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AEROSPACE STANDARD

AS 714

AIRCRAFT HYDRAULIC STARTERS

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Revised

1. SCOPE - This Aerospace Standard establishes the common requirements for hydraulic starters, suitable for use in aircraft and missiles, and the methods to be used for demonstrating compliance with these requirements.

1.1 Model Specification - A Model Specification, conforming to Appendix I of this AS, shall be prepared for each starter model by either the procuring activity or the starter manufacturer. Where conflicts exist, the requirements of the Model Specification shall govern.

2. APPLICABLE DOCUMENTS

2.1 The following documents shall form a part of this standard to the extent specified herein. The applicable issue of each shall be that in effect on the date of this AS unless otherwise specified in the manufacturer's Model Specification. Supplementary specifications, standards, or the like, which by reference in any of the following publications are indicated to be part thereof, shall not be considered as effective except as specifically stated in the manufacturer's Model Specification or as may be otherwise mutually agreed upon between the vendor and the purchaser.

2.1.1 Federal

QQ-C-320	Chromium Plating (Electrodeposited)
QQ-N-290	Nickel Plating
QQ-P-416-1	Plating, Cadmium (Electrodeposited)
QQ-S-365	Silver Plating (Electrodeposited)
QQ-Z-325	Zinc Plating (Electrodeposited)

2.1.2 Military

MIL-A-8625	Anodic Films; Corrosion-Protective (For) Aluminum Alloys
MIL-B-18364	Bulletins; Aircraft Power Plant, Propeller, Auxiliary Power and Starting Unit; Preparation of
MIL-C-5501	Caps and Plugs, Protective, Dust and Moisture Seal
MIL-C-5541	Chemical Films for Aluminum and Aluminum Alloys
MIL-C-11796	Corrosion Preventative, Petrolatum, Hot Application
MIL-D-70327	Drawings, Engineering and Associated Lists
MIL-E-5009	Engines, Aircraft, Turbojet, Qualification Tests For
MIL-F-8815	Filter and Filter Elements, Fluid Pressure, Hydraulic, Line, 15 Micron Absolute, Type II Systems

2.1.2 Military (Continued)

MIL-H-5440	Hydraulic Systems; Design, Installation and Tests of Aircraft, General Specification For
MIL-H-6083	Hydraulic Fluid, Petroleum Base, Preservative
MIL-H-8775	Hydraulic Systems Components, Aircraft General Specification For
MIL-H-25475	Hydraulic Systems, Missile, Design, Installation, Tests, and Data Requirements, General Requirements For
MIL-M-3171	Magnesium Alloy, Processes For Corrosion Protection of
MIL-P-116	Preservation, Methods of
MIL-P-6906	Plates, Information and Identification
MIL-S-7742	Screw Threads, Standard, Aeronautical
MIL-T-10727	Tin Plating

2.1.3 Standards

MIL-STD-10	Surface Roughness, Waviness and Lay
MIL-STD-129	Marking of Shipments
MIL-STD-130	Identification Marking of U.S. Military Property
MIL-STD-143	Specifications and Standards, Use of
MIL-STD-33540	Safety Wiring, General Practices for
MIL-STD-33586	Metals, Definition of Dissimilar

2.1.4 Drawings (Air Force-Navy Aeronautical Standard Drawings)

AND 10050	Bosses, Standard Dimensions for Gasket-Seal Straight Thread

2.1.5 Publications (Air Force-Navy Aeronautical Bulletins)

No. 445	Engineering Changes to Weapons, Systems, Equipments, and Facilities

3. DESIGN REQUIREMENTS

3.1 General Requirements - This section describes the general requirements for hydraulic starters, either fixed or variable displacement, suitable for operation in hydraulic systems conforming to the requirements of Specifications MIL-H-5440 or MIL-H-25475, or as otherwise specified by the Model Specification. The starters shall include any combination of the components listed below needed to satisfactorily meet the requirements of this AS and the Model Specification.

