MIL-S-38399A(USAF)
14 February 1975
Superseding
MIL-S-38399 (USAF)
16 February 1965

MILITARY SPECIFICATION

STARTER, PNEUMATIC, AIRCRAFT ENGINE

GENERAL SPECIFICATION FOR

This specification is approved for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 Scope. This specification covers the general requirements for pneumatic starters for aeronautical gas turbine engines.

1.2 Classification. The military type and model designation will be assigned by the procuring activity in accordance with MIL-STD-875 and shall be specified in the model specification.

2. APPLICABLE DOCUMENTS

2.1 The following documents of the issue in effect on date of invitation for bids or request for proposals, form a part of this specification to the extent specified herein:

SPECIFICATIONS

Military

MIL-T-5021	Tests; Aircraft and Missile Welding, Operators' Qualification
MIL-E-5007	Engines, Aircraft, Turbojet and Turbofan, General Specification for
MIL-C-6021	Castings, Classification and Inspection of
MIL-I-6866	Inspection, Penetrant Method of
MIL-I-6868	Inspection Process, Magnetic Particle
MIL-E-7080	Electric Equipment, Aircraft, Selections and Installation of
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

FSC 2995

MIL-C-8188	Corrosion-Preventive Oil, Gas Turbine Engine, Aircraft, Synthetic Base
MIL-I-8500	Interchangeability and Replaceability of Component Parts for Aircraft and Missiles
MIL-S-8516	Sealing Compound, Polysulfide Rubber, Electric Connectors and Electrical Systems, Chemically Cured
MIL-A-8625	Anodic Coatings, for Aluminum and Aluminum Alloys
MIL-D-8706	Data and Tests, Engineering, Contract Requirements for Aircraft Weapons Systems
MIL-S-8879	Screw Threads, Controlled Radius Root with Increased Minor Diameter, General Specification for
MIL-S-23586	Sealing Compound, Electrical, Silicone Rubber, Accelerator Required
MIL-I-81550	Insulating Compound, Electrical, Embedding, Reversion Resistant Silicone

STANDARDS

Military

MIL-STD-100	Engineering Drawing Practices
MIL-STD-129	Marking for Shipment and Storage
MIL-STD-130	Identification Marking of US Military Property
MIL-STD-143	Standards and Specifications, Order of Precedence for the Selection of
MIL-STD-453	Inspection, Radiographic
MIL-STD-454	Standard General Requirements for Electronic Equipment
MIL-STD-470	Maintainability Program Requirements (for Systems and Equipment)
MIL-STD-480	Configuration Control - Engineering Changes, Deviations and Waivers
MIL-STD-490	Specification Practices
MIL-STD-704	Electric Power, Aircraft, Characteristics and Utilization of
MIL-STD-810	Environmental Test Methods
MIL-STD-831	Test Reports, Preparation of
MIL-STD-875	Type Designation System for Aeronautical and Support Equipment
MIL-STD-889	Dissimilar Metals
MIL-STD-1523	Age-Control of Age-sensitive Elastomeric Materials
MS 20995	Wire, Safety of Lock
MS 33540	Safety Wiring and Cotton Pinning, General Practices for
MS 33588	Nut, Self-Locking, Aircraft Design and Usage Limitations of

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

3. REQUIREMENTS

3.1 Preproduction. This specification makes provisions for preproduction testing.

3.2 Model specification and data submittal. When specified in the procurement contract, a starter model specification conforming to the outline and instructions for preparation specified herein, shall be prepared by the contractor and submitted to the procuring activity for approval (see 6.2 and 6.3.14). The model specification shall provide all the necessary information to completely describe the starter for one weapon system application. Approval of the model specification is required prior to initiation of preproduction and quality conformance testing. Changes and revisions to the model specification shall be in accordance with MIL-STD-490.

a. The headings and numbering of sections and paragraphs in the model specification shall correspond to those in this specification. Specific data required by this specification and such other additional data as may be required to completely describe the unit shall be included in the model specification. Omission of reference in the model specification to a particular requirement of this specification by the manufacturer shall be interpreted as compliance therewith. When departures from the requirements of this specification are necessary, the details of such departures shall be stated as specific requirements bearing the same section, paragraph heading, and numbering as in this specification.

b. All applicable documents shall be listed in numerical order in Section 2 of model specification and shall include the applicable revision and date of issue.

c. All curves shall be presented on graph paper having an adequate number of subdivisions to permit easy interpolation.

d. Definitions and symbols. Terms, their definitions, and symbols used in the model specification shall be in accordance with 6.3 herein.

3.2.1 Detail specification. Requirements for individual items shall be as specified herein and shall be in accordance with the applicable detail specification (see 6.3.15) for the system.

3.2.2 Starter system data submittal and approval. Starter system data submittal and approval requirements for a specific model aircraft shall be covered by a contract with the appropriate procuring activity. Typical information and data requested are listed in 6.2. The data shall be furnished in accordance with MIL-D-8706 or in accordance with appropriate line items of the Contractor Data Requirements List (DD form 1423) as applicable.

3.3 Mockup. A full-scale mockup shall be prepared for examination and aircraft installation suitability as soon as the contractor has established the necessary design features of the starter. Prior to initiation of the preproduction testing, the mockup shall be installed on the aircraft for which the design was finalized to demonstrate satisfactory fit and installation features. Examination shall be at the option of the procuring activity.

3.3.1 Changes. Changes to the starter features requiring changes in the vehicle or ground support equipment made after approval of the mockup shall be submitted to the procuring activity for approval in accordance with MIL-STD-480. Any changes required by the procuring activity shall be subject to negotiation as provided in the contract. Unless otherwise authorized, the mockup shall be kept current with approved changes at least through the first production contract.

3.4 Components. Normally, the starter shall consist of the following assemblies and systems:

a. Energy conversion and speed reduction assembly . . . 3.12.1
b. Clutch and output assembly . . . 3.12.2
c. Control system . . . 3.12.3
d. Lubrication system . . . 3.12.4

3.5 Selection of specifications and standards. Specifications and standards for necessary items and services not specified herein shall be selected according to MIL-STD-143.

3.6 Materials

3.6.1 Metals. Metal parts shall be of the corrosion-resistant type or suitably treated to resist corrosion due to combustion gases or residue, or atmospheric conditions likely to be met in storage or service use. Any corrosion resistant protective coating applied shall provide maximum protection against cracking, chipping or scaling of the coating with age, use, or extremes of atmospheric conditions.

3.6.1.1 Dissimilar metals. Unless protected against electrolytic corrosion, dissimilar metals shall not be used in contact with each other. Dissimilar metals are defined in MIL-STD-889.

3.6.2 Nonexpendable metal parts. Nonexpendable metal parts may be reworked and reused as agreed between the procuring activity and the contractor, if such parts comply with specifications and drawings in all respects.

3.6.3 Synthetic rubber parts. Age of synthetic rubber parts shall be controlled in accordance with MIL-STD-1523.

3.6.4 Castings. Castings shall be in accordance with MIL-C-6021.

3.6.5 Potting compounds. Requirement 47 of MIL-STD-454 shall be adhered to for encapsulation and embedment. Only those materials which meet the requirements of MIL-S-8516, MIL-S-23586, or MIL-I-81550 shall be used.

3.6.6 Organic materials. Materials that are nutrients for fungi shall not be used where it is practical to avoid them. Where used, they shall be treated with a suitable fungicidal agent.

3.7 Design and construction. The starter shall be designed for operational use with a pneumatic energy source, and its design shall be amenable to production processing methods. The starter shall be constructed to withstand the strains, jars, vibrations, and other conditions incident to shipping, storage, installation, and service usage. The pneumatic energy sources shall be defined in the detail specification and model specification.

3.7.1 Overspeed protection. The starter shall be capable of containment of all fragments within its envelope and remain on its mount should a failure occur when the starter is supplied with the maximum combination of pneumatic inlet conditions of pressure and temperature possible in the system from sea level to the maximum aircraft operation altitude. Fragments may be emitted from the starter's exhaust provided they do not constitute a fire hazard or contain sufficient energy to harm equipment, structure, or personnel. In addition, any rotation of the starter case which could shear ducts or other attachments shall not be permitted. The containment features and associated rotor maximum operating and failure speeds shall be described in detail in the model specification.

