

SAE The Engineering Society
For Advancing Mobility
Land Sea Air and Space®
INTERNATIONAL

400 Commonwealth Drive, Warrendale, PA 15096-0001

AEROSPACE STANDARD

SAE AS1606

Issued 1992-09-15

Submitted for recognition as an American National Standard

GAS TURBINE STARTER (JET FUEL STARTER) SPECIFICATION

FOREWORD

This SAE Aerospace Standard (AS) is a compilation of requirements extracted from various procurement specifications for similar equipment. The arrangement of this document is such that it might serve as an aid in the preparation of a gas turbine starter (also referred to as a jet fuel starter) specification.

Specific requirements or conditions are denoted "to be specified" (TBS) to allow for use of actual application data or requirements.

The "qualifying activity" term used in this document is intended to be the organization that would typically issue the actual specification (airframe manufacturer, engine manufacturer, or government agency).

1. SCOPE:

This specification establishes the requirements for the (TBS) jet fuel starter for the (TBS) gas turbine engine used in the (TBS) aircraft.

1.1 Type:

The jet fuel starter covered by this specification shall be designed to operate on jet fuel as a self-contained unit (subsequently called unit).

SAE Technical Standards Board Rules provide that: "This report is published by SAE to advance the state of technical and engineering sciences. The use of this report is entirely voluntary, and its applicability and suitability for any particular use, including any patent infringement arising therefrom, is the sole responsibility of the user."

SAE reviews each technical report at least every five years at which time it may be reaffirmed, revised, or cancelled. SAE invites your written comments and suggestions.

SAE AS1606

2. APPLICABLE DOCUMENTS:

2.1 Military Documents:

The following documents form a part of this specification to the extent specified herein. The applicable issue of governmental documents shall be the issue in effect on date of invitation for bids.

2.1.1 Specifications

MIL-P-116	Preservation, Method of
MIL-C-3702	Cable, Power, Electrical, Ignition, High-Tension
MIL-S-5002	Surface Treatments and Inorganic Coatings for Metal Surfaces of Weapons Systems
MIL-H-5606	Hydraulic Fluid, Petroleum Base, Aircraft Missile and Ordnance
MIL-T-5624	Turbine Fuel, Aviation, Grades JP-4, JP-5, and JP-5/JP-8 ST
MIL-L-6081	Lubricating Oil, Jet Engine
MIL-P-7105	Pipe Threads, Taper, Aeronautical National Form, Symbol ANPT, General Requirements for
MIL-S-7742	Screw Threads, Standard, Optimum Selected Series, General Specification for
MIL-L-7808	Lubricating Oil, Aircraft Turbine Engine, Synthetic Base, NATO Code Number 0-148
MIL-C-8188	Corrosion-Preventive Oil, Gas Turbine Engine Aircraft Synthetic Base
MIL-I-8500	Interchangeability and Replaceability of Component Parts for Aerospace Vehicles
MIL-S-8879	Screw Threads, Controlled Radius Root with Increased Minor Diameter, General Specification for
MIL-L-23699	Lubricating Oil Aircraft Turbine Engines
MIL-E-25499	Electrical Systems, Aircraft, Design and Installation of, General Specification for
MIL-T-83133	Turbine Fuels, Aviation, Kerosene Types NATO F-34 (JP-8) and NATO F-35
MIL-H-83282	Hydraulic Fluid, Fire Resistant, Synthetic Hydrocarbon Base, Aircraft, Metric, NATO Code Number H-537

2.1.2 Standards

DOD-STD-100	Engineering Drawing Practice
MIL-STD-129	Markings for Shipment and Storage
MIL-STD-130	Identification Marking of U.S. Military Property
MIL-STD-453	Inspection, Radiographic
MIL-STD-461	Electromagnetic Emission and Susceptibility Requirements for the Control of Electromagnetic Interference
MIL-STD-471	Maintainability Verification/Demonstration Evaluation
MIL-STD-480	Configuration Control - Engineering Changes Deviations and Waivers
MIL-STD-481	Configuration Control - Engineering Changes (Short Form), Deviations and Waivers
MIL-STD-704	Aircraft Electric Power Characteristics
MIL-STD-810	Environmental Test Methods and Engineering Guidelines
MIL-STD-831	Test Reports, Preparation of
MIL-STD-889	Dissimilar Metals

SAE AS1606

2.1.2 (Continued):

MIL-STD-1523	Age Control of Age-Sensitive Elastomeric Material (For Aerospace Applications)
MIL-STD-1595	Qualification of Aircraft, Missile and Aerospace Fusion Welders
MIL-STD-1949	Inspection, Magnetic Particle
MIL-STD-2175	Castings, Classification and Inspection of
MIL-STD-6866	Inspection, Liquid Penetrant

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.

