INCH-POUND
MIL-DTL-6162C
05 April 2000
SUPERSEDING
MIL-G-6162B
15 February 1972

DETAIL SPECIFICATION

GENERATORS AND STARTER-GENERATORS, ELECTRICAL DIRECT CURRENT, NOMINAL 30 VOLTS, AIRCRAFT GENERAL SPECIFICATION FOR

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

1. SCOPE

1.1 This specification covers the general requirements for aircraft generators and starter-generators for use in 28-volt (V) direct current (DC) systems. As generators, both type machines are engine driven. The starter-generators, however, also function as engine starters when energized by electric power.

1.2 Classification. The generators and starter-generators will be of the following type and class as specified:

TYPE	STYLE	DESCRIPTION
Type I	Blast Cooled	Cooled by externally forced air for all rated operating conditions
Type II	Self Cooled	Cooled by internal means and will require no externally forced air for rated operating conditions
Type III	Combination Cooled	Utilizes a combination of both Type I and Type II cooling methods to meet overall performance requirements. Type III machines will be capable of operating self-cooled at rated load and speeds under Class A sea level conditions
Type IV	Liquid Cooled	Meet overall performance requirements under the cooling conditions as defined in the associated specification sheet

CLASS	DESCRIPTION
Class A	Machines designed to operate within the temperature-altitude range of Figure 1.
Class B	Machines designed to operate within the temperature-altitude range of Figure 2.
Class C	Machines designed to operate within the temperature-altitude range of Figure 3.

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: WR-ALC/TILCC, 420 Second Street Suite 100, Robins AFB, GA 31098-1640 by using the Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

2. APPLICABLE DOCUMENTS

2.1 General. The documents listed in this section are specified in sections 3 and 4 of this specification. This section does not include documents cited in other sections of this specification or recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirements documents cited in sections 3 and 4 of this specification, whether or not they are listed.

2.2 Government documents.

2.2.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those listed in the issue of the Department of Defense Index for Specifications and Standards (DODISS) and supplement thereto, cited in the solicitation (see 6.2).

SPECIFICATIONS

FEDERAL

QQ-P-416	Plating, Cadmium (Electrodeposited)

DEPARTMENT OF DEFENSE

MIL-S-5002	Surface Treatments and Inorganic Coatings for Metal Surfaces of Weapon Systems
MIL-C-5541	Chemical Conversion Coatings on Aluminum and Aluminum Alloys
MIL-A-8625	Anodic Coatings for Aluminum and Aluminum Alloys
MIL-S-8879	Screw Threads, Controlled Radius Root with Increased Minor Diameter, General Specification for
MIL-PRF-23699	Lubricating Oil, Aircraft Turbine Engine, Synthetic Base, NATO Code Number O-156
MIL-R-23761	Regulator, Voltage, and Control Panels Aircraft, Direct Current Generator, General Specification for
MIL-DTL-25027	Nut, Self-Locking, 250° F, 450° F, and 800° F
MIL-PRF-81322	Grease, Aircraft, General Purpose, Wide Temperature Range

STANDARDS

FEDERAL

FED-STD-595	Colors Used in Government Procurement

DEPARTMENT OF DEFENSE

MIL-STD-100	Engineering Drawings
MIL-STD-130	Identification Marking of U.S. Military Property
MIL-STD-461	Requirements for the Control of Electromagnetic Interference Characteristics, of Subsystems and Equipment
MIL-STD-704	Aircraft Electric Power Characteristics
MIL-STD-810	Environmental Engineering Considerations and Laboratory Tests
MIL-STD-889	Dissimilar Metals
MIL-STD-973	Configuration Management
MIL-STD-2175	Castings, Classification and Inspection of
NASMS33540	Safety Wiring and Cotter Pinning

HANDBOOKS

DEPARTMENT OF DEFENSE

MIL-HDBK-454	General Guidelines for Electronic Equipment
MIL-HDBK-781	Reliability Test Methods, Plans, and Environments for Engineering, Development Qualification, and Production, Handbook for

(Unless otherwise indicated, copies of the above specifications, standards, and handbooks are available from the Defense Automated Printing Service (DAPS), 700 Robbins Ave, Building 4D, Philadelphia, PA 19111-5094, phone (215) 697-2197 or DSN 442-5164.)

2.3 Non-Government publications. The following document forms a part of this document to the extent specified herein. Unless otherwise specified, the issues of the documents, which are DOD adopted, are those listed in the issue of the DODISS cited in the solicitation. Unless otherwise specified, the issues of documents not listed in the DODISS are the issues of the documents cited in the solicitation (see 6.2).

SOCIETY OF AUTOMOTIVE ENGINEERS

SAE AS-1933	Hose Containing AGE-Sensitive Elastomeric Material, Age Controls for
SAE AMS-M-3171	Magnesium Alloy, Processes for Pretreatment and Prevention of Corrosion on

(Applications for copies may be addressed to the Society of Automotive Engineers, 400 Commonwealth Drive, Warrendale, PA 15096-0001, phone (412) 776-4841 or FAX: (412) 776-4026)

2.4 Order of Precedence. In the event of a conflict between the text of this document and the references cited herein (except for related associated specifications, specification sheets, or MS standards), the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. REQUIREMENTS

3.1 Specification sheets. The individual item requirements shall be as specified herein and in accordance with the applicable specification sheet. In the event of any conflict between the requirements of this specification and the specification sheet, the latter shall govern.

3.2 Qualification. Generators or starter-generators furnished under this specification shall be products that are authorized by the qualifying activity for listing on the applicable qualified products list (QPL) before contract award (see 4.2 and 6.3).

3.3 Selection of specifications, standards, and materials. Specifications and standards for all materials, 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 current industry practices, except as provided in paragraph 3.4.1.

3.3.1 Standard parts. Military Standard parts shall be used wherever they are suitable for the purpose, and shall be identified on the specification sheets or other applicable documents by their military part number (see 4.6.1). Any standard part, of the same part number, shall be interchangeable as applied within the machine. Commercial utility parts such as screws, bolts, nuts, cotter pins, etc., may be used provided they possess suitable properties and are replaceable by the standard parts (MS and AN) without alteration and provided the corresponding standard part numbers are referenced in the parts list and on the contractor's specification sheets. In the event there is no suitable corresponding standard part in effect on date of invitation for bids, commercial parts may be used provided they conform to all requirements of this specification.

3.3.2 Materials. Materials used in the manufacture of the machine 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 approved by the qualifying Government activity and contain provisions for adequate tests. The use of the contractor's specifications does not constitute waiver of Government inspection.

3.3.2.1 Metals. To the maximum extent practicable, metals shall be of a corrosion-resistant type or suitably treated to resist corrosion due to aircraft fluids, salt spray, or atmospheric conditions as may be encountered in storage and normal service.

3.3.2.1.1 Dissimilar metals. Dissimilar metals, as defined by MIL-STD-889, shall not be used in contact with each other. Where such contact is unavoidable, the metals shall be protected against electrolytic corrosion. When protection is used, it shall be of such a type that a low impedance path is offered to radio frequency currents.

3.3.2.1.2 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 SAE-AMS-M-3171.

3.3.2.1.3 Castings. Castings shall be in accordance with MIL-STD-2175, and shall be so indicated on the applicable specification sheets.

3.3.2.2 Nonmetals. Nonmetals when used, including plastics, fabrics, and protective finishes, shall be moisture resistant, and shall not support fungus growth, or shall be treated with a fungicidal agent acceptable to the procuring agency. The nonmetals shall not support combustion, and shall not be adversely affected by weather, aircraft fluids, temperatures, and ambient conditions encountered during operation of the aircraft. Nonmetals may be treated to conform to this requirement.

3.3.2.3 Finishes and protective coatings.

3.3.2.3.1 Cleaning, treating, and painting. Unless otherwise specified herein, metal parts shall be cleaned, treated, and painted in accordance with current industry practices. However, when plating is specified, the cleaning of the metal shall conform to MIL-S-5002 or current industry practices. Alternate methods satisfactory to the procuring agency may be utilized.

3.3.2.3.2 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-416, Type II or 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 agency, shall be provided.

EXCEPTIONS

a. Corrosion-resistant steel parts.
b. Members or portions of members which act as bearing surfaces or journals.
c. Magnet frame.
d. Steel end-bells, brush-cover band.
e. Quill shaft.
f. Mounting face.
g. QAD mating "V" sections.

3.3.2.3.3 Anodic film for aluminum and aluminum parts. Aluminum and aluminum alloy parts shall be covered by an anodic film conforming to MIL-A-8625. 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, or other hardware used for assembly or mounting purposes, to provide an adequate bonding connection. Aluminum alloys, which do not anodize satisfactorily shall be coated with a chemical coat conforming to MIL-C-5541. Where the 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. Castings containing non-aluminum alloy integral inserts may be treated with chemical films in accordance with MIL-C-5541 in lieu of anodizing. When abrasion resistance is a factor, chemical films in accordance with MIL-C-5541 shall not be used in lieu of anodizing.

3.3.3 Color. With the exception of the surfaces listed below, all exposed surfaces shall be finished in a color conforming to FED-STD-595, color No. 17875. As an alternate, the machine finish may be an aluminum or stainless steel color. The finishes shall be unaffected by the environmental or performance tests specified.

EXCEPTIONS

a. Corrosion-resistant steel, copper, or bronze parts.
b. Cable.
c. Working surface.
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 satisfaction of the procuring activity to be impractical or unnecessary.

3.3.4 Lubricants. Unless otherwise specified, bearing lubricant shall conform to MIL-G-81322. Silicon base grease shall not be used.

3.3.5 Varnishes and insulation. Silicone varnishes or insulation shall not be utilized.

3.3.6 Encapsulation. Encapsulation and embedment (potting) shall be in accordance with current industry practices (reference MIL-HDBK-454, requirement 47), except that silicone compounds shall not be used.

3.3.7 Age control. Age control of all synthetic rubber parts except for fluorocarbon material shall be in accordance with SAE AS-1933.

3.4 Design and construction. The machine design shall be consistent with good aircraft accessory practice and conform to the associated specification sheet. Unless otherwise specified by the associated specification sheet, the machine shall be designed to operate with voltage regulators conforming to MIL-R-23761 or current industry practices.

3.4.1 Reliability. High equipment reliability is a primary objective. Trouble-free operation during a definite specifiable period after initial installation and after overhaul is mandatory. In order to provide the required reliability, the machine shall be fabricated and constructed to provide a specified minimum mean time between failure (MTBF) in accordance with current industry practices (reference MIL-HDBK-781), of 2000 starting cycles and 1500 hours of Class A or 1250 hours of Class B or C generator operation. If not used as a starter, the machine shall have a specified MTBF of 2000 hours of Class A or 1650 hours of Class B or C generator operation, as applicable, all based on a 90 percent confidence level. Failure is defined as any malfunction which results in performance diminished from specification requirements no matter what the cause, undue careless handling or test equipment malfunction excepted. For brush type machines, the above figures are predicated on one (1) change of brushes (see 3.3).

3.4.2 Simplification. Simplicity of design resulting from the use of the same part for as many applications as possible in a given model or various models is highly desirable. The machine shall have a minimum number of parts consistent with reliability (see 4.6.1).

3.4.3 Interchangeability. All parts having the same manufacturer's part number shall be functionally and dimensionally interchangeable (see 4.6.1). The drawing requirements of MIL-STD-100 shall govern changes in the manufacturer's part number.

3.4.4 Maintainability. Careful attention shall be given in the design to provide for ease of inspection, testing, disassembly, maintenance, repair and re-assembly, preferably without the need for special tools or fixtures. Machine

component parts shall be as foolproof as possible to avoid incorrect assembly which would result in damage or malfunction, or involve safety of flight (see 4.6.1).

