MIL-S-6150D
15 OCTOBER 1987
SUPERSEDING
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22 Jun 1965

MILITARY SPECIFICATION

STARTER: ENGINE, ELECTRICAL, DIRECT CRANKING AIRCRAFT, 28 VOLTS DC

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

1. SCOPE

1.1 Scope. This specification covers direct-cranking electric starters.

1.2 Classification. Starters shall be of one type and five classes, as specified:

Classes A & A(1). For use on engines up to and including 1,000 cubic inches displacement with an approximate ratio of 1:1 between the starter jaw and engine crankshaft.

Class B. For use on engines of more than 1,000 cubic inches up to and including 2,650 cubic inches displacement with an approximate ratio of 1:1 between the starter jaw and engine crankshaft.

Class C. For use on engines of more than 2,650 cubic inches up to and including 3,500 cubic inches displacement with an approximate ratio of 1:1 between the starter jaw and engine crankshaft.

Class D. For use on engines of more than 2,650 cubic inches up to and including 4,500 cubic inches displacement with an approximate ratio of 3:1 between the starter jaw and engine crankshaft.

Class E. For use on engines of more than 1,000 cubic inches up to and including 2,650 cubic inches displacement with an approximate ratio of 1:1 between the starter jaw and engine crankshaft and requiring reduced starter clutch slipping torque.

2. APPLICABLE DOCUMENTS

2.1 Government documents.

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: the Engineering Division, San Antonio Air Logistics Center, Kelly AFB, TX 78241 by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

AMSC N/A FSC 2925

2.1.1 Specifications and standards. The following specifications and standards form a part of this specification to the extent specified herein. Unless otherwise specified, the issues of these documents shall be those listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereto, cited in the solicitation.

SPECIFICATIONS

FEDERAL

QQ-P-416	Plating Cadmium (Electrodeposited).
TT-E-489	Enamel Alkyd, Gloss for Exterior and Interior Surfaces.
PPP-B-601	Boxes, Wood Cleated-Plywood.
PPP-B-636	Box, Shipping, Fiberboard.
TT-S-1732	Sealing Compound, Pipe Joint and Thread, Lead Free, General Purpose.
TT-P-1757	Primer Coating Zinc Chromate, Low Moisture Sensitivity.

MILITARY

MIL-P-116	Preservation, Methods of.
DOD-D-1000	Drawing, Engineering and Associated List.
MIL-M-3171	Magnesium Alloy Processes for Pretreatment and Prevention of Corrosion on.
MIL-S-7742	Screw Threads; Standard Optimum Selected Series General Specification for.
MIL-A-8625	Anodic Coatings, for Aluminum and Aluminum Alloys.
MIL-N-25027	Nut, Self Locking, 250°F, 450°F, and 800°F.

STANDARDS

MILITARY

MIL-STD-129	Marking for Shipment and Storage.
MIL-STD-130	Identification Marking of U.S. Military Property.
MIL-STD-143	Standards and Specifications Order of Precedence for the Selection of.
MIL-STD-147	Palletized Unit Loads.
MIL-STD-838	Lubrication and Military Equipment.
MIL-STD-889	Dissimilar Metals.
MIL-STD-1186	Cushioning Anchoring, Bracing Blocking and Waterproofing; with Appropriate Test Methods.

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

2.1.2 Other government documents. The following other Government documents form a part of this specification to the extent specified herein. Unless otherwise specified, the issues shall be those in effect on the date of the solicitation.

AIR FORCE-NAVY AERONAUTICAL

USAF ANA STANDARD

AN4116 Starter and Aircraft, Direct Cranking 28V DC

ANA DESIGN STANDARD

AND10264 Flange Type XIV Accessory Mounting.

* (Copies of other Government documents required by contractors in connection with specific acquisition functions should be obtained from the contracting activity or as directed by the contracting activity.

2.3 Order of precedence. In the event of a conflict between the text of this specification and the references cited herein (except for associated detail specifications, specification sheets or MS standards), the text of this specification shall take precedence. Nothing in this specification, however, shall supersede applicable laws and regulations unless a specific exemption has been obtained.