2.2.1 Specification Control Drawing:

MS20995	Wire, Safety or Lock
MS33540	Safety Wiring and Cotter Pinning, General Practice for

2.2.2 Qualification Agency Specifications:

AFR 39-1

2.2.3 Commercial Specifications and Standards

SAE AMS 2650

2.3 Definitions and Symbols:

The applicable definitions and symbols used herein and in the model specification are as follows:

2.3.1 **QUALIFYING ACTIVITY:** The qualifying activity is the activity which is responsible for the unit contract.

2.3.2 **RATING:** A rating is the value of some characteristic of performance as specified in the model specification.

2.3.3 **ESTIMATE:** An estimate is a predicted value of performance.

2.3.4 **INITIAL YIELD:** Initial yield is that point at which 0.2% permanent deformation has occurred.

2.3.5 **TRANSFER TIME:** Transfer time is the time interval from the removal of the unit or component from one conditioning chamber to the insertion of the unit or component into another conditioning chamber, or the time interval from the removal of the unit or component from the conditioning chamber to the initiation of testing.

2.3.6 **START CYCLE:** A start cycle shall consist of unit initiation (time zero) and acceleration of the load from zero rpm to unit cutout speed.

SAE AS1606

- 2.3.7 **MOTORING RUN:** A motoring run shall consist of unit initiation (time zero) and acceleration of the load from zero rpm to a sustained speed. This point will occur when unit output torque equals the engine drag torque without engine light off.
- 2.3.8 **NO-LOAD CYCLE:** No-load is the operation of the unit without load on the output shaft.
- 2.3.9 **ZERO TIME:** Zero time is that time at which starting switch actuation occurs.
- 2.3.10 **CUTOFF:** Cutoff is the speed at which the unit ceases to drive the output shaft.
- 2.3.11 **OVERRUNNING:** Overrunning is the driving of the unit output shaft by some means other than by energizing the unit turbine.
- 2.3.12 **MAXIMUM OPERATING SPEED:** Maximum operating speed is defined as the highest speed obtained by the unit under the most severe temperature and altitude condition.
- 2.3.13 **OVER SPEED:** Over speed is the rotation of high speed parts at a speed which causes the yield strength of the parts to be exceeded.
- 2.3.14 **PROOF SPEED:** The proof speed is that speed above maximum operating speed which is used to nondestructively test high speed rotating components.
- 2.3.15 **IMPACT TORQUE:** Impact torque is the maximum torque resulting from initial engagement of the unit with the load.
- 2.3.16 **MAXIMUM TORQUE:** Maximum torque is the highest torque value occurring after the initial impact torque occurs.
- 2.3.17 **MODEL SPECIFICATION:** The model specification referred to herein is defined as the vendor prepared document used to define the unit.

3. REQUIREMENTS:

3.1 Operational Requirements:

3.1.1 **Performance Characteristics:** The unit shall meet the minimum performance requirements specified herein. (If other than installed performance is intended, it shall be so stated.) The actual performance characteristics shall be specified in the model specification and shall be predicated on the use of production hardware. The minimum performance shown shall include adequate allowance for variations due to controls, manufacturing tolerances, performance deterioration over the life of the unit, etc. Performance characteristics shall be based upon the use of MIL-T-5624 fuels.

3.1.1.1 **Output Torque:** The minimum steady state and transient torque output shall be defined in the model specification. Steady state torque shall not be less than that shown in Figure 2. Maximum steady state torque shall not exceed (TBS).

SAE AS1606

- 3.1.1.2 Start Time: The unit shall be capable of accelerating the engine and accessories described in Figure 3 to cutout speed in accordance with the times shown in Figure 4. Calculated start times to cutout speed conditions of (TBS temperature and altitude points) shall be defined in the model specification.
- 3.1.1.3 Performance Ratings: The unit performance shall be defined in the form of curves and a computer program which shall be part of the model specification. The curves shall include nominal and minimum performance. Performance shall be defined for operation of the unit under the following conditions in Table 1:

TABLE 1 - Performance Ratings

Unit Temperature	Altitude	Inlet Air Temperature	Fuel Temperature
(TBS)	(TBS)	(TBS)	(TBS)
-65 °F	S.L.	-65 °F	-65 °F
-40 °F	S.L.	-40 °F	-40 °F
+59 °F	S.L.	+59 °F	+59 °F
+160 °F	S.L.	+125 °F	+130 °F
+250 °F	S.L.	+125 °F	+160 °F
+160 °F	8000 ft	+95 °F	+100 °F

