

A-49-01

SOCIETY OF AUTOMOTIVE ENGINEERS, Inc.
 485 LEXINGTON AVENUE
 NEW YORK 17, N.Y.

AEROSPACE RECOMMENDED PRACTICE

ARP892**D-C STARTER-GENERATOR, ENGINE, GENERAL SPECIFICATION FOR**

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Revised

1. SCOPE - This recommended practice covers requirements for turbine engine-generators designated as follows:

1.1 Cooling

1.1.1 Type I - Blast Cooled

1.1.2 Type II - Self Cooled

1.2 Life

1.2.1 Class A, 1000 Hours Rated

1.2.2 Class B, 2500 Hours Rated

2. APPLICABLE DOCUMENTS

- 2.1 The following documents shall form a part of this recommended practice to the extent specified herein. The applicable issue of each shall be that in effect on the date of this recommended practice unless otherwise specified in the manufacturer's model (detail) specifications. 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 (detail) specification or as may be otherwise mutually agreed upon between the vendor and the purchaser.

SPECIFICATIONS

Federal

QQ-P-416 Plating, Cadmium (Electrodeposited)

Military

JAN-A-669 Anti-Seize Compound; White Lead Base, General Purpose
(For Threaded Fittings)

MIL-T-704 Treatment and Painting of Material

MIL-M-3171 Magnesium Alloy, Processes for Corrosion Protection of
 MIL-S-5002 Surface Treatments (Except Priming and Painting)
 For Metal and Metal Parts in Aircraft

MIL-C-5541 Chemical Films for Aluminum and Aluminum Alloys

MIL-E-5557 Enamel: Heat-Resisting, Glyceryl-Phthalate, Black

MIL-C-6021 Castings, Classification and Inspection of
(For Aeronautical Applications)

MIL-O-6081 Oil, Lubrication, Jet Engine

MIL-R-6809 Regulator, Voltage, 30-Volt, Direct Current Generator, General
 Specification For



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Military (continued)

MIL-S-7742	Screw Threads, Standard, Aeronautical
MIL-L-7808	Lubricating Oil, Aircraft Turbine Engine, Synthetic Base
MIL-P-8585	Primer Coating, Zinc Chromate, Low-Moisture-Sensitivity
MIL-A-8625	Anodic Coatings, For Aluminum and Aluminum Alloys
MIL-T-9107	Test Reports, Preparation Of
MIL-P-16298	Preservation, Packaging, Packing, and Marking of Electric Machines Having Rotating Parts and Associated Repair Parts
MIL-J-5624	Jet Fuel, Grades JP-3, JP-4, and JP-5
MIL-H-5606	Hydraulic Fluid, Petroleum Base, Aircraft, Missile & Ord.
MIL-I-26600	Interference Control Requirements, Aeronautical Equipment
MIL-D-70327	Drawings, Engineering and Associated Lists
MIL-E-5272	Environmental Testing, Aeronautical and Associated Equipment, General Specification For
MIL-B-22227	Bearing, Ball, Annular Generator and Motor-Generator
MIL-L-23699	Lubricating Oil, Aircraft Turboprop & Turboshift Engines, Synthetic Base
MIL-G-6162	Generators, 30 Volt, Direct Current, Aircraft, Engine Driven, General Specification For

STANDARDSMilitary

MIL-STD-129	Marking for Shipment and Storage
MIL-STD-130	Identification Marking of U. S. Military Property
MIL-STD-143	Specifications and Standards, Use of
MS-17107	Bearing, Ball, Annular
MS-17794	Criteria, Jet Electrical Starting System, D. C.
MS-33586	Metals, Definition of Dissimilar
MS-17108	Bearing, Ball, Annular
Air Force	Navy Aeronautical
AND-10261	Flange-Type XI Accessory Mounting
AND-10262	Flange-Type XII Accessory Mounting

(Copies of documents required by contractors in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