3.4.5 Generator component design.

3.4.5.1 Armature/rotor - The machine shall be so constructed that the armature or rotor is readily removable for maintenance. In no case shall it be necessary to disconnect soldered or brazed connections. Care shall be taken to remove all burrs or projections, which might result in injury to the coils.

3.4.5.2 Commutator (for brush type machines). 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. The copper segments, when worn to the diameter of the step, shall be of ample section to operate satisfactorily and not throw out due to centrifugal force. The method of securing the commutator to the shaft shall positively prevent rotational or axial motion of the commutator relative to the shaft.

3.4.5.3 Shunt field. Unless otherwise specified in the associated specification sheet, the shunt field shall not require more than eight (8) amperes maximum regulated field current nor require more than ninety (90) watts power dissipation by the regulator. The required resistance in the external field shall not be less than 1.25 ohms (Ω) nor more than 35 Ω under any operating condition. The accidental closure of the reverse current relay shall not reverse the residual field. The shunt field shall be so designed that stabilization will occur and allow continuous generator operation at any rated condition. External excitation shall not be required for buildup. At minimum speed, the residual voltage shall not be less than + 0.8 volt.

3.4.5.3.1 Equalizer voltage. Unless otherwise specified in the associated specification sheet, provisions shall be made in the machine such that a voltage drop of 2 volts ± 0.1 volts (V) is available between terminals D and E of the generator, with the generator stabilized in temperature at rated load and cooling conditions. In brush type machines, this voltage drop shall be accomplished by tapping the commutating and compensating field windings between the E terminal and the negative brushes. A calibration curve may be used to permit acceptance testing at temperatures between 5° C and 45° C.

3.4.5.4 Mounting flange. The machine mounting flange and spline drive shall be in accordance with the associated specification sheet (see 4.6.1).

3.4.5.5 Oil seepage. The machine shall be designed to tolerate seepage of oil from the engine into the machine at the rate of 3 cubic centimeters (cc) per hour or as specified on the applicable accessory mounting pad drawing if greater.

3.4.5.6 Quick attach-detach (QAD) coupling. QAD coupling, if specified by the associated specification sheet, shall incorporate provisions to prevent rotation of the frame during the starting or generating cycle in the event the holding clamp is not properly torqued. Installation or removal of the machine shall not require special tools (see 4.6.1).

3.4.5.7 Flexible drive. Unless otherwise specified on the associated specification sheet, the machine shall be equipped with a flexible drive and a shear section between the spline drive and armature. The shear section shall limit the maximum torque, which the machine can transmit to the value specified in the associated specification sheet. The shear section shall be so designed that damage to adjacent components will not result from the shearing action. In addition, replacement of the failed shear section shall be possible without requiring major disassembly of the machine.

3.4.5.8 Torsional vibration damper. A torsional vibration damping or coupling assembly shall be incorporated between the drive spline and the rotor or armature of the machine for suppression of flexible drive torsional vibration amplitudes (see 4.6.25).

3.4.5.9 Shaft deflection. The machine shall be designed to operate with the drive shaft in misalignment to the maximum allowable limits specified for the mating engine accessory drive (see 4.6.1).

3.4.5.10 Electrical connections. For brush type machines, the internal wiring of the machine shall be in accordance with Figure 4. Terminations shall be as shown on the associated specification sheet. Connectors and leads shall be secured in a reliable manner to prevent contact with moving parts or chafing by contact with stationary parts. All leads shall be permanently marked with the designating letters. For other than shunt wound machines, reference shall be made to the associated specification sheet (see 4.6.1).

3.4.5.11 Terminal block design. Where terminals are used for the external connection, they shall be of the stud-type and shall be designed so that the current is conducted by means of surface to surface contact and not through the stud. All studs shall be steel, corrosion resistant and C-34 Rockwell minimum hardness. All nuts by which external wiring is attached to a component shall conform to MIL-DTL-25027. Threads on studs and nuts shall conform to MIL-S-8879 or current industry practices (see 3.9). There shall be no compression of the insulating material when assembled. The terminal block shall be so designed that it can be removed and replaced on the machine without the necessity for re-brazing or soldering. Barriers affording a positive separation of leads and terminals shall be provided on the terminal block. Terminal designations shall be durably, legibly, and prominently marked on the terminal block. Terminals shall be provided with a durable, reusable cover and wire fanning strip to prevent interchanging connections.

3.4.5.12 Terminal block location. The terminal block shall be located and marked as shown on the associated specification sheet.

3.4.5.13 Brushes and brush holders (for brush type machines). The following requirements shall apply to brushes (see 4.6.1) and brush holders.

3.4.5.13.1 Accessibility. Brushes shall be readily accessible for inspection and replacement when brush cover is removed.

3.4.5.13.2 Fit. After seating, the face of each brush shall contact its commutator 100 percent. There shall be no evidence of surface damage to the face of the brush or commutator. Commutation shall be such that no more than 1¼ sparking is in evidence as shown in Figure 5.

3.4.5.13.3 Brush type. Unless otherwise specified by the procuring activity, brushes shall be of the immediate filming type, which do not require prolonged operation of the machine at sea level to establish an altitude protective film on the commutator. In any event, machines shall be supplied with the necessary filming. Rivets used to secure the leads to the brushes shall be silver soldered to the pigtail at the point of riveted contact using an alloy with a minimum melting point of 1000° F.

3.4.5.13.4 Brush rigging. Brush rigging shall be a fixed position (unshift) type with respect to the field structure. The brush rigging shall be permanently pinned during manufacture, and shall be identical and completely interchangeable for all generators of the same part number made by the same manufacturer. The brush rigging shall be so mounted and aligned that brushes are parallel to the shaft. Proper running clearance between the rigging and commutator face and risers shall be maintained. The brush rigging shall be of such a design that brushes will not bind. Contact surfaces shall be of such material as to not react chemically to produce corrosion and sticking of brushes. The brush-feeding device shall insure proper brush pressure and contact during all normal conditions of brush and commutator wear including any commutator which have been turned to the minimum allowable diameter. Brush springs shall be self-centering or the brushes shall provide spring guides.

3.4.5.13.5 Spare brushes. All spare and replacement brushes shall be formed to a radius equal to the radius of the new commutator and shall be the qualified brushes. The brushes shall be packed in kit form (complete set for one generator) with installation instructions packed with each kit.

3.4.5.13.6 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 percent allowable, wear.

3.4.5.13.7 Brush life. The machines shall have a minimum brush life as follows:

a. Generators shall have a minimum brush life as follows:
(1) Class A generators - 1000 hours from sea level to 35,000 feet, and 600 hours from 35,000 to 50,000 feet.

(2) Class B and Class C generators - 750 hours from sea level to 50,000 feet, and 500 hours from 50,000 to 65,000 feet.

b. Starter-generators shall meet the above requirements for generator brush life plus a minimum of 1200 engine starts.

3.4.5.13.8 Brush stop. Design of brush and holder shall be such that the commutator will not be subjected to mechanical damage if the brushes are not replaced when their wearing depth is exhausted. Additionally, means shall be provided to prevent brushes from being thrown out of the holders as a result of severe shock or from being displaced to such a position that they may bind and not return to normal operating position. The devices used shall not unduly complicate brush replacement.

3.4.5.14 Bearings. The armature or rotor of the machine shall be designed to be supported on both ends by bearings conforming to the reliability and performance requirements contained herein. The manufacturer shall furnish bearing specifications and data with machines submitted for qualification.

3.4.6 Cooling.

3.4.6.1 Blast cooling. Type I and Type III. (See 4.5.11).

3.4.6.1.1 Blast cooling inlet tube. Air cooled machines shall include provisions for entrance of air to provide cooling in addition to that already provided by integral means. Radial inlet tubes, when specified, shall be positional to four (4) approximately equally spaced positions (preferably adjustable to any position).

3.4.6.1.2 Amount of blast cooling. The quantity of cooling air for Type I and Type III generators is based on the total head at the entrance of the cooling duct and the duct loss. Total head shall be 7 ± 0.5 inches of water for Class A machines and 11 ± 0.5 inches of water for Class B and C machines. Rated mass airflow for Type I and Type III machines operating at rated output at sea level are determined from Figure 6. Type I machines shall operate with an air duct which produces a duct loss of one (1) inch of water at rated air flow and 1.69 inches of water at 130 percent of rated mass air flow. Type III machine shall operate from a duct, which produces a duct loss of 0.5 inches of water at, rated airflow and 0.85 inches at 130 percent air flow. During altitude operation, a head of 7.0 ± 0.5 or 11.0 ± 0.5 inches of water, as applicable, shall be maintained at the cooling duct inlet.

3.4.6.1.3 Duct loss simulation. Hydrodynamic head losses in the cooling air duct shall be simulated by an adjustable restriction within the cooling duct. Head measurements shall be made with a pitot tube located in the center of the duct and in a region of essentially laminar flow. The pitot tube shall be located in a length of straight smooth duct. There shall be no obstruction or other causes of turbulence for at least 20-cooling duct diameters up stream from the pitot tube and 10-diameters down stream. During self-cooled Type II and Type III operation, the duct loss shall be measured as the difference between atmospheric pressure and the pitot tube head as indicated by a water manometer. During blast air cooling, the duct loss shall be measured as the difference between manometer readings above and below the adjustable restriction.

3.4.6.2 Self-cooling - Type II. The machine shall be self-cooled by internal means which provide sufficient cooling to permit full rated generator output at minimum speed regulation at sea level at 71° C (160° F) and at continuous revolutions per minute (RPM) at 15,000 feet altitude with cooling air at 0° C (32° F). When a cooling air duct is used, the duct loss shall be the same as that specified for Type III machines, except that no cooling tube inlet head will be provided during altitude operation unless otherwise specified in the associated specification sheet.

3.4.6.3 Liquid cooling - Type IV. Unless otherwise specified, MIL-PRF-23699 turbine oil shall be used as the cooling fluid. The generator shall provide an integral pump for oil circulation. The associated specification sheet will provide oil temperature limits, flow, pressure, and airframe coordination requirements.

3.4.7 Rating charts. (See 4.6.1).

3.4.7.1 Altitude rating chart. The machine manufacturer shall supply altitude rating charts (2000-hour life except for brushes) of safe allowable ratings for generator operation in blast-cooled and, where applicable, self-cooled operating conditions. This chart shall be in the general form of Figure 7. The spacing and number of lines shall be selected to provide a readable accuracy of 90 percent. The rating charts shall be prepared for the following minimum range of parameters:

Generator pressure drop	0 to 4 times rated
Air inlet temperature	- 40° to 20° C (-40° to 68° F) above maximum rated
Pressure altitude	sea level to 65,000 feet
Generator speed	minimum speed for regulation to maximum speed for regulation

3.4.7.2 Starter speed-torque characteristics. For starter-generators, the manufacturer shall furnish a speed-torque characteristic chart. This chart shall be in the general form of Figure 8 with both current and voltage as parameters. The spacing and number of lines shall be selected to provide a readable accuracy within 10 percent. The charts shall be prepared for the following minimum range of parameters:

Terminal volt	0 to nominal starting voltage (24 or 48V)
Current	0 to 1100 amperes (A)
Speed	0 to no load rpm

Where the starter-generator no load speed would be destructive, the test shall be interrupted when starter attains speed specified for continuous generator operation.

3.4.7.3 Equalizing voltage-temperature characteristics. The machine manufacturer shall supply a chart of equalizing voltage versus cooling temperatures for temperatures between 5° C (41° F) and 45° C (113° F) when the machine is operated as a generator at rated load and continuous operating speed.

3.4.8 Operating position. The machine shall be designed to operate in any position.

3.4.9 Maintenance operation. Starter generators are required to crank the aircraft engine during engine service and maintenance operation. This operation consists of a start cycle, which is aborted when the engine reaches ignition speed. The engine is allowed to coast to rest and the cycle repeated. A minimum of five consecutive cycles is required. The residual field voltage shall not be reversed or diminished below the specified minimum as a result of this operation.