3.1.1 Motor Assembly - The starter design shall incorporate a hydraulic motor assembly, suitable for converting fluid energy into mechanical energy in the form of rotary motion. Variable units shall include the necessary mechanism for providing a change in displacement during the starting cycle.

3.1.2 Starter Controls - Variable displacement starters shall be equipped with suitable controls for providing a controlled change in displacement during the starting cycle, in accordance with Curve C of Fig. 1.

3.1.3 Clutch Assembly - The starter design shall incorporate a clutch mechanism to provide engagement, disengagement and reengagement of the output shaft independent of any external signal.

3.1.4 Gear Assembly - For applications requiring a speed ratio between the hydraulic assembly and the output shaft, the necessary gear assembly shall be incorporated within the construction of the starters.

3.1.5 Drive Couplings - The starter design shall incorporate a replaceable drive coupling with a shear section or other torque limiting device sized to limit transmitted torque within the intended engine drive rating.

3.1.6 Cut-out Device - The starter design shall incorporate a suitable cut-out device for operation in conjunction with a system shut-off valve to stop the supply of fluid at the end of the starting cycle.

3.1.7 Speed Limiter - The no-load runaway speed of the starters shall be limited to a safe value, either by inherent design characteristics or by the incorporation of speed limiting devices.

3.1.8 Shaft Seal - The starter design shall incorporate an output shaft seal assembly to prevent the leakage of hydraulic fluid or gear case lubricant from the starter or the entry of engine lubricant into the starter.

3.1.9 Parts Containment - In the event of an internal failure of the starter all parts shall be contained within the starter housing and there shall be no loss of fluid from the starter due to the failure.

3.2 Performance Characteristics - The following paragraphs, together with Fig. 1, describe the typical performance characteristics of hydraulic starters when operated from different types of hydraulic power sources.

3.2.1 Fixed Displacement - Constant Pressure - Fixed displacement starters, except for variations in efficiency, produce essentially constant torque output when operating from a constant pressure source. Typical performance is shown as Curve A of Fig. 1.

3.2.2 Fixed Displacement - Accumulator Supply - Fixed displacement starters produce a diminishing torque output during the starting cycle when operating from a fixed volume supply such as an accumulator. Output torque, except for variations in efficiency, is essentially proportional to input hydraulic pressure. Typical performance is shown as Curve B of Fig. 1.

3.2.3 Variable Displacement - Flow Limited - Variable displacement starters, when operated from a pressure regulated source, produce essentially constant torque during the initial portion of the starting cycle. For the balance of the starting cycle, output torque decreases along an approximately constant horsepower line which is usually determined on the basis of fluid flow rate limitations. Typical performance is shown as Curve C of Fig. 1.

3.3 Design Requirements

3.3.1 Functional Requirements - The starters shall be designed and constructed to satisfy the performance requirements specified below when operating under the rated hydraulic conditions as defined.

3.3.1.1 Hydraulic Fluid - The starters shall meet the functional requirements using the hydraulic fluid defined in the Model Specification. Contamination level shall be based upon continuous filtration of the inlet fluid through a 15 micron absolute filter conforming to Specification MIL-F-8815.

3.3.1.2 Rated Inlet Pressure - The rated inlet pressure is defined as the maximum pressure required at the starter inlet port when operating at rated torque, rated outlet pressure and rated temperature. The rated inlet pressure shall be stated in the Model Specification and shall be one of the values listed in Table I.

TABLE I

System Pressure	Rated Inlet Pressure
3000 PSIG	2800 PSIG
4000 PSIG	3750 PSIG
5000 PSIG	4700 PSIG

3.3.1.3 Rated Outlet Pressure - The rated outlet pressure is defined as the pressure at the starter outlet port against which the starter is designed to produce rated torque at rated inlet pressure and rated temperature. The rated outlet pressure shall be 150 PSIG.

