FEDERAL AVIATION AGENCY

FLIGHT STANDARDS SERVICE

(14 CFR 514)

[Regulatory Docket No. 1339; Draft Release No. 62-37]

TECHNICAL STANDARD ORDERS FOR AIRCRAFT MATERIALS

PARTS, PROCESSES AND APPLIANCES

NOTICE OF PROPOSED RULE MAKING

Pursuant to the authority delegated to me by the Administrator (14 CFR Part 405) notice is hereby given that the Federal Aviation Agency has under consideration a proposal to amend Part 514 of the Regulations of the Administrator by adopting a new Technical Standard Order. This Technical Standard Order establishes minimum performance standards for approval of gas turbine auxiliary power units on a separate basis, for use on civil aircraft of the United States. Auxiliary power units were originally approved as a part of an aircraft.

Interested persons may participate in the making of the proposed rule by submitting such written data, views or arguments as they may desire. Communications should be submitted in duplicate to the Docket Section of the Federal Aviation Agency, Room A-103, 1711 New York Avenue, N. W., Washington 25, D. C. All communications received on or before September 28, 1962, will be considered by the Administrator before taking action on the proposed rule. The proposals contained in this notice may be changed in light of comments received. All comments submitted will be available in the Docket Section for examination by interested persons at any time.

This amendment is proposed under the authority of Sections 313(a) and 601 of the Federal Aviation Act of 1958 (72 Stat. 752, 775; 49 U.S.C. 1354(a), 1421).

In consideration of the foregoing it is proposed to amend Part 514 as follows:

By adding the following section 514.83:

§ 514.83 Gas turbine auxiliary power units - TSO-C77--(a) Applicability --(1) Minimum performance standards. Minimum performance standards are hereby established for gas turbine auxiliary power units for use on civil aircraft of the United States. New models of gas turbine auxiliary power units manufactured on or after the effective date of this section shall meet the standards specified in the Federal Aviation Agency Standard, "Gas Turbine Auxiliary Power Units", dated June 8, 1962.

(b) Marking. In addition to the markings specified in § 514.3(d), the following shall also be shown:

(1) Maximum rated speeds and temperature.

(2) Maximum allowable speeds and temperature.

(3) Maximum rated output.

(4) Category and class of service.

(5) Fuel grade and specification..

(6) Lubricating oil grade and specification.

(c) Data requirements. In addition to the data specified in Section 514.2, the manufacturer shall furnish the following to the Chief, Engineering and Manufacturing Branch, Flight Standards Division, Federal Aviation Agency, in the region in which the manufacturer is located:

(1) Instruction manual containing instructions for the installation, operation, servicing, maintenance, repair, and overhaul of the unit.

(2) Model specification.

Acting Director
Flight Standards Service

Issued in Washington, D. C., on August 7, 1962.

FEDERAL AVIATION AGENCY
FLIGHT STANDARDS SERVICE
Washington 25, D. C.

August 7, 1962

REGULATIONS OF THE ADMINISTRATOR DRAFT RELEASE NO. 62-37

SUBJECT: Technical Standard Order C77 "Gas Turbine Auxiliary Power Units"

The Flight Standards Service of the Federal Aviation Agency has under consideration an amendment to Part 514 of the Regulations of the Administrator to add a new Technical Standard Order TSO-C77 "Gas Turbine Auxiliary Power Units". The reasons therefor are set forth in the explanatory statement of the attached proposal which is being published in the Federal Register as a notice of proposed rule making.

The Flight Standards Service desires that all persons who will be affected by the requirements of this proposal be fully informed as to its effect upon them and is therefore circulating copies in order to afford interested persons ample opportunity to submit comments as they may desire.

Because of the large number of comments which we anticipate receiving in response to this draft release, we will be unable to acknowledge receipt of each reply. However, you may be assured that all comment will be given careful consideration.

It should be noted that comments should be submitted, preferably in duplicate, to the Docket Section of the Federal Aviation Agency, and in order to insure consideration must be received on or before September 28, 1962.