- a. Unit transient output torque for (TBS) slug-ft² test flywheel versus output shaft speed. (Sample shown as Figure 13)
 - b. Gas generator speed versus time at no-load condition. (Sample shown as Figure 14a)
 - c. Output speed versus time at no-load condition. (Sample shown as Figure 14b)
 - d. Unit exhaust gas temperature at discharge port versus time. (Sample Shown as Figure 15a)
 - e. Unit airflow versus speed. (Sample shown as Figure 15b)
 - f. Torque transient at unit output drive versus running engagement speed showing maximum impact torque.
- 3.1.1.4 Fuel Consumption: The unit model specification shall define the units fuel consumption per start cycle for each operating condition including main engine motoring.
- 3.1.1.5 Air Consumption: Unit airflow requirements for all extreme operating conditions shall be defined in the model specification.
- 3.1.1.6 Exhaust Gas Temperature: The unit model specification shall define the maximum allowable exhaust gas temperature at the exhaust connection and shall specify the condition under which this occurs.

SAE AS1606

- 3.1.1.7 Performance Deterioration: Performance deterioration of the unit shall not be more than (TBS) percent of the specification rating level after (TBS) start cycles and (TBS) hours motoring. Performance during initial calibration of the unit must meet or exceed the minimum specification requirements.
- 3.1.2 Overhaul Life: The unit shall perform in accordance with the requirements of this document throughout (TBS) hours of overrunning (normal aircraft operating time), (TBS) start cycles, and (TBS) hours of motoring time.
- 3.1.3 Unit Operation:
- 3.1.3.1 Start Cycle: The unit shall be capable of making at least (TBS) consecutive start cycles, when exposed to the environmental conditions specified herein, with a maximum time interval of 60 s between the completion of one cycle and the initiation of the next cycle. No more than (TBS) start cycles shall be required within a 1 h period. The actual consecutive start cycle capability shall be specified in the model specification.
- 3.1.3.2 Automatic Starting and Cutout: The unit shall be designed such that operation of a single switch or other device shall provide automatic unit operation from initiation to cutout. The unit shall not start without the initiation signal being provided (i.e., due to windmilling or inadvertent unit rollover). The automatic starting and cutout provisions shall be specified in the model specification.
- 3.1.3.3 Stopping: It shall be possible to terminate the starting cycle at any time during the start cycle without damage to the unit. The stopping provisions shall be specified in the model specification.
- 3.1.3.4 Running Engagement: The unit shall suffer no detrimental effects when subjected to running engagements at any speed up to cutout.
- 3.1.3.5 Motoring: The unit shall be capable of motoring the aircraft engine or similar load for periods up to (TBS) minutes duration followed by a normal start cycle within (TBS) minutes. It shall be possible to make consecutive motoring runs of lesser duration provided the total motoring time does not exceed (TBS) minutes. No more than (TBS) minutes total motoring shall be required in any 1 h period. The actual motoring capability of the unit and any limitations shall be specified in the model specification. If a motoring speed/motoring time allowed relationships exists, it shall be specified in the model specification. Minimum motoring speed at S.L. 59 °F shall be (TBS).
- 3.1.3.6 Altitude Starts: The unit shall be capable of providing minimum performance per Figure 7, when operated in the flight regime of Figure 8 at inlet and exhaust conditions of Zone A of Figure 6.

SAE AS1606

3.1.4 Unit Characteristics:

3.1.4.1 Unit Starting System: The unit shall be equipped with a device that will drive the gas generator to self-sustaining speed. The energy source to be supplied by the airframe can be electrical, hydraulic, pneumatic or a combination of these. The unit shall be capable of making a minimum of (TBS) consecutive start cycles throughout the operating envelope when supplied with the energy source specified in the model specification.

- a. Electric: A (TBS) battery with the electrolyte maintained between (TBS) °F and (TBS) °F.

Cable and relays with total resistance of (TBS) ohm.

- b. Hydraulic:

- (1) Accumulator of (TBS) volume.
- (2) Precharge pressure of dry nitrogen at gas temperature of (TBS) psig.
- (3) Charge pressure of (TBS) psig stabilized at (TBS) °F gas temperature.
- (4) Fluid used: (TBS)
- (5) Line and valve losses.
 - (a) Supply per Figure (TBS)
 - (b) Return per Figure (TBS)
- (6) Return reservoir pressure at (TBS) psig.