3.4.10 Cooling air port screens. The machine shall be equipped with screened cooling-air exhaust ports to prevent entry of foreign objects. The size of the openings in the screen shall be such that a ¼-inch diameter ball or rod will not pass through (see 4.6.1).

3.4.11 Bonding. The frame structure of the machine shall be so assembled that there will be a continuous, low impedance path from the anti-drive end-bell to face of mounting flange. The direct current resistance end-bell to mounting flange shall not exceed 0.001 ohm. The area normally covered by mounting nuts shall be free from any insulating type of surface treatment (see 4.6.1).

3.4.12 Dimensions. The machine shall conform to the dimensions as shown in the associated specification sheet or drawing listed in the QPL (see 4.6.1 and 6.3).

3.4.13 Weight. The machine, including the mounting flange, complete with QAD clamping band, if specified, shall not exceed the weight specified in the associated specification sheet (see 4.6.1).

3.4.14 Overhung moment. The overhung moment shall not exceed the value specified in the associated specification sheet (see 4.6.1).

3.4.15 Rotation marking. The direction of rotation of the spline drive shall be as indicated on the associated specification sheet and shall be plainly indicated on generator housing by an arrow (see 4.6.1).

3.5 Identification of product. Parts and subassemblies of machines requiring replacement during normal maintenance shall be marked with the manufacturer's part number and the manufacturer's name or trade-mark, where practicable, and shall be in accordance with MIL-STD-130, as applicable (see 4.6.1). The nomenclature appearing on the nameplate shall be as shown on the associated specification sheet.

3.5.1 MIL or military designations. MIL or other military designations shall not be applied to a product, except for qualification test samples, until notification of product approval has been received.

3.6 Installation instructions. The contractor shall pack with each machine one printed copy of simple instructions, with illustrations and diagrams, if necessary, covering the installation of the machine (see 4.6.1). Instructions shall be packaged to be completely legible after exposure to the humidity and fungus conditions specified herein. Prior to printing, two copies shall be furnished to the procuring agency for review and approval.

3.7 Performance requirements. The machines shall satisfactorily meet the applicable electrical, mechanical, and environmental tests in Table I of this specification.

3.8 Safety wiring and staking. Accidental loosening of screws and screw parts and other connections shall be prevented by safety wiring (0.032 inch minimum OD, where practicable), staking, or other approved methods in accordance with NASMS33540 (see 4.6.1). Washers and cotter pins, where used, shall be assembled in a manner which prevents rotation of washers and movement of cotter pins under conditions of vibration.

3.9 Threaded parts. All threads shall conform to MIL-S-8879 or current industry practices (see 3.4.5.11 and 4.6.1). Non-reinforced threads in nonferrous parts will require specific approval from the procurement agency. All internal or external parts, which are threaded, shall be positively locked. Self-locking nuts, safety wiring, staking, or other approved methods shall prevent accidental loosening of threaded elements. Staking shall be used only when parts are permanently assembled.

3.10 Workmanship. Workmanship (see 4.6.1) shall be in accordance with high grade manufacturing practices for aircraft accessories and equipment. The units shall be free from dirt, sand, metal chips, machining compounds, and other foreign matter. All machined surfaces shall have a smooth finish and all details of manufacture, including the preparation of parts and accessories, shall be in accordance with good practice for high quality electric equipment. Particular attention shall be given to neatness and thoroughness of soldering, wiring, impregnation of coils, marking of parts, plating, coatings, riveting, clearance between soldered connections, and ruggedness.

4. QUALITY ASSURANCE PROVISIONS

4.1 Classification of tests. The inspection and testing of the machines shall be classified as follows:

a. Qualification tests. Qualification tests are those tests accomplished on machines submitted for qualification as a satisfactory product.

b. Acceptance tests. Acceptance tests are those tests accomplished on machines manufactured and submitted for acceptance under a production contract.

c. Qualification verification tests. Qualification verification tests are those tests conducted on production samples to verify that the design is identical to that qualified and that production units meet all the requirements of the associated specification sheet.

4.2 Qualification and qualification verification.

4.2.1 Qualification. A machine will be considered qualified and placed on the QPL if qualification test samples (as defined below) successfully complete the qualification tests designated by Table I essentially in the order listed and upon acceptance by the qualifying activity (see 3.2). The machines will be retained on the QPL as long as qualification verification samples delivered as required below (paragraph 4.2.2) continue to demonstrate conformance to the associated specification sheet.

TABLE I. Qualification and acceptance tests.

Test Title	Test Paragraph	Qualification Samples			Spare Shaft	Acceptance
		No. 1	No. 2	No. 3		
Examination of Product	4.6.1	X	X	X		X
Machine Characteristics	4.6.1.1	X	X	X		
Dielectric Strength	4.6.2	X	X	X		X
No Load Speed	4.6.3	X	X	X		
Maximum Speed for Regulation	4.6.4	X	X	X		X
Minimum Speed for Regulation	4.6.5	X	X	X		X
Field Temperature	4.6.6	X	X	X		
Commutation	4.6.7	X	X	X		
Equalizing Voltage	4.6.8	X	X	X		X
Shunt Field Excitation	4.6.9	X	X	X		X
Ripple Voltage	4.6.10	X	X			X
Over-speed	4.6.11	X	X	X		
Efficiency	4.6.12	X	X			
Cranking Torque and Speed	4.6.13	X	X			X
Altitude Rating Chart	4.6.14	X	X			
Consecutive Start Cycle	4.6.15	X	X			
Overload	4.6.16	X	X			
Voltage Regulator Compatibility	4.6.17	X	X	X		
Endurance	4.6.18		X			
Radio Interference	4.6.19	X				
Operating Position	4.6.20		X			
Environmental Low Temperature Storage	4.6.21.1	X				
Low Temperature	4.6.21.2	X		X		
High Temperature	4.6.21.3	X		X		
Vibration	4.6.21.4		X			
Explosion Proof	4.6.21.5			X		
Humidity	4.6.21.6	X				
Fungus	4.6.21.7		X			
Salt Fog	4.6.21.8			X		
Fluid Exposure	4.6.21.9		X	X		
Shock	4.6.21.10			X		
Sand and Dust	4.6.21.11	X		X		
Brush and Commutator W	4.6.22	X				
Disassembly and Inspection	4.6.23	X	X	X		
Bearing Failure	4.6.24	X	X			
Drive Shear Section	4.6.25				X	

4.2.1.1 Qualification test sample. The qualification test sample shall consist of:

a. Three (3) machines as described by the associated specification sheet. The manufacturer to permit measurement of critical machine temperatures shall instrument two (2) of the machines.

b. One drive shaft assembly complete with torsional vibration dampener.

c. A mating plug for each connector used.

d. Two (2) sets of wiring diagrams, brush and bearing design control drawings, machine assembly and detail drawings, operating instructions, and

e. Three (3) copies of the material to be included in the installation instructions to be packaged with each production unit as an example of how this material is to be printed, protected, and attached to the machine.

Instrumentation used and the location of the temperature measuring points shall be subject to approval of the qualifying agency. The temperature at these points shall be monitored throughout the qualification tests of samples No. 1 and No. 2.

4.2.1.2 Qualification testing. Qualification testing must be specifically authorized by the qualifying activity. At the option of the qualifying activity, any or all qualification tests may be conducted on machines submitted for qualification, for production acceptance, or delivered under a production contract for which conformance to this specification is required. Also, a test report, conforming to the contractor standard format, is required.

4.2.2 Qualification verification of production machines. When qualification verification is required by the production contract, the sample(s) will be selected at random by the government inspector and forwarded to the qualifying activity (see 4.2.1). To meet delivery requirements for the first 50-machines, 51-machines must successfully meet the acceptance tests of Table I. Fifty (50) machines will be shipped as directed by the contract and one (1) random selected sample will be forwarded to the qualifying activity. To meet the delivery for each succeeding 150-machines, 151-machines must successfully meet the required acceptance tests. One hundred and fifty (150) will be shipped as directed by the contract and one (1) machine selected and forwarded as above. Once qualified, production machines successfully passing the acceptance tests are to be accepted until qualification is officially rescinded (see 4.4.1). Delivery of production machines is not to be delayed pending results of tests conducted on qualification verification samples. All qualification verification testing is to be conducted by the qualifying activity. With each qualification verification sample, the Government Inspector shall furnish the contract number and the serial number of all machines in the production lot from which the verification sample was selected.

4.2.3 Rejection and retest.

4.2.3.1 Qualification samples. Machines, which have been rejected or returned to the manufacturer for any reason during qualification tests, may be reworked or have parts replaced to correct defects. Before resubmitting the machines, full particulars concerning the rejection and the corrective action taken by the manufacturer must be submitted in writing by the manufacturer to the qualifying activity. Tests shall not be resumed until such a report is received. Where qualification tests are conducted under the auspices of the manufacturer, the qualifying activity shall be advised upon failure of the qualification sample and of the action taken by the manufacturer with regard to failure.

4.2.3.2 Qualification verification samples. Machines may be subjected to any or all requirements and tests of this specification to assure continued compliance with the qualification requirements. Machines, which are found to be defective for any reason, shall be returned to the manufacturer for rework or parts replacement. The manufacturer shall submit full particulars concerning the manufacturer's analysis of the defect and the corrective action required, in writing to the qualifying activity. The manufacturer shall also immediately inspect and/or test machines currently in production and those awaiting shipment and certify that the deficiency has been corrected prior to further shipment. In addition, the manufacturer shall rework all of the machines in the production lot represented by the qualification verification test sample provided that these machines are returned to the manufacturer

within one year of the date of manufacture. This requirement shall in no way prejudice the Government's position with respect to any other warranty stated or implied under the terms of the contract.

4.3 Disassembly and inspection. Each machine shall, following completion of all qualification tests, be disassembled and inspected for conformance design requirements and to assure there has been no excessive wear or other defects effecting reliability. Additional disassembly and inspection shall be as required by the individual tests specified herein.

4.4 Acceptance.

4.4.1 Acceptance requirements. Generators and starter-generators produced under this specification will be accepted if:

a. Qualified to this specification as amended by the associated specification sheet and if the qualification is sustained in conformance with paragraph 4.2.2.

b. Acceptance tests of Table I are successfully completed.

c. Installation instructions approved by the qualifying activity are securely attached to each machine in such a way that they need not be removed for check out of the machine prior to its installation on the aircraft.

d. A package holding one nut for each mounting hole in the generator flange is securely attached to each generator in such a way that it need not be removed for check out of the machine prior to installation on the aircraft.

e. All changes to equipment have been processed in accordance with MIL-STD-973, as applicable.

4.5 Test Conditions. Unless otherwise specified, each test required by Table I shall be made under the following conditions.

4.5.1 Mounting. The machine shall be mounted on a suitable test stand. The rotational axis of the machine shall be horizontal.

4.5.2 Excitation. The machine shall be self-excited and controlled by suitable variable resistance or regulator in series with the shunt field. The shunt field current shall not be considered as part of generator load current. External excitation shall not be required in meeting test requirements.

4.5.3 Ambient temperature. Unless otherwise specified herein, test ambient temperature shall be 25° C ± 0.5° C (77° F ± 0.9° F). Examination of product shall be conducted at room ambient temperature.

4.5.4 Altitude. Unless otherwise specified herein, the tests shall be run at approximately sea level altitude.

4.5.5 Location of load. The electrical load for generator operator operation shall be so located that it will not appreciably affect the ambient or the blast cooling air temperatures.

4.5.6 Warm-up. Except as noted herein, prior to each test the machine shall be operated as a generator at the specified continuous operating speed, rated load, and rated voltage for sufficient time to reach a substantially constant temperature. Warm-up shall be completed when the shunt field temperature does not increase more than 1° C above the then existing ambient temperature during a period of five minutes. Readings shall be taken at intervals not in excess of two minutes.