3.7.1.1 Turbine rotor containment demonstration. Demonstration of maximum-energy hub burst (3 piece, 120° segments) shall be required as follows:

a. For starters restricted solely to ground operation, induced turbine rotor hub burst containment demonstration shall be required at a speed not less than the maximum operating speed of the starter under normal operating conditions. (Maximum starter cut-out speed.)

b. For starters to be used in flight, induced turbine rotor hub burst containment demonstration shall be required at maximum free run speed, assuming starter control valve failure when being supplied with maximum pneumatic inlet conditions.

3.7.1.2 Rotor integrity

3.7.1.2.1 Low cycle fatigue. The starter rotor shall be designed and constructed to minimize the probability of low cycle fatigue. As a minimum, the rotor hub shall be designed to withstand cyclic stresses which occur when cycling up to the maximum normal operating speed with maximum inlet temperature, for two times the number of start cycles which can occur throughout the operational life of the starter. The rotor hub shall also withstand 25 percent of the number of operational life start cycles under maximum free-run conditions.

In those applications where the starter is also required to operate from different types of gas i.e., AGE compressed air, monopropellant and engine bleed air, the rotor hub shall be designed to withstand these normal operating and free running requirements under the maximum conditions occurring with each type of gas. The number of life start cycles with each type of gas used for design and test purposes shall be specified in the detail specification. The number of design operational life start cycle occurring with compressed air shall not be less than 10,000.

3.7.1.2.2 High cycle fatigue. The starter rotor shall be designed such that it is capable of operation to infinite life up to the maximum normal operating speed without fatigue failure. It shall be demonstrated that high cycle fatigue stress is below the endurance limit of the material. For demonstration purposes, infinite life may be considered as 10^7 cycles for ferrous material and 10^9 for non-ferrous material. The starter rotor shall also be designed to operate for two minutes of maximum free run speed per cycle for 25 percent of the operational life start cycles. In those applications where the starter is also required to operate from different types of gas, i.e. AGE compressed air, engine bleed air and monopropellants, the rotor shall withstand free running under the maximum conditions of each type of gas for a duration that is equal to 2 minutes per cycle for 25 percent of the operational life start cycles occurring with each gas.

3.7.1.3 Free run. The starter shall be capable of withstanding a minimum of 10 cycles for two minutes each (not in succession) at the maximum normal free run speed without failure.

3.7.1.4 Free run to failure. The starter shall be capable of containing all fragments and remain on its mount should a free-run failure occur, with cessation of rotation at the conditions that produce maximum free run speed, without possibility of the spread of fire because of structural failure, overheating, leaking flammables or other causes. Also in the event the unit is allowed to free run until a turbine bearing failure occurs, a means shall be provided to prevent an axial shift of the turbine wheel that would negate the containment provisions.

3.7.1.5 Engaging mechanism failure. Unless it can be shown that the starter engaging mechanism is fail safe, the unit shall incorporate at least one of the provisions defined below to prevent a hazardous condition in the event the starter rotor is driven by the engine due to a failure of the engaging mechanism:
a. An automatic emergency starter drive disengagement mechanism shall be incorporated external of the starter gear section to effect emergency disengagement of the starter from the engine in the event normal disengagement does not occur. The disengaging mechanism shall be so designed that removal of the starter from the engine pad shall be required to effect re-engagement of the starter drive. An attempted start, after an emergency disengagement has been experienced, shall not cause damage to the starter or the engine.

b. Containment of a maximum energy tri-hub burst (3-piece, 120° segments) shall be provided up to the starter rotor burst speed or to maximum speed at which the engine can drive the starter rotor due to a failed engaging mechanism.
c. The starter rotor shall incorporate rim and blade fusing such that at a predetermined speed the rim and blades shall separate from the turbine hub. The minimum fuse burst speed shall be greater than the maximum free run speed and the fused parts shall be contained at the fuse burst speed. Containment shall also be provided for the remaining rotating parts up to the maximum possible driven speed.

3.7.2 External surface temperature. The external surface temperature of the starter shall not exceed 371° C (700°F) during or after any operating condition throughout the ambient temperature range specified herein. Provisions necessary to meet this requirement shall be integral with the starter and shall not require external covering or insulating blanket(s).

3.7.3 Flight and ground loading conditions. The starter shall withstand, without permanent deformation or failure, the largest forces resulting from all critical combinations of loads and rotational accelerations specified in 3.7.3.1. 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 seizure during containment. For design purposes, the weight of the starter shall include all components and parts that make up the complete starter assembly.

3.7.3.1 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 overhung moment:
a. Applicable loads and accelerations resulting from maximum flight maneuvers and ground loading conditions of 10g, unless otherwise specified in the detail specification, acting in any direction through the center gravity of the starter.
b. Duct attachment load. Unless otherwise specified in the detail specification, the starter duct connecting flange(s) shall be capable of withstanding, without permanent deformation or failure, a force of 222N (50 pounds) direct thrust acting either inward or outward or a moment of 16.9 NM (150 inch pounds) acting in any direction around the axial centerline of the flange.

3.7.4 Electrical equipment. All electrical equipment shall be designed in accordance with MIL-E-7080. Electrical equipment shall operate with power as defined in MIL-STD-704.

3.7.4.1 Dielectric strength. All parts of electrical equipment, except critical components such as transistors and capacitors, shall be capable of withstanding, at commercial frequency, a voltage of 1,000V (rms) plus twice the working voltage. Transistors and capacitors shall withstand twice the peak voltage to which they will be subjected during service or 100V, whichever is greater, for a period of 1 minute.

3.7.5 Threads

3.7.5.1 Straight screw threads. All conventional straight screw threads shall conform to the requirements of MIL-S-8879, Classes 3A or 3B. The use of MIL-S-7742 is optional for threads used for:

a. Electrical connections.
b. Screw threads 3.5 mm (.138 inch) diameter and smaller.
c. Interference fits and other applications where MIL-S-7742 threads are suitable for the intended purpose, such as installation of studs or external threads of inserts and their mating tapped holes.

3.7.5.2 Tapered pipe threads. Tapered pipe threads shall be in accordance with MIL-P-7105 and may be used only for permanently plugging drilled or cored openings.

3.7.5.3 Threaded inserts. All threaded connections in nonferrous materials which are heavily loaded or removed frequently shall have steel inserts which are suitably protected from electrolytic corrosion. Fill and drain boss inserts shall be designed to permit the use of standard gaskets or seals and standard straight thread plugs.

3.7.6 Starter adapter flange. Unless specified otherwise in the detail specification, the starter shall incorporate a quick-attach-detach (QAD) type of mounting flange. The adapter shall provide for indexing and torsional restraint of the starter. The QAD shall not require special tools for its use. Any adapter required to modify the engine accessory drive in order to mount the starter or to make the starter compatible with the engine drive, shall be furnished with the starter. Mounting of the starter shall be accomplished without requiring any measurements or adjustments of the engine accessory drive or starter prior to installation. The device for actuation of the QAD mounting shall be automatically safetied when not in use.

3.7.7 Envelope. All components of the starter shall be contained within the envelope dimensions specified in the detail specification. The exact dimensions of the starter shall be noted in the model specification, or on the installation drawings.

3.7.8 Weight. The weight of the starter, filled with lubricant, shall be specified in the model specification and shall not exceed that specified in the detail specification.

3.7.9 Overhung moment. Maximum overhung moment of the complete starter, filled with lubricant, shall be specified in the model specification and shall not exceed that specified in the detail specification when measured from the face of the mounting flange. The location of the starter's center of gravity, weight, and overhung shall be specified on the starter vendor's outline drawing.

3.7.10 Polar moment of inertia. The starter effective mass polar moment of inertia at the starter drive shall be specified in the model specification.

3.7.11 Inspection seals. Calibration adjustment points and other critical points shall be assembled at the factory with inspection seals so that no part of the starter can be disassembled without breaking a seal.