- c. Pneumatic:

- (1) Pneumatic bottle with a volume of (TBS) charged to (TBS) psi at stabilized gas temperature of (TBS).
- (2) Supply line and valve losses per Figure (TBS)
- (3) Gas used. Dry air or nitrogen.

Cutoff of the initiating device shall be automatically controlled by a signal from the unit, which will be specified in the model specification. Input power requirements from the aircraft electrical system shall be specified in the model specification.

The transient performance of 3.1.1.2 and 3.1.1.3 shall include time from the initiation of the starting of the unit.

SAE AS1606

3.1.4.2 Compressor and Turbine System:

- 3.1.4.2.1 Mass Moment of Inertia: The mass moment of inertia of the entire gas generator rotating system referred to the gas generator initiating device pad shall be specified in the model specification.
- 3.1.4.2.2 Maximum Operating Speeds: The maximum operating speeds for all rotating aerodynamic components (compressor, gas generator turbine, power turbine, etc.) shall be specified in the model specification for all operational extremes. Maximum operating speed shall be no greater than 110% of normal operating speed for each condition.
- 3.1.4.2.3 Minimum Yield Speed: The minimum yield speeds of all rotating aerodynamic components shall be greater than the maximum operating speeds and shall be specified in the model specification for each component.
- 3.1.4.2.4 Minimum Burst Speeds: The minimum burst speeds for all rotating aerodynamic components shall be specified in the model specification.
- 3.1.4.2.5 Proof Speeds: Proof speeds for all rotating aerodynamic components shall be less than the minimum yield speeds and greater than the maximum operating speeds and shall be specified in the model specification.

3.1.4.3 Speed Reduction and Output System:

- 3.1.4.3.1 Gears: The gear ratio between the energy conversion mechanism and the unit output shaft shall be specified in the model specification. The amount of gear backlash shall be specified in the model specification.
- 3.1.4.3.2 Clutches: An engage-disengage clutch system shall be provided, which will automatically engage or disengage the unit from the engine under all engine starting conditions. The clutch system shall be of a fail-safe design and shall prevent the engine from driving the unit rotating components to over speed condition. The clutch system operating limits (both driving and driven) shall be specified in the model specification.
- 3.1.4.3.3 Output Shaft: The maximum unit output shaft torque and direction of rotation shall be specified in the model specification. The direction of rotation shall be (TBS) when facing the unit output shaft.
- 3.1.4.3.3.1 Overtorque Protection: A torque limiting device shall be provided as part of the unit output shaft. The maximum applied torque and the allowable tolerance limit (both driving and driven) shall be specified in the model specification. The maximum allowable torque shall not exceed (TBS). If the device limits torque by failing in shear or tension, it shall be readily replaceable with no disassembly required beyond removal of the unit.

SAE AS1606

- 3.1.4.3.3.2 **Emergency Disengagement:** An emergency drive disengagement mechanism shall be incorporated as a part of the unit to affect emergency disengagement of the unit from the engine in the event normal disengagement does not occur. The disengagement mechanism shall be designed such that removal of the unit from the engine pad shall be required to affect reengagement. An attempted start, after an emergency disengagement has been experienced, shall not result in damage to the unit or engine. The disengagement mechanism shall be described in detail and its operating limits specified in the model specification.
- 3.1.4.3.4 **Mass Moment of Inertia:** The effective mass moment of inertia of the units rotating parts referred to the output drive shall be specified in the model specification.
- 3.1.4.3.4.1 **Critical Speed:** The bending mode critical speed of the units high speed rotating assembly referred to the output drive shaft shall be specified in the model specification. There shall be no damaging critical speeds in any high speed rotating component in the speed range 0 rpm to 20% above the maximum operating speed.
- 3.1.4.3.5 **Cutout Device:** The unit shall be provided with redundant speed responsive cutout systems, which will terminate the power supplied to the output shaft and unit operation in accordance with the following requirements:
- a. **Primary Cutout:** Provides unit shutdown at normal cutout speed of $(TBS) \pm (TBS)$ rpm. This device resets automatically after the unit has come to rest and is able to perform another cycle.
 - b. **Secondary Cutout:** Provides for unit shutdown in the event of failure of the primary shutdown. The actuation speed for this device shall be set at a speed higher than the maximum primary cutout speed but shall be no greater than a speed which corresponds to maximum unit operating speed. Actuation of the secondary cutout device shall cause a visual indicator trip out device to actuate and shall prevent subsequent unit initiations. The trip out device shall be resettable and shall be positioned on the unit to be accessible from the aircraft access panel.
- The actuation speeds of both the primary and secondary cutout systems shall be specified in the model specification.
- 3.1.4.3.6 **Backlash and Stiffness:** The backlash and stiffness of the units rotating parts referred to the output drive shall be specified in the model specification.
- 3.1.4.4 **Control System and Accessories:** All controls necessary for satisfactory operation of the unit shall be contained within the unit envelope. Remote mounting of accessories and components will not be accomplished unless specifically permitted by the qualifying activity.