Acting Director
Flight Standards Service

June 8, 1962

Federal Aviation Agency Standard

for

Gas Turbine Auxiliary Power Units

1.0 Purpose: To specify minimum requirements for gas turbine auxiliary power units for use in civil aircraft.

2.0 Scope: This standard covers gas turbine auxiliary power units intended to be used as a power source for the driving of generators, hydraulic pumps, and other aircraft accessories and equipment, or to provide compressed air for aircraft pneumatic systems. This standard establishes minimum design and performance standards for the following categories and classes of gas turbine auxiliary power units:

Category I. Essential Power

Class A. A source of shaft power.

Class B. A source of compressor bleed air.

Class C. A combination source of shaft power and compressor bleed air.

Category II. Nonessential Power

Class A. A source of shaft power.

Class B. A source of compressor bleed air.

Class C. A combination source of shaft power and compressor bleed air.

This technical standard order does not specify installation standards; therefore, consideration should be given for the inclusion of design features desirable for complying with applicable requirements for installing the unit in an aircraft. Regulations pertaining to the design and performance standards of applicable aircraft are Civil Air Regulations, Parts 3, 4b, 6, and 7.

3.0 Definitions: As used in this standard, terms are defined as follows:

3.1 Auxiliary Power Unit: Any gas turbine power units delivering shaft horsepower or bleed-air power, or both, exclusive of direct propulsion of the aircraft.

3.2 Essential Power: Power which is used to drive accessories necessary for maintaining safe operation of the aircraft either on the ground or in flight.

3.3 Nonesential Power: Power which may be discontinued without jeopardizing safe operation of the aircraft either on the ground or in flight.

3.4 Standard Atmosphere: The standard atmosphere is an atmosphere as defined by Federal Aviation Regulation Part 1, Sec. 1.1.

3.5 Type and Model: An auxiliary power unit type includes all of a series of units each one of which was developed as an alternate configuration to or a refinement of the same basic unit. Each configuration of such a series is a model.

3.6 Fireproof. As defined by Federal Aviation Regulation Part 1, Sec. 1.1.

3.7 Fire-resistant: As defined by Federal Aviation Regulation Part 1, Sec. 1.1.

3.8 Demonstrate: To prove by actual physical test or experience under the conditions to be satisfied.

3.9 Substantiate: To prove on the basis of adequate evidence obtained by demonstration or analysis or both.

3.10 Containment: Parts being contained may penetrate containing components but may not have passed clear through such components. It must be established that no parts have passed clear through containing components in the event these components are penetrated.

3.11 Rotor: The entire rotating assembly with exception of accessory drive shafts and gears.

3.12 Hub: The inner portion of the rotor.

3.13 High Energy Rotor: A rotating component or assembly which, if it ruptures, will generate particles with sufficient energy as to cause secondary damage to the rotor housing.

3.14 Maximum Rated Temperature: The maximum continuous exhaust gas or turbine inlet temperature at which the unit will meet the performance and service life specified in the model specification and the overhaul manual. This temperature shall be specified in the model specification.

3.15 Maximum Allowable Temperature: The maximum exhaust gas or turbine inlet temperature which the unit would experience under overload or transient conditions and which is limited by a safety device, if applicable. This temperature shall be specified in the model specification.

3.16 Maximum Rated Speeds: The maximum continuous speed of the gas producer rotor and the maximum continuous speed of the output shaft, if applicable, at which the unit will meet the performance and service life specified in the model specification and the overhaul manual. These speeds shall be specified in the model specification.

3.17 Maximum Allowable Speeds: The maximum speed of the gas producer rotor and the maximum speed of the output shaft, if applicable, which the unit would experience under overload or transient conditions and which are limited by safety devices, if applicable. These speeds shall be specified in the model specification.

3.18 Maximum Rated Output: The maximum continuous shaft power or compressor bleed air output, or both, that the unit will deliver while meeting the service life specified in the model specification and the overhaul manual.

3.19 Blade: The power generating elements of the rotor whether of integral or attached design.

3.20 Main Output Pads: Any drive pad or bleed-air output flange which is used by the customer to extract usable shaft or pneumatic power from the unit.

3.21 Accessory Pads: Any accessory drive or utility pad furnished as a part of the unit for extraction of power to drive accessories, components, or controls essential to operation of the unit or any of its associated systems.