4.5.7 Voltage measurement. When operating as a generator, voltage shall be measured between terminals E (negative) and B (positive).

4.5.8 Shunt field voltage. The voltage drop across the shunt field shall be measured between E (negative) and A for long shunt field generators or between A and the negative brush for short shunt field generators.

4.5.9 Brushes (for brush type machines). Unless otherwise specified, all tests shall be performed without replacement of brushes.

4.5.10 General instrumentation. Provisions shall be made to determine the following:

a. Terminal voltage

b. Load current

c. Equalizing voltage

d. Generator speed

e. Cooling inlet air temperature

f. Field shunt voltage

g. Field shunt current

h. Resistance in series with the shunt field

i. Total pressure of the inlet cooling air

j. Ambient air temperature

Additional instrumentation required is specified in the individual test, qualification test information, or acceptance test information.

4.5.11 Air blast. Unless otherwise specified, blast-cooling air within ± 5° C of the ambient temperature shall be supplied to the machine in the quantity indicated in Figure 6 (see 3.4.6.1). The temperature of the air shall be determined by means of a suitable temperature-indicating device whose responsive element is located in the cooling air duct between the air inlet of the machine and the pressure-determining element.

4.6 Test methods.

4.6.1 Examination of product. Each machine, subassembly, and part shall be examined as the Government Inspector may deem necessary to determine compliance with this specification with respect to material, standard parts (see 3.3.1), simplification (see 3.4.2), mounting flange (see 3.4.5.4), QAD coupling (see 3.4.5.6), maintainability (see 3.4.4), shaft deflection (see 3.4.5.9), cooling air screens (see 3.4.10), overhung moment (see 3.4.14), identification of product (see 3.5), installation instructions (see 3.6), safety wire and staking (see 3.8), screw threads (see 3.9), rating charts (see 3.4.7), electrical connections (see 3.4.5.10), brushes (see 3.4.5.13), interchangeability (see 3.4.3), rotation marking (see 3.4.15), dimensions (see 3.4.12), weight (see 3.4.13), bonding (see 3.4.11), and workmanship (see 3.10).

4.6.1.1 Machine characteristics. The machine bonding and the cold resistance of all windings at the stabilized ambient temperature of the machine shall be measured (see 4.6.2 and 4.6.18.3) and recorded.

4.6.2 Dielectric strength. The machine shall be run at minimum rated speed, rated voltage, and rated load until temperature stabilization occurs. While the unit is running and with radio noise filters disconnected, the following voltages shall be applied between windings and between each winding and frame. No sign of insulation breakdown or arcing shall be in evidence. Following the dielectric test, the machine shall meet the requirements and initial measurements of paragraphs 4.6.1.1 and 4.6.7.

Test Voltage	Test Time
500 VDC + 5 VDC	1 Minute
600 VDC + 6 VDC	1 Minute

4.6.3 No load speed. If applicable, the machine shall be operated as a starter, at no lead and with the power source specified in the associated specification sheet. The maximum speed attained during no load motor operation shall be in excess of the specified minimum cutout speed and shall not result in self-destruction of the unit.

4.6.3.1 Series start. Machines used as series motors shall meet the no load speed requirement with the generator shunt field disconnected.

4.6.3.2 Shunt start. Machines which utilize the generator shunt field during the start cycle shall meet the no load speed requirement with the shunt field terminal (A) connected directly to the positive input terminal. Unless otherwise specified, no series resistance shall be used in the field circuit.

4.6.4 Maximum speed for regulation. Prior to warm-up, the machine operating as a generator, with a manually controlled variable resistance in the field circuit, shall be accelerated from zero rpm to the maximum speed for regulation specified on the associated specification sheet. Unless otherwise specified in the associated specification sheet, the unit shall deliver no more than rated voltage at no load with 35 ohms or less in the field circuit (see 4.6.11).

4.6.5 Minimum speed for regulation. The machine, operating as a generator, shall be temperature stabilized at rated load after warm-up and shall be reduced from the continuous operating speed to the minimum speed for regulation specified on the associated specification sheet. Unless otherwise stated in the associated specification sheet, the unit shall provide rated voltage at full load, with no less than 1.25 ohms in the field circuit.

4.6.6 Field temperature. The machine shall be operated as a generator at rated voltage and full load current and at the following speeds specified on the associated specification sheet (see 4.6.18.3; 4.6.20; 4.6.21; 4.6.21.8; 4.6.21.9; 4.6.22.1; and 4.6.22.3).

4.6.6.1 Maximum speed for regulation.

4.6.6.2 Continuous operating speed. (Strip chart or equivalent record shall show a minimum of 90 minutes of operation after temperature stabilization at this speed.)

4.6.6.3 Minimum speed for regulation.

4.6.6.4 Minimum rated speed. (26 volts minimum and full load.) Temperature stabilization must occur at each speed with no indication of thermal runaway. The temperature attained shall not be cause for rejection provided all other requirements of the specification are met and component temperature limits are not exceeded.

4.6.7 Commutation (brush type machines). Immediately following the minimum speed run of the field temperature test (see 4.6.2) and while the machine is temperature stabilized, the commutation shall be observed over the speed range for rated load, half load, and no load. There shall be no more than number 1¼ sparking as shown in Figure 5 (see 4.6.11; 4.6.20; 4.6.21.9; and 4.6.21.11).

4.6.8 Equalizing voltage. The machine shall be operated as a generator at continuous operating speed, rated voltage, and rated load with blast cooling, if applicable, supplied in the amount indicated in Figure 6. Upon temperature stabilization, the equalizing voltage shall be measured between terminals D and E. Unless otherwise specified, the equalizing voltage shall be 2.0 ± 0.1 volts. The equalizing voltage-cooling air temperature chart furnished by the manufacturer shall be substantiated by measuring the voltage at three random temperatures between 5° to + 45° C (-41° to +113° F).

4.6.9 Shunt field excitation.

4.6.9.1 Exciting current. The machine shall be connected into the test setup and operated as a generator over the speed range. For any speed or load within the range, field current shall increase with an increase in load. Unless otherwise specified in the associated specification sheet, the field current shall not exceed 8 amperes at any speed between the minimum and maximum speed for regulation. At any rated speed, the external field resistance shall not be required to dissipate more than 90 watts.

Upon completion of the above test, the generator residual voltage shall be measured with the generator operating at the minimum rated speed and the shunt field circuit open. The residual voltage shall not be less than + 0.8 volts.

4.6.9.2 Residual field. The generator shall be operated with an approved voltage regulator to furnish power through a reverse current relay to a 15-ampere resistive load in parallel with a fully charged 34-ampere hour nickel cadmium battery. The generator shall be operated until the battery charging current is less than 10 amperes at 28.0 volts. The voltage regulator power lead shall be interrupted to de-energize the generator. The generator shall be automatically disconnected from the load bus by the operation of the reverse current relay. The generator residual voltage shall be measured without further generator operation. The residual voltage shall not reverse its polarity and shall not be less than 0.8 volts with the generator speed at the specified minimum rated.

4.6.10 Ripple voltage. The machine shall be operated as a generator under the conditions specified in paragraph 4.6.12.2. The ripple voltage appearing on the d-c output shall be measured using a calibrated, wide-band oscilloscope (10-megahertz minimum) at a sweep time of 2.5 milliseconds, and an oscillogram shall be made. The peak ripple voltage shall not exceed the direct current average voltage by more than 1.5 volts for either polarity (see 4.6.11). Ripple voltage frequency characteristics shall be recorded.

4.6.11 Over-speed. The machine shall be operated as a generator at rated voltage and load at the continuous operating speed. When the unit has stabilized in temperature, the load shall be removed, the field circuit opened, and the generator driven to the over-speed rpm specified on the associated specification sheet. The unit shall withstand five minutes of continuous over-speed operation without signs of mechanical failure, throwing of varnish or solder, or bearing noise. Upon completion of the over-speed period, the unit shall not show signs of electrical failure as evidenced by compliance with paragraphs 4.6.4, 4.6.7 and 4.6.10.

4.6.12 Efficiency. The machine shall successfully complete the applicable efficiency tests below.

4.6.12.1 Starter. The machine shall be operated as a starter at a terminal voltage of 28 +0/-1 volts with a torque load sufficient to produce an armature current equal to the rated current for generator operation. Efficiency of the machine shall not be less than 70 percent or as specified on the associated specification sheet, whichever is greater.

4.6.12.2 Generator. The machine shall be operated as a generator at rated terminal voltage and loads of 25, 50, 75, 100 and 125 percent in 1000 rpm speed increments between minimum speed for regulation and maximum speed for regulation (see 4.6.10). The efficiency shall be recorded after temperature stabilization at each speed increment and up to 125 percent load. The 125 percent load efficiency tests shall commence after temperature stabilization at full rated load, and shall be completed within five minutes. The efficiency shall not be less than 60 percent or as specified on the associated specification sheet, whichever is greater.

4.6.13 Cranking torque and speed. If applicable, the machine shall be operated as a starter. The test setup shall be instrumented to measure the starter drive speeds, drive torque, input current, and voltage specified on the associated specification sheet in addition to the general instrumentation. The machine shall deliver the specified torque at the corresponding speeds with the power source(s) indicated on the associated specification sheet. Total feeder resistance between the starter generator terminals and the power source terminals shall be adjusted to obtain a voltage drop of 1.8 to 2.0 volts at rated generator current.

4.6.14 Altitude rating chart. The altitude-rating chart furnished by the manufacturer and brush life (for brush type generators) shall be substantiated during the applicable altitude tests of paragraph 4.6.18.2.

4.6.15 Consecutive start cycle. The starter generator shall be operated for five consecutive start cycles at the beginning and at the end of the 1200-cycle starter endurance test (see 4.6.18.1.1). Each cycle shall be the same as that specified for the endurance test, except that the off time between cycles shall be one minute and no external cooling shall be permitted other than that afforded by internal fans. Upon completion of the consecutive start cycle test the machine shall be operated at the specified minimum rated speed and the residual voltage measured without any form of shunt field excitation, field flashing or prior generator operation. The residual voltage shall not be less than 0.8 volts.

4.6.16 Overload. Once every two hours during the endurance test specified in paragraph 4.6.18.2, the load shall be increased to 150 percent of rated load for a period of two minutes. After one minute of cooling at no load, the test shall be repeated at 200 percent of rated load for five seconds. A cooling period of one minute at no load may follow the 200 percent load application (see 4.6.22.1). During the overloads, the regulated voltage shall not be less than 26 volts. During the 150 percent load, commutator sparking shall not exceed the number 2 requirement of Figure 5. During the 200 percent load, commutator sparking shall not damage the commutator or degrade subsequent performance.

4.6.17 Voltage regulator compatibility. The machine shall be operated with approved voltage regulators conforming to MIL-R-23761 or as designated by the associated specification sheet. The machine shall be properly connected to be controlled by the specified voltage regulator. The total resistance of the field circuit leads shall be 0.1 ± 0.01 ohms. The total feeder resistance (positive and negative) shall be adjusted to provide a 1.9 ± 0.1 volt feeder voltage drop after temperature stabilization at rated load current and standard sea level conditions. The voltage sensing leads shall carry no current other than that required by the voltage regulator sensing circuit.

4.6.17.1 Voltage regulation (single generator). The voltage regulation shall be observed over the rated generator speed range from no load to rated load current. The regulated voltage shall comply with the fixed ambient temperature voltage regulation requirements as specified on the associated specification sheet for the voltage regulator. Voltage transients due to switching up to 200 percent rated current shall not exceed the limits of MIL-STD-704, and shall recover and remain within the steady state limits with no more than one overshoot. No sustained oscillations shall occur.