SAE AS1606

3.1.4.5 Fuel System:

- 3.1.4.5.1 Fuel: The unit shall function satisfactorily throughout its operating range using MIL-T-5624 jet fuel, grades JP-4 and JP-5, as well as MIL-T-83133 (JP-8), provided fuel is supplied at a fuel viscosity of 12 centistokes or less. The unit shall be capable of operation on alternate fuel (TBS). Operating restriction using alternate fuel shall be specified in the model specification.
- 3.1.4.5.2 Fuel Pressure and Temperature: The unit shall meet the performance requirements of the model specification when furnished fuel from the aircraft fuel system with pressure from 5 psi above true vapor pressure to (TBS) psig and temperature from (TBS) °F to (TBS) °F.
- 3.1.4.5.3 Fuel Contamination: The unit shall function satisfactorily when using fuel contaminated to the extent specified in Table 2 as follows:

TABLE 2 - Fuel Contamination Levels

Contaminant	Particle Size	Quantity
Iron oxide	0 - 5 μm	28.5 gm/1000 gal
Iron oxide	0 - 10 μm	1.5 gm/1000 gal
Sharp silica sand	300 - 420 μm	1.0 gm/1000 gal
Sharp silica sand	150 - 300 μm	1.0 gm/1000 gal
Prepared dirt conforming to AC Spark Plug Company P/N 1543636 (coarse Arizona road dust)	Mixture as follows: 0 - 5 μm (12%) 5 - 10 μm (12%) 10 - 20 μm (14%) 20 - 40 μm (23%) 40 - 80 μm (30%) 80 - 200 μm (9%)	8.0 gm/1000 gal
Cotton linters	Staple below 7: (US Department of Agriculture Grading Standards)	0.1 gm/1000 gal
Crude naphthenic acid		0.03% by volume
Salt water shall be prepared by dissolving 4 parts by weight of salt in 96 parts by weight of distilled or other water containing not more than 200 parts per million of total solids.		0.01% entrained

- 3.1.4.5.4 Fuel Filters: Provisions for fuel filtering, if required, and cleaning of filters shall be defined in the model specification. The element shall be the disposable type and shall not require replacement before (TBS) start cycles.

SAE AS1606

- 3.1.4.5.5 Residual Fuel: The unit shall be designed so that residual fuel shall be purged or drained automatically from the units combustion areas at each shutdown through a connection suitable for overboard drainage. Purging of the fuel manifold system is at the option of the manufacturer; however, the method shall be specified in the model specification.
- 3.1.4.6 Inlet and Exhaust System: Inlet and exhaust ducts, with mating flanges, as approved by the qualifying activity, shall be provided as a part of the unit. All performance will include these ducts. In the event that the ducts are supplied by the airframe manufacturer, their configuration shall be provided to the unit manufacturer. Unit performance shall include appropriate losses for inlet and exhaust ducting.
- 3.1.4.6.1 Inlet Air System: The unit inlet shall include means for the prevention of foreign object damage to the unit. The maximum size of object that can pass through shall be (TBS). The duct mounting provisions at the airframe interface shall be defined in the model specification. Maximum external loads applied at the interface shall be defined in the model specification.
- 3.1.4.6.2 Exhaust System: The exhaust duct mounting provisions at the airframe interface shall be defined in the model specification. Maximum external loads applied at the interface shall be defined in the model specification. The unit design shall be such that no exhaust gases shall leak into the compartment.
- 3.1.4.7 Lubrication System: The lubrication system shall be integral with the unit and shall be adequate to lubricate the unit throughout its operating range. The unit design shall be such that no change in lubricant shall be required for operation throughout the ambient temperature range specified herein and no change in operating procedure is required when ambient temperature conditions change. Within the temperature range specified, the unit shall be capable of completing (TBS) start cycles and (TBS) hours of overrunning without adding to or changing the lubricant. Unit operating temperature range for cycling shall be -65 to 250 °F when using MIL-L-7808 and -40 to 250 °F when using MIL-L-23699. Overrunning temperature condition shall be as shown on Figure 9.
- 3.1.4.7.1 Oil Supply: An oil reservoir shall be furnished as an integral part of the unit. The reservoir shall have sufficient capacity to be capable of operation for the time specified in 3.1.4.7 while experiencing the maximum oil consumption rate per 3.1.4.7.2. The minimum amount of oil necessary for satisfactory unit operation shall be specified in the model specification.
- 3.1.4.7.2 Oil Consumption: The unit maximum oil consumption rate shall be (TBS) cubic centimeters per cycle, (TBS) cubic centimeters per minute of motoring, and (TBS) cubic centimeters per hour of overrunning. Values shall be specified in the model specification.

