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MILITARY SPECIFICATION

MOTORS, ALTERNATING CURRENT, 400-CYCLE, 115/200-VOLT SYSTEM, AIRCRAFT, GENERAL SPECIFICATION FOR

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

1. SCOPE

1.1 Scope. This specification covers the general requirements for aircraft electric motors and, together with the detail specification or with the military standard (MS) containing equivalent information, as described in 3.5.2, forms the complete specification for procurement of aircraft electric motors operable from 115/200-volt, 400-cycle, alternating current systems.

1.2 Classification. Motors shall be of the following classes, as specified (see 6.2):

Class A—Class A motors are operable under temperature-altitude conditions of curve II of MS33543.

Class B—Class B motors are operable under temperature-altitude conditions of curve I of MS33543.

2. APPLICABLE DOCUMENTS

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

SPECIFICATIONS

FEDERAL

QQ-P-416—Plating, Cadmium (Electrodeposited)

MILITARY

MIL-M-3171—Magnesium Alloy, Process for Corrosion Protection of

MIL-E-5272—Environmental Testing, Aeronautical and Associated Equipment, General Specification for

MIL-C-5541—Chemical Films and Chemical Film Materials for Aluminum and Aluminum Alloys

MIL-I-6181—Interference Control Requirements, Aircraft Equipment

MIL-L-6880—Lubrication of Aircraft, General Specification for

MIL-S-7742—Screw Threads, Standard, Optimum Selected Series: General Specification for

MIL-A-8625—Anodic Coatings, for Aluminum and Aluminum Alloys

MIL-E-16298—Electric Machines Having Rotating Parts and Associated Repair Parts: Packaging of

MIL-D-70327—Drawings, Engineering and Associated Lists

STANDARDS

MILITARY

MIL-STD-130—Identification Marking of US Military Property

MIL-STD-143—Specifications and Standards, Order of Precedence for the Selection of

MIL-STD-195—Marking of Connections for Electric Assemblies

MIL-STD-202—Test Methods for Electronic and Electrical Component Parts

MIL-STD-704—Electric Power, Aircraft, Chracteristics and Utilization of

MS33540—Safety Wiring, General Practices for

MS33543—Criteria Temperature and Altitude Range Self Cooled Electric Equipment

MS33568—Drive, Square Mounting Flange with Involute Spline-Pinion

MS33569—Drive, Round Mounting Flange with Involute Spline-Pinion

FSC 6105

MS33570—Drive, Square Mounting Flange with Round Shaft and Key
MS33571—Drive, Round Mounting Flange with Round Shaft and Key
MS33586—Metals, Definition of Dissimilar

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

3. REQUIREMENTS

3.1 Preproduction. This specification provides for preproduction testing (see 4.3).

3.2 Data. Unless otherwise specified in the contract or order, no data are required by this specification or any of the documents listed in section 2 (see 6.2).

3.3 Materials. Materials used in the manufacture of motors shall be of high quality, suitable for the purpose, and shall conform to applicable Government specifications wherever practicable.

3.3.1 *Corrosion resistance.* Materials shall be corrosion resistant or be suitably processed to resist corrosion.

3.3.2 *Dissimilar metals.* Unless suitably protected, dissimilar metals as defined in MS33586 shall not be used in intimate contact with each other. When protection is used, it shall be of such type that a low-impedance path is offered to radio frequency currents.

3.4 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 3.4.1 and 3.4.2.

3.4.1 *Standard parts.* Standard parts (MS and AN) shall be used wherever they are suitable for the purpose, and shall be identified on the drawing by their part numbers. 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.

3.4.2 *Commercial parts.* Commercial utility parts, such as screws, bolts, nuts, and cotter pins may be used, provided they possess suitable properties and are replaceable by the MS or AN parts without alteration, and provided the corresponding MS or AN part numbers are referenced in the parts list and, if practicable, on the contractor's drawings.

3.5 Design and construction.

3.5.1 *Duty cycle.* The duty cycle shall be as specified in the detail specification.

3.5.2 *Detail requirements.* The detail requirements, as specified in the detail specification or MS, shall include all of the applicable data shown in 6.5.

3.5.3 *Mounting flange.* The mounting flange, when required, and clearance for mounting studs shall be in accordance with the applicable MS or detail specification. Flanges in accordance with MS33568, MS33569, MS33570, or MS33571 are preferred in the applicable motor sizes.

3.5.4 *Coupling spline.* The coupling spline, or drive shaft, shall be in accordance with the applicable MS or detail specification. Splines or drive shafts in accordance with MS33568, MS33569, MS33570, or MS33571 are preferred in the applicable motor sizes.