4.6.17.2 Parallel operation. Two or more generators shall be connected as specified for parallel operation. Load division over the generator rated speed range shall remain within 10 percent of the generator rated current from 25 percent to full rated load current. Load shifting among generators operating in parallel shall not produce a peak-to-peak load variation about the average load current of any machine greater than 10 percent of the generator rated current.

4.6.18 Endurance. The machine shall successfully complete the applicable endurance tests below.

4.6.18.1 Starter. The starter generator shall be subjected to a 1200 cycle endurance test. Each cycle shall consist of three phases of operation as follows:

a. Phase A - This phase shall consist of accelerating the specified flywheel inertia load from rest to the specified speed within the specified time and with the input current limited to the specified value as indicated on the associated specification sheet.

b. Phase B - This phase shall consist of a 10-second period of steady state operation at the specified load and terminal voltage.

c. Phase C - After completing Phase B, the torque load shall be removed and the starter permitted to accelerate the flywheel inertia load to the specified speed within the specified time. Off time between cycles shall be as specified.

Note: The acceleration specified for Phases A and C assumed a frictionless system and does not consider test stand losses such as windage or bearing friction. Accordingly, in order to ensure that the minimum drive speed specified in Phase C is attained, an external assist torque may be supplied or the flywheel inertia load may be reduced. In

addition, Phase C operation may be terminated at a drive speed less than the specified value provided the total horsepower - second output of the starter is equivalent to that which would be required to accelerate a frictionless system to the specified cutoff speed.

If replacement of parts is required during the endurance test this shall be cause for rejection. Supplemental cooling air may be used to expedite testing and prevent excessive temperatures. Total brush wear shall not exceed 50 percent of the allowable wear on any one brush and commutator wear shall not exceed 25 percent of the total allowable reduction of diameter. Allowable wear shall be as specified by the manufacturer and approved by the procuring activity.

4.6.18.1.1 Starter endurance alternate method. If a drive stand equipped with an engine simulator is available, both the consecutive start-cycle tests of paragraph 4.6.15 and the endurance test may be performed using this equipment. The simulated moment of inertia and engine drag torque characteristic shall be adjusted to the maximum starter design limits as specified on the associated specification sheet.

4.6.18.2 Generator.

a. Air-cooled generators shall be subjected to the endurance test schedule of Table II under the conditions outlined in Table III according to generator class and type (see 4.6.16). Cumulative brush or commutator wear shall not exceed a total of 20 percent of the allowable wear during parts (a) and (b) of this test. Wear during part (c) shall not exceed four percent of the allowable wear. Failure during this test shall be cause for rejection. Allowable commutator wear shall be as specified by the manufacturer and approved by the procuring activity. During run 1 of Table III, the blast cooling air flow shall be adjusted to the rated mass air flow as shown on Figure 6 or maximum generator pressure drop, whichever occurs first. Airflow during subsequent runs shall be established by holding the generator pressure drop constant at the value established in run 1. The generator shall be operated for at least 30 minutes and no more than 60 minutes additional operating time at continuous operating speed and rated load under standard sea level conditions prior to each altitude run which is not preceded by a period of sea level operation in the test schedule. The rate of change of altitude need not be controlled; however, temperature must remain within 10 degrees of the maximum temperature shown in Figures 1, 2 or 3, as applicable. The order in which the test runs are performed is optional.

b. Type IV generators shall be operated for 100 hours at sea level maximum temperature cooling conditions and for eight 12-hour cycles at the maximum altitude (see 4.6.14) and maximum temperature cooling conditions for that altitude unless otherwise specified by the associated specification sheet.

Table II. Generator endurance test schedule. 1/

Generator Type	Class A			Class B			Class C		
	Test Part	Cycles Required	Run 2/ Number	Test Part	Cycles Required	Run 2/ Number	Test Part	Cycles Required	Run 2/ Number
I	a	4	1	a	4	1	a	4	1
	a	4	3	a	4	5	a	4	6
	b	4	8	b	4	10	b	4	12
	c	2	9	c	2	11	c	2	13
II	a	8	2						
	a	2	4						
	b	8	7						
III	a	5	1	a	3	1	a	3	1
	a	3	4	a	3	5	a	3	6
				a	2	4	a	2	4
	b	4	8	b	4	10	b	4	12
	c	2	9	c	2	11	c	2	13

1/ Table II identifies the test run numbers of the Table III conditions which must be performed, depending upon the machine type and class. Table II also establishes the number of times each run (from Table III) must be repeated to accumulate the required total test time.

2/ The order in which the required test runs specified by Table II are performed is optional. The endurance test need not be continuous; however, no test run shall be divided into increments of less than six hours each. Generator speed during all test runs shall be rated continuous operating speed or mid-speed range, whichever is greater except as follows:

a. At least one run of part "a" having the maximum cooling air temperature shall be performed at each of the following generator speeds:

1. Minimum speed for regulation
2. Maximum rated speed

b. At least one run each of parts b and c shall be performed with the generator operating at its maximum rated speed.

Table III. Generator endurance tests.

Run 1/ Number	Duration (Hours)	Generator Load (Percent)	Cooling Air Source	Temperature (° C)	Maximum Dew Point (° C)	Altitude (Feet x 1000)
1	12	100	Blast	+ 40	--	Sea Level
2	12	100	Self	+ 40	--	Sea Level
3	12	100	Blast	+ 71	--	Sea Level
4	12	100	Self	+ 71	--	Sea Level
5	12	100	Blast	+ 80	--	Sea Level
6	12	100	Blast	+ 120	--	Sea Level
7	12	100	Self	0	--	15
8	24	100	Blast	- 55	60	35
9	12	50	Blast	- 55	60	50
10	24	100	Blast	0	60	50
11	12	50	Blast	- 55	60	65
12	24	100	Blast	+ 40	60	50
13	12	50	Blast	- 15	60	65

1/ Table III defines 13 test run conditions identified as run number 1 through run number 13. Each run specifies the test duration; machine load current; altitude; and cooling air source, temperature, and dew point.

4.6.18.3 Engine compatibility. The machine shall be operated on an engine for 100 hours within the load and speed ratings specified on the manufacturers data plate, except for such operation as is consistent with engine performance to simulate start, idle takeoff, and emergency speed conditions. Upon completion of the test, the machine shall meet the requirements and measurements of paragraphs 4.6.1.1 and 4.6.6. No part of the generator shall exhibit signs of structural weakness. Failure, excessive wear, or indication of flaws of any part of the generator shall be cause for rejection.

4.6.19 Radio interference. The machine shall be operated as a generator, and radio interference measurements conducted. Tests shall be performed at minimum speed for regulation, continuous operating speed, and maximum speed for regulation. For each speed, loads of 10, 50, 75, and 100 percent of rated capacity shall be applied. Rated generator voltage shall be maintained throughout the test using a manually controlled field rheostat.

4.6.19.1 Conducted interference. Conducted interference shall be within the CE03 limits for Class III B equipment. Measurements shall be made in accordance with the specified techniques of MIL-STD-461.

4.6.19.2 Radiated interference. Radiated interference shall be within the RE05 limits for Class III B equipment. Measurements shall be made in accordance with the specified techniques of MIL-STD-461.

4.6.20 Operating position. The machine shall be placed in a suitable test stand such that the rotating axis of the machine is vertical, and the tests of paragraphs 4.6.6 and 4.6.7 shall be performed. After completion of these tests, the machine shall be run at the continuous operating speed, rated voltage, and rated load until the total of 10 hours of vertical operation in each of the two orientations (drive end up and drive end down) has been completed. Bearing temperatures shall not exceed design limits. Failure, excessive wear, or indication of flaws of any part shall be cause for rejection.

4.6.21 Environmental. The machine shall be subjected to the following environmental tests in accordance with the specified method of MIL-STD-810 except where noted. Upon completion of each of the environmental tests the machine shall be operated as a starter, if applicable, and a generator. As a starter, it shall be subjected to four consecutive start cycles. The machine shall then be subjected to the tests of paragraph 4.6.6. Failure to meet the requirements of either test shall be cause for rejection.

4.6.21.1 Low temperature storage - Method 502, Procedure I. The machine shall be exposed and maintained at a temperature of -65° C (-85° F) for a period of 72 hours after which it shall be removed and allowed to normalize. The machine shall be visually inspected upon removal from the cold chamber and after normalization.

4.6.21.2 Low temperature - Method 502, Procedure I. The machine shall be exposed and maintained at a temperature of -54° C (-65° F) for a period of 24 hours. The machine shall be subjected to the tests specified with normal cooling at the minimum specified sea level temperature.

4.6.21.3 High temperature - Method 501, Procedure I. The machines shall be maintained at a temperature of 248° F (120° C) for a minimum period of 72 hours. Class A and B machines shall be permitted to cool to 70° C (158° F) and 80° C (176° F), respectively, before the test(s). The machines shall be subjected to the tests specified with normal cooling at the maximum specified sea level temperature.

4.6.21.4 Vibration. The machine shall be mounted on the test apparatus in such a manner that sufficient rigidity is obtained so that the fundamental bending resonance of the machine does not induce appreciable flexure in the mounting. The machine shall be rotated at its continuous operating speed. Normal cooling shall be provided. Equipment operation may be as a motor or as a generator. Vibration shall be in accordance with MIL-STD-810, Method 514, Category (a), Procedure (I), Curve (Z). The fundamental bending resonant frequency shall not be less than that specified on the associated specification sheet. Any mechanical damage due to vibration test shall be cause for rejection.

4.6.21.5 Explosion proof. When specified on the associated specification sheet, the explosion proof test shall be conducted in accordance with Method 511, Procedure I of MIL-STD-810. Any ignition of ambient explosive gaseous mixture shall be cause for rejection.

4.6.21.6 Humidity. The humidity test shall be in accordance with Method 507, Procedure I of MIL-STD-810.

4.6.21.7 Fungus. The machine shall be subjected to the fungus test in accordance with Method 508 of MIL-STD-810.

4.6.21.8 Salt fog. The machine shall be subjected to the salt fog test Method 509, Procedure I of MIL-STD-810. The synthetic salt spray solution to be atomized and injected into the test chamber shall be formulated as follows:

Chemical	Grams Per Liter
Sodium Chloride	24.540
Magnesium Chloride	11.110
Sodium Sulfate	4.094

Calcium Chloride	1.159
Potassium Chloride	0.695
Sodium Bicarbonate	0.201
Potassium Bromide	0.101
Strontium Chloride	0.042
Boric Acid	0.207
Sodium Fluoride	0.003

The pH of the solution shall be adjusted to 8.2 with 0.1 normal sodium carbonate solution. The first 10 hours of the test shall consist of 10 periods, each in turn consisting of 10-minute operative and 45-minute inoperative duration. During the operative periods, the machine shall be operated without excitation at any convenient speed greater than 1700 RPM. The remainder of the test shall be performed with the generator inoperative. Upon completion of the test the machine shall be washed with a gentle spray of water not exceeding 38° C (101° F) in temperature. The machine shall then be dried for 20 hours at a temperature of 50° C ± 0.5° C (118° F ± 5.0° F), after which it shall meet the requirements of paragraph 4.6.6.

4.6.21.9 Fluid exposure. The machine shall be immersed horizontally into engine oil (MIL-L-23699) at 114° C ± 7° C (237° F ± 13° F) up to the bearings and the complete unit rotated in the oil approximately 60 degrees every 15 minutes for 16 hours. The machine shall be allowed to drain for one hour, then subjected to the tests of paragraphs 4.6.6 and 4.6.7.

4.6.21.10 Shock tests. Generators and starter generators shall be subjected to the shock crash safety test of MIL-STD-810, Method 516, Procedure III.

4.6.21.11 Sand and dust. The machine shall be subjected to the sand and dust test, Method 510, Procedure I of MIL-STD-810. The machine shall be mounted in the test chamber with the air blast and bell opening in a horizontal position. The machine shall be operated at continuous rated speed and no load for 30 minutes and then inoperative for 90 minutes. This procedure shall be repeated for a total test period of six hours; three hours at each temperature. At the end of the test period, the machine shall be removed from the test chamber and shall meet the requirements of paragraph 4.6.7.