SAE AS1606

- 3.1.4.7.3 Oil Flow and Heat Rejection: Unless specified by the qualifying agency, no airframe supplied oil coolers are permitted. Unit heat rejection and lube system capacity shall be such that lube oil temperature shall not exceed allowable limits at the conclusion of any operating cycle specified throughout the unit operating range.
- 3.1.4.7.4 Oil Filter: A suitable replaceable oil filter element, if required, shall be provided as a component of the lubrication system and shall be specified in the model specification. Oil filter replacement time interval shall be specified in the model specification. Filter replacement shall be possible with unit mounted in aircraft without removal of any other components.
- 3.1.4.7.5 Oil Fill Provisions: Unless specified otherwise by the qualifying activity, oil fill shall be through a pressure fill connection per MS24476-1. A method shall be incorporated to prevent overfill.
- 3.1.4.7.6 Oil Drain Provisions: Each oil reservoir in the unit shall be provided with a drain boss located so as to insure adequate drainage when the unit is mounted in the aircraft in the normal position. A self-sealing magnetic particle chip detector shall be incorporated in the drain plug.
- 3.1.4.7.7 Oil Level Measurement: Each oil reservoir of the unit shall be provided with a means for measurement of the oil level. Maximum and minimum oil levels shall be indicated. The method of oil measurement shall be defined in the model specification.
- 3.1.4.8 Flight and Ground Loading Conditions: The unit and its attaching hardware shall withstand, without permanent deformation or failure, the largest forces resulting from all critical combinations of loads and rotational accelerations specified in 3.1.4.8.1. For design purposes, minimum yield strength shall provide for at least 1.5 times the largest forces resulting from the loading conditions and a minimum ultimate strength of at least 1.67 times the largest forces resulting from the loading conditions. The design limit torque load shall be the highest value of torque specified in the model specification and shall also include the torque loading conditions resulting from turbine wheel or compressor seizure during containment. For design purposes, the weight of the unit shall include all components, ducting, and parts that make up the complete unit assembly.
- 3.1.4.8.1 External Loads: The load factors and rotational accelerations specified below are to be considered acting separately and in combination with the design limit torque load and over hung moment.
- Applicable loads and accelerations resulting from maximum flight maneuver and ground loading conditions of (TBS) grams, acting in any direction through the center of gravity of the unit.
 - Duct attachment load. The units duct connecting flange(s) shall be capable of withstanding, without permanent deformation or failure, a force of (TBS) pounds direct thrust acting either inward or outward or a moment of (TBS) pound inches acting in any direction around the axial centerline of the flange.

SAE AS1606

3.1.4.9 Safety:

- 3.1.4.9.1 Containment: The unit shall provide for containment, without penetration of a 0.032 in thick aluminum witness shield, of all fragments resulting from a maximum energy hub burst of all high speed rotating components. Witness shield shall be placed a maximum of (TBS) inches away from the skin of the unit.
- 3.1.4.9.2 Clutch Failure Mode: The starter clutch shall not fail in the engaged mode. The failure mode for the starter in the event of a failed output bearing or seal should be such that loads transmitted into the engine gearbox are low enough not to damage the engine gearbox or cause engine shutdown. The resulting imbalance of the starter shaft system shall be such that a failure will not result with the maximum specified imbalance permitted at the engine gearbox pad face.
- 3.1.4.9.3 Over Speed Protection: The unit shall incorporate the following features:
- a. The unit shall provide complete containment of all unit fragments (including three section hub burst) and remain on its mount should a failure occur under any operating condition (temperature and altitude) from sea level to (TBS) feet. In addition, the unit shall contain any failure that occurs due to uncontrolled acceleration of the gas generator or energy conversion and speed reduction assembly including failure of the disengaging clutch. The containment features and associated wheel maximum operating and failure speeds shall be described in detail in the model specification.
 - b. The unit shall incorporate a speed limiting feature, which will safely limit the unit speed, either loaded or unloaded. The speed limiting feature(s) shall limit rotation of all high speed components to 75% of the minimum burst speed(s). The limiting feature shall not require manual resetting and shall function, as necessary, through the overhaul life of the unit without maintenance or adjustment. In addition, the speed limiting feature shall be totally contained within the unit and shall not require external power of any kind. The speed limiting feature(s) shall be described in detail in the model specification.
- 3.1.4.9.4 Over Temperature Sensing Device: The unit shall incorporate an over temperature sensing device, which will terminate unit operation when over temperature occurs. The over temperature device and the method of termination shall be defined in the model specification. At the option of the qualifying activity, the over temperature device may be used to provide cockpit indication in lieu of unit shutdown.