3. REQUIREMENTS

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

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- 3.2 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 3.2.1 and 3.2.2.
- 3.2.1 Commercial Parts - Commercial parts having suitable properties may be used where, on the date of invitations for bids, there are no standard parts. In any case, commercial utility parts, such as screws, bolts, nuts, and cotter pins, having suitable properties may be used provided:
- They can be replaced by the standard parts (MS or AN) without alteration.
 - The corresponding standard part numbers are referenced in the parts list and, if practical, on the contractor's drawing.
- 3.2.2 Standard Parts - With the exception of 3.2.1, MS and AN standard parts shall be used where they suit the purpose. They shall be identified on the drawings by their part numbers.
- 3.3 Materials
- 3.3.1 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.
- 3.3.2 Metals - Metals shall be of the corrosion-resistant type or be treated to resist corrosion due to fuels, salt spray, or atmospheric conditions, as may be encountered in storage or normal service.
- 3.3.2.1 Dissimilar Metals - Unless protected against electrolytic corrosion, dissimilar metals shall not be used in intimate contact with each other. Dissimilar metals are defined in MS-33586.
- 3.3.3 Castings - Castings shall be in accordance with MIL-C-6021, and shall be so indicated on the applicable detail drawings.
- 3.3.4 Finishes and Protective Coatings
- 3.3.4.1 Cleaning, Treating, and Painting - Unless otherwise specified herein, metal parts shall be cleaned, treated, and painted in accordance with MIL-T-704. However, when plating is specified, the cleaning of the metal shall conform to MIL-S-5002.
- 3.3.4.2 Cadmium Plating (Steel Parts) - With the exception of the parts listed below, all exterior steel parts, and other steel parts subject to corrosion and not in constant contact with oil, shall be cadmium-plated in accordance with QQ-P-43.

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III, and class 2 as applicable. In cases where cadmium plating is considered impractical or undesirable, an equivalent treatment which is acceptable to the procuring activity shall be provided.

- a. Corrosion-resistant steel parts.
- b. Members or portions of members which act as bearing or journals.
- c. Magnet frame.
- d. Steel end-bells.

3.3.4.3 Anodic Film for Aluminum and Aluminum Parts - Aluminum and aluminum alloy parts shall be covered by an anodic film conforming to MIL-A-8625, unless otherwise specified below.

3.3.4.3.1 The aluminum oxide film deposited by the treatment shall be removed from actual contact area of all surfaces required to act as a path for electric current and from local areas under screws, nuts, etc. used for assembly or mounting purposes, to provide an adequate bonding connection.

3.3.4.3.2 Aluminum alloys which do not anodize satisfactorily shall be coated with a chemical coat conforming to MIL-C-5541.

3.3.4.3.3 Where primary purpose of the treatment is to afford a suitable paint base, chemical treatment in accordance with MIL-C-5541 may be used in lieu of anodizing.

3.3.4.3.4 Castings containing non-aluminum alloy integral inserts may be treated with chemical films in accordance with MIL-C-5541 in lieu of anodizing.

3.3.4.3.5 When abrasion resistance is a factor, chemical films in accordance with MIL-C-5541 shall not be used in lieu of anodizing.

3.3.4.4 Magnesium Alloy Parts - The use of magnesium is prohibited unless specifically approved for each application by the using service. Where approved, magnesium alloy parts shall be surface treated for protection against corrosion in accordance with MIL-M-3171.

3.3.4.5 Paint Finishes - All exposed metal surfaces shall be painted with one coat of primer conforming to MIL-P-8585 and two finish coats of enamel conforming to MIL-E-5557, type I, with exception of the following:

- a. Corrosion-resistant steel, brass, copper, or bronze parts.
- b. Cable
- c. Working surface

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- d. Threads
- e. Oil holes
- f. Cadmium - or zine-plated parts
- g. Those parts on which the application of paint has been demonstrated to the satisfaction of the procuring activity to be impractical or unnecessary.

3.3.4.6 Age Control - Age control of all synthetic rubber parts except for fluorocarbon material shall be in accordance with ANA Bulletin No. 438.

3.4 Design and Construction

3.4.1 Generators shall conform to the requirements specified on the applicable MS drawings. (For example, see Figures 4, 5, 6, 7, and 8.)

3.4.2 The information specified in the detail specification and/or drawing is applicable to detail requirements of this standard. Whenever the requirements of this standard and the detail specification or drawing conflict, the requirements of the detail specification or drawing shall govern.