3.7.12 Safetying. All threaded connections shall be locked to prevent loosening in service by means of safety wiring, self-locking nuts, cotter pins, or other methods approved by the procuring activity. Safety wire shall conform to MS20995 and be installed in accordance with MS33540. The use of lockwashers or staking is prohibited if used as a primary locking device. The general design and usage limitation of self-locking nuts specified in MS33588 shall be applied.

3.7.13 Drainage. The starter shall incorporate provision for drainage or be sealed to prevent water from accumulating within the unit. Drainage shall be such that any condensed or accumulated water will not cause malfunction or cause delay in operation if frozen.

3.7.14 Fitting identification. The starter shall be permanently marked to indicate pneumatic connections, fill and drain ports, electrical connections, and safety devices such as burst diaphragms and safety valves.

3.7.15 Index marking. All components of the starter, such as the pneumatic plenum and gear train housing, shall be marked relative to each other to prevent mispositioning of the components with respect to the mounting pad during starter assembly.

3.7.16 Accessibility. Parts of the starter that require routine service checking, adjustment or replacement shall be readily accessible for servicing and replacement without disassembly of the unit or removal of any major part, component, or accessory.

3.7.17 Disassembly and reassembly. To the extent practical, design of the starter should be such that special tools are not required for disassembly or reassembly of the unit or its components. If special tools are required they shall be defined in the model specification.

3.7.18 Handling supports. For heavy or bulky starters (or starter and valve assemblies if the valve is normally attached during installation and removal) that cannot be conveniently installed or removed by hand, the unit shall have provisions incorporated for hoisting and resting on a level area without damaging attached lines, cables, fittings, or components.

3.7.19 Cover plates. Cover plates or plugs, suitable for transient or storage conditions, shall be provided for all openings on the starter.

3.7.20 Overhaul life. The unit shall perform in accordance with the requirements of this specification throughout 2000 start cycles and 3000 hours of overrunning (normal aircraft flight operating time) or as specified in the detail specification.

3.7.21 Design and fabrication changes. No changes shall be made in the design of parts or materials listed in the approved starter parts list except when such changes are approved in accordance with the provisions of MIL-STD-480. Approval of changes does not relieve the contractor of full responsibility for the results of such changes on starter characteristics. No changes shall be made in vendors or fabrication sources except when such changes are approved by the procuring activity.

3.7.22 Parts list. The parts list for the starter that successfully completes the preproduction test shall constitute the approved parts list for subsequent starters of the same model to be delivered to the procuring activity.

3.8 Inspection process and certification

3.8.1 Magnetic particle inspection. Magnetic particle inspection shall be in accordance with MIL-I-6868.

3.8.2 Fluorescent penetrant inspection. Fluorescent penetrant inspection shall be in accordance with MIL-I-6866.

3.8.3 Fusion welding certification. All operators performing fusion welding shall be certified in accordance with MIL-T-5021.

3.8.4 Radiographic inspection. Radiographic inspection shall be in accordance with MIL-STD-453.

3.8.5 Hydrostatic test methods. Hydrostatic test methods shall be approved by the procuring activity.

3.9 Reliability and maintainability

3.9.1 Reliability. The starter shall be designed and developed to achieve the highest operational reliability commensurate with the design requirements. A minimum demonstrated reliability of 0.999 based on a one cycle mission with a confidence level of 90 percent is required. Satisfactory completion of all tests set forth under section 4 of this specification will demonstrate compliance with the quantitative reliability requirements of this specification. Factors to be considered during the design and manufacture of the starter to assure in-service reliability are:

a. Simplicity of design.
b. Selection and application of reliable components
c. Consideration of operational and environmental parameters.

d. Mechanical structures - adequate design stress margin on all parts.
e. Design review by technical specialists prior to drawing release.
f. Use of proven manufacturing techniques.
g. Rigid quality control procedures imposed throughout procurement, manufacturing, assembly, and testing to assure that maximum design reliability is built into the equipment.

3.9.2 Maintainability. The starter design shall permit easy assembly, disassembly, location of trouble sources, routine service checking, adjustment, and maintenence by service personnel with a minimum of training, using tools and equipment normally available commercially. Maintenance between overhaul periods shall be held to an absolute minimum with a design goal being only routine oil changes at 1000 flight hour intervals. The man minutes required to check and change oil and perform all other field maintenance shall be specified in the model specification. Maintainability considerations shall be in accordance with MIL-STD-470.

3.9.2.1 Quick change capability. It shall be possible to remove and reinstall the starter, and accomplish one aircraft engine start within a ten-minute period. It is intended that the replacement starter would be available at the aircraft and special tools would not be required.

3.9.2.2 Modular assembly. The modular concept of assembly shall be utilized wherever possible in order to improve maintainability and reduce overhaul and maintenance costs. The design goal shall be such that any subassembly of the starter can be replaced without disassembly of the complete starter or removal of other components. The model specification shall define the modules required, the necessary tools for disassembly and assembly, and the estimated time standards to remove and replace each module.

3.10 Performance characteristics. The starter, after being subjected to the tests specified in section 4, shall meet the minimum performance requirements specified herein when operated either with or without a starter control valve. The actual performance characteristics shall be specified in the model specification and shall be predicated on the use of production hardware with adequate allowance for tolerance variations. Performance characteristics shall be based upon the pneumatic inlet conditions listed below and defined in the detail specification.

INLET CONDITIONS TO THE STARTER:

Rated
Maximum Temperature
Minimum Pressure
Maximum Pressure
Maximum Engine Interbleed

3.10.1 Starter output torque. The starter output torque versus rpm shall be as measured at the output drive of the starter for each inlet condition defined in the detail specification. The minimum torque output when defined in the model specification shall not be less than that required in the detail specification.

3.10.2 Duty cycle. The starter shall be capable of making consecutive start cycles when exposed to the environmental conditions specified herein with a maximum interval of 60 seconds between the completion of one cycle and the beginning of the next cycle. In addition, the starter shall be capable of motoring the engine for a minimum of 5 minutes followed by a 5-minute rest period. A starting cycle shall consist of unit initiation and acceleration of the output drive shaft from zero rpm to cutout speed. Duty cycles and engine motoring capability of the unit shall be specified in the model specification.

3.10.3 Automatic starting. The starter shall be so designed that initiation of a single switch or other device shall provide automatic starter operation from initiation to starter cutout. Initiation of the automatic starting cycle shall be from the aircraft cockpit. The automatic starting provisions shall be specified in the model specification.

3.10.4 Stopping. It shall be possible to terminate the starting cycle at any time during the start cycle without damage to the starter.

3.10.5 Running engagement. The starter shall suffer no detrimental effects when subjected to running engagements at any speed up to cutout rpm.

3.10.6 Performance curves. The starter performance shall be defined by the following curves which shall be part of the model specification. The curves shall include minumum and maximum performance limits. Performance shall be defined for each pneumatic inlet condition over the complete altitude and temperature range specified in the detail specification.

3.10.6.1 Starter output torque versus output shaft speed.

3.10.6.2 Typical torque transients at starter output drive versus time showing maximum impact torque.

3.10.6.3 Starter maximum no load speeds versus time.

3.10.6.4 Typical starter output torque at various pressure and temperature inlet conditions.

3.10.6.5 Starter airflow consumption at each inlet condition versus speed.

3.10.6.6 Starter output efficiency at each inlet condition.

3.10.7 Initial calibration. Initial calibration shall be conducted after the break-in run and before initiation of the scheduled test program. The starter shall not be operated between completion of the initial calibration runs and start of the scheduled test program.

3.10.8 Performance deterioration. Performance deterioration shall not be more than 5 percent of the initial calibration values throughout 2000 cycles of operation. Performance during initial calibration of the unit shall meet or exceed the minimum model specification requirements.

3.10.9 Noise level. The starter shall operate such that under all operating conditions the discrete frequency and broad band noise components shall be minimized.

3.11 Environmental conditions. The starter shall suffer no detrimental effects and shall operate satisfactorily during and after exposure to the environmental conditions specified herein or any natural combination of environments as might be anticipated in world-wide operating conditions.

