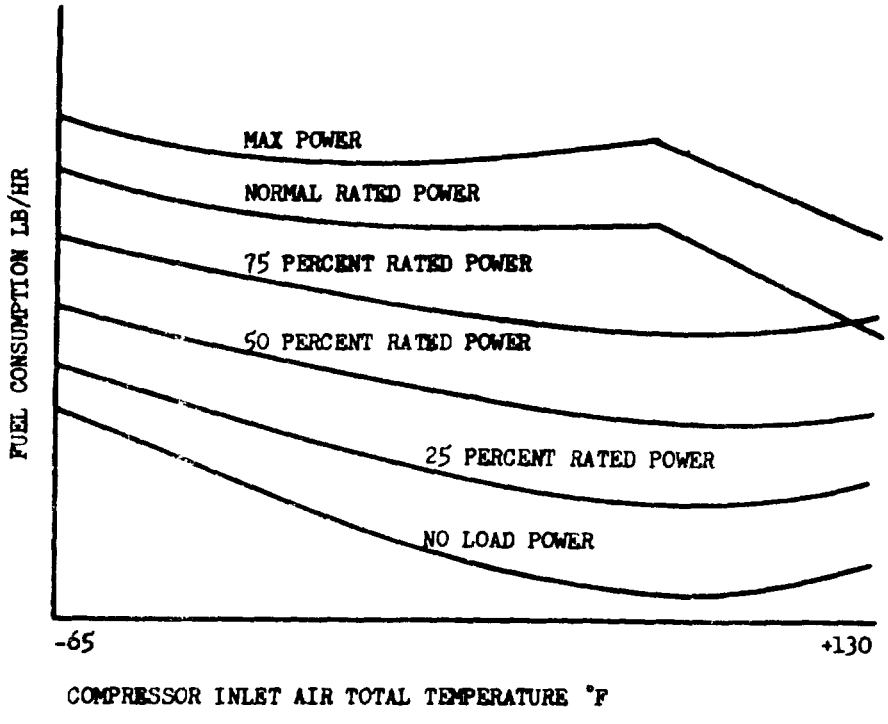


FIGURE 5. Nominal performance types I and IV

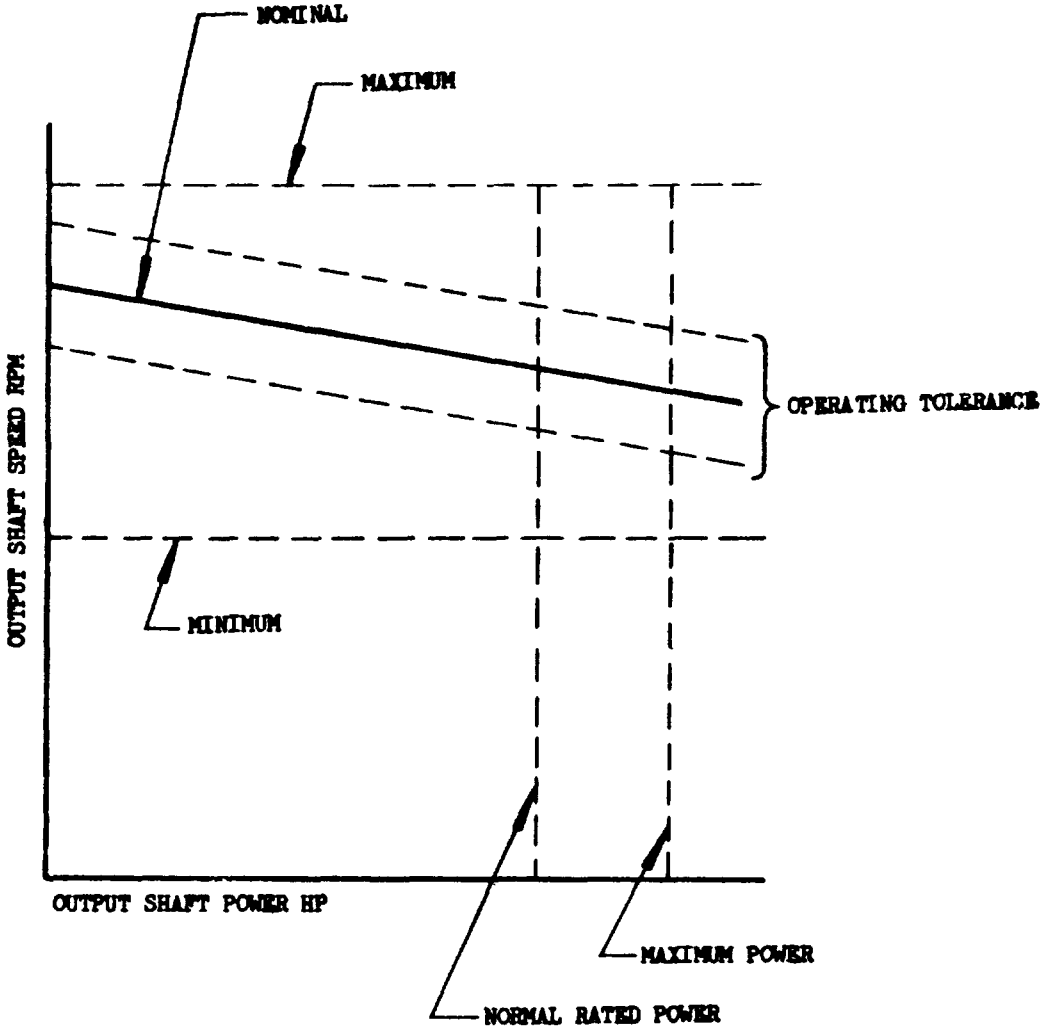


FIGURE 6. Nominal performance types I and IV

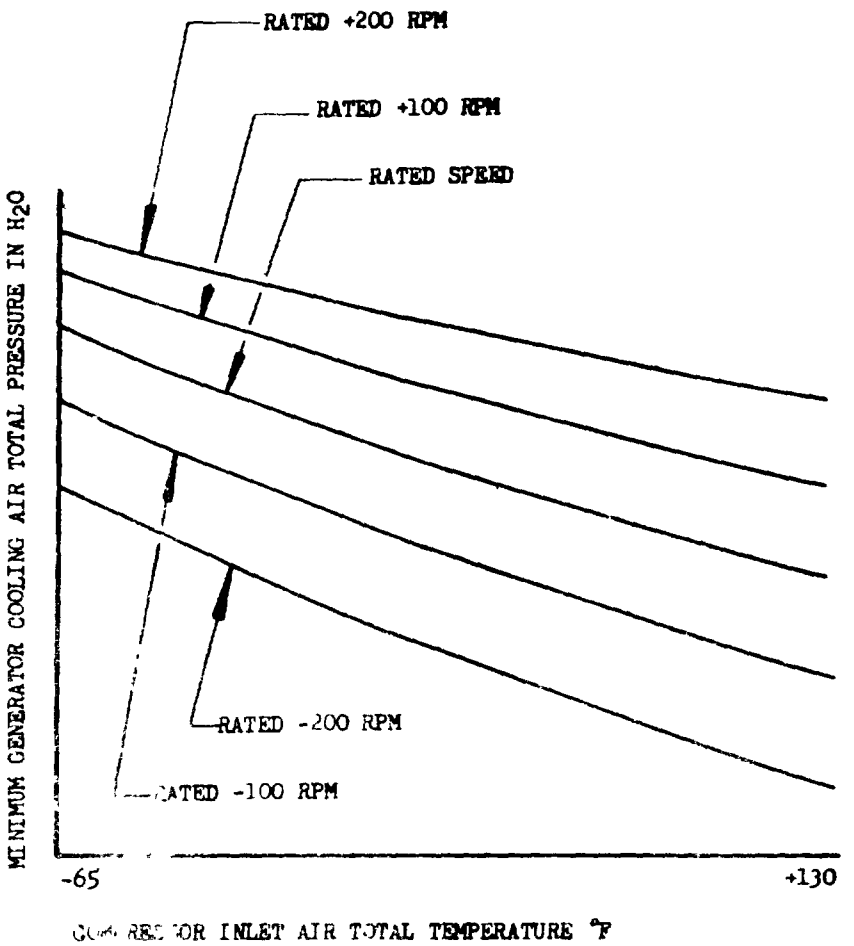


FIGURE 7. Nominal performance types I and IV

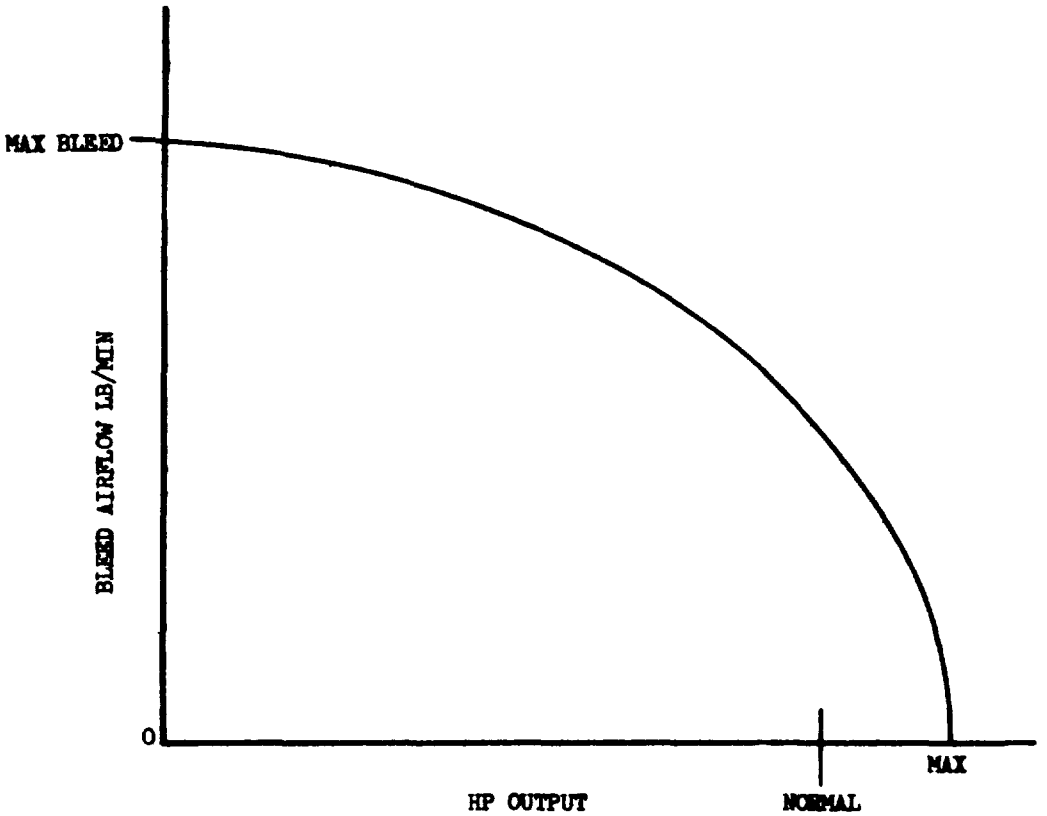


FIGURE 8. Shaft hp versus bleed airflow for type IV

* 3.5.5.2 Correction data.- (Data for correcting the performance of the unit at nonstandard temperature conditions for various specified altitudes over the full operating range of the unit shall be provided.)

3.5.6 Oil consumption.- The oil consumption shall not exceed ____ lb per hour under any operating condition specified herein.

3.5.7 Altitude operation.-

* 3.5.7.1 Altitude-temperature limits for starting and operation.- The unit shall start and operate at the altitudes and in the range of ambient temperatures specified on figure ____. (This may be shown in other than curve form, if desired by the manufacturer.)

3.5.10 Reduced-speed, idle operation.- (Describe the means provided for operation of the unit at reduced idle speeds.)

* 3.5.12 Gas temperature limits.- The maximum allowable measured gas temperature shall be as follows:

Condition	Temperature °F (°C)
Maximum	
Normal	

The measured transient gas temperature shall not exceed ____°F (____°C) for more than _____ seconds.