3.22 Start: A successful start shall be defined as a complete start and acceleration from starter torque initiation to stabilized speed and temperature in the governed range without exceeding allowable limits.

4.0 General Requirements:

4.1 Materials and Processes: The suitability and durability of all materials and processes used in manufacturing the unit shall be established on the basis of tests or experience, or both. These materials and processes shall conform to specifications selected or prepared by the manufacturer which will insure that the strength and other properties assumed in the design data are valid.

4.2 Accessibility: Parts of the unit requiring routine service checking, adjustment, or replacement shall be made readily accessible for servicing without teardown of the unit or removal of any major part, component, or accessory.

4.3 Attitude Conditions: The manufacturer shall specify in the model specification the attitude limits at which the unit will function satisfactorily. These limits shall be substantiated by actual tests.

4.4 Magnetic and Electronic Interference: The conducted and radiated magnetic and electronic interference limits of the unit, where appropriate, shall be specified in the model specification as well as the testing procedure.

4.5 Operating Characteristics: The overall range of engine operation and environmental conditions shall be specified by the manufacturer. Starting envelopes and operational envelopes within which the unit can be operated without detrimental effects such as stall, surge, flameout, etc., shall be specified. These envelopes shall be substantiated by test or by equivalently reliable analysis.

Data showing the effects of inlet temperature, altitude, air bleed, inlet pressure recovery, and ram pressure ratio upon performance parameters such as RPM, power output, airflow, fuelflow, exhaust gas temperature, compressor temperature, and pressure ratio shall be provided for the desired operating envelope.

4.6 Flight Maneuver Loads: The manufacturer shall establish the maximum translational, rotational, and combined accelerations in all three principal directions, which the unit including all accessories and its mounting provisions can withstand without permanent deformation or failure or adversely affecting its operating characteristics. These loads shall be included in the model specification as installation design limitations.

4.7 Negative Acceleration: The manufacturer shall specify and substantiate the maximum duration of time under negative acceleration conditions for which the unit will function satisfactorily. This time will appear in the model specification as an installation design limitation.

5.0 Design and Construction: The unit shall not incorporate design features or details which are hazardous or unreliable. The suitability of all design details and parts shall be established by tests, experience, or analysis as prescribed herein. All parts of the unit shall be designed and constructed to minimize the development of unsafe conditions in the unit between overhaul periods.

5.1 Fire Prevention: The design and construction of the unit and materials used shall be such as to minimize the possibility of occurrence and spread of fire because of structural failure, overheating, leaking flammables or other causes.

5.1.1 Lines and Fittings: Fuel and oil system hose assemblies shall meet the appropriate fire-resistant standards of Technical Standard Order C53a dated February 1, 1961.

5.1.2 Isolation of High Temperature Components: Flammable fluid or gas components, lines, and fittings shall be isolated from surface areas having temperatures in excess of 500° F. by suitable firewalls, deflectors, or tight-fitting shrouds. Firewalls shall be constructed of fireproof material, however, deflectors and shrouds may be constructed of fire-resistant material. Shrouds shall be fitted with provisions for attaching external drains.

5.2 Air Intake: The air intake passages within essential units shall be designed and constructed so as to prevent accumulations of ice in sufficient quantities as to cause malfuntioning of the unit during continuous operation throughout the icing envelope defined by CAR, Sections 4b.1(b) (7) and (8). Both essential and nonessential units shall incorporate suitable fittings for the connection of air intake ducts. The maximum permissible shear load, axial load, and moment which may be applied to the intake connection shall be specified in the model specification. The presence of flammable fluid carrying lines, fittings, and components in the air intake should be avoided wherever possible. When flammable fluid carrying lines, fittings, or components must be in the air intake, they will be enclosed in tight-fitting shrouds. Shrouds shall be fitted with provisions for attaching external drains.

5.2.1 Foreign Object Ingestion: The effect on engine functioning, performance, or reliability of ingesting foreign objects such as sand, gravel, dust, insects, and other environmental objects shall be investigated by the manufacturer. Necessary provisions for protection from ingestion of foreign objects, if required, shall be specified in the model specification.