3.11.1 Altitude. The starter shall meet the performance requirements of this specification from sea level to the maximum starter operating and maximum aircraft operational (starter overrunning condition) altitudes specified in the detail specification.

3.11.2 Temperature. The starter shall meet the requirements of this specification when subjected to the extreme thermal conditions of its installation that are associated with the following temperature conditions:

a. Ambient temperature operating range -54°C to 149°C (-65°F to 300°F).
b. Exposure temperature range -73°C to 201°C (-100°F to 400°F).

3.11.3 Humidity. The starter shall meet the performance requirements of this specification and shall suffer no detrimental effects when exposed to any relative humidity conditions from 0 to 100 percent within the temperature range of -53.9°C (-65°F) to 71.1°C (+160°F) including conditions wherein moisture freely condenses on the starter.

3.11.4 Salt fog. The starter shall meet the requirements of this specification and shall suffer no detrimental effects during and after exposure to salt laden moisture.

3.11.5 Sand and dust. The starter shall meet the requirements of this specification and shall suffer no detrimental effects during and after exposure to sand and dust laden air as may be encountered in desert operation.

3.11.6 Fungus. The starter shall suffer no detrimental effects from being exposed to fungus growth as encountered in tropical climates.

3.11.7 Explosive atmosphere. Operation of the starter in an explosive atmosphere shall not create a hazard. The details necessary to meet this requirement shall be defined in the model specification.

3.11.8 Vibration. The starter shall withstand without damage the vibration environment at the engine mounting pad.

3.11.9 Attitude. The starter shall be capable of meeting the starting requirement of this specification in attitudes from 90° down to 105° up and 20° of roll in either direction.

3.12 Details of components

3.12.1 Energy conversion and speed reduction assembly

3.12.1.1 Turbine characteristics

3.12.1.1.1 Operating and free running speed. The maximum operating and free running speeds of the turbine wheel, at sea level and maximum operating altitude specified in the detail specification, shall be specified in the model specification.

3.12.1.1.2 Minimum yield speed. The minimum yield speed of the turbine shall be greater than the maximum free running speed and shall be specified in the model specification.

3.12.1.1.3 Minimum burst speed. The turbine minimum burst speed shall be specified in the model specification.

3.12.1.1.4 Proof speed. The turbine proof speed shall be less than the minimum yield speed and greater than the maximum free running speed and shall be specified in the model specification.

3.12.1.1.5 Turbine identification. Each turbine wheel shall be identified by serial number. The turbine wheel serial number and date of installation shall be shown on a turbine identification plate. The identification plate shall be in accordance with MIL-STD-130. Sufficient space shall be provided on the plate to enter the appropriate turbine record through five overhaul periods.

3.12.1.2 Speed reduction

3.12.1.2.1 Gears. The gear ratio between the energy conversion mechanism and the starter output shaft shall be specified in the model specification. The amount of gear backlash shall be the minimum consistent with the application and shall be specified in the model specification.

3.12.2 Clutch and output assembly

3.12.2.1 Clutches

3.12.2.1.1 Engaging clutch. An engage-disengage clutch shall be provided which will automatically engage or disengage the starter from the engine under all engine starting conditions. The clutch operating limits shall be specified in the model specification.

3.12.2.1.2 Slip clutch. In the event a slip clutch is used, the operating limits shall be specified in the model specification.

3.12.2.2 Output shaft. The starter output shaft shall be replaceable without disassembly of the starter. The maximum starter output shaft torque and direction of rotation shall be defined in the detail specification, and the actual maximum torque shall be specified in the model specification.

3.12.2.2.1 Shear section. A shear section shall be provided as part of the starter output shaft. The shearing torque for new shafts and for shafts that have accumulated life cycle fatigue degradations shall not be less than 80 percent nor more than 90 percent of the shearing torque of the engine starting drive train shear section as defined in MIL-E-5007. The maximum applied torque value at which shear will occur shall be specified in the detail specification. The maximum and minimum values at which the shaft will shear shall be specified in the model specification.

3.12.2.3 Mounting flange and drive. The starter mounting flange and drive spline shall conform to the detail specification requirement and shall mount on the corresponding engine accessory drive or remote gearbox. The accessory drive or remote gearbox type number shall be specified in the model specification.

3.12.3 Control system

3.12.3.1 Cutout device. The starter shall be provided with a speed responsive cutout device which will terminate the power supplied to output shaft at that speed at which the engine no longer requires starter assist (-0 percent, +10 percent). The cutout device shall be defined in the model specification.

3.12.3.2 Starter control valve. The starter control valve shall not be a part of the starter and shall not be furnished with the starter unless specified by the procuring activity. However, if a valve is required in the starting system, the valve requirement shall be specified in the detail specification.

3.12.4 Lubrication system. The lubricant used, whether grease or oil, shall be specified in the model specification. The lubricating system shall be integral with the unit and shall be adequate to lubricate the starter throughout its operating range. The starter design shall be such that no change in lubricant shall be required for operating throughout the ambient temperature range specified in the detail specification. The starter shall be capable of completing the number of starting cycles and hours of overrunning required by the detail specification without changing or adding to the lubricant.

3.12.4.1 Oil supply. If oil is used as a starter lubricant, the oil reservoir shall be furnished as a component part of the starter. The consumption rate shall be specified in the model specification. It shall not be necessary to disassemble the starter or remove it from the engine in order to refill the reservoir. The lubricant used shall be in accordance with MIL-L-7808 unless otherwise specified. The minimum and maximum amount of oil necessary for satisfactory starter operation shall be specified in the model specification. Positive engine or gear-box oil lubrication shall be provided to the spline. The spline shall include an appropriate seal to prevent loss of lubricating oil.

3.12.4.2 Oil loss. All sources of oil loss from the starter and their rate of oil loss shall be specified in the model specification.

3.12.4.3 Oil flow and heat rejection. In the event pressure lubrication is utilized, the oil flow and heat rejection rates shall be specified in the model specification.

3.12.4.4 Oil filter. A suitable oil filter element, if required, shall be provided as a component of the lubrication system and shall be specified in the model specification.

3.12.4.5 Oil fill and drain provisions. Suitable oil fill and drain provisions shall be provided. The unit shall be adequately marked as to capacity and type of oil to be used. A magnetic type oil drain plug shall be provided.

3.12.4.6 Oil level measurement. The oil reservoir of the starter shall be provided with a means for manual measurement of the oil level. The method of oil measurement shall be defined in the model specification.

3.12.5 Other components. The description and performance characteristics of other starter components not specified herein shall be in the model specification.

3.13 Interchangeability. All parts having the same manufacturer's part number shall be functionally and dimensionally interchangeable. Matched parts or selective fits will be avoided wherever possible; however, where required, these parts shall be serialized. The drawing number requirements of MIL-STD-100 shall govern changes in the manufacturer's part numbers. Physical interchangeability shall be in accordance with MIL-I-8500.

3.14 Finishes. All aluminum parts shall be anodized in accordance with MIL-A-8625. Unless otherwise specified by the procuring activity, all exposed surfaces, threads, and plated parts shall be finished with one coat of primer followed by two coats of black enamel.

3.15 Identification of product. The starter shall be marked for identification in accordance with MIL-STD-130 as follows:

Nomenclature

Manufacturer's Part No.

Manufacturer's Serial No.

Federal Stock No.

Design Activity Identification

Contract No.

Rotation (Output Shaft) 1/

1/ The arrow showing the direction of rotation may be included on a single nameplate with other specified data or, at the option of the contractor, it may be stamped on a separate plate attached immediately adjacent to the main nameplate.

3.16 Workmanship. The workmanship and finish shall be of sufficiently high grade to insure satisfactory operation, reliability, and durability consistent with the application and storage life requirements of the starter.

3.17 Deviations. The contractor shall include in the model specification under this paragraph a complete listing of all deviations to the requirements of this specification and the detail specification.

4. QUALITY ASSURANCE PROVISIONS

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

4.1.1 All tests shall be subject to witnessing by an authorized representative or representatives of the procuring activity.

4.2 Classification of tests. The inspection and testing of starters shall be classified as follows:

a. Preproduction tests.
b. Quality conformance tests.