3.5.5 *Lubrication.* When lubrication of the motors is permitted by the MS or detail specification, it shall be in accordance with MIL-L-6880.

3.5.6 *Electrical connections.* Unless otherwise shown on the applicable MS or detail specification, external termination of the motor wiring shall be in accordance with MIL-STD-195. The motor mounting provisions shall not be used to complete the motor electrical circuits in lieu of a lead. Positive connections which depend upon insulation in compression shall not be used.

3.5.7 *Rotor.* Motors shall be so constructed that the rotor is readily removed without the use of special tools.

3.5.8 *Electric power.* When furnished with category C ac power in accordance with MIL-STD-704, as specified on the detail specification or MS, each motor shall conform to the requirements of MIL-STD-704 and shall meet all other requirements of this specification and the detail specification or MS.

3.5.9 *Protection.* When used, all ventilating openings in the housing shall be of such size as not to permit passage of a 5/16-inch-diameter rod.

3.5.10 *Life of motor.* The motor shall be so designed that when operating under any of the temperature or altitude conditions specified in 3.5.18, the useful life of the motor shall be not less than 1,000 hours.

3.5.11 *Rotation.* The direction of rotation

of the motor output shaft shall be in accordance with MIL-STD-195.

3.5.12 *Thermal protection.* When specified by the applicable motor drawing or detail specification, a protective means shall be supplied. One of the following methods and types of protection is to be specified:

(a) *Thermal protection method.*

(1) *Method I:* Protection shall be provided by a nonautomatic reset means to prevent smoke or toxic fumes from being generated by a motor under locked rotor or operating conditions. The protective device must be manually resetable or replaceable after partial disassembly of the motor.

(2) *Method II:* Protection shall be provided to permit a motor to develop maximum output or locked rotor torque to the point of failure without being a fire hazard. The protective system must not be automatically reset and both motor and protector system are considered expended after one operation.

(3) *Method III:* Protection shall be provided to permit average rated torque capability under all operable environmental, power, and load conditions, and attain a substantial portion of the rated life of the motor under overload conditions which cause cycling of the thermal protective device. The motor and protector shall provide a minimum of 25 hours of intermittent or continuous locked rotor protection at rated voltage and frequency.

(b) *Thermal protection type.*

(1) *Direct acting:* A protector within or on the motor enclosure shall interrupt the motor power supply and shall be of sufficient rating to interrupt the maximum locked rotor current and perform in accordance with the appropriate part of 3.5.12(a), as specified. The protector must be rated to provide a minimum of 5,000 interruptions of the maximum current, or 25 hours of intermittent or continuous locked rotor protection at rated voltage and frequency.

(2) *Indirect acting:* A protector shall be provided with a minimum inductive contact rating of 2 amp. at 28V dc to operate relays and signal devices. The protector must perform in accordance with the appropriate part of 3.5.12(a) specified, and must have a minimum life of 5,000 operations.

3.5.13 *Fluid resistance.* When specified by the applicable MS or detail specification, the motor shall be designed and constructed to operate under conditions of fluid leakage upon the motor as specified in 4.6.20.

3.5.14 *Explosion-proof (aeronautical).* When specified by the applicable MS or detail specification, the motor and thermal protector (if specified) shall be explosion-proof, as specified in 4.6.21.

3.5.15 *Interference.* Conducted and radiated radio frequency noise shall not exceed the limits specified in MIL-I-6181.

3.5.16 *Emergency two-phase operation.* When required by the applicable MS or detail specification, a grounded neutral, three-phase, Y-connected motor shall operate with one of the input power lines removed under one or more of the following conditions, as specified in the applicable MS or detail specification:

(a) Motor shall be capable of delivering specified reduced horsepower output continuously.

(b) Motor shall be capable of delivering specified minimum stalled torque.

(c) Motor shall be capable of delivering a specified minimum running torque.

(d) Motor shall be capable of delivering a specified horsepower output for a specified number of operational cycles prior to failure.

(e) Other.

3.5.17 *Brakes.* When required by the MS or detail specification, the motor shall be equipped with a brake. Stopping revolutions and inertia load shall be as specified by the MS or detail specification.

3.5.18 *Operating conditions.* The motor shall provide mechanical energy in aircraft under any of the following operating conditions or natural combination of conditions:

(a) Altitude-temperature: Altitude-tem-

perature range in accordance with MS33543, curve I (Class B) or curve II (Class A), as specified on the applicable MS or detail specification. The pressure may remain constant, or may vary at a rate as high as 1.5 inches Hg./sec.