3. REQUIREMENTS

3.1 Qualification. The starter furnished under this specification shall be a product which has been listed on or approved for listing on the applicable qualification tests specified herein, and has been listed on or approved for listing on the applicable qualified products list.

3.2 Components. The starter shall consist of a grounded 28V d-c motor; a gear reduction unit; and adjustable, automatic, reclosing overload protective device (preferably of the multiple friction disc type); and an engaging and automatic disengaging mechanism for meshing with the engine crankshaft drive.

3.3 Selection of specifications and standards. Specifications and standards for necessary commodities and services not specified herein shall be selected in accordance with MIL-STD-143 except as provided in 3.3.1 and 3.3.2.

3.3.1 Commercial parts. Commercial parts having suitable properties may be used where, on the date of invitation for bids, there are no suitable standard parts. In any case, commercial utility parts, such as screws, bolts, nuts, and cotter pins, having suitable properties may be used provided:

a. They can be replaced by the standard parts (MS or AN) without alteration.

b. The corresponding standard part numbers are referenced in the parts listed and, if practical, on the contractor's drawings.

3.3.2 Standard parts. With the exception in 3.3.1, MS and AN standard parts shall be used where they suit the purpose. They shall be identified on the drawings by their part numbers.

3.4 Materials.

3.4.1 Fungus-proof materials. Materials that are nutrients for fungi shall not be used where it is practical to avoid them. Where used and not hermetically sealed, they shall be treated with a fungicidal agent acceptable to the procuring activity. However, if they will be used in a hermetically sealed enclosure, fungicidal treatment will not be necessary.

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

3.5 Design and construction. The starter shall be designed and constructed so that no parts will work loose in service. It shall be built to withstand the strains, jars, vibrations, and other conditions incident to shipping, storage, installation, and service.

3.5.1 Maintenance. The starter shall have a minimum number of parts consistent with reliability. Its design shall, where practicable, permit easy assembly, disassembly, location of trouble sources, and maintenance with tools and equipment normally available commercially, by service maintenance personnel with a minimum of training.

3.5.2 Brush inspection access. An opening and cover shall be provided for brush inspection. The cover for the opening shall fit snugly to protect the motor. The use of felt or similar materials is prohibited.

3.5.3 Mounting flange, drive, and wrench clearance. The mounting flange, drive, and wrench clearance shall be as specified on AND10264.

3.5.4 Rotation. Drive rotation shall be either clockwise or counter clockwise as specified on AN4116; the rotation referred to being that of the starter jaw viewed from the rear of the starter when mounted on the engine.

3.6 Performance. The starter shall be capable of operating satisfactorily between temperatures of minus 54°C and plus 71°C (minus 65°F and plus 160°F), and shall not be damaged when exposed to storage temperatures of from minus 59°C to plus 93°C (minus 75°F to plus 200°F).

3.6.1 Continuous load. The starter shall be capable of operation at loads specified in Table I with 24V applied to the motor terminals.

TABLE I. Direct cracking torque and speed (voltage maintained at starter terminals).

Class	Voltage ±0.5	Jaw speed RPM	Continuous direct load (pound-feet)	Efficiency (minimum) (percent)	Slipping torque (pound-feet)
A	13.5	42	135	45	300±35
A(1)	13.5	42	135	45	350±35
B&C	13.5	25	400	65	850±100
D	15.0	75	185	65	400±50
E	13.5	25	300	65	400±50

3.6.2 Endurance. The starter shall be capable of withstanding 800 cycles of operation as specified in Table II.

TABLE II. Endurance test.

Class	Number of cycles	Brake torque (min) (pound-feet)	Maximum permissible prony brake moment of inertia (pound-feet squared)
A & A(1)	300	250	100
	300	175	
	200	100	
B&C	250	700	1,000
	250	600	
	150	400	
	150	200	
D&E	300	325	400
	300	250	
	200	185	

3.6.3 Overspeed. The starter shall be capable of operation at no-load for a period of 60 seconds.

3.6.4 Extreme temperature exposure. The starter shall be capable of meeting the maximum breakaway torque requirements specified in Table III after exposure to extreme temperatures of minus 54°C and plus 71°C.