5.2.2 Inlet Air Pressure Drop: The following inlet air pressure drop characteristics which will permit operation of the unit at rated power without adverse effects shall be specified in the model specification:

a. Maximum inlet air pressure drop uniformly distributed over the inlet area.

b. Maximum inlet air pressure drop distribution over the inlet area.

5.3 Lubrication System: The auxiliary power unit lubrication system shall be designed to function satisfactorily under all of the normal operating conditions defined by paragraphs 4.3 and 4.5 of

this standard. The applicable lubricant specification shall be specified in the model specification. The lubrication system, when furnished as part of the auxiliary power unit, shall incorporate the following features:

5.3.1 Oil Drains: Accessible drains shall be provided to permit safe drainage of the entire oil system. The oil drains shall be located at the lowest points of the system.

5.3.2 Breather: A breather or other suitable means shall be provided to prevent detrimental differential pressure in the oil tank.

5.3.3 Filters: If the unit is equipped with an oil filter, the filter shall be constructed in such a manner that complete blocking of the flow through the filter element will not prevent the safe operation of the engine oil supply system.

5.3.4 Oil Tank: The oil tank shall incorporate the following features:

5.3.4.1 Oil Tank Material: The oil tank and its supports shall be constructed of fireproof material.

5.3.4.2 Expansion Space: The oil tank shall incorporate an expansion space of at least 10 percent of the total tank capacity. The tank filler shall be so located that the expansion space cannot be inadvertently filled. The tank vent shall be located at the top of the expansion space.

5.3.4.3 Negative Acceleration: Provisions shall be made in the oil tanks of essential units for supplying the unit with a continuous flow of oil during operation with both positive and negative acceleration unless the unit has been demonstrated capable of operation at rated power without adverse effects with interruption of oil flow for the time specified by paragraph 4.7 of this standard.

5.3.4.4 Oil Tank Pressure Test: The oil tank shall be demonstrated capable of withstanding a differential pressure of 5 p.s.i. more than the maximum differential pressure which would be encountered during operation throughout the normal operating envelope defined by paragraph 4.5 of this standard.

5.3.4.5 Oil Level Gage: The oil tank shall be provided with a dipstick or other suitable means for determing the level of oil in the tank when the unit is in the normal installed attitude.

5.3.5 Nonintegral Systems: If any portion of the lubrication system is not supplied with the unit, the manufacturer shall specify all oil inlet requirements in the model specification.

5.4 Fuel System: The fuel specification, rate, pressure, and temperature range of fuel flow to the inlet of the auxiliary power unit fuel system and the degree of filtration necessary for satisfactory unit functioning shall be established by the manufacturer and specified in the model specification.

5.4.1 Fuel System Drains: Accessible drains shall be provided to permit safe drainage of the entire unit fuel system. Fuel drains shall be located at the lowest points in the system. A drain shall also be supplied in the combustor to prevent the accumulation of fuel in the event of a false start.

5.4.2 Fuel Resistance: All materials used in the fuel system shall be sufficiently resistant to fuels used in the unit as to permit continuous normal operation of the fuel system and all its components throughout the overall range of engine operation and environmental conditions as defined by paragraph 4.5 of this standard.

5.5 Exhaust System: The exhaust system of the unit shall be so designed and constructed as to prevent the leakage of exhaust gases into the aircraft. The unit shall incorporate suitable fittings for the connection of exhaust ducts.

5.5.1 Exhaust Piping: Exhaust piping shall be constructed of fireproof, heat and corrosion resistant material and shall incorporate provisions to prevent failure due to expansion when heated to operating temperatures.

5.5.2 Turbine Exhaust Pressure Drop: The model specification shall specify the maximum allowable exhaust back pressure which will permit operation of the unit at rated power without adverse effects. If the configuration of the exhaust duct has an appreciable effect on the operation of the unit, the manufacturer shall specify the configuration. The manufacturer shall also specify the maximum permissible shear and axial loads and moments which may be applied to the exhaust connection.

5.6 Cooling: Temperature limits shall be established for all critical components and/or exterior areas of the units as well as the engine heat rejection rates. These limits shall appear in the model specification.