3.4.3 The starter-generator shall be so designed and constructed that no parts will work loose in service and shall be built to withstand the strains, jars, vibrations, and other conditions incident to shipping, storage, installation, and service. Insofar as practical, the starter-generator shall be so designed that no part can be assembled in reverse and cause faulty operation or lead to eventual failure. The starter-generator shall be so constructed that in the event of failure of one or all bearings, the resultant rubbing of the armature against the field poles will not result in a fire.

3.4.4 Life - The starter-generator shall be designed and constructed to provide an inherent reliability of 1000 hours minimum (for class A), or 2500 hours minimum (for class B) maintenance-free operation between overhauls under the conditions required herein except for one change of brushes. To meet this requirement, careful attention shall be given to selection of materials, treatment of materials, finishes, securing of all electrical conductors, and the assembly of each and every part.

3.4.5 Reliability - For the starting mode, the unit shall have a mean-cycle-between-failures (MCBF) of 500 cycles for Class A, and 1250 cycles for Class B, and in the generating mode, the unit shall have an operational mean-time-between-failures (MTBF) of 500 hours for Class A and 1250 hours for Class B, both conditions based on a 90% confidence level. The reliability figures are predicated on one allowable brush change.

3.4.6 Maintainability - The starter-generator shall have a minimum number of parts consistent with reliability. Its design shall, where practical, 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.



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- 3.4.6.1 Armature - The starter-generator shall be so constructed that the armature is readily removable for maintenance. In no case shall it be necessary to disconnect soldered or brazed connections.
- 3.4.6.2 Commutator - A turned-down section (step) shall be provided at the outboard end of the commutator, the diameter of which shall be the minimum diameter to which the commutator can be safely reduced during its maintenance life. Minimum diameter shall be consistent with brush stability.
- 3.4.7 Simplification - Simplicity of design resulting from use of the same part for as many applications as possible in a given model is highly desirable (for example, use of identical ball bearing assemblies on both ends of the armature).
- 3.4.8 Generator - The generator shall be designed to operate with a voltage regulator in accordance with MIL-R-6809.
- 3.4.8.1 The generator shunt field shall be so designed that the maximum regulated field current shall be not more than 8 amperes continuous average and the power to be dissipated by the regulator shall be not more than 90 w. The required resistance in the external field circuit shall not be less than 1.25 ohms or more than 35 ohms under any operating condition within the specified load and speed range. Accidental closure of the reverse-current relay shall not reverse the field.
- 3.4.9 Mounting Flange - The starter-generator mounting flange and splined drive shall be in accordance with the applicable starter-generator drawing.
- 3.4.10 Quick Attach-Detach (QAD) Coupling - If specified, the starter-generator shall be equipped with a QAD coupling to facilitate installation and removal of the unit where normal access to the mounting studs is not available. The QAD shall incorporate provisions to prevent rotation of the frame during the starting and generating cycle in the event the holding clamp is not properly torqued. The flange and band assembly will not be included in the unit part number. Installation or removal of the starter-generator shall not require special tools nor shall there be any small loose parts such as nuts and washers or separable parts when removal of the starter-generator is accomplished. The starter-generator shall be designed to permit installation without requiring any measurements or adjustments to either the engine accessory drive or the starter-generator. The device for actuation of the QAD mechanism shall be automatically safetied when not in use.
- 3.4.11 Flexible Drive - The starter-generator shall be equipped with a flexible drive coupling and a shear section between the drive spline and armature in accordance with the applicable starter-generator drawing. The shear section shall limit the maximum torque which the starter-generator can transmit to a value specified in the detail specification. The shear section shall be so designed that its failure will not result in loose pieces which could damage adjacent components. In addition, replacement of a failed shear section shall be possible without requiring major disassembly of the starter-generator.