TABLE III. Maximum breakaway torque.

Class	Torque (pound-feet)
A & A(1)	800
B	1,400
C	2,500
D&E	1,000

3.6.4.1 Efficiency. The starter shall be capable of meeting the effeciency specified in Table I.

3.6.5 Direct-cranking torque. The starter shall be capable of meeting the direct-cranking torque requirements specified in Table I.

3.6.6 Slipping torque. The starter shall be capable of meeting the slipping torque requirements specified in Table I.

3.6.7 Dielectric strength. During construction, the starter shall be capable of withstanding, without breakdown, a potential of 500V rms 60 cycles for 1 second applied between windings and frame.

3.7 Interchangeability. All parts having the same manufacturer's part number shall be functionally and dimensionally interchangeable. The drawing number requirements of DOD-D-1000 shall govern changes in the manufacturer's part numbers.

3.8 Dimensions. The dimensions of the starter shall not exceed the overall dimensions specified on AN4116.

3.9 Weight. The weight of the starter shall not exceed the values specified in Table IV.

TABLE IV. Starter weight (maximum).

Class	Pounds
A & A(1)	20
B	28
C	29.75
D	28
E	27

3.10 Lubrication. The components parts of the starter requiring lubrication shall be lubricated in accordance with MIL-STD-838.

3.11 Screw threads. Unless otherwise specified, the threads of all machine screws 0.06 inch in diameter, or larger, shall conform to MIL-S-7742.

3.11.1 Safety measures. Provisions shall be made to prevent all screws and screw parts from accidental loosening. Such parts shall be safery-wired or fitted with self-locking nuts in accordance with MIL-N-25027, wherever applicable. All other connections liable to be loosened by vibration shall be secured in a similar manner.

3.12 Finishes and protective coatings.

3.12.1 Aluminum alloy parts. All exposed aluminum-alloy parts shall be covered with a chemical film conforming to MIL-A-8625. The aluminum-oxide film deposited by this treatment shall be removed from the actual contract area of all surfaces required to act as a patch for electrical current and from the local areas under screws, nuts, et cetera, used for assembly or mounting purposes, to provide an adequate bonding connection.

3.12.2 Magnesium-alloy parts. All exposed magnesium-alloy parts shall be surface treated in accordance with MIL-M-3171.

3.12.3 Steel parts. Where practicable, steel parts that are subject to corrosion shall be cadmium plated in accordance with QQ-P-416, type II or III, as applicable, and of a class that is adequate to achieve the degree of protection required.

3.12.4 Threaded parts. All threaded parts, except electrical terminals and self-locking nuts, shall have a thin coating of compound conforming to TT-S-1732 applied to the threads. No more of this compound shall be applied than is necessary to cover the surface of the threads.

3.12.5 Paint finishes. All exposed metal surfaces shall be painted with one coat of primer and two finish coats of oil and heat resistant paint, except the following:

a. Corrosion-resistant steel, brass, copper, or bronze parts.

b. Cable.

c. Working surfaces.

d. Threads.

e. Oil holes.

f. Cadmium or zinc-plated parts.

g. Those parts on which the application of paint has been demonstrated to the procuring activity's satisfaction to be impracticable or unnecessary.

3.12.5.1 Primer coat. The primer coat shall be zinc-chromate primer conforming to TT-P-1757. The primer shall be applied as soon as possible after primer surface treatment or coating. When the primer coat is soiled or damaged by intervening operations between priming and finish coats, it shall be throughly cleaned and another very light coat of primer applied before the finish coat is applied.

3.12.5.2 Finish coat. The finish coat shall be gloss black enamel conforming to TT-E-489.

3.13 Operation marking.

3.13.1 Clutch setting. The nominal starter clutch setting (slipping torque) shall be marked on the starter base with contrasting numerals not less than 3/8-inch high.