3.3.1.4 Rated Temperature - The rated temperature is defined as the maximum fluid temperature at the starter inlet port when operating at rated torque and rated pressures. The rated temperature shall be stated in the Model Specification and shall be one of the values listed in Table II.

TABLE II

Hydraulic System	Rated Temperature
Type I	160 F
Type II	275 F
Type III	450 F

3.3.1.5 Rated Torque - The rated torque is defined as the minimum torque at the starter output shaft when operating at rated pressures, rated temperature, and rated speed. The rated torque shall be stated in the Model Specification together with the maximum continuous torque, the maximum peak transient torque and the minimum torque at minimum cut-off speed.

3.3.1.6 Rated Flow - The rated flow is defined as the maximum fluid flow needed to meet the torque requirements at any starter output shaft speed from zero RPM to cut-out speed. The rated flow shall be stated in the Model Specification together with the maximum flow during no-load operation.

3.3.1.7 Rated Speed - The rated speed is defined as the maximum starter output shaft speed at which rated torque is produced and is usually related to engine light-off speed. The rated speed shall be stated in the Model Specification.

3.3.1.8 Cut-out Speed - The cut-out speed is defined as the starter output shaft speed at which the cut-out device will signal the termination of starter operation, for example, opening a normally closed electrical circuit. The minimum and maximum cut-out speeds shall be stated in the Model Specification.

3.3.1.9 Over-running Speed - The starters shall be capable of continuous over-running operation at the maximum over-running speed stated in the Model Specification and under the conditions specified in Paragraph 4.5.14.

3.3.1.10 Leakage - External leakage from the starter housing or from any static seal thereof, of sufficient magnitude to form a drop, shall not be permitted. Leakage from the drive shaft seal, under specified operating conditions, shall not exceed the values specified in Paragraph 4.5.

3.3.1.11 Continuous Motoring - The starters shall be capable of continuous motoring operation for a minimum of 5 minutes at any speed and torque within the limits of Figure 1, provided that rated hydraulic conditions are maintained.

3.3.1.12 No-Load Operation - The starters shall be capable of operating for a minimum of 1 minute at rated hydraulic conditions with the output shaft unloaded and the cut-out device inoperative.

3.3.1.13 Service Life - The starters shall be designed to perform satisfactorily for 600 cycles of engine starting operation and 500 hours of over-running operation under specified conditions as defined in Paragraphs 4.5.13 and 4.5.14.

3.3.2 Environmental Requirements - The starters shall be designed to operate, without impairment of function or change in adjustment, under environmental conditions as specified below. Except as specifically directed under Section 4 (Quality Assurance Provisions), testing to demonstrate compliance with these requirements shall not be mandatory.

3.3.2.1 Altitude - Provided inlet and discharge pressures are maintained at rated conditions, starter performance shall not be affected by change of altitude.

3.3.2.2 Temperature - The starters shall be designed to withstand an ambient temperature range of -65 to +275 F.

3.3.2.3 Vibration - The starters shall be designed to be inherently balanced and shall be capable of meeting the vibration test requirements of MIL-E-5009, as related to Environmental Tests for engine components, particularly during over-running operation.

3.3.2.4 Impact - The starters shall be designed to withstand impact shocks of 30 g, applied in any direction, for a minimum time duration of 10 milli-seconds.

3.3.2.5 Acceleration - The starters shall be designed to withstand sustained accelerations (greater than 1 second) of 10 g applied in any direction.

3.3.2.6 Atmospheric Conditions - The starters shall be designed to withstand continuous exposure, either operating or non-operating, to salt spray, sand and dust, humidity and fungus.

3.3.3 Installation Requirements - The starters shall be designed for mounting on the engine accessory drive specified in the Model Specification. Installation or removal of the starters shall be accomplished as a single unit without separable parts and shall not require special tools.

3.3.3.1 Rotation - Drive rotation for the starters shall be identified as viewed from the anti-drive end of the starter and shall be stated in the Model Specification.