5.7 Instrumentation: Provisions shall be made for attaching a turbine inlet or exhaust gas temperature probe, a tachometer generator for each independent rotor assembly, and the sensing elements of any other instrumentation necessary to monitor the continued safe operation of the unit. These provisions shall be specified in the model specification.

5.8 Accessory Attachments: Accessory drives and mounting attachments shall be designed and constructed so that the unit will operate properly with the accessories attached. The design of the unit shall incorporate provisions for the examination, adjustment, or removal of all accessories. Limiting conditions of torque, speed, direction of rotation, and overhanging moment shall be determined and substantiated and, together with a description of the type of pad and drive, shall be specified in the model specification.

5.9 Temperature Control: The unit shall be provided with an automatic temperature control capable of maintaining all critical gas temperatures within the limits specified by the manufacturer. The temperature control shall be so designed and constructed as to prevent the maximum allowable turbine temperature from being exceeded under any of the specified operating conditions.

5.10 Speed and Acceleration Control: The speed and acceleration control systems shall maintain the unit speed and acceleration within the limits specified by the manufacturer. The control systems shall be designed so that the unit rotational speed shall be automatically controlled to prevent the predetermined maximum allowable speed from being exceeded under the specified operating conditions.

5.11 Safety Devices: If safety devices are incorporated and if they must be relied upon to prevent a hazardous overspeed or over-temperature condition, means shall be provided for ascertaining from the control panel on the ground or during normal flight operation that these devices are functioning properly.

5.12 Bleed-Air Provisions: Units of a type permitting the extraction of compressor bleed air shall incorporate suitable fittings for the connection of bleed-air ducts. The manufacturer shall specify in the model specification the amount, cleanliness, and characteristics of bleed air available and the maximum permissible shear and axial loads and moments which may be applied to the bleed-air connection.

5.13 Rotor Blade Failure Protection: Except for those nonessential units for which rotor containment will be demonstrated in accordance with paragraph 7.3 below, compressor and turbine rotor cases shall be designed to provide for containment of damage from rotor blade failure. Whole vanes from radial flow rotors shall be contained unless smaller portions of these vanes are substantiated by the manufacturer as the largest portions likely to occur. The entire airfoil section of the blade of exducers, inducers, and axial flow rotors shall be contained. Blade containment shall be demonstrated in accordance with paragraph 7.3 below. For rotors incorporating more than one stage, containment need be demonstrated for the critical stage only. The manufacturer shall substantiate which stage is the critical stage.

5.14 High Energy Rotors: The compressor and turbine rotor cases of nonessential units shall be designed to contain maximum energy failed rotor fragments unless compliance with paragraphs 5.15, 5.16, and 7.2 below is established. Containment, if applicable, shall be demonstrated in accordance with paragraph 7.3 below. All rotors of essential units shall be capable of overtemperature and overspeed operation in accordance with paragraph 7.2 below.

5.15 Vibration: The manufacturer shall investigate the vibration amplitudes and frequencies which could be transmitted to the airframe throughout the normal operating range of the unit. Critical frequencies and amplitudes shall be specified in the model specification. The manufacturer shall demonstrate by actual measurement under operating conditions or equivalently reliable techniques that the compressors, turbines, and other highly stressed parts of essential units and nonessential units complying with paragraph 7.2 below are free from harmful vibration stresses.

5.16 Stress Rupture and Start/Stop Cycle Fatigue: For essential auxiliary power units and nonessential power units complying with paragraph 7.2 below, the stress rupture and start/stop cycle fatigue characteristics shall be investigated and substantiated. Based on the results of these investigations, life and/or growth limits, if applicable, shall be established. These life and/or growth limits shall be specified in the model specification.

5.17 Control of Unit Rotation: In the event that unit windmilling in either direction could have adverse effects on the unit, provisions shall be made to prevent such rotation. The limitations of any antirotation device shall be substantiated by test or equivalently reliable analysis and shall be specified in the model specification.

5.18 Ignition System: The ignition systems of essential units shall incorporate at least two igniters and two separate secondary electrical circuits.