3.14 Identification of product. Equipment, assemblies, and parts shall be marked for identification in accordance with MIL-STD-130. The data shall be attached to a part of the starter which will not ordinarily be renewed during normal service life. The following special characteristics shall be included:

AN4116-(proper dash number)
Jaw Rotation (indicated by arrow)

3.14.1 Parts. Each part and assembly shall be marked in accordance with MIL-STD-130, except the following:

a. Those parts which do not have a suitable or sufficient surface for a part number.

b. Those parts which are permanently assembled by welding, brazing, soldering, or riveting shall carry the assembly part number.

3.15 Workmanship.

3.15.1 General. The starter, including all parts and accessories shall be fabricated and finished in a thoroughly workmanlike manner. Particular attention shall be given to the following:

a. Freedom from blemishes, defects, burrs, and sharp edges.

b. Accuracy of dimensions, radii or fillets, and marking of parts and assemblies.

c. Thoroughness of soldering, welding, and riveting.

d. Alignment of parts and tightness of assembly screws and bolts, et cetera.

3.15.2 Riveting. Riveting operations shall be carefully performed to insure that the rivets are tight and satisfactorily headed.

3.15.3 Cleaning. The starter shall be thoroughly cleaned, and loose, spattered, or excess solder, metal chips, and other foreign material removed during and after final assembly.

4. QUALITY ASSURANCE PROVISIONS.

4.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order, the contractor is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract or purchase order, the contractor 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 prescribed requirements.

4.1.1 Responsibility for compliance. All items must meet all requirements of sections 3 and 5. The inspection set forth in this specification shall become a part of the contractor's overall inspection system or quality program. The absence of any inspection requirements in the specification shall not relieve the contractor of the responsibility of assuring that all products or supplies submitted to the Government for acceptance comply with all requirements of the contract. Sampling in quality conformance does not authorize submission of known defective material, either indicated or actual, nor does it commit the Government to acceptance of defective material.

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

a. Quality conformance inspection. Quality conformance inspection's are tests performed on starters which have been submitted for acceptance under contract (see 4.3).

b. Qualification inspection. Qualification inspection is performed on samples submitted for approval as qualified products (see 4.6).

4.3 Quality conformance inspection. Quality conformance inspection shall consist of the individual tests.

4.3.1 Individual tests. Each starter shall be subjected to the following tests as described under 4.5:

a. Inspection.

b. Direct-cranking torque and speed.

c. Slipping torque.

d. Dielectric strength.

4.4 Inspection conditions. Unless otherwise specified, all tests shall be conducted at a temperature within the range of 18°C to 35°C (64°F to 95°F) and the electrical power source shall be capable of maintaining 24V at the motor terminals.

4.5 Test methods.

4.5.1 Inspection. The starter shall be inspected to determine compliance with the requirements specified herein with respect to materials, workmanship, and marking.

4.5.1.1 Noncompliance. If a sample fails to pass inspection requirements of paragraph 4.5.1 the manufacturer shall notify the qualifying activity and the cognizant inspection activity of such failure and take corrective action on the materials or processes, or both as warranted, and on all units which can be corrected and which are manufactured under essentially the same materials and processes, and which we considered subject to the same failure. Acceptance and shipment of the item shall be discontinued until corrective action. Acceptance to the qualifying activity has been taken. After the corrective action has been taken, inspection in accordance with paragraph 4.5.1 shall be repeated on additional sample units. In the event of failure after reinspection, information concerning the failure shall be furnished to the cognizant inspection activity and the qualifying activity.

4.5.2 Direct-cracking torque and speed. The starter shall be tested to determine compliance with the direct-cracking torque and speed requirements specified in Table I.

4.5.3 Slipping torque. The starter shall be subjected to at least three consecutive engagements against a locked prony brake at 1-minute intervals to check clutch slipping torque. The clutch shall be slipped for 3 seconds following each engagement. The torque developed during slippage shall be as specified in Table I.