4.3 Test conditions. Unless otherwise specified, the following conditions shall apply for all tests.

4.3.1 Temperature

4.3.1.1 Ambient temperature. Ambient temperature tests shall be conducted at the conditions existing within the test cell at the time of test.

4.3.1.2 Low temperature. Low temperature tests shall be conducted at -53.9°C (-65°F).

4.3.1.3 Normal temperature. Normal temperature tests shall be conducted at 15°C (59°F).

4.3.1.4 High temperature operating. As specified in the detail specification.

4.3.1.5 High temperature overrunning. As specified in the detail specification.

4.3.2 Pressure. Unless otherwise specified herein, all tests shall be conducted at ambient atmospheric pressure.

4.3.3 Inlet conditions. Unless otherwise specified, all pneumatic cycling tests shall be conducted at rated inlet conditions. The pressure and temperature parameters for the following inlet conditions shall be specified in the detail specification for the applicable starter installation. Pressure and temperature limits for all acceptance and calibration cycles shall be ±.07 Bar (±1 psia) and ±8.4°C (±15°F).

4.3.3.1 Rated

4.3.3.2 Maximum temperature

4.3.3.3 Minimum pressure

4.3.3.4 Maximum pressure

4.3.3.5 Maximum engine interbleed

4.3.4 Conditioning time. Conditioning time for the starter shall be such that all parts shall have reached a temperature within ±2.8°C (±5°F) of the specified temperature. A starter shall be considered conditioned when it has been continuously exposed to the specified temperature for the conditioning time, making suitable allowance for the starting temperature. During the conditioning time, the temperature of the conditioning chamber shall not vary more than ±2.8°C (±5°F) from the specified temperature.

4.3.4.1 Long term low temperature soak. The starter shall be maintained at the low temperature for a period of 72 hours.

4.3.5 Transfer time. The starter and component transfer time shall not exceed 5 minutes.

4.3.6 Test apparatus

4.3.6.1 Accuracy. For all starter and component tests, the test apparatus shall be such as to insure that recorded parameters will have the accuracy specified in MIL-STD-810. Other parameters will have a steady-state accuracy within ±2 percent, except that the weight shall be accurate within ±0.2 percent. All apparatus shall be calibrated often to insure that this degree of accuracy is maintained. Calibration records shall be retained by the testing agency for 2 years and furnished to the procuring activity upon request.

4.3.6.2 Recalibration. The point at which an unusual difference occurs in any parameter shall be recorded and the starter shall be recalibrated. If this point occurs prior to the last cycle of testing, the test shall be stopped until the procuring activity is notified and gives approval to proceed.

4.3.6.3 Test flywheels. Two flywheels shall be used in the preproduction test. They shall have different moments of inertia as described below and shall be referred to as flywheel A and flywheel B.

4.3.6.3.1 Flywheel A. Flywheel A shall have a polar moment of inertia which will subject the starter to a loading condition similar to a normal engine starting cycle. This polar moment of inertia shall be defined in the detail specification and shall be specified in the model specification.

4.3.6.3.2 Flywheel B. Flywheel B shall have a polar moment of inertia which will subject the starter to a loading condition similar to an engine exhibiting early light off and rapid acceleration after light off. This polar moment of inertia shall be defined in the detail specification and shall be specified in the model specification.

4.3.6.4 Starter attitude during testing. All starter tests shall be conducted with the starter mounted in its installed operational attitude. The mounting attitude shall be described in the model specification.

4.3.7 Tests and inspection for preproduction and quality conformance approval. Tests and inspections required of the starter and its components for the purpose of establishing preproduction approval and quality conformance approval will be limited to those tests specified herein except as modified for a particular starter design. All verification of requirements by means of results of testing on similar starters or components shall require approval of the procuring activity. This limitation of tests and inspections does not relieve the contractor of responsibility for fulfilling all requirements of this specification or the detail specification.

4.4 Preproduction testing

4.4.1 Preproduction test method. When specified (see 6.2.4), a preproduction test method shall be prepared. The test method shall have been approved by the procuring activity prior to the initiation of preproduction testing. This document shall not be a part of the model specification; however, any deviation to MIL-S-38399 or the detail specification shall be specified in the model specification.

4.4.2 Preproduction tests. Preproduction tests as proposed by the contractor in accordance with 4.4.1 shall be designed to demonstrate complete compliance with all the requirements of Section 3 herein. The following test schedule is provided as an outline for the tests to be conducted on each of the three test units. Specific tests required to demonstrate compliance with each requirement shall be integrated into the individual unit test schedules. Unless otherwise specified in the detail specification, one-half of the endurance testing shall be conducted using flywheel A and the other half using flywheel B.

4.4.2.1 Test sample number one:

a. Calibration.

b. Endurance cycling (at all operating and all inlet conditions - 2000 cycles minimum).

c. Valve compatibility (at maximum pressure inlet conditions - 100 cycles minimum).

d. Free-running.

e. Vibration.

f. Recalibration.

g. Teardown and inspection.

h. Containment demonstration.

4.4.2.2 Test sample number two:

a. Calibration.

b. Endurance cycling((at all operating and inlet conditions - 500 cycles minimum).

c. High temperature cycling overrunning test (1000 hours minimum). Cycling shall consist of 10-hour cycles at temperatures as specified in 3.11.2a.

d. Running engagements (60 cycles minimum). (Engagements to be made at 100, 500, 1000, 1500, and at each successive 500 rpm increment up to starter cut off speed.)

e. Environmental tests.

f. Dielectric test.

g. Recalibration.

h. Teardown inspection.

i. Containment demonstration.

4.4.2.3 Test sample number three:

a. Calibration.

b. Endurance cycling (at all operating and all inlet conditions - 250 cycles minimum.

c. Endurance overrunning test (3000 hours minimum at the mounting pad temperature specified in 3.11.2a).

d. Endurance cycling (at all operating and all inlet conditions - 250 cycles minimum).

e. Recalibration.

f. Teardown and inspection.

g. Engaging mechanism failure test.

h. Structural load test.

4.4.3 Maintenance, adjustment, or replacement of components or parts. Maintenance, adjustment, or replacement of components or parts on preproduction test samples shall not be permitted after initial acceptance of the starters. Disassembly of any part of the starter to any extent prior to the final teardown inspection shall not be permitted.

4.4.3.1 Lubrication. Lubrication shall be accomplished prior to the cycling and endurance testing. After initiation of the testing, addition of oil shall not be permitted. The oil may be changed after completion of 1000 hours of overrunning.

4.4.4 Preproduction failure / success criteria. Preproduction shall be considered successful when all preproduction requirements of section 3 are satisfactorily met. When conditions exist such that an unqualified success cannot be assigned to a particular test the following applies:

a. When the success of a particular test cannot be determined due to instrumentation or a failure not related to the starter, that test shall be repeated at least once.

b. When a starter or starter component related failure or malfunction occurs during a test it shall be repeated at least twice.

4.4.5 Design changes during preproduction. If the design is changed after start of preproduction, testing associated with those performance characteristics stics that could be affected by design changes shall be re-run.

4.4.6 Notification of test failures. A failure analysis report shall be submitted to the procuring activity immediately after any failure of a preproduction test.

4.5 Quality conformance tests. The quality conformance tests shall consist of:

a. Individual tests.

b. Sampling plans and tests.

4.5.1 Individual tests. Each starter and each high speed component shall be subjected to the individual tests specified in 4.5.1.1 and 4.5.1.2 as a minimum. Additional tests may be required depending upon the particular starter design.

4.5.1.1 Individual tests for starters. Each starter shall be subjected to the following tests as described under 4.6:

a. Examination of product (see 4.6.1).

b. Initial cycling (see 4.6.2).

c. Overrunning test (see 4.6.3).

4.5.1.2 Individual tests for high speed components. Each high speed component shall be subjected to the tests described in 4.6.5. These component tests shall be completed prior to initiation of the individual starter tests specified in 4.5.1.1.

4.5.2 Sampling plans and tests

4.5.2.1 Sampling plan A. Each starter of the first 10 production units, every tenth of the next 90, and every 50th production configuration starter thereafter shall be subjected to the teardown inspection as described in 4.6.4.