6.0 Block Tests: A complete unit representative of production units shall be subjected to the following tests and whatever additional tests the manufacturer deems necessary to demonstrate compliance with these standards:

a. Essential units shall comply with paragraphs 6.1 to 6.5.

b. Nonessential units shall comply with paragraph 6.1.

6.1 Unit Calibration: The unit shall be subjected to such calibration tests as are necessary to establish its power characteristics and the conditions for the endurance test. Calibration shall be conducted prior to the endurance test. Calibration data shall be presented in the form of curves of output shaft power or torque and speed, fuel flow and bleed air flow, temperature and pressure versus turbine inlet or exhaust gas temperature and turbine speed.

6.2 Endurance Test: Essential power units shall be subjected to and satisfactorily pass a 150-hour endurance test in accordance with paragraphs 6.2.1, 6.2.2, and 6.2.3 . . . . below. To have satisfactorily passed this test, there must be no indication of impending failure, or excessive wear in any of the unit's major components. The unit must be functioning properly and be in such condition that it could be overhauled without the replacement of major components and subsequently run properly for at least one overhaul period under normal operation. During the maximum rated portions of this test, the normal speed and gas temperature control devices shall maintain these parameters within the tolerances specified in the model specification.

6.2.1 Test Periods: Twenty periods of seven and one-half hours each shall be run in accordance with the following schedule:

Note: Maximum rated output in the following schedule means the maximum shaft power output for which approval is desired for Class I units, the maximum bleed air output (mass and pressure) for which approval is desired for Class II units and the maximum simultaneous combination of shaft power output and bleed air output for which approval is desired for Class III units.

a. Five minutes at or above maximum rated output, five minutes at no load, one hour at or above maximum rated output and five minutes at no load.

b. Five minutes at or above maximum rated output, five minutes at no load, one hour at seventy-five percent maximum rated output and five minutes at no load.

c. Five minutes at or above maximum rated output, five minutes at no load, one hour at or above maximum rated output and five minutes at no load.

d. Five minutes at or above maximum rated output, five minutes at no load, one hour at fifty percent maximum rated output and five minutes at no load.

e. Five minutes at or above maximum rated output, five minutes at no load, one hour at or above maximum rated output and five minutes at no load.

f. Five minutes at or above maximum rated output, five minutes at no load, one hour at twenty-five percent maximum rated output and five minutes at no load.

6.2.2 Test Conditions: The following test conditions shall be observed during the endurance test:

6.2.2.1 Speed: During the maximum rated output portions of the endurance test, the speed of each rotor must be at least equal of the maximum rated speed. During all other portions of the endurance test, definite rotor speeds need not be maintained.

6.2.2.2 Temperatures: During the endurance test, all temperature limits including the turbine inlet or exhaust gas temperature and oil temperature limits shall be substantiated by maintaining the temperatures of the affected components at or above these limits during all maximum rated output portions of the endurance test. The temperature of the inlet air may be controlled in order to match the turbine temperature, speed, and power output and avoid unnecessarily exceeding either temperature, speed, or power during this test.

6.2.2.3 Pressures: The minimum oil and fuel pressures specified by the manufacturer in the model specification shall be maintained during all maximum rated output portions of the endurance test.

6.2.2.4 Accessory Drives: During the endurance test, all accessory drives shall be subjected to the maximum torque and overhang moment loadings for which approval is desired. These loadings shall appear in the model specification.

6.2.3 Adjustments and Repair or Replacement of Parts: During the endurance test, repair, or replacement of minor parts or infrequent adjustment not requiring disassembly of major components shall be permissible. Minor parts are parts the failure of which could not affect the performance, operating characteristics, reliability, or integrity of the unit. All other parts are major parts. Major parts may not be repaired or replaced during the endurance test.

6.3 Starts: A minimum of 100 starts shall be made on the unit intended for essential power operation. There shall be at least 30 starts each of which is preceded by a minimum of two hours shutdown.

6.4 Recalibration: After completion of the endurance test, a recalibration check run shall be made in accordance with Section 6.1. 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.

6.5 Teardown Inspection: After completion of the recalibration test, essential power units shall be completely disassemblied, and a detailed inspection shall be made of auxiliary power unit parts to check for fatigue and wear. Redesign and testing of components shall be accomplished as necessary.