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- 3.4.12 Torsional Vibration Damper - Shall be incorporated in the starter-generator for suppression of flexible drive torsional vibration amplitudes.
- 3.4.13 Shaft Deflection - The starter-generator shall be designed to operate with the drive shaft misaligned to the maximum allowable limits defined by the tolerances of the mating engine accessory drive and the starter generator flange.
- 3.4.14 Bearings - The armature in the starter-generator shall be designed to be supported on both ends by ball bearings replaceable with MS-17107 or MS-17108 conforming to MIL-B-22227. The bearing support on the drive shaft end shall be vented to equalize pressure or suction on both sides of the bearing. The method of accomplishing this requirement shall meet the approval of the procuring activity.
- 3.4.14.1 Bearing Installation - The inner and outer bearing races shall be so fitted in the starter-generator that circumferential creepage shall be sufficiently controlled to minimize contact erosion, spinning of races, and resultant wear of shaft or housing.
- 3.4.15 Terminal Parts - The terminal block shall provide studs in the quantity, size and labeling as noted on the schematic wiring diagram shown on the applicable starter-generator drawing. Each stud shall be provided with a plain washer and a self-locking nut. Note that the starter winding terminal C+ shall be provided if specified on the detailed drawing, Figure 4. Unless otherwise specified the design of the terminal block shall not depend on current to be transmitted by the studs. Insulating barriers shall be provided between adjacent terminals. In addition, each terminal stud shall be adequately marked to identify it as noted on the detailed drawing.
- 3.4.15.1 Terminal Location - The terminal block shall be located as shown on the applicable starter-generator drawing.
- 3.4.16 Brushes
- 3.4.16.1 Brushes Accessibility - Brushes shall be accessible for inspection and replacement when brush cover is removed.
- 3.4.16.2 Brush Fit - The face of each brush shall contact its commutator 100% in the direction of rotation and for at least 75% of brush dimension parallel to the shaft. There shall be no evidence of surface damage to the face of the brush or commutator.
- 3.4.16.3 Replacement Brushes - All replacement brushes shall be formed to a radius equal to the radius of the new commutator and shall be identical to the corresponding brushes approved by the qualification tests.
- 3.4.16.4 Brush Position - The brush rigging shall be a fixed position (non-shifting) type. The brush rigging position shall be identical for all generators of the same model number made by the same manufacturer.



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- 3.4.16.5 Brush Marking - Each brush shall have a diagonal groove extending from one corner of the brush face to a point at the brush back or front which indicates 100% allowable wear.
- 3.4.16.6 Brush Type - Brushes shall be of the immediate filming type which do not require prolonged operation of the starter-generator to establish an altitude protective film on the commutator. Rivets used to secure the leads to the brushes shall be silver soldered to the pigtail at point of riveted contact with alloy having a melting point of 1000 F minimum.
- 3.4.16.7 Brush Life - The brushes shall have a minimum useful life of 500 hours when operated at altitudes varying from sea level to maximum rated as specified on the applicable starter-generator drawing. The starter-generator shall be designed to be capable of completing all of the qualification tests specified herein without replacing the brushes.
- 3.4.17 Cooling
- 3.4.17.1 Blast Cooling - Type I
- 3.4.17.1.1 Blast Cooling Inlet Tube - When specified on the applicable drawings, the generator shall include provisions for entrance of external air to provide cooling in addition to any already provided by means integral with the generator. The inlet tube shall be positionable to four (4) approximately equally-spaced radial positions (preferably adjustable to any position), with respect to the longitudinal axis of the generator.
- 3.4.17.1.2 Amount of Blast Cooling - The rating of the generator is based on the air blast to the blast-cooling inlet tube referred to in the above paragraph. The pressure drop available across the generator shall not be more than 5.31 in. of water when the generator is being provided with a quantity of air equal to 130% of the basic cfm as determined from Figure 3. At volumes of 130% basic cfm and less, the pressure available to the generator is based on the following:
- a. A total pressure (static plus velocity) head of 7 in. of water at the entrance of the cooling air duct.
 - b. A pressure drop through the cooling-air duct of 1.69 in. of water at 130% cfm and 1 in. of water at basic cfm.
- 3.4.17.2 Self-Cooling - Type II
- 3.4.17.2.1 The starter-generator when operating as a self-cooled unit by using an internal fan, shall be rated at sea level with the starter-generator inlet cooling air at 160 F and 15,000 ft with cooling air at 0 F. The maximum ambient operating temperature shall be specified in model specifications and may result in de-rating.