4.5.2.2 Sampling plan B. The first and every 50th production unit thereafter shall be subjected to the dielectric test as described in 4.6.13.

4.5.3 Rejection and retest. Failure of any unit to pass any individual test listed in 4.5.1 shall be cause for rejection of that unit (rework and retesting is acceptable). Failure of any sampling test on a unit from a lot shall be cause for rejection of the entire lot. Once a lot has been rejected by a procuring agency (Government or industrial), full particulars concerning the cause of rejection and the action(s) taken to correct the defects in the lot shall be furnished in writing before the lot can be retested.

4.5.4 Quality conformance test method. A quality conformance test method, including performance parameters, shall be included as part of the model specification.

4.6 Test methods

4.6.1 Examination of product. Each starter shall be subjected to a careful inspection to insure proper assembly, configuration, workmanship, materials, finishes, processing, weight, identification, and compliance with applicable specifications.

4.6.2 Initial cycling. Each starter shall be subjected to a minimum of four cycles, two of which shall be at rated inlet conditions, and two at maximum inlet pressure conditions. Performance shall be within the limits specified in the model specification curves or the unit shall be rejected.

4.6.3 Overrunning test. The starter output shaft shall be driven for 10 minutes at a speed equivalent to the maximum engine speed at the starter mounting pad as specified in the detail specification. Failure of the starter to remain disengaged shall be cause for rejection. All starters submitted for inspection in accordance with 4.6.4 shall be subjected to a total of 30 minutes of overrunning at the specified speed before teardown.

4.6.4 Teardown inspection. After completion of the initial cycling and overrunning tests, all preproduction starters and the starters tested in accordance with sampling plan A (4.5.2.1) shall be disassembled sufficiently to allow a detailed inspection of all working parts. The extent of the disassembly shall be at the option of procuring activity or its authorized representative. If at any time the disassembly discloses internal deficiencies after the initial cycling and overrunning tests which can only be detected by disassembly, the original schedule for teardown inspection shall be re-initiated. Final cycling shall be accomplished and shall consist of two cycles at rated inlet conditions.

4.6.5 High speed components. Prior to conducting any starter tests, the following shall be accomplished on all high speed components:

a. Subject each part to X-ray inspection in accordance with MIL-STD-453. Any cracks or occlusions that will adversely affect starter performance shall be cause for rejection.

b. Subject each part to fluorescent penetrant inspection in accordance with MIL-I-6866. Any cracks or occlusions that will adversely affect starter performance shall be cause for rejection.

c. Proof spin each turbine wheel for 1 minute at room temperature at the proof speed.

d. Upon completion of items a, b, and c above, subject each turbine wheel to X-ray inspection to determine the extent of deformity, structural damage, and growth of cracks or occlusions. Any wheel growth, deformity, structural damage, growth of cracks or occlusions, or any new cracks shall be cause for rejection.

4.6.6 Calibration. Two cycles of operation shall be completed at each of the following inlet conditions: Rated, maximum temperature, minimum pressure, and maximum pressure inlet conditions with pressure limits of ±.07 Bar (±1 psia) and temperature limits of ±8.4°C (±15°F). Individual test units shall be rejected if initial preproduction test unit calibrations do not meet the performance specified in the model specification.

4.6.7 Starter cycling and endurance test. Including the initial calibration, the starter shall be subjected to 2000 pneumatic cycles, and 3000 hours of endurance running of the starter drive in the overrunning condition as specified in the detail specification. The order of testing and the test conditions shall be as specified herein and in the detail specification. Each cycle shall be conducted as follows:

a. The starter shall be operated such that the load will be accelerated to the cutoff speed of the starter.

b. Upon completing the operation specified in 4.6.7a, the output shaft of the starter shall be driven in excess of 105 percent of the starter cutoff speed for a period of 1 minute.

4.6.7.1 Following each group of approximately 200 test cycles, conducted as specified in 4.6.7a and 4.6.7b, the starter output shall be driven (overrunning) at a speed equal to the maximum speed of the engine accessory drive pad, ±100 rpm, for a period of time equal to one-tenth of the total endurance overrunning time. The temperature conditions shall be as specified in 3.11.2.

4.6.8 Valve compatibility. If the intended application for the starter requires the use of a starter control valve in the installation, the starter shall be subjected to a minimum of 100 test cycles with pneumatic inlet conditions to the starter equivalent to the maximum rise rate of the valve at maximum regulated pressure condition, as applicable. These cycles may be conducted in conjunction with the pneumatic endurance cycles required in 4.6.7.

4.6.9 Free run. With the cutout switch made inoperative, the starter shall be operated at stabilized free run speed for a period of two minutes at maximum inlet conditions. Ten cycles shall be interspersed and conducted during the endurance cycles required in 4.6.7.

4.6.10 Vibration test. Unless otherwise specified in the detail specification, the starter shall be subjected to a vibration test in accordance with MIL-STD-810, Method 514, equipment category (b), mounted without vibration isolators and mounted directly on the aircraft equipment that duplicates the vibration characteristics of the aircraft. The output shaft of the starter shall be accelerated from rest to cutout speed at a normal start cycle acceleration rate, a minimum of 3 times during each resonant frequency endurance test to check the speed sensing devices for sensitivity to vibration. An oscillograph trace of each cutout switch actuation shall be taken for each acceleration cycle. Operation of the speed sensing devices shall be normal, and chatter during actuation or actuation outside of the specified cutout speed ranges shall be cause for rejection. The starter may be overrun during vibration if desired. The starter shall be subjected to two cycles of operation before and after the vibration test and shall meet specified performance. Data obtained shall be corrected to show sea level performance on a 15°C (59°F) day.

4.6.11 Running engagement test. The starter shall be subjected to five series of starts into a moving load. The engagements shall be made at 100 rpm, 500 rpm, 1000 rpm, 1500 rpm, etc., up to minimum starter cutout speed. Each engagement shall be made by accelerating Flywheel A to a speed above that designated for the engagement. As the flywheel coasts down to the engaging speed, a normal start cycle shall be made so that the starter will pick up the rotating load at the proper test speed. The starter output shaft shall be marked so that any permanent twist can be noted in the test report. Failure of any part of the starter including the shear shaft shall be cause for rejection.

4.6.12 Environmental tests.

4.6.12.1 Fungus test. If the starter contains fungus nutrients, the starter shall be subjected to a Fungus Test in accordance with Method 508, Procedure 1, of MIL-STD-810. If no fungus nutrients exist in the starter, a statement to this effect shall be in the test report.

4.6.12.2 Salt fog test. The starter shall be subjected to a 50-hour Salt Fog Test in accordance with Method 509, Procedure I, of MIL-STD-810, while mounted in a manner similar to its intended installation. All openings normally open on the aircraft installation (exhaust, etc.) shall be left open during the test; however, the salt fog shall not be caused to impinge directly into the opening(s). The starter shall be operated before and after the test period as specified in MIL-STD-810 and once every 5 hours during the test. Rated inlet conditions shall be used for all cycles. Data in accordance with fig. 1 shall be recorded for each cycle.

4.6.12.3 Humidity test. With the starter mounted in a manner similar to its intended installation, the starter shall be subjected to a 25-hour Humidity Test. The humidity shall be naintained at 95 percent and the temperature at 51.7°±14°C (125°±25°F). All openings normally open on the aircraft installation (exhaust, etc.) shall be left open during the test. The starter shall be operated before and after the test as specified in MIL-STD-810 and at the end of 5, 10, 20, and 25 hours. At the end of 15 hours, the test shall be interrupted and the starter shall be subjected to an ambient temperature of -53.9°±2.8°C (-65°±5°F) for 5 hours without drying, shaking, or otherwise removing condensed water from the starter. At the end of the 5-hour cold soak period, the starter shall be operated for one cycle. Rated inlet conditions shall be used for all cycles. Data as required for 6.2.1.4 shall be recorded for each cycle.