7.0 Special Tests: The following special tests shall be conducted:

a. Essential units shall comply with paragraphs 7.1 and 7.2 below.

b. Nonessential units shall comply with either paragraphs 7.1 and 7.2 or paragraphs 7.1 and 7.3.

7.1 Test of Safety Devices: If overspeed and/or overtemperature limiting devices are provided, the unit shall be operated in such a manner that each such device is called upon to function ten times. Each device shall demonstrate its ability to limit the speed and/or temperature of the unit to no more than the maximum allowable value specified in the model specification each of the ten times it is called upon to function.

7.2 Rotor Integrity Substantiation: The overspeed and overtemperature capabilities of rotor assemblies, when applicable, shall be substantiated by complying with the following test:

7.2.1 Test: The overstress margin for compressor and turbine rotors shall be substantiated to be adequate to withstand operation for five minutes at the critical rotational speed which is the highest of the speeds specified by subparagraphs a. through c. below while at the turbine inlet or exhaust gas temperature which would prevail during actual operation at the critical overspeed.

The overstress margin for compressor and turbine rotors shall also be substantiated to be adequate to withstand operation for five minutes at a turbine inlet or exhaust gas temperature 75° F. more than the maximum rated turbine inlet or exhaust gas temperature while at not less than the maximum rated speed.

Note: If the critical overspeed condition is accompanied by a turbine inlet or exhaust gas temperature at least 75° F. greater than the maximum rated turbine inlet or exhaust gas temperature, then both the overspeed and the overtemperature capabilities

will have been substantiated simultaneously. If the critical overspeed condition is accompanied by a turbine inlet or exhaust gas temperature less than 75° F. greater than the maximum rated turbine inlet or exhaust gas temperature, then the overspeed and overtemperature capabilities will not have been substantiated simultaneously and must, therefore, be substantiated separately.

a. A speed equal to 115 percent of the maximum rated speed.

b. If no safety devices are incorporated which cannot be checked for proper functioning from the control panel prior to flight or during flight a speed equal to 105 percent of the highest speed which would result from failure of any one of the normal engine control system.

c. If safety devices are incorporated which cannot be checked for proper functioning from the control panel prior to flight or during flight, a speed equal to the highest speed which would result from the failure of any one normal engine control system assuming all such safety devices to be inoperative.

Note: Failure of structural elements of the unit and its installation need not be considered if the probability of such failure is considered to be extremely remote.

7.2.1.1 Methods for Substantiating the Overstress Margin: Acceptable methods for substantiating the overstress margin on turbine and compressor rotors as covered by Section 7.2.1 above are:

a. Testing a full scale rotor at speed and temperature in a complete unit.

b. Testing a full scale rotor at speed and temperature in a spin pit.

c. Testing a modified rotor in a complete unit at a speed and temperature which will induce stresses equal to or greater than those required.

d. Calculation of the overstress margin of the rotor at speed and temperature from basic data obtained by cold spinning.

7.3 Rotor and Rotor Blade Containment Demonstration: Rotor and rotor blade containment shall be demonstrated under the following conditions:

7.3.1 Speed: Containment shall be demonstrated at the maximum obtainable speed defined by subparagraphs a. and b. below:

a. If no safety devices are incorporated which cannot be checked for proper functioning from the control panel prior to flight or during flight a speed equal to the highest speed which would result from failure of any one of the normal engine control systems.

b. If safety devices are incorporated which cannot be checked for proper functioning from the control panel prior to flight or during flight a speed equal to the highest speed which would result from the failure of any one normal engine control system assuming all such safety devices to be inoperative.

Note: Failure of structural elements of the unit and its installation need not be considered if the probability of such failure is considered to be extremely remote.

7.3.2 Temperature: Containment shall be demonstrated with the containing components at the temperature prevalent during operation at maximum rated power.

8.0 Ratings: The performance ratings shall be listed in the model specification. These data contemplate no restriction of the air inlet or exhaust and no loading of the accessory drives. The ratings shall be based on the data obtained by paragraph 6.1 and the atmospheric conditions specified in paragraph 3.4 herein.