4.5.3 Slipping torque. The starter shall be subjected to at least three consecutive engagements against a locked prony brake at 1-minute intervals to check clutch slipping torque. The clutch shall be slipped for 3 seconds following each engagement. The torque developed during slippage shall be as specified in Table I.

4.5.4 Dielectric strength. The starter shall withstand the following test voltage at 60 cycles applied between windings and between each winding and frame for the specified time.

500V rms for 1 minute
600V rms for 1 second

4.5.5 Continuous load. With 24V applied at the motor terminal, the starter shall drive a load as specified in Table I continuously for 6 minutes, without damage. The starter temperature shall be not less than 18°C (64°F) at the beginning of the test.

4.5.6 Endurance. The starter shall complete the 800-cycle endurance test specified in Table II without replacement of, or damage to, any of the component parts. Total brush wear shall not have exceeded 75 percent of the original effective brush length on any one brush. At the end of this test, the starter efficiency shall not have decreased more than 5 percent from the original value. Each cycle shall be of 30 seconds duration with a rest period of 2 to 5 minutes between cycles. Cooling air may be supplied to prevent excessive temperatures.

4.5.7 Overspeed. The starter shall be subjected to a no-load test for a period of at least 60 seconds with 27.5V applied at the starter terminals without failure.

4.5.8 Extreme temperature test.

4.5.8.1 Storage. The starter shall be exposed to minus 59°C and to plus 93°C (minus 75°F to plus 200°F) for periods of 12 hours at each extreme temperature without damage.

4.5.8.2 Clutch breakway. Subsequent to exposing the starter to extreme operating temperature of minus 54°C and 71°C (minus 65°F and plus 160°F) for a period of not less than 12 hours, the starter shall be subjected to three consecutive engagements not to exceed 3 seconds on a locked prony brake at 1-minute intervals. The maximum breakaway torque developed slippage shall not exceed the value specified in Table III.

4.5.8.3 Efficiency. Subsequent to an additional exposure of the starter to extreme operating temperatures of minus 54°C and plus 71°C for a period of not less than 12 hours, the starter shall be subjected to the continuous torque load specified in Table I for 1 minute. The efficiency at the end of 15 seconds shall be not less than 90 percent of the efficiency specified in Table I.

4.6 Qualification inspection.

4.6.1 Qualification test samples. Qualification test samples shall consist of two starters. Samples shall be appropriately identified with the manufacturer's own part number and any additional identification required by the authorizing letter.

4.6.2 Qualification tests. Qualification tests shall consist of all tests described under 4.5 and shall be conducted in the order deemed most desirable by the qualifying activity. The qualifying activity reserves the right to partially or completely disassemble the starter before, during, and after the qualification testing.

4.6.3 Retention of qualification. To retain qualification, the contractor shall forward a report at 36 month intervals certifying that the company still has the capabilities and facilities necessary to produce the item.

4.7 Inspection of the preservation, packaging and marking for shipment and storage. Sample items or packs and the inspection of the preservation, packaging, packing and marking for shipment and storage shall be in accordance with the requirements of section 5, or the documents specified therein.

5. PACKAGING

5.1 Preservation. Preservation shall be level A or C as specified (see 6.2).

5.1.1 Level A. Unless otherwise specified in the contract or order, each starter shall be individually preserved and packaged in accordance with MIL-P-116, method IIB with exterior unit container conforming to PPP-B-636, class weather resistent, type CF, variety SW, grade V3C.

5.1.2 Level C. Unless otherwise specified in the contract or order, each starter shall be individually preserved and packaged in accordance with the manufactuer's commercial practice.

5.2 Packing. Packing shall be level A, B or C, as specified (see 6.2).

5.2.1 Level A. Starters preserved and packaged as specified in 5.1.1 shall be unitized in pallets in accordance with MIL-STD-147 in quantities of 18 each per pallet. Quantities of 4 each through 17 each shall be packed in export type shipping containers conforming to PPP-B-601. As far as practicable, exterior shipping containers shall be of uniform shape and size, and of minimum cube and tare. The gross weight of each shipping container shall not exceed the weight limitations of the specification. Closure and strapping shall be in accordance with the standard or appendix of the specification as applicable. For quantities of 3 each or less, the exterior unit container shall be used as the shipping container. Waterproofing shall be in accordance with MIL-STD-1186.