4.6.22 Brush and commutator wear. Two complete sets of brushes shall be prepared to simulate worn brush performance. One set of brushes shall be worn to simulate full brush life. The top of the brush life indicator groove on the brush shall be just discernible. The second set of brushes shall simulate excessive brush wear. The brushes shall be worn so that the rivet is just exposed.

4.6.22.1 Normal brush wear. With the brushes simulating full brush wear properly seated (see 4.6.22.3), the machine shall be subjected to the commutation test, of paragraph 4.6.7. Sparking shall not exceed the 1½ requirement of Figure 5. Starter generators shall also complete two consecutive start cycles of paragraph 4.6.16.

4.6.22.2 Excessive brush wear. Upon completion of the above test, the brushes shall be removed and inspected. The commutator shall be inspected for signs of damage without disassembly of the machine. The second set of brushes to simulate excessive brush wear shall be installed. The machine shall be operated at its continuous operating speed for two hours with the shunt field not excited. Upon completion of this test, the rotor shall be removed and the commutator inspected. There shall be no evidence of commutator damage due to this test.

4.6.22.3 Turned Commutator. Upon completion of the above test, the commutator shall be turned to its minimum diameter as indicated by the step. The machine shall be assembled with new brushes installed and operated at light generator loads until the brushes are properly seated and a normal commutator film develops. The machine shall meet the commutation requirements of paragraph 4.6.7. The brushes used for the test of paragraph 4.6.22.1 shall be installed in the machine and run until they are properly seated. The test of paragraph 4.6.22.1 shall be repeated.

4.6.23 Disassembly and inspection. Upon completion of the test specified for both starter and generator operation, the machine shall be disassembled and inspected. There shall be no evidence of major deterioration, excessive heating, corrosion, or undue wear.

4.6.24 Bearing failure. After disassembly and inspection the machine shall be reassembled minus the lubricant, cage, and seals in the bearings. The machine shall be operated as a generator at rated load, rated voltage, and continuous operating speed for a total period of four hours regardless of electrical failure. Only intermittent sparks that emanate from within shall be permitted and any tendency to flame shall be cause for rejection.

4.6.25 Drive shear section. The spare drive shaft complete with torsional vibration damping device shall be installed in a torque measuring test setup and sufficient torsional force shall be applied to the drive spline to result in failure of the shaft at the shear section. The necessary torque indicating instrumentation shall be provided. Failure shall occur at the shear section and at the applied torque as specified on the associated specification sheet (see 3.4.5.8).

5. PACKAGING

5.1 Packaging. For acquisition purposes, the packaging requirements shall be as specified in the contract or order (see 6.2). When actual packaging of materiel is to be performed by DOD personnel, these personnel need to contact the responsible packaging activity to ascertain requisite packaging requirements. Packaging requirements are maintained by the Inventory Control Point's packaging activity within the Military Department or Defense Agency, or within the Military Department's System Command. Packaging data retrieval is available from the managing Military Department or Defense Agency's automated packaging files, CD-ROM products, or by contacting the responsible packaging activity.

6. NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

6.1 Intended use. The machines covered by this specification are intended for new and retrofit use as generators or starter-generators in aircraft. As generators, the machines function as a continuous source of 28-volt direct current. As starter-generators, when energized by electric power, the machines will provide the additional function of starting aircraft engines.

6.2 Acquisition requirements. Acquisition documents must specify the following:

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

b. Issue of DODISS to be cited in the solicitation, and if required, the specific issue of individual documents referenced (see 2.2.1 and 2.3).

c. Packaging requirements (see 5.1).

d. Level of preservation and packaging and level of packing required (see 5.1).

e. In the event of new usage, any differences in shunt field design relative to the intended regulator.

f. Responsibility for inspection. Specify in the contract or purchase order which entity (supplier or Government) is responsible for the performance of inspection requirements, where those inspections must (or may) be performed, and any inspection rights the Government chooses to reserve in order to assure the products conform to prescribed requirements.

6.3 Qualification. With respect to products requiring qualification, awards will be made only for products which are, at the time of award of contract, qualified for inclusion in Qualified Products List QPL No. 6162 whether or not such products have actually been so listed by that date (see 3.2). 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. Information pertaining to qualification of products may be obtained from the Naval Air Test Center, Weapons Systems Test Division, Electrical and Environmental Branch, Patuxent River, Maryland 20670.

6.4 Definitions.

6.4.1 Machine. Machine, as used in the specification, is a generator or starter-generator, as applicable.

6.5 Subject term (key word) listing.

Brush
Cooling
DC
Damper
Load
Phase
QAD
Rotation
Shunt field
Speed
Torque
Torsional
Vibration

6.6 Changes from previous issue. Marginal notations are not used in this revision to identify changes with respect to the previous issue due to the extent of the changes.

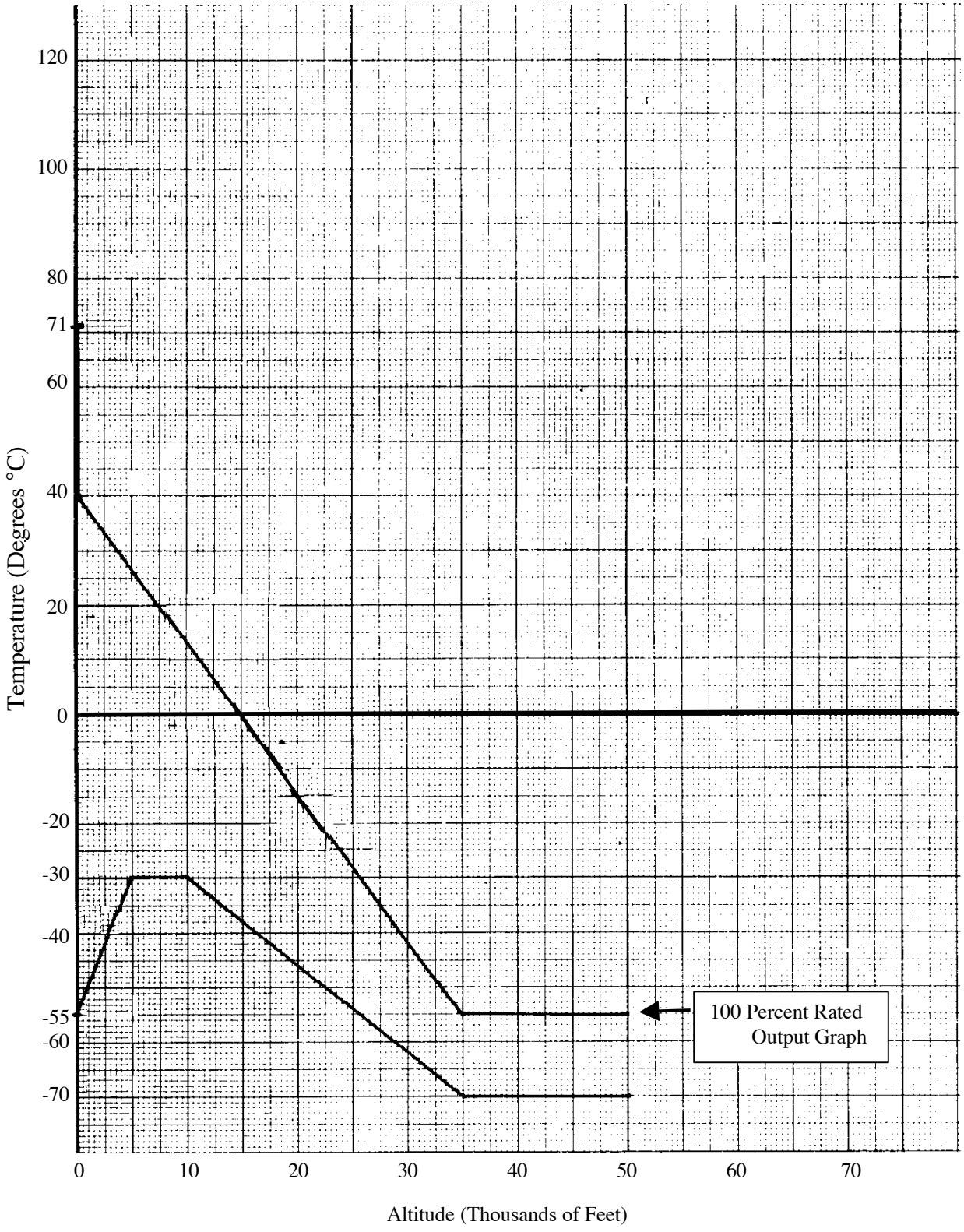


FIGURE 1. Class A temperature-altitude range.

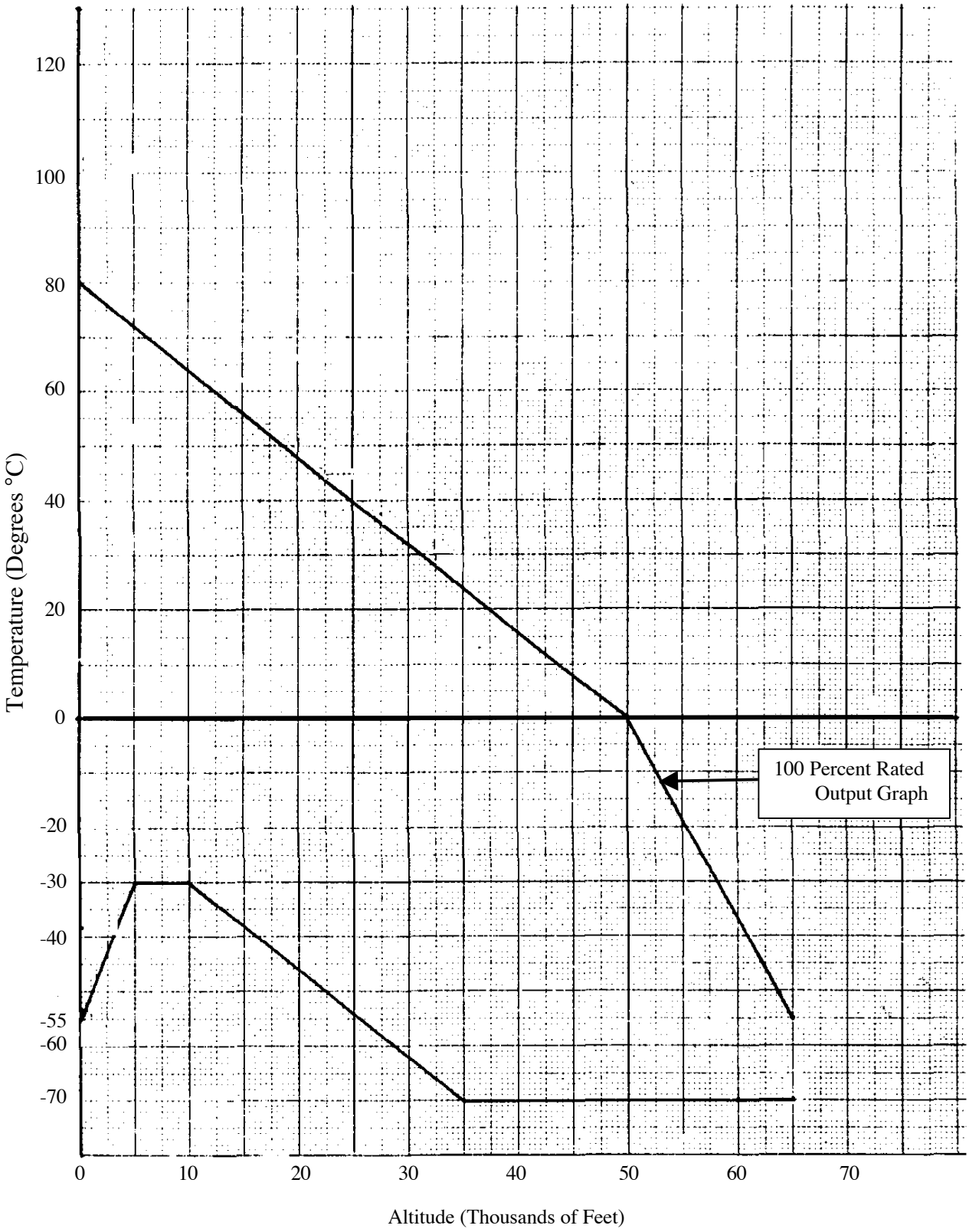


FIGURE 2. Class B temperature-altitude range.