3.3.3.2 Moment of Inertia - The effective moment of inertia of the engine assembly, related to the starter output shaft, shall be determined and shall be stated in the Model Specification.

3.3.3.3 Dimensions - The starter envelope shall be within the dimensions shown on the manufacturer's installation drawing and the location of fluid ports and electrical connectors shall be as shown. The location of the center of gravity of the starter shall be indicated on the drawing.

3.3.3.4 Weight - The dry weight of the starters shall not exceed the value stated in the Model Specification.

3.3.3.5 Drive Couplings - The starter shall incorporate a drive coupling with a shear section or torque limiting device sized so that the maximum static torque transmitted will not exceed the value stated in the Model Specification. The drive coupling shall be held in place by a positive retainer and shall be replaceable without disassembly of the starter.

3.3.3.6 Ports - Inlet and outlet ports shall conform to Drawing AND-10050. Seal drain ports shall conform to Drawing AND-10050-4. All ports shall be sized and located as shown on the manufacturer's installation drawing. The starter design shall eliminate the necessity for a case drain port.

3.3.4 Detail Requirements - The starters shall be designed and constructed so as to perform the intended purpose defined in the Model Specification during normal service usage and to withstand the environmental conditions as defined in Paragraph 3.3.2.

3.3.4.1 Materials - Materials used in the manufacture of these starters shall be of high quality, suitable for the purpose, and shall conform to applicable Government specifications. Materials conforming to contractor's specifications may be used provided the specifications are released by the Government and contain provisions for adequate tests. The use of contractor's specifications will not constitute waiver of Government inspection.

3.3.4.1.1 Selection of Materials - Specifications and standards for all materials and parts, and Government certification and approval of processes and equipment, which are not specifically designated herein, and which are necessary for the execution of this specification, shall be selected in accordance with Standard MIL-STD-143, except as provided in paragraphs 3.3.4.1.2 and 3.3.4.1.3.

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

3.3.4.1.3 Standard Materials and Processes - Where performance or reliability of the starters will be jeopardized by the use of materials and processes as defined in Paragraph 3.3.4.1.1, alternate materials and processes may be used subject to the approval of the procuring activity. Such materials and processes shall be selected so as to provide the maximum degree of corrosion resistance consistent with the performance requirements.

3.3.4.1.4 Metals - All metals used in the construction of the starters, except metals which are in constant contact with hydraulic fluid, shall be of a corrosion-resisting type or shall be suitably protected in accordance with Paragraph 3.3.4.2. The use of dissimilar metals, as defined by Standard MIL-STD-33586, shall be avoided wherever practicable.

3.3.4.1.5 Packings - All packings shall be in accordance with the requirements of Specifications MIL-H-5440 or MIL-H-25475.

3.3.4.2 Corrosion Protection - Metals which do not inherently possess adequate corrosion-resisting characteristics shall be suitably protected, in accordance with the following sub-paragraphs, to resist corrosion which may result from such conditions as dissimilar metal combinations, moisture, salt spray, and high temperature deterioration as applicable.

3.3.4.2.1 Ferrous and Copper Alloys - Ferrous alloys requiring corrosion preventative treatment, and all copper alloys except for parts having bearing surfaces, shall have a suitable electrodeposited metallic coating selected from the following list, except that tin, cadmium, and zinc plating shall not be used for internal parts or on internal surfaces in contact with hydraulic fluid or exposed to its vapors, nor where subject to abrasion. Where not indicated, class or type is at the option of the manufacturer.

Cadmium Plating	Spec. QQ-P-416-1, Type II, Class B
Zinc Plating	Spec. QQ-Z-325, Class II, Type II
Chromium	Spec. QQ-C-320
Nickel	QQ-N-290
Silver	QQ-S-365
Tin	MIL-T-10727, Type 1

3.3.4.2.2 Aluminum Alloys - Unless otherwise authorized, all aluminum alloys shall be anodized in accordance with Specification MIL-A-8625 except that in the absence of abrasive conditions they may be coated with chemical film in accordance with Specification MIL-C-5541. The exceptions noted will be subject to the approval of the procuring activity.