SAE AS1606

- 3.1.4.9.5 External Surface Temperature: The external surface temperature of the unit shall not exceed (TBS) °F during or following any operating condition when mounted in an unventilated compartment as defined in Figure 16. This requirement shall be applicable throughout the ambient temperature range specified herein. Provisions necessary to meet this requirement shall be integral with the unit. The unit external surface temperature profile shall be included in the model specification.
- 3.1.4.9.6 Leakage: There shall be no leakage of liquids or gases into the starter compartment from any part of the unit during or following operation. Fluid overboard drain provisions are permitted but must be identified in the model specification.
- 3.1.4.9.7 Fire: The design and construction of the unit and the materials used must minimize the occurrence and spread of fire. Flammable fluid carrying components shall be designed and tested to be fire resistant (2000 °F flame for 5 min) while fluid holding components shall be designed and tested to be fireproof (2000 °F flame for 15 min).

3.2 Environmental Requirements:

The unit shall meet all the performance requirements of this specification and shall suffer no detrimental effects when exposed to the environmental conditions or natural combination of conditions specified therein.

3.2.1 Temperature: The unit shall withstand the following temperature environment:

- a. Unit Mounting Pad: -65 °F to (TBS) continuous and (TBS) for 30 min.
- b. Local Ambient During Overrunning: -65 °F to (TBS) continuous and (TBS) for 30-min periods
- c. Local Ambient During Start Cycle or Motoring Cycle:
 - (1) Sea Level:
 - (a) -65 to (TBS) °F - Conditioned unit
 - (b) -65 to +125 °F - Conditioned inlet air
 - (c) -65 to +160 °F - Conditioned inlet fuel
 - (2) Altitude; 8000 ft:
 - (a) -65 to +(TBS) °F - Conditioned unit
 - (b) -65 to +95 °F - Conditioned inlet air
 - (c) -65 to +130 °F - Conditioned inlet fuel

NOTE: Low temperature requirement is limited to -40 °F when using MIL-L-23699 oil.

3.2.2 Altitudes: The unit shall meet the performance requirement of the model specification from sea level to (TBS) and in addition shall satisfactorily withstand overrunning from sea level to (TBS) feet.

SAE AS1606

- 3.2.3 Humidity: The unit shall meet the performance requirements of the model specification and suffer no detrimental effects when exposed to any relative humidity conditions from 0 to 100% within the temperature range of -65 to +160 °F, including conditions wherein moisture freely condenses on the unit.
- 3.2.4 Salt Fog: The unit shall meet the performance requirements of this exhibit and shall suffer no detrimental effects during and after exposure to salt laden moisture.
- 3.2.5 Sand and Dust: The unit shall meet the performance requirements of this exhibit and shall suffer no detrimental effects during and after exposure to sand and dust laden air as may be encountered in desert operation.
- 3.2.6 Fungus: The unit shall suffer no detrimental effects from being exposed to fungus growth as encountered in tropical climates.
- 3.2.7 Explosive Atmosphere: Operation of the unit in an explosive atmosphere shall not create a hazard. The details necessary to meet this requirement shall be defined in the model specification.
- 3.2.8 Structural Load: The unit shall have sufficient strength to withstand operating loads and maneuvering loads as specified in the model specification. Strength for both limit and ultimate loads as shown in Figure 11 is required. The cumulative effects of elastic, permanent and thermal deformation, which result from the application of design limit loads, shall not interfere with the mechanical operation of the unit, require repair, or require replacement of parts. Unit operation is not required during or after application of ultimate loads; however, there shall be no structural failure.
- 3.2.8.1 Vibration: The unit shall withstand without damage, the vibration environment at the mounting pad of aircraft induced vibration levels specified in Figure 12. Remotely mounted components shall withstand without damage the vibration environment specified for these components in the model specification.
- 3.2.8.2 Crash Safety: The unit in the area of the mounting provisions shall be designed to withstand a (TBS) g load in any direction.
- 3.2.9 Attitude: The unit shall meet the requirements of the model specification when operated in Zone A of Figure 5. The unit shall be capable of satisfactory operation after continuous overrunning in Zone B of Figure 5. The unit shall be capable of satisfactory operation after periods of overrunning not to exceed (TBS) in Zone C of Figure 5 and after a period not to exceed (TBS) of overrunning in inverted flight.
- 3.2.10 Windmilling: The unit shall suffer no detrimental effects when subjected to windmilling conditions as imposed by (TBS) hours of in-flight airflow, which would result from conditions described in Figure 6.