3.5.12.1 Measurement.- (Describe the provisions for the measurement of gas temperature.)

* 3.5.13.2 Starting power.- The estimated electrical power requirements for all components which are operative during the starting cycle shall not exceed the following, at the voltage specified in table II.

TABLE II

Estimated electrical power requirements during starting cycle

Condition	Volts dc	Amperes at 60°F	Amperes at -65°F	Approximate rotor rpm
Current inrush (momentary)	24			
Firing	24			
Starter cutout	24			

3.5.13.3 Automatic starting.- The control components required for automatic starting and not furnished with the unit are specified on Drawing _____.

3.6 Drawings and data.- The following _____(insert manufacturer's corporate name) drawings and photographs form a part of this specification: (Designate applicable drawings.)

3.13 Electrical components.-

* 3.13.4 Electrical power.- The electrical power requirements of the unit for all components requiring electrical power, during starting only, are as specified in 3.5.13.2 entitled "Starting power." The electrical power requirements of individual

components, other than the starter motor, and the approximate rotor speeds of the component energization, are as specified in table III.

TABLE III

Estimated electrical power requirements

Components 1/	Volts dc	Amperes at 60°F	Amperes at -65°F	Approximate rotor rpm	
				At cut-in	At cutout
Ignition system	24				
Control circuit	24				

1/ All additional components requiring electrical power shall be included in the above table.

3.14 Dry weight.- The dry weight of the complete gas-turbine power unit shall not exceed _____ pounds.

3.14.1 Weights of additional equipment.- (When additional equipment is furnished, such items, their estimated weight, and a reference as to whether contractor- or Government-furnished, shall be included.)

3.15 Over-all dimensions.- The over-all dimensions of the unit and allowances for expansion shall not exceed those shown on Drawing _____.

3.16 Mounting provisions.- The number, type, and location of the mounting provisions shall be as shown on Drawing _____.

3.16.1 Handling supports.- The provisions for hoisting of the unit, and for resting on the ground, shall be as shown on Drawing _____.

3.18 Polar moment of inertia of compressor-turbine system.- The polar moment of inertia of the complete rotor about the rotor axis is _____ pound feet squared.

3.18.1 Speed.- The maximum unit rotor speed shall be _____rpm.

3.19.2 Generator cooling air.- Generator cooling air of the following characteristics under standard conditions is provided:

(a) Quantity: _____ pounds per minute.

(b) Temperature: _____°F.

(c) Pressure: _____ inches of water.

3.20 Compressed air product (type II, type III, and type IV units).-

3.20.1 Compressor bleed.- The types II, III, and IV units shall provide for the extraction of compressed air from the compressor only in the quantity, pressure, and temperature shown on figures 1, 3, and 4. The bleed airpower shall be as shown on figure 2.

3.20.2 Mixed bleed.- The type III units shall incorporate provisions for the mixing of compressor bleed and combustion chamber products to raise the temperature of the bleed air to _____ ± _____ °F above the compressor inlet temperature.

3.21.2 Fire-detecting and extinguishing systems.- Describe the provisions for fire-detecting and fire-extinguishing systems as specified in the basic specification.

3.22.2 Duct attachment.- Provisions for intake duct attachment shall be as shown on Drawing _____. The following loads on the intake flange shall not be exceeded: Shear _____pounds, axial _____pounds, and overhung moment _____pound-inches.

3.22.3 Inlet air pressure drop.- The maximum allowable inlet air pressure drop to the unit shall be as shown on figure ____. (The contractor may show these limits in other than curve form.)

3.23 Exhaust system.-

3.23.1 Turbine exhaust.- Attachment provisions for the turbine exhaust duct shall be as shown on Drawing _____. The following loads on the exhaust duct attachment flange shall not be exceeded: Shear _____pounds, axial _____pounds, overhung moment _____ pound-inches.

* 3.23.1.1 Turbine exhaust pressure drop.- The maximum allowable exhaust gas pressure drop external to the unit shall be as shown on figure ____. (The contractor may show these limits in other than curve form.)