3.3.4.2.3 Magnesium Alloys - All magnesium parts shall be treated for protection against corrosion in accordance with Specification MIL-M-3171, or by other treatments specifically approved for the purpose by the procuring activity.

3.3.4.3 Screw Threads - Except where necessary for functional or manufacturing purposes, only straight threads conforming to Specification MIL-S-7742 shall be used.

3.3.4.3.1 Safetying - Threaded parts shall be positively locked or safetied by safety wiring, self-locking nuts, or other approved methods. Safety wire shall be applied in accordance with the practices outlined in Standard MIL-STD-33540. Star washers and lockwashers shall not be used. Jam nuts shall also be properly safetied. Parts with tapered threads need not be safety wired or positively locked.

3.3.4.4 Identification of Product - The equipment shall be marked for identification in accordance with Standard MIL-STD-130.

3.3.4.4.1 Nameplate - Each starter shall be clearly and permanently marked with a durable nameplate conforming to Specification MIL-P-6906, securely attached to a part of the starter which will not ordinarily be renewed during normal service life, specifying the following information:

STARTER: HYDRAULIC, (FIXED) (VARIABLE) DISPLACEMENT

Model Specification
Type (If Applicable)
Stock No. (If Applicable)
Direction of Rotation (Arrows)
Rated Inlet Pressure_____PSIG
Rated Flow_____GPM
Manufacturer's Part No.
Manufacturer's Serial No.
Contract No.
Manufacturer's Name or Trade-Mark
U. S. Property (If Applicable)
Hydraulic Fluid

3.3.4.4.2 AN or MIL Designations - AN or MIL designations shall not be applied to a product, except for Qualification test samples, nor referred to in correspondence, until notice of approval has been received from the activity responsible for qualification, or from the Aeronautical Standards Group.

3.3.4.5 Automatic Cut-out Device - The starter design shall incorporate an automatic cut-out device which will open a normally closed circuit within the cut-out speed range specified in the Model Specification when operating at rated conditions. The device shall be designed to meet the electrical requirements stated in the Model Specification.

3.3.4.6 Lubrication - It is preferred that the starters be self-lubricated with no provisions for lubrication other than the hydraulic fluid. It is further desired that only the specified hydraulic fluid be used to lubricate seals during assembly and installation of the starters.

3.3.4.7 Disengagement and Re-engagement - Provision for disengagement and re-engagement of the starters shall be internal in the construction and shall be independent of external signal. Re-engagement of the starters after interruption during a starting cycle shall be accomplished without damage. There shall be no limitation, within the rated life, of the number of starts performed in succession.

3.3.4.8 Interchangeability - All parts having the same manufacturer's part number shall be directly and completely interchangeable with each other with respect to installation and performance. Changes in manufacturer's part numbers shall be governed by the drawing number requirements of Specification MIL-D-70327. Sub-assemblies of selected mating parts must be interchangeable as assembled units, and shall be indicated on the manufacturer's drawings. The individual parts of such sub-assemblies need not be interchangeable.

3.3.4.9 Surface Finish - Surface finishes where required shall be established and shall be specified in the manufacturer's drawings as defined in Standard MIL-STD-10.

3.3.4.10 Workmanship - All details of workmanship shall be in accordance with high grade manufacturing practices for aircraft hydraulic motors.

3.3.4.11 Design Changes - No changes shall be made in the design or materials of a starter model which has successfully completed the Qualification tests, except when such changes are processed in accordance with the provisions of ANA Bulletin No. 391.

3.3.4.11.1 Service Bulletins - When requested by the procuring activity at the time of approval of a change, the contractor shall submit a service bulletin, prepared in accordance with Specification MIL-B-18364, in order to permit the procuring activity to incorporate the change in starters previously delivered.