5.2.2 Level B. Starters preserved and packaged as specified in 5.1.1. shall not be overboxed for domestic shipment. Quantities of 18 each shall be unitized on pallets in accordance with MIL-STD-147. For quantities of 17 each or less, the exterior unit container closed and strapped in accordance with the applicable container specification shall be the shipping container.

5.2.3 Level C. Packages that require overpacking for acceptance by the carrier shall be placed in exterior type shipping containers in a manner that will insure safe transporation at lowest rate to the point of delivery. Containers shall comply with Uniform Freight Classification Rules or Regulations of other carriers as applicable to the mode of transportation.

5.3 Physical protection. Cushioning, blocking, bracing and bolting shall be in accordance with MIL-STD-1186, except that for domestic shipments, waterproofing requirements for cushioning materials and containers shall be waived. Drop tests of MIL-STD-1186 shall be waived when preservation, packaging, and packing of the item is for immediate use or when rough handling tests of MIL-P-116 are applicable.

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

Starter, Engine Electrical, Direct Cranking, Aircraft
28-volt DC
Specification MIL-S-6150D
Manufacturer's part number
Name of manufacturer
Name of contractor (if different from manufacturer)
Contract or order number

5.4.1 Additional marking not covered by MIL-STD-129. The following shall also be added:

Rotation _____

Clutch setting _____ ± _____

6. NOTES

6.1 Intended use. The starter covered by this specification is intended for use in starting reciprocating-type aircraft engines.

6.2 Ordering data. Procurement documents should specify the following:

a. Title, number, and date of this specification.

b. The AN part number and class of the starter desired.

c. Invitation for bids, contracts, and purchase orders shall specify the applicable levels of preservation, packaging and packing required.

6.3 Qualifications. With respect to products requiring qualification, awards will be made only for products which are, at the time set for opening of bids, qualified for inclusion in Qualified Products List QPL 6150 whether or not such products have actually been so listed by that date. The attention of the contractors is called to these requirements, and manufacturers are urged to arrange to have the products that they propose to offer to the Federal Government tested for qualification in order that they may be eligible to be awarded contracts or purchase orders for the products covered by this specification. The activity, responsible for the Qualified Products List is San Antonio Air Logistics Center, Engineering Division, MMEDO, Kelly AFB, TX 78241 and information pertaining to qualification of products may be obtained from that activity.

6.4 Subject term (key word) listing.

Starter
Aircraft
Reciprocating engine

6.5 Changes from previous issue. Asterisks (or vertical lines) are not used in this revision to identify changes with respect to the previous issue due to the extensiveness of the changes.

Custodians:
Army - AV
Navy - AS
Air Force - 99

Reviewers:
Army - AV
Navy - AS

Preparing activity:
Air Force - 82

(Project 2925-0025)

(TO DETACH THIS FORM, CUT ALONG THIS LINE.)

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

(See Instructions – Reverse Side)

1. DOCUMENT NUMBER	2. DOCUMENT TITLE

3a. NAME OF SUBMITTING ORGANIZATION	4. TYPE OF ORGANIZATION *(Mark one)*
	☐ VENDOR ☐ USER ☐ MANUFACTURER ☐ OTHER *(Specify)*: _____
b. ADDRESS *(Street, City, State, ZIP Code)*	

5. PROBLEM AREAS

a. Paragraph Number and Wording:

b. Recommended Wording:

c. Reason/Rationale for Recommendation:

6. REMARKS

7a. NAME OF SUBMITTER *(Last, First, MI)* – Optional	b. WORK TELEPHONE NUMBER *(Include Area Code)* – Optional
c. MAILING ADDRESS *(Street, City, State, ZIP Code)* – Optional	8. DATE OF SUBMISSION *(YYMMDD)*

DD FORM 82 MAR 1426

PREVIOUS EDITION IS OBSOLETE.