9.0 Model Specification: The manufacturer shall prepare a model specification in which the following information shall be included:

a. Manufacturer's name.

b. Model designation.

c. Category and class of service for which approved (IC, IIA, etc.).

d. Sea level output ratings.

(1) RPM (each rotor) - maximum rated and maximum allowable.

(2) Rated utput shaft power - minimum (if applicable).

(3) Rated output shaft speed (if applicable).

(4) Bleed air flow - nominal (if applicable).

(5) Bleed air pressure ratio - nominal (if applicable).

(6) Bleed air temperature rise ratio - nominal (if applicable).

(7) Fuel consumption - maximum.

(8) Turbine inlet or exhaust gas temperature - maximum rated and maximum allowable.

e. The normal temperature (if applicable) and speed control tolerances under maximum rated output conditions.

f. The life and/or growth limits of all parts for which such limits have been established.

g. Operating envelope throughout which the operating characteristics have been found to be free of detrimental effects per Section 4.5 (essential units only).

h. Maximum structural loading envelope per Section 4.6.

i. Maximum time unit may be operated satisfactorily under negative "g" conditions per Section 4.7.

j. Maximum permissible component and surrounding ambient temperature limits where such limits are established.

(1) Type and location of thermocouple to use for cooling test, if applicable.

(2) Description of temperature sensing provisions if incorporated.

k. Maximum permissible air inlet duct attachment loads.

(1) Shear

(2) Axial

(3) Overhung moment

1. Inlet air requirements per Section 5.2.2.

(1) Maximum air pressure drop.

(2) Maximum air pressure drop distribution.

m. Lubrication system requirements.

(1) Grade of oil and specification.

(2) Maximum oil consumption rate.

(3) Minimum inlet oil pressure (if applicable).

(4) Maximum inlet oil temperature (if applicable).

(5) Inlet oil flow rate (if applicable).

(6) Degree of aircraft installed filtering necessary (if applicable).

(7) Usable oil capacity (if applicable).

(8) Maximum heat ejection (if applicable).

(9) Maximum oil system outlet pressure (if applicable).

n. Fuel system requirements.

(1) Grade of fuel and specification.

(2) Minimum inlet fuel pressure.

(3) Maximum and minimum inlet fuel temperatures.

(4) Inlet fuel flow rate.

(5) Degree of aircraft installed filtering necessary.

(6) Method of preventing filter icing (if applicable).

o. Exhaust system requirements.

(1) Maximum permissible back pressure.

(2) Exhaust configuration limitations (if applicable).

p. Maximum permissible exhaust attachment loads.

(1) Shear

(2) Axial

(3) Overhung moment.

q. Main shaft power output pad (if applicable). See ratings

for output shaft speed and power.

(1) Output shaft configuration

(2) Direction of rotation.

r. Bleed air attachment loads (if applicable).

(1) Shear

(2) Axial

(3) Overhung moment

s. Accessory attachments

(1) Type of drive and mounting pad

(2) Direction of rotation

(3) Maximum static torque

(4) Maximum continuous torque

(5) Drive shaft speed ratio

(6) Maximum permissible overhang moment

t. Monitoring instrumentation attachments - describe all instrumentation attachments in detail.

u. Give model designation, setting numbers or any other pertinent information relative to the engine accessories or controls such as:

(1) Fuel control

(2) Igniter system

(3) Igniter plug

(4) Safety devices

(5) Any other accessories or components furnished as a part of the unit

v. Performance data shall be presented in the form of suitable curves and shall portray the relationships of the various

parameters obtained by Section 6.1. The effects of ram pressure ratio, ambient temperature, and altitude shall be ascertained and included with the performance data.

w. The manufacturer shall include an installation drawing of the unit showing all dimensions and details necessary for proper installation of the unit in an aircraft.

x. The manufacturer shall identify the axes of the unit and shall specify the maximum displacement in each direction or combined displacements under which the unit will function satisfactorily.

y. The manufacturer shall specify the maximum conducted and radiated electronic and magnetic interference present in the unit.

z. The manufacturer shall specify any additional information necessary to adequately describe the unit's operating and/or installation limitations.