3.3.4.11.2 Parts List - The parts list of a starter model which successfully completes the Qualification test shall constitute a requirement for production starters. Departure from the approved starter parts list in features of design and construction shall be governed by the provision herein for changes in design.

3.3.4.11.3 Responsibility for Changes - Approval by the procuring activity of changes from the Qualification test starter does not relieve the contractor of full responsibility for the results of such changes on any starter characteristic.

4. QUALITY ASSURANCE PROVISIONS

4.1 Classification of Tests - The inspection and testing of the starters shall be classified as follows:

(a) Qualification Tests - Qualification tests are those tests accomplished on samples submitted for qualification as a satisfactory product.

(b) Inspection Tests - Inspection tests are those tests accomplished on all starters manufactured and submitted for acceptance under contract.

4.2 Qualification Tests

4.2.1 Sampling Instructions - The Qualification test samples shall consist of two starters. The Qualification test program shall be conducted by the starter manufacturer at his own facility or at a testing laboratory acceptable to the procuring activity. The division of tests between samples and the order of testing shall be specified in the Model Specification.

4.2.2 Tests - The Qualification tests of starters shall consist of all the tests of this specification as described under Paragraph 4.5 (Test Methods). The Qualification tests may be supplemented with tests under actual service conditions, if specified in the Model Specification.

4.3 Inspection Tests - Each starter shall be subjected to the following tests, in the order listed, as described under Paragraph 4.5 (Test Methods):

(a) Examination of Product
(b) Break-in Run
(c) No Load Operation
(d) Over-running Operation
(e) Proof Pressure Test
(f) Tear-down Inspection
(g) Functional Test

4.4 Test Conditions - Unless otherwise specified herein all tests shall be conducted at an ambient temperature within the range of 50 to 100 F. Inspection tests shall be conducted in the order specified in Paragraph 4.3. The order in which all other tests are conducted shall be as specified in the Model Specification.

4.4.1 Hydraulic Fluid - All tests shall be conducted using the hydraulic fluid specified in the Model Specification.

4.4.2 Filtration - All test systems shall incorporate 15 micron absolute filters, conforming to Specification MIL-F-8815, located in the inlet lines to the starters.

4.4.3 Measurements - The required test operating conditions shall be maintained and/or measured within the following limits:

±1%	Inlet Pressure
±1%	Outlet Pressure
± 10 F	Inlet Temperature
±1%	Shaft Speed
±1%	Torque
±2%	Fluid Flow

4.5 Test Methods

4.5.1 Examination of Product - Each starter shall be carefully examined to determine conformance with the applicable drawings and with all other requirements of this specification not covered by specific tests.

4.5.2 Break-in Run - The minimum break-in run shall consist of at least 1/2 hour at rated torque and 1/2 hour at cut-out speed and torque.

4.5.3 No-load Operation - Each starter shall be operated at no-load for a period of 60 seconds with rated hydraulic conditions applied. The maximum free-running speed shall be recorded in the test log.

4.5.4 Over-running Operation - Each starter shall be subjected to an over-running test for a period of 30 minutes by driving the starter output shaft in the direction of rotation at the maximum over-running speed defined in the Model Specification. During this test the starter inlet port is to be blocked off and the outlet port pressurized at rated outlet pressure. Shaft seal leakage shall not exceed 1 ML per hour.

4.5.5 Proof Pressure Test - Each starter shall be operated for 5 minutes at 125% of rated inlet pressure, 500 PSIG case and outlet pressure, and rated temperature. The load on the starter output shaft shall be regulated so as to maintain rated speed. During this run there shall be no external leakage sufficient to form a drop, except that the shaft seal may leak at a rate not to exceed 5 ML per hour.