4.6.12.4 Dust tests

a. Non-operating. The starter shall be subjected to a dust test in accordance with MIL-STD-810, Method 510. All openings normally open on the aircraft installation (exhaust, etc.) shall be left open during the test; however, the dust shall not be caused to impinge directly into the opening(s). The starter shall be subjected to two cycles of operation before and after the test using rated inlet conditions.

b. Operating. The starter shall be subjected to four cycles of dust ingestion at ambient temperature and pressure condititions. The concentration of sand and dust shall be .0529 gram per cubic meter (.0015 grams per cubic foot) of inlet air. The sand and dust containment shall consist of crushed quartz with the total particle size distribution as follows:

Particle Size, Microns	Quantity Percent by Weight Finer than Size Indicated
1,000	100
900	98-99
600	93-97
400	82-86
200	46-50
125	18-22
75	3-7

Any performance deterioration during this test shall be noted in the test report.

4.6.13 Dielectric strength test. The electrical equipment shall be subjected to a test voltage of 1,000V (RMS) plus twice the working voltage at commercial frequency for a period of 1 minute. The test voltage shall be applied between the terminals (shorted together) and ground at sea level atmospheric pressure. If the preceding method of testing is not feasible, the dielectric tests may be conducted on the components prior to final assembly with the critical components disconnected. The test voltage for critical components shall be twice the peak voltage to which they will be subjected during service or 100V, whichever is greater, for a period of 1 minute.

4.6.14 Containment demonstrations

4.6.14.1 The containment demonstration required on sample number 1 shall consist of an induced tri-hub-burst turbine wheel failure at or above maximum cutout speed. Demonstrations which result in fire external of the starter, external surface temperatures in excess of 371°C (700°F), or failure of the starter to contain all fragments and remain on its mounting, shall be cause for rejection. Parts may fall from the starter's exhaust provided they contain no destructive energy. This shall be demonstrated by placing a sheet of soft aluminum [.08cm (.032 inches) or thinner] within three feet of the starter's exhaust such that the exhaust gases will impinge on the aluminum. The aluminum sheet shall be supported such that it will not have a solid backing within one inch of the under side. Any pronounced dent or puncture of the aluminum shall also be cause for rejection. After the containment demonstration, the starter shall be disassembled and inspected for damage resulting from the test. Photographs shall be taken of the starter before disassemble showing any exterior damage and during disassembly showing all internal damage.

4.6.14.2 The containment demonstration required on sample number 2 shall consist of free run to failure with unregulated maximum interbleed inlet conditions to the starter. The failure criteria and method of demonstration shall be the same as specified in 4.6.14.1.

4.6.15 Attitude test. During the high temperature overrunning test required on test sample number 2, the starter shall be subjected to the following attitude cycling once during each 100-hour period of overrunning:

a. Horizontal position - 15 minutes

b. 45° nose up position - 30 minutes

c. 105° nose up position - 3 minutes

d. Horizontal position - 15 minutes

e. 45° nose down position - 30 minutes

f. 90° nose down position - 3 minutes

4.6.16 Structural load test. Unless otherwise specified in the detail specification, the starter shall be subjected to a static load equivalent to 15 g's acting through the center of gravity in 20° increments from 90° to 270°. The top of the starter vertical center line as installed on the aircraft shall be defined as 0°. A complete examination for structural failure of the unit shall be made at completion of the load test. This examination shall include X-ray inspection of the unit and mounting flange. Any evidence of deformity or structural damage shall be cause for rejection.

4.6.17 Recalibration. After completion of all non-destructive testing, a calibration test shall be conducted. The starter shall be within initial calibration after accounting for the allowance for deterioration (3.10.8).

4.6.18 Emergency disengagement mechanism test. If the starter incorporates an emergency disengagement feature, the starter shall be disassembled sufficiently to render the clutch inoperative. After reassembly, the output shaft shall be accelerated until the emergency disengagement feature is actuated. The starter shall then be subjected to a normal acceleration cycle with the disengagement feature actuated. Damage to the starter shall be cause for rejection. If a jaw type decoupler is used to meet the requirements of 3.7.1.5, the following test shall also be run. The starter shall be installed on a test stand with a weakened shear shaft installed. A start cycle shall be run that will cause the shaft to shear and the unit to shut down in its normal manner. A second start cycle shall then be performed with the shaft sheared. Any damage to the starter or the mounting pad shall be cause for rejection.

4.6.19 Teardown and inspection. The starter shall be completely disassembled for inspection. A complete examination of all parts shall be made to determine wear as well as distress or failure. The procuring activity shall be notified at least five working days prior to the scheduled teardown in order that the procuring activity engineering personnel may witness the inspection. Complete photo coverage shall be made of starter and all parts showing general condition of the parts and enlarged views of any wear, distress, or failure of the parts. After completion of the inspection, the replaceable shear shaft shall be sheared to demonstrate that the shaft will fail within the allowable limits.

4.6.20 Shear section. Five shear sections shall be operated for 2,000 cycles from zero to maximum torque under normal starter operating conditions without failure. The rate of loading shall simulate the maximum rate of loading to which the starter is subjected during normal operation. Upon completion of the 2,000 cycles, the section shall be loaded to failure. The loads causing failure shall be as specified in the model specification.

4.6.21 Other tests. Additional component tests may be required depending upon the starter's design.

4.6.22 Test completion. The starter preproduction test will be considered complete when the starter and the components have been subjected to the required tests and inspections and the required reports have been submitted to the procuring activity and approved.

5. PREPARATION FOR DELIVERY

5.1 Preservation. Unless otherwise specified in the applicable contract or order, the oil used in preservation of the starter shall conform to either MIL-L-7808 or MIL-C-8188. If MIL-C-8188 is to be used, the contractor may, at his discretion, conduct the last acceptance run using undiluted MIL-C-8188 oil as the starter lubricant, after which all excess oil shall be drained. The exposed mounting flange and drive shall be cleaned and coated with a light film of either MIL-L-7808 or MIL-C-8188 oil.

5.2 Packaging and packing. Packaging and packing shall be as specified in the detail specification for individual items.

5.3 Marking. In addition to any special marking required, unit packages, intermediate packages, and shipping containers shall be marked in accordance with MIL-STD-129. The shipment marking nomenclature shall be: Starter, Pneumatic, Aircraft Engine.

6. NOTES

6.1 Intended use. The starters covered by this specification are intended for use in aircraft and missiles using gas turbine engines.

6.2 Typical submittal data. To obtain approval of the starter, applicable data in the following subparagraph should be included in compliance with 3.2.2.

6.2.1 Preproduction test data

6.2.1.1 General test data requirements

6.2.1.1.1 Temperature corrections. Performance characteristics shall not be corrected for ambient air temperature. Temperature correction factors shall be furnished in the Preproduction Test Report.

6.2.1.1.2 Pressure corrections. Performance characteristics shall not be corrected for ambient pressure. Pressure correction factors shall be furnished in the Preproduction Test Report.

6.2.1.2 Preproduction data summary. A summary shall be prepared by the contractor of all preproduction testing accomplished. It shall include, as a minimum, the general data required in the following paragraphs and all specific data required in the particular test paragraphs. Where the length of traces makes their inclusion difficult, only the initial and final portions and any other portions of significant interest shall be included. Component test reports covering all component tests conducted on each type of component shall also be submitted. These reports shall be prepared in accordance with MIL-STD-831. (See 6.2.4.)

6.2.1.3 Limits. Specification limits shall be superimposed on the plots of curves made from test data collected in preproduction testing.

6.2.1.4 Cycle data. A preproduction data summary sheet shall be prepared for each preproduction test unit and shall include the requirements of figure 1 as a minimum. In addition the following is required:

a. High speed trace of impact torque versus time with point of starter actuation shown.

b. On the same recording sheet, a trace of acceleration versus time and torque versus time with point of starter actuation shown.

NOTE: High speed traces shall be required for each calibration cycle, first and every tenth valve compatibility cycle, first and every 50th endurance cycle and wherever specified for special tests.

6.2.1.5 Reduced data. The following data shall be reduced for all cycles which are recorded on traces:

a. Impact torque.

b. Torque at 500, 1000, 1500, 2000, and at each 500 rpm increment up to maximum speed.

c. Air consumption.

d. Time from cycle initiation to 2000 rpm.

e. Cutoff switch actuation.

f. Maximum speed.

g. Inlet air total pressure.

h. Inlet air total temperature.