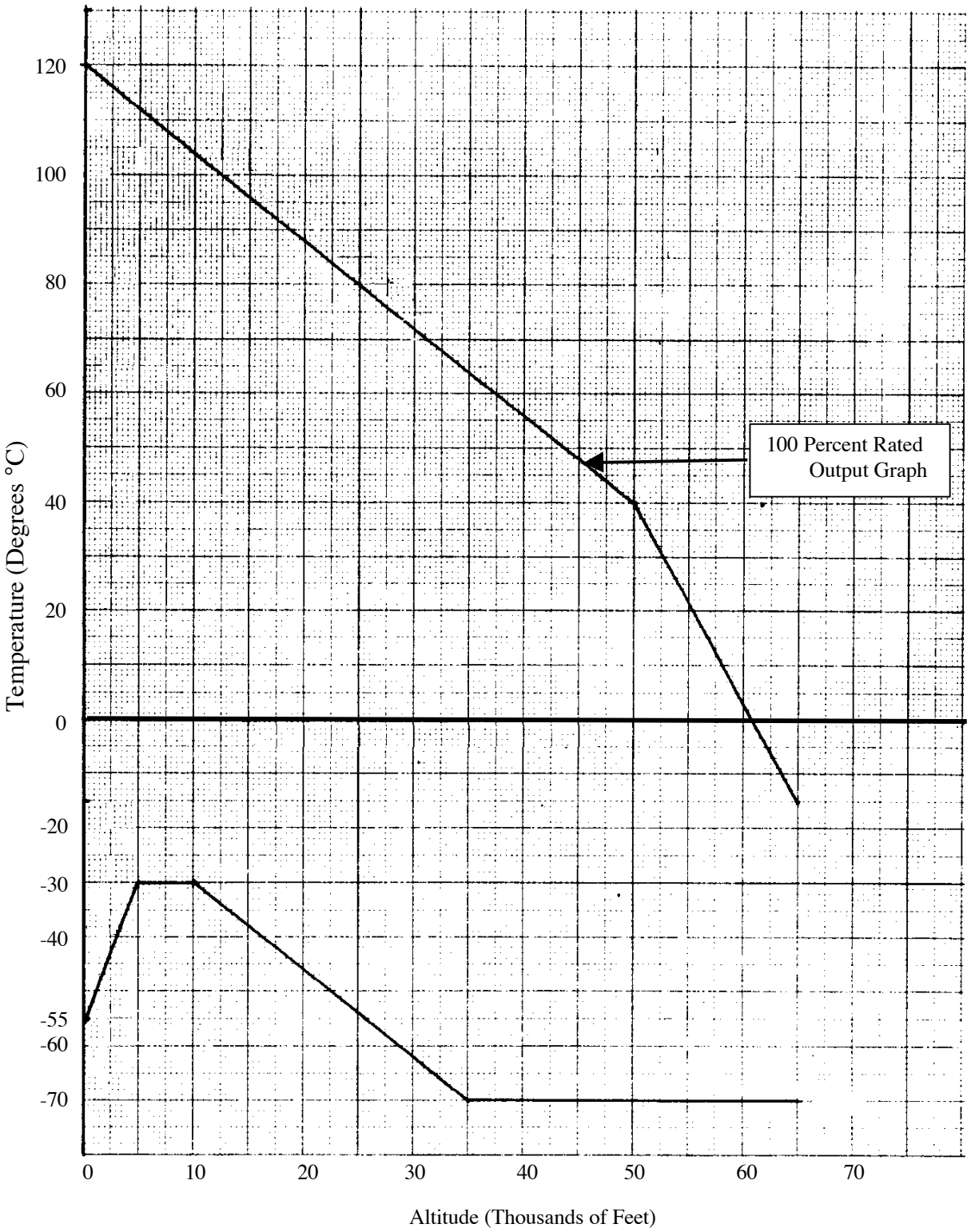


FIGURE 3. Class C temperature-altitude range.

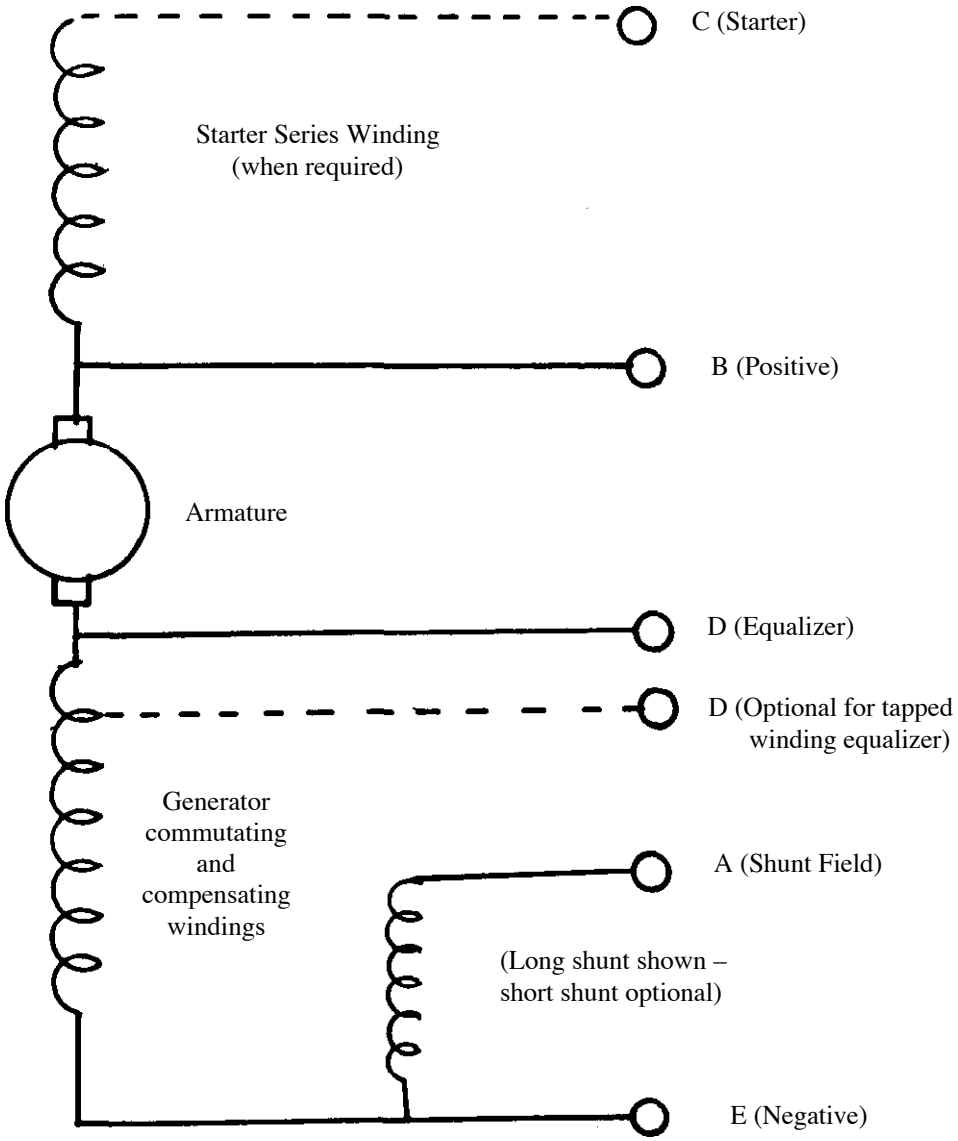
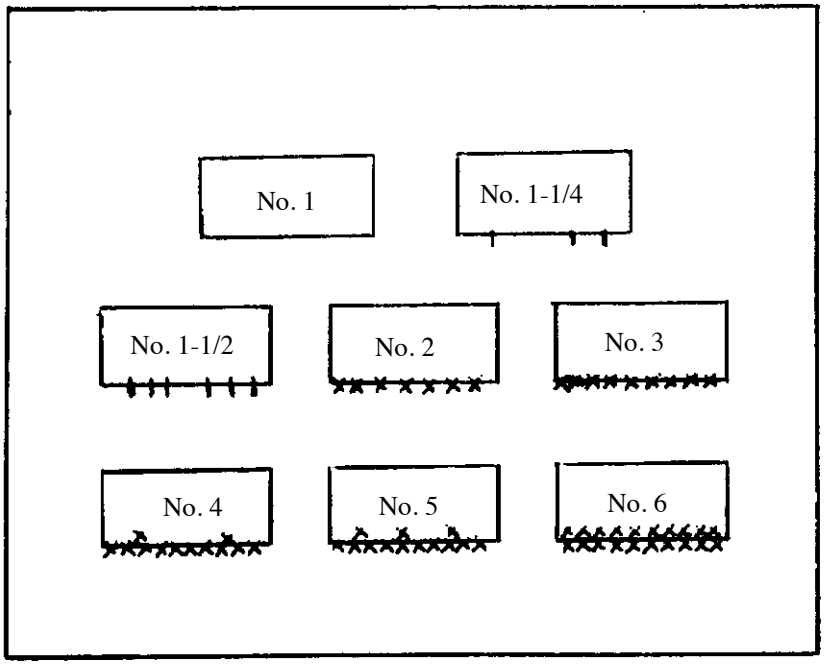


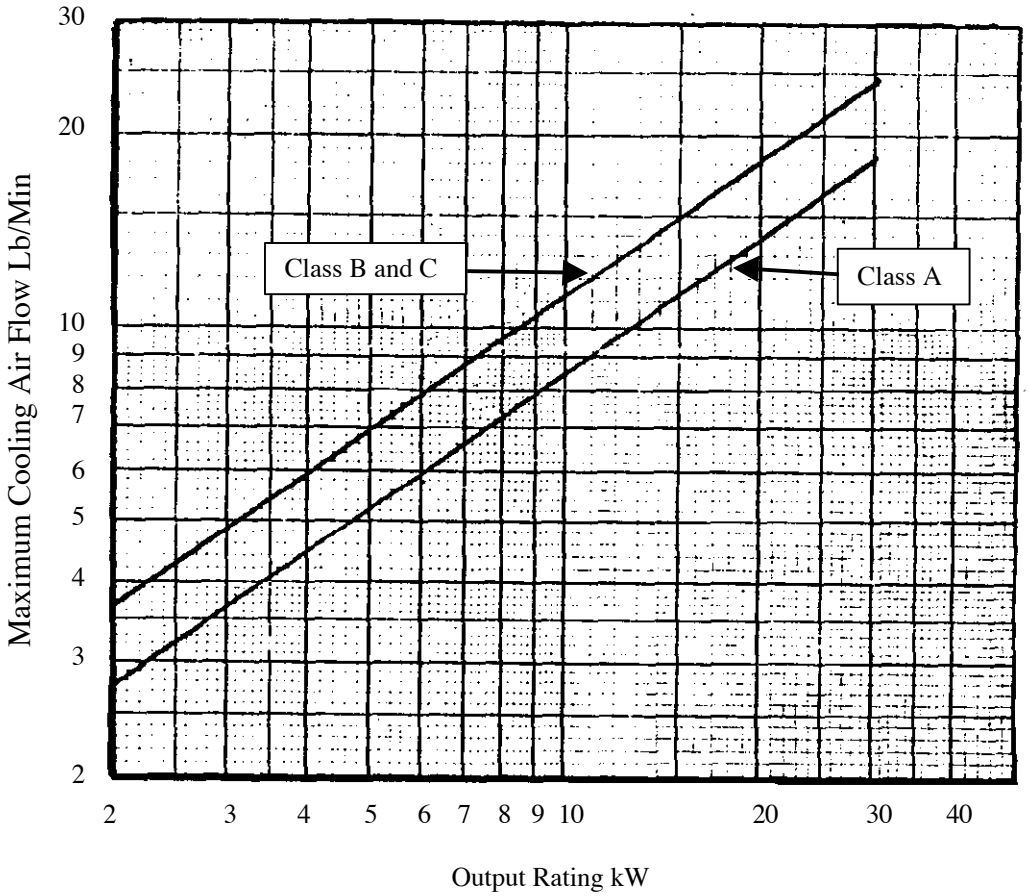
FIGURE 4. Schematic Diagram – shunt wound generator with optional series wound field for starting duty.