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- 3.4.18 Operating Position - The starter-generator shall be designed to operate in any attitude.
- 3.4.19 Rotation - The direction of the armature rotation shall be as specified on the applicable starter-generator drawing, for both starter and generator operation.
- 3.4.20 Cooling Air Outlet Screen - The starter-generator shall be equipped with screened cooling air ports to prevent entry of foreign objects into the starter-generator. The size of the openings in the screen shall be such that a 1/4 in. ball will not pass through. Cooling duct connections at other than drive end may omit this requirement.
- 3.5 Performance
- 3.5.1 Environmental Conditions - The starter-generator shall be capable of satisfactory operation under the following environmental conditions.
- a. Ambient and cooling air temperatures as defined in 3.4.16 and Figure 1 of Specification MIL-G-6162.
 - b. Relative humidity up to 100%, including conditions wherein condensation takes place in the form of both water and frost.
 - c. Vibration incident to service use.
 - d. Fungus growth as encountered in tropical climates.
 - e. Operation in an explosive vapor within or surrounding the equipment.
 - f. Exposure to MIL-L-7808, MIL-L-23699, oils, MIL-J-5624 grades JP-4, JP-5, fuels, and MIL-H-5606.
- 3.5.1.1 Low Temperature Storage - The starter-generator shall operate satisfactorily after having been stored at temperatures of -80 F.
- 3.5.1.2 Fluid Resistance - The starter-generator shall withstand without deterioration, swelling, or loss of insulating resistance, fluids and vapors which could be present in an engine compartment. These shall include MIL-J-5624, grades JP-4 and JP-5, fuel, and MIL-L-7808 and MIL-L-23699, oil, and MIL-H-5606.
- 3.5.2 Maximum Speed For Regulation - The starter-generator, when operated as a generator, shall be capable of delivering rated voltage at no load, at not less than specified rpm on the applicable drawing with no more than 35 ohms in the external field circuit.



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- 3.5.3 Minimum Speed For Regulation - The generator shall be capable of continuously delivering full-rated load at rated voltage at the minimum speed for regulation with an external resistance in the shunt-field circuit of 1.25 ohms minimum and not more than 8 amp field current.
- 3.5.4 Heating - Commutation - and Minimum Speed - The starter-generator shall produce the stipulated terminal voltages when operated under the load and altitude conditions as specified in Table I, run I and with a regulator in accordance with MIL-R-6809, providing the field resistance is between 1.25 and 35.0 ohms inclusive. The regulated field current for rated load at any speed between minimum and maximum speed for regulation shall not exceed 8 amperes, and the maximum power to be dissipated by the regulator shall not exceed 90 watts.
- 3.5.5 Compounding - For any speed in the speed range, the field current shall always increase with an increase in generator load.
- 3.5.6 Overspeed - The starter-generator shall be capable of being driven at the specified overspeed at no load for five minutes without mechanical failure or impairing of electrical performance.
- 3.5.7 No-Load Speed - At zero output torque, the starter-generator when operated in the starting mode as specified on the applicable drawing and with the specified voltage applied to the terminals, shall be capable of developing the specified no-load speed.
- 3.5.8 Radial Vibration - The radial vibration shall not exceed 0.001 in. total deflection at no-load speed when operated as a starter.
- 3.5.9 Paralleling Voltage Drop - Under conditions of full rated load, 30 v d-c, rated speed with the starter-generator stabilized in temperature and an air inlet temperature of 86 F, the voltage drop between the terminals D and E shall be within $\pm 10\%$ of the specified value on the applicable drawing. The generator equalizing voltage shall be obtained between terminal E and the negative brushes or a tap in the winding between negative brushes and terminal E.
- 3.5.10 Dielectric Strength - The starter-generator shall withstand a test voltage of 500 v a-c for one minute, or 600 v a-c for 1 sec, at commercial frequency applied between windings and frame. Radio noise filter need not be subjected to this test.
- 3.5.11 Ripple Voltage - Generator - The ripple voltage shall not exceed 1.5 v when the starter-generator is operated as shown on Figure 1 and operated at 120% of minimum rated speed under 50% load.
- 3.5.12 Cranking Torque and Speed - The starter-generator, when operated as a starter and connected as specified on the control drawing, shall be capable of delivering the minimum cranking torque and speed requirements specified (Figure 6) when powered by the specified power supply (Figure 7) curve C or D (as applicable) at any ambient temperature within the range of -65 to +160 F.

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