4.5.6 Tear-down Inspection - After the above break-in run, no-load operation, over-running operation and proof pressure test, each starter shall be disassembled and inspected by the starter manufacturer. If all parts are in acceptable condition, the starter shall be reassembled and placed on functional test. If working parts require replacement, the starter shall be reassembled using the replacement parts, and the entire inspection test procedure repeated.

4.5.7 Functional Test - Each starter shall be subjected to the following runs to determine conformance with the functional requirements.

4.5.7.1 Static Torque - The starter output shaft shall be locked and rated pressure applied to the inlet port with the outlet port open. Leakage from the outlet port and output shaft torque shall be measured and recorded. Torque shall not be less than 90% of rated torque.

4.5.7.2 Running Torque - The starter shall be operated at rated speed with rated hydraulic conditions applied to the fluid ports. Speed, torque, and fluid flow shall be measured and recorded. Torque shall not be less than rated torque and flow shall not exceed rated flow. This test shall be repeated at minimum cut-out speed at which point torque shall not be less than the value specified in the Model Specification and flow shall not exceed rated flow.

4.5.7.3 Cut-out Device - The starter shall be accelerated from zero RPM to cut-out speed in approximately 20 seconds. The cut-out device setting shall be checked and shall be within the cut-out speed limits specified in the Model Specification.

4.5.7.4 Leakage - During the functional test no external leakage, other than at the shaft seal, of sufficient magnitude to form a drop shall be permitted. Shaft seal leakage shall not exceed 1 ML per hour when measured during the running torque test for a period of at least 15 minutes of operation.

4.5.8 Stall Torque Test - The stalled output torque of the starter shall be measured, with rated inlet pressure applied and the outlet port open, at 36 equally spaced positions of the output shaft within one revolution. The minimum torque measured shall not be less than 90% of rated torque.

4.5.9 Transient Torque Test - The starter shall be operated in accordance with the endurance duty cycle of Paragraph 4.5.13. Continuous torque recording instrumentation, with a flat sinusoidal response to 1000 CPS, shall be used to demonstrate that the maximum peak transient torque does not exceed the value specified in the Model Specification.

4.5.10 Low Temperature Test - The starter and hydraulic test system shall be maintained at a temperature of -65 ± 5 F for a minimum period of 8 hours and then operated for 10 consecutive endurance duty cycles in accordance with Paragraph 4.5.13 except that the torque load shall be 90% of rated torque. Rated inlet and outlet pressures shall be maintained during the operating periods. The length of time between starts shall be such that the starter and fluid shall be at a temperature of -65 ± 5 F for each start. The time required for each phase of each duty cycle and the temperature rise of the inlet fluid during each start shall be recorded.

4.5.11 High Temperature Test - The starter shall be maintained at an ambient, temperature of +275 ± 10 F for a minimum period of 8 hours and then operated at the same ambient temperature for 10 consecutive endurance duty cycles in accordance with Paragraph 4.5.13. Rated hydraulic conditions shall be maintained during the operating periods. The time required for each phase of each duty cycle shall be recorded.

4.5.12 Calibration Test - The starter shall be tested to determine conformance to the minimum requirements of the Model Specification. Values of fluid flow rate and starter output torque shall be determined for each 1000 RPM increment of speed from 1000 RPM to cut-out speed. Rated hydraulic conditions shall be maintained and all measurements shall be made under steady state operating conditions.

4.5.13 Cycle Endurance Test - The starter shall complete a 600 cycle starting test without replacement of, or damage to, any of the component parts. All portions of the endurance test shall be run with rated hydraulic conditions applied to the starter. Each cycle shall consist of three consecutive phases as shown in the following table. Phase A shall consist of the acceleration of the specified inertia load to the specified speed. After the speed specified in Phase A is reached, the torque load of Phase B shall be added for 10 seconds. This torque load shall then be removed for Phase C, which shall be completed in a maximum of 8 seconds. The cut-out device shall operate at the end of each cycle and cut-out speed shall be recorded.