No. 1	Black with no sparking evident
No. 1-1/4	Slight intermittent sparking
No. 1-1/2	Slight continuous sparking
No. 2	Continuous sparking heavier than 1-1/2. Streamers just begin to extend from edge of brush.
No. 3	Sparks heavier than No. 2
No. 4	Sparks heavier than No. 3
No. 5	Sparks heavier than No. 4
No. 6	Sparks – entire brush covered with continuous heavy sparks

From 0 to 100 percent load, the sparking shall be no greater than 1-1/4
From 100 to 125 percent load, the sparking shall be no greater than 1-1/2
From 125 to 150 percent load, the sparking shall be not exceed 2

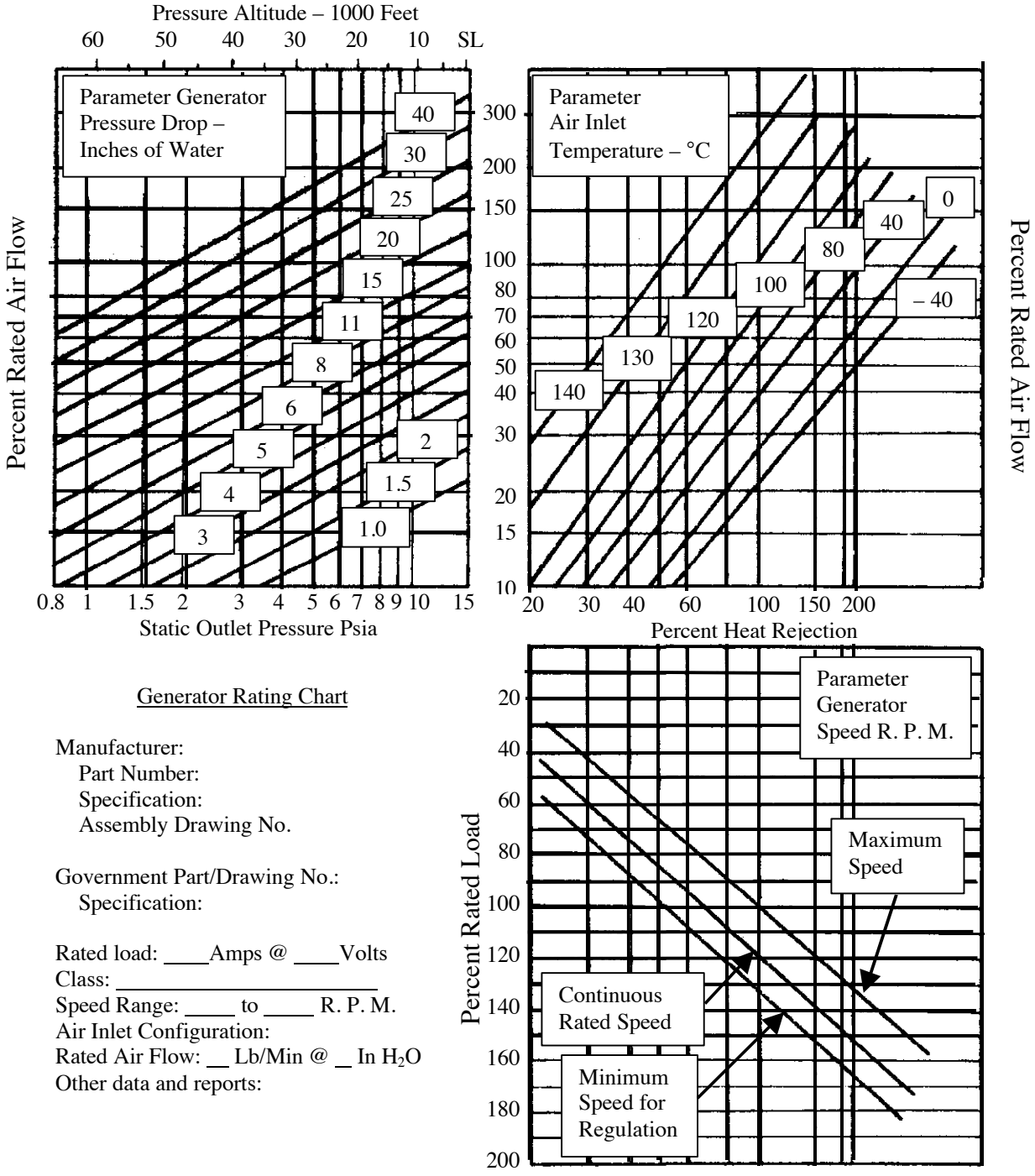
FIGURE 5. Commutation chart.



Applicable Conditions

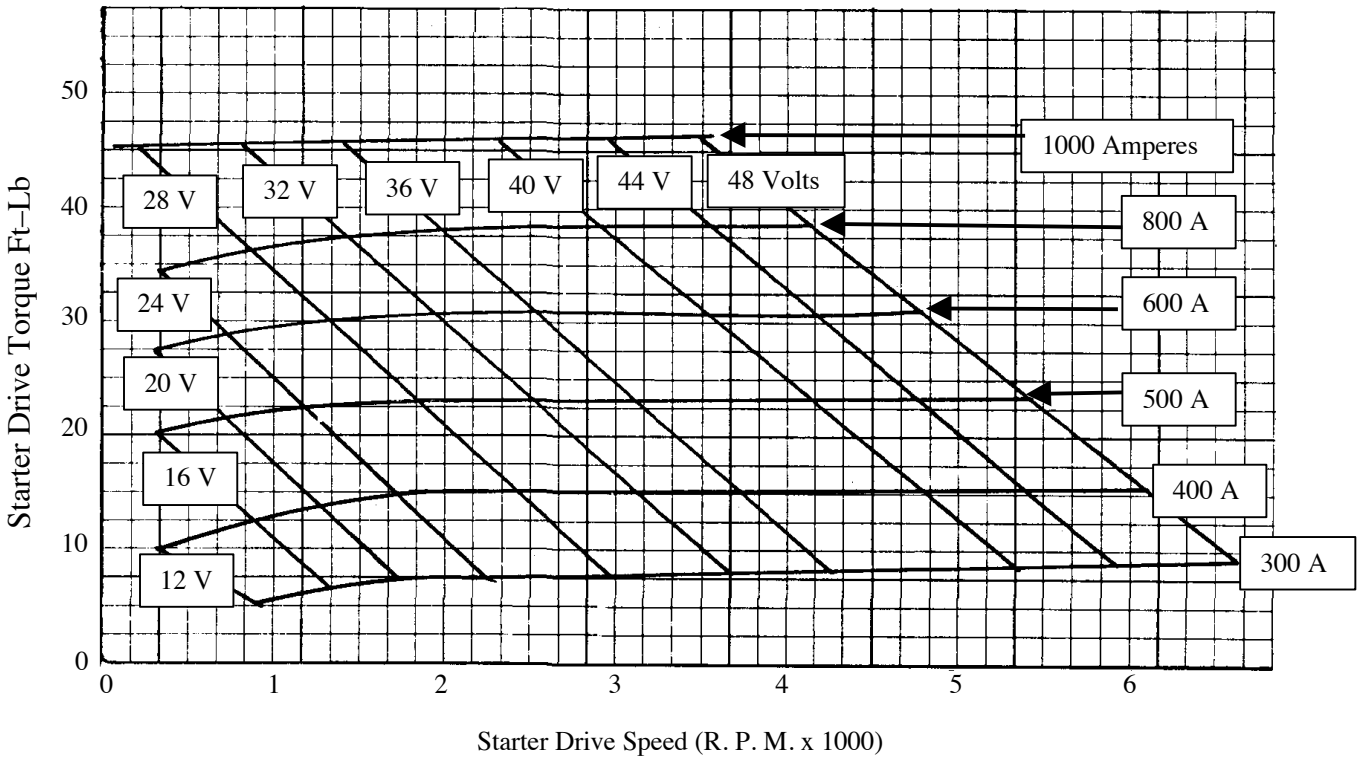
Class	Rating Percent	Air Outlet Pressure	Air Inlet Temperature	Maximum Pressure Drop
A	100	14.7 Psia	40 °C	6 In. Water
B	100	14.7 Psia	30 °C	11 In. Water
C	100	14.7 Psia	120 °C	11 In. Water

FIGURE 6. Generator external blast cooling air flow.



Note: These sample charts are for illustration purposes only

FIGURE 7. Generator altitude rating chart.



Note: This sample chart is for illustration purposes only.

FIGURE 8. Starter speed-torque characteristics.

Custodian:
Army – CR4
Navy – AS
Air Force – 99

Reviewer:
Army – AV

Preparing Activity:
Air Force – 84

Agent:
Air Force – 99

(Project Number 6115-0810)

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

INSTRUCTIONS

1. The preparing activity must complete blocks 1, 2, 3, and 8. In block 1, both the document number and revision letter should be given.

2. The submitter of this form must complete blocks 4, 5, 6, and 7, and send to preparing activity.

3. The preparing activity must provide a reply within 30 days from receipt of the form.

NOTE: This form may not be used to request copies of documents, nor to request waivers, or clarification of requirements on current contracts. 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.

I RECOMMEND A CHANGE:	**1. DOCUMENT NUMBER** MIL-DTL-6162C	**2. DOCUMENT DATE *(YYYYMMDD)*** 05 April 2000

3. DOCUMENT TITLE GENERATORS AND STARTER-GENERATORS, ELECTRICAL DIRECT CURRENT, NOMINAL 30 VOLTS, AIRCRAFT GENERAL SPECIFICATION FOR

4. NATURE OF CHANGE *(Identify paragraph number and include proposed rewrite, if possible. Attach extra sheets as needed.)*

5. REASON FOR RECOMMENDATION

6. SUBMITTER

a. NAME (Last, First, Middle Initial)	**b. ORGANIZATION**	
c. ADDRESS (Include Zip Code)	**d. TELEPHONE** (Include Area Code) (1) Commercial: (2) DSN: (3) FAX: (4) EMAIL:	**7. DATE SUBMITTED** ***(YYYYMMDD)***

8. PREPARING ACTIVITY

a. NAME Robert Yohe	**b. TELEPHONE** **Commercial:** 912-926-1183 **DSN:** 468-1183 **FAX:** 468-4771 **EMAIL:** bob.yohe@robins.af.mil
c. ADDRESS WR-ALC/TILCC 420 Second Street, Suite 100 Robins AFB GA 31098-1640	**IF YOU DO NOT RECEIVE A REPLY WITHIN 45 DAYS, CONTACT:** Defense Standardization Program Office (DLSC-LM) 8725 John J. Kingman Road, Suite 2533 Fort Belvoir, Virginia 22060-6221 Telephone (703) 767-6888 DSN 427-6888