3.23.2 Cooling air discharge.- Attachment provisions for the cooling air discharge duct shall be as shown on Drawing _____. The following loads on the cooling air discharge duct flange shall not be exceeded: Shear _____pounds, axial _____pounds, overhung moment_____pound-inches. (Delete this paragraph where inapplicable.)

* 3.23.2.1 Cooling air discharge pressure drop.- The maximum allowable cooling air pressure drop external to the unit shall be as shown on figure ____. (The contractor may show these limits in other than curve form.)

* 3.24 Lubricating system.- The oil pressure and temperature indicator ranges required for remote indication are ____ to ____ psi and ____ to ____ °F, respectively.

3.24.6.1 Oil pressure pump.- The operating oil pressure at normal governed speed at any operating condition specified herein, when using the lubricant specified herein, shall be _____ ± _____ psi. The operating oil pressure at the minimum reduced idle speed operating condition shall be _____ ± _____ psi.

3.24.6.2 Oil pressure measurement.- The provisions for the measurement of unit oil pressure shall be as shown on Drawing _____.

3.24.7 Oil drain.-

3.24.7.1 Details of the oil drain shall be as shown on Drawing _____.

3.24.8.2 Capacity.- The oil tank capacity shall be as follows:

(a) Residual capacity _____ gallons.

(b) Usuable quantity _____ gallons.

(c) Unusable quantity _____ gallons.

3.24.9 Oil cooler.-

3.24.9.1 Type.- (The type of oil cooler shall be specified.)

3.24.10 Breather.- (The size and location of the outlet connection shall be specified.)

3.25 Fuel system.-

3.25.4 Fuel pressure connection.- The provisions for the measurement of fuel pressure shall be as shown on Drawing _____.

3.25.6 Fuel drains.- The time required to drain the unit of fuel sufficiently to safely attempt another start following one normal ground-starting attempt shall not exceed ____ seconds. Details of the fuel drain fitting(s) shall be as shown on Drawing _____.

3.26 Ignition system.- (Describe the type of ignition system used in the unit, including manufacturer's name and model, if applicable. Specify the number of igniters used, crossfire provisions, single or multiple ignition, continuous or self-maintained combustion and specify type of magneto, transformer, coil, igniter plug(s), torch igniter, or any other means of ignition, as is applicable.

3.26.3 Connections.- (Describe ignition system external connections.)

3.27 Control systems.-

3.27.1 Primary controls.- (Describe all components required for the unit control system, including provisions for reduced-speed control.)

3.27.2 Emergency controls.- (Describe the emergency control provisions of the unit as specified in the basic specification.)

3.28 Accessory drives.- The gas-turbine-driven power unit shall include the following described special accessory drives: (Insert here, in tabulated form, the names of the special accessory drives, the type, the number used, the speed at rated unit output, the maximum permissible torque for continuous operation, the maximum permissible static torque, overhung moment and accessory weight (for Government-furnished accessories), and the direction of rotation when looking at the drive on the unit.)

3.29 Counting devices.- (Describe the provisions for counting devices as specified in the basic specification.)

3.35 General additional information.- (The gas-turbine power unit manufacturer shall specify as subparagraphs under this number and heading in the model specification any additional information, deviations, or requirements, which are not covered by the basic specification.)

4. QUALITY ASSURANCE PROVISIONS

4.1 General.- (The requirements for sampling, inspection, and tests shall be as specified in the basic specification.)

5. PREPARATION FOR DELIVERY

5.1 General.- (The requirements for preparation for delivery shall be as specified in the basic specification.)

6. NOTES

6.4 Definitions.-

6.4.1.1 Ratings and operating conditions.- (The manufacturer may define the various ratings and operating conditions used in the model specification in this section.)

6.4.1.1.1 Standard conditions.- Standard conditions are the values of air temperature and pressure given in NACA TN 3182. The standard humidity, for the purpose of this specification, is zero vapor pressure at all altitudes.

6.4.2 Symbols.- (Symbols used in the model specification may be inserted here or defined on the estimated performance curves.)

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