6.2.1.6 Calibration data. In addition to the data required in 6.2.1.5 separate curve sheets shall be prepared for each calibration run. The curve shall have torque plotted versus speed and each sheet shall have the specification performance limits superimposed on the curve.

TEST DATA SUMMARY SHEET

The following data shall be recorded for all tests:

a. Date and time of cycle.

b. Starter model designation (if applicable).

c. Starter serial number.

d. Size and flywheel used (if applicable).

e. Barometric pressure.

f. Ambient air temperature.

g. Type of pretest treatment or conditioning (if applicable).

h. Time in and out of conditioning (if applicable).

i. Starter oil temperature.

j. Cutoff switch actuation speed.

k. Pneumatic inlet conditions.

l. Stall torque.

m. Torque output at 1/3 and 2/3's specification cutout speed.

n. Actual dry weight of unit.

o. Maximum vibration.

p. Stall airflow.

Figure 1

6.2.1.7 Disposition of preproduction test data. Preproduction test data shall be retained by the testing agency for 2 years and furnished to the procuring activity or authorized representative upon request.

6.2.1.8 Preproduction test data analysis. An analysis of all preproduction test data shall be conducted by the contractor and shall be included in the preproduction test report. Any unusual condition, malfunction, failure, or out of specification performance shall be explained in detail in the test report and the procuring activity shall be notified in writing as soon as any of the above conditions are evident.

6.2.2 Quality conformance test data. Performance data shall be obtained from tests conducted on starters submitted for acceptance and shall not be corrected for ambient air temperature or ambient pressure.

6.2.2.1 Quality conformance data summary sheet. A quality conformance data summary sheet shall be prepared in accordance with the applicable portions of figure 1 for each starter.

6.2.3 Drawings and diagrams. When specified (see 6.2.4), the contractor shall prepare the following drawings and diagrams for submission to the procuring activity with the model specification. In addition, reduced size copies of the same drawings and diagrams shall be incorporated in the body of the model specification.

a. Starter installation drawing, showing clearance required for removal, periodic inspections, identification, location, and definition of all connecting points.

b. Electrical installation connection diagrams showing the circuits up to the connection points of the aircraft.

c. A complete cutaway or cross-sectional drawing showing the starter's components and assembly.

d. All contractor specifications listed in the model specification.

e. Preproduction test method (if available).

6.2.4 Ordering data. Procurement documents should specify:

a. Title, number, and date of this specification

b. Requirements for submission of the following data:

(1) Model specification (see 3.2)

(2) Drawings and data specified in 3.15

(3) Preproduction test method and test reports (see 4.4.1 and 6.2.1.2).

c. The parts list should be delivered to the procuring activity prior to delivery of production hardware.

d. Applicable levels of preservation, packaging, and packing (see 5.1 and 5.2).

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

6.3.1 Procuring activity. The procuring activity is the Department of Defense activity which is responsible for the starter contract.

6.3.2 Rating. A rating is the value of some characteristic of performance as specified in the model specification. The starter shall be rated at that condition at which the peak required starting torque occurs for the design engine at -54°C (-65°F). The rating shall also include (1) the maximum design air inlet total temperature and the maximum air inlet total pressure achieving this torque at this design point and (2) the air flow and speed (to the nearest 100 rpm) that occur at these conditions.

6.3.3 Estimate. An estimate is a predicted value of performance.

6.3.4 Initial yield. Initial yield is that point at which 0.2 percent permanent deformation has occurred.

6.3.5 Transfer time. Transfer time is the time interval from the removal of the starter or component from one conditioning chamber to the insertion of the starter into another conditioning chamber, or the time interval from the removal of the starter or component from the conditioning chamber to the initiation of testing.

6.3.6 Zero-time. Zero time is that time at which the starting switch actuation occurs.

6.3.7 Free-run. Free-run speed is that speed which occurs with no load on the output shaft of the starter, with the starter control valve operating normally and with the turbine wheel rpm stabilizing at a speed commensurate with the pneumatic inlet conditions.

6.3.8 Maximum operating speed. Maximum operating speed is that speed which occurs when cut-off actuation takes place at the upper limit of the cutoff operating tolerance.

6.3.9 Cutoff. Cutoff is the speed at which the starter ceases to drive the output shaft.

6.3.10 Overrunning. Overrunning is the driving of the starter output shaft by some means other than by energizing the starter turbine.

6.3.11 Overspeed. Overspeed is the rotation of high speed starter parts at a speed which causes the yield strength of the parts to be exceeded.

6.3.12 Impact torque. Impact torque is the maximum torque delivered to the output shaft of the starter, when engaged to the engine, due to gear backlash during initial operation.

6.3.13 Maximum torque. Maximum torque is the highest torque value occurring after the initial impact torque occurs.

6.3.14 Model specification. The model specification referred to herein is defined as the starter vendor prepared document used to define a particular starter.

6.3.15 Detail specification. The detail specification referred to herein is defined as the document used to define the applicable design and performance parameters required for a particular starter application.

6.3.16 Symbols

Symbols	Quantity
A	Area
A_e	Exhaust nozzle exit area(s)
g	Gravitational constant
T	Temperature
W_s	Total weight of the starter
n_s	Output shaft speed
t_{ws}	Turbine speed
P	Pressure
τ	Torque
τ_{max}	Maximum torque
τ_i	Impact torque
τ_s	Stall torque

6.4 Limitation of demonstrations. Demonstrations required of a starter and its components for the purposes of establishing a service type approval or production acceptance will be limited to those tests specified herein as modified by the individual starter detail and model specification. This limitation of demonstrations will not relieve the starter manufacturer of responsibility for fulfilling all model specification requirements.

6.5 Identification of changes. Asterisks are not used in this revision to identify changes with respect to the previous issue, due to the extensiveness of the changes.

Custodian:
Air Force - 11

Preparing activity:
Air Force - 11

Reviewer activity: 71

FOLD

ASD/ENYESS
Wright-Patterson AFB, O 45433

OFFICIAL BUSINESS
PENALTY FOR PRIVATE USE $300

POSTAGE AND FEES PAID
DEPARTMENT OF THE AIR FORCE
DoD-318

ASD/ENYESS
Wright-Patterson AFB, Ohio 45433

FOLD

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

OMB Approval
No. 22-R255

INSTRUCTIONS: The purpose of this form is to solicit beneficial comments which will help achieve procurement of suitable products at reasonable cost and minimum delay, or will otherwise enhance use of the document. DoD contractors, government activities, or manufacturers/vendors who are prospective suppliers of the product are invited to submit comments to the government. Fold on lines on reverse side, staple in corner, and send to preparing activity. Comments submitted on this form do not constitute or imply authorization to waive any portion of the referenced document(s) or to amend contractual requirements. Attach any pertinent data which may be of use in improving this document. If there are additional papers, attach to form and place both in an envelope addressed to preparing activity.

DOCUMENT IDENTIFIER AND TITLE

NAME OF ORGANIZATION AND ADDRESS

CONTRACT NUMBER

MATERIAL PROCURED UNDER A

☐ DIRECT GOVERNMENT CONTRACT ☐ SUBCONTRACT

1. HAS ANY PART OF THE DOCUMENT CREATED PROBLEMS OR REQUIRED INTERPRETATION IN PROCUREMENT USE?

   A. GIVE PARAGRAPH NUMBER AND WORDING.

   B. RECOMMENDATIONS FOR CORRECTING THE DEFICIENCIES

2. COMMENTS ON ANY DOCUMENT REQUIREMENT CONSIDERED TOO RIGID

3. IS THE DOCUMENT RESTRICTIVE?

   ☐ YES ☐ NO *(If "Yes", in what way?)*

4. REMARKS

SUBMITTED BY *(Printed or typed name and address - Optional)*

TELEPHONE NO.

DATE

DD FORM 1 JAN 72 1426 REPLACES EDITION OF 1 JAN 66 WHICH MAY BE USED

C16061