SAE AS1606

3.3 Design Requirements:

- 3.3.1 Envelope: The size envelope of the unit shall not exceed that shown in Figure 10. The exact dimensions shall be noted on the unit outline drawing, which shall be a part of the model specification.
- 3.3.2 Weight: The weight of the unit shall not exceed (TBS) pound and shall be specified in the model specification. The weight specified shall include the complete unit, lubrication, all accessories necessary for operation of the unit, and all ducting extending to the mating aircraft ducting flanges. The weight of each major component shall also be specified.
- 3.3.3 Over Hung Moment: Maximum over hung moment of the complete unit including ducting, accessories, and lubrication, shall be specified in the model specification and shall not exceed (TBS) pound inches when measured from the face of the mounting flange. Stabilizing mounts shall not be permitted, unless authorized by the qualifying activity. The location of the unit's center of gravity and over hung moment shall be specified in the manufacturers outline drawing.
- 3.3.4 Mounting Flange and Drive: The unit mounting flange and drive spline shall conform to (TBS). The unit shall mount on an engine accessory drive conforming to (TBS).
- 3.3.4.1 Quick Change Capability: It shall be possible to remove and reinstall the unit, and accomplish one aircraft engine start within a (TBS) minute period. It is intended that the replacement unit would be available at the aircraft and access to the unit accomplished. No special tools are to be required.
- 3.3.5 Unit Configuration Control:
- 3.3.5.1 Drawings and Diagrams: The manufacturer shall incorporate reduced size copies of the following drawings and diagrams in the body of the model specification:
- Unit outline drawing.
 - Unit installation drawing, including clearance for periodic inspection, servicing and LRU removal, as well as identification, location, and definition of all connecting points and interfaces.
 - Accessory installation drawings for all major accessories and components (LRU's).
 - Schematic diagrams of the units fuel, electrical, and lubrication system. These schematics must show aircraft attachment and define interface.
 - A complete cut away or cross sectional drawing showing the unit and its components.
 - Logic diagrams for troubleshooting.

SAE AS1606

3.3.5.2 Parts List: The parts list for the unit that successfully completes the preproduction test shall constitute the approved parts list for subsequent units of the same model. The parts list shall be delivered to the qualifying activity prior to delivery of production hardware.

3.3.5.2.1 Part Numbers: Each part and assembly shall be marked with its part number, which shall be the same as the drawing number, except for the following:

- a. Those parts which do not have a suitable or sufficient surface for a part number.
- b. Those parts that are permanently assembled, which shall carry the assembly part number.

The part numbering requirements of DOD-STD-100 shall apply.

3.3.5.2.2 Identification and Marking: Equipment, assemblies, and parts shall be marked for identification in accordance with MIL-STD-130. The identification plate(s) shall be securely attached and shall not work loose in service through normal operation and handling or as a result of contact with MIL-L-7808, MIL-L-23699, MIL-H-5606, MIL-T-5624, MIL-T-83133, and MIL-H-83282 fluids. As a minimum, the identification plate shall include the following:

STARTER, AIRCRAFT ENGINE, GAS TURBINE, MODEL _____
 Manufacturers Part No.
 Manufacturers Serial No.
 Federal Stock No.
 Qualifying Activity Specification
 Date Manufactured

3.3.5.2.3 Critical Component Identification: All critical components shall be specified as such in the model specification and shall be identified by serial number. As a minimum, aerodynamic rotating components (compressor wheels and turbine wheels) shall be considered critical. The manufacturer shall maintain traceability of serialized components for each unit shipped.

3.3.5.2.4 Interchangeability and Replaceability: All parts having the same part number shall be functionally and dimensionally interchangeable in accordance with MIL-I-8500. Matched parts or selective fits will be avoided wherever possible, however, where required these shall be identified as "matched assembly" and shall be serialized.

3.3.5.3 Changes: Changes to the unit features requiring changes in the aircraft or ground support equipment, made after approval of the mockup, shall be submitted to the qualifying activity in accordance with MIL-STD-480 and MIL-STD-481 for approval. Unless otherwise authorized, the mockup shall be kept current with approved changes to completion of qualification testing.