DUTY CYCLE

	PHASES			
	A	B		C
Flywheel Polar Moment of Inertia $lb\text{-}ft^2$	RPM to which flywheel shall be accelerated within 4 sec.	10 seconds at following conditions		RPM to which flywheel shall be accelerated within 8 seconds
		RPM (Min)	Torque lb-ft.	
Per Model Specification	Rated Speed	Rated Speed	Rated Torque	Cut-out Speed

At the completion of the endurance test the calibration test of Paragraph 4.5.12 shall be repeated. Torque shall not have decreased more than 5% and fluid flow shall not have increased more than 5% during the endurance test. The cut-out device setting shall also be checked in accordance with Paragraph 4.5.7.3 after the endurance test and the cut-out speed recorded. Shaft seal leakage shall not exceed 5 ML per hour at any time during the endurance test or recalibration.

4.5.14 Over-running Endurance Test - The starter shall complete a 500 hour over-running test with the out-put shaft driven in the direction of rotation specified in the Model Specification. During this test the starter inlet port is to be blocked off and the outlet port pressurized at rated outlet pressure. If desired, it is permissible to temporarily pressurize the starter inlet port every 10 hours to provide fluid circulation through the starter. The test conditions shall be maintained in accordance with the following table. Shaft seal leakage shall not exceed 5 ML per hour during the test.

No. of Hours	Over-running Speed	Ambient Temperature
50	60% of Max.	Per Model Specification
100	100% of Max.	
50	110% of Max.	
300	90% of Max.	

4.5.15 Disengagement and Re-engagement Test - With rated hydraulic conditions applied, the starter shall be disengaged and re-engaged at each 1000 RPM increment of speed from 1000 RPM to cut-out speed. The hydraulic shut-off valve used in this test shall have an operating time not in excess of 0.1 second. Operation of the starter engagement mechanism during this test shall occur with a minimum of shock.

4.5.16 Vibration Test - The starter shall be subjected to the vibration test requirements of MIL-E-5009, as related to Environmental Tests for engine components, while over-running at the maximum over-running speed specified in the Model Specification.

4.5.17 Overspeed Test - After the completion of all qualification tests, one starter shall be subjected to an overspeed test to prove conformance to Paragraph 3.1.9 herein. The starter shall be driven from the output shaft end at maximum over-running speed until failure occurs. If maximum over-running speed is not reached prior to failure then the speed at which failure occurs shall be recorded. There shall be no parts or pieces ejected from the starter and no external damage shall be evident as a result of the failure. The starter may be driven in the reverse direction of rotation and operated without fluid, if desired, in order to perform this test.

4.5.18 Coupling Shear Test - After the completion of all qualification tests the coupling shear section of one qualification starter shall be torsionally sheared. The shear value shall not exceed the maximum torque limit specified in the Model Specification.

4.6 PREPARATION FOR DELIVERY

4.6.1 General - The provisions contained in Section 5 of Specification MIL-H-8775, as applicable, form a part of this specification.

4.6.2 Preservation - Unless otherwise specified by the procuring activity, each starter shall be completely filled with hydraulic fluid conforming to Specification MIL-H-6083. Each starter shall then be sealed by caps conforming to Specification MIL-C-5501. The exterior surfaces of the starters shall be protected from corrosion, in accordance with Specification MIL-P-116, using a corrosion preventative compound conforming to Specification MIL-C-11796.

4.6.3 Marking - Interior and exterior containers shall be marked in accordance with Standard MIL-STD-129. The nomenclature shall be as follows:

STARTER: Hydraulic
Specification
Type
Date of Manufacture
Stock No.

4.7 NOTES

4.7.1 General - The provisions contained in Section 6 of Specification MIL-H-8775, as applicable, form a part of this specification.

4.7.2 Intended Use - These starters are intended for use in starting aircraft turbojet and turboprop engines for use in aircraft and missiles.

PREPARED BY SAE COMMITTEE AE-6, STARTING SYSTEMS