(b) Humidity: Relative humidity ranging up to 100 percent, including conditions wherein condensation will take place in or on the equipment.

(c) Sand and dust resistance: Under conditions of airborne sand and dust particles.

(d) Resistance to salt spray: Atmosphere containing salt-laden moisture.

(e) Fungus: When exposed to fungus growth as encountered in tropical climates.

(f) Operating position: When installed in any position.

(g) Input power: Category C ac electric power in accordance with MIL-STD-704 and as specified on the detail specification or MS.

3.6 Interchangeability. All parts having the same manufacturer's part number shall be directly and completely interchangeable with respect to installation and performance. Changes in manufacturer's part numbers shall be governed by the drawing number requirements of MIL-D-70327.

3.7 Finish.

3.7.1 *Anodizing.* When used, anodic treatment of aluminum alloy parts shall be in accordance with MIL-A-8625. The aluminum oxide film formed by this treatment shall be removed from the actual contact area of all surfaces required to act as a path for electrical current and from the local area under screws, nuts, or the like used for assembly or mounting purposes, to provide an adequate bonding connection.

3.7.2 *Chemical films.* Chemical films in accordance with MIL-C-5541, or approved equivalent, may be used when the motor component parts are not subject to abrasion.

3.7.3 *Magnesium-alloy parts.* Wherever practicable, magnesium-alloy parts shall be surface treated in accordance with MIL-M-3171 to provide protection against corrosion.

3.7.4 *Electrical sheet-steel assemblies.* Electrical sheet-steel assemblies such as rotors, stators, etc., shall be processed by acceptable commercial methods to provide protection against corrosion.

3.7.5 *Plating.* When utilized as the sole protective finish, cadmium plating shall be in accordance with QQ-P-416, type I or type II, as applicable, and of a class that is adequate to achieve the degree of protection required.

3.8 Screw Threads. Screw threads shall conform to the requirements of MIL-S-7742.

3.9 Safety wiring and staking. Accidental loosening of screws, screw parts, and other connections shall be prevented by safetying in accordance with MS33540. Staking or other methods may be used if approved by the procuring activity.

3.10 Performance. The motor shall satisfy any natural combination of the tests as specified in section 4.

3.11 Terminal marking. Markings of terminals shall be in accordance with MIL-STD-195, unless otherwise specified by the applicable MS or detail specification. When deviations from MIL-STD-195 exist, a diagram or chart of the terminals shall be affixed to the motor (see 6.2).

3.12 Identification of product. Equipment, assemblies, and parts shall be marked in accordance with MIL-STD-130. The identification data applied to the motor shall be:

AC AIRCRAFT MOTOR
FOR USE ON 115/200-VOLT, ---------[1]
CYCLE SYSTEM
HP----------, RPM----------, PHASES
--------, LINE AMPS----------
Duty ---------- (Continuout or intermittent and, if intermittent, state the duty cycle)
Military Part No.----------
Federal stock No.----------
Manufacturer's part No. (or identification)
Manufacturer's serial No.
Contract or order No.
Manufacturer's name or trademark

Any additional nameplates with proprietary data shall be attached to the motor by means of easily removable screws.

[1] Manufacturer to insert applicable frequency range of the type power specified in the detail specification or MS. If a variable frequency range is specified, the HP/RPM ratio and current must be specified.

3.13 Workmanship. All machined surfaces shall have a finish suitable for the purpose intended, and all details of manufacture, including the preparation of parts and accessories, shall be in accordance with best practice for high quality electrical equipment. Particular attention shall be given to neatness and thoroughness of soldering, wiring, impregnation of coils, marking of parts, plating, lacquering, riveting, clearance between soldered connections, removal of burrs and sharp edges, and ruggedness.

4. QUALITY ASSURANCE PROVISIONS

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

4.2 Classification of inspections. The examining and testing of motors shall be classified as:

(a) Preproduction inspections.....(4.3)
(b) Quality conformance inspections.(4.4)

4.3 Preproduction inspections.

4.3.1 *Sampling instructions.* The preproduction samples shall consist of four motors representative of the production aircraft electric motors.

4.3.2 *Inspections.* The preproduction inspections shall consist of all the examinations and tests of this specification. The inspections shall be conducted on each of four motors as shown below, and must be conducted essentially in the order listed for each motor.

MOTOR NO. 1

(a) Examination of product..... (4.6.1)
(b) Performance..... (4.6.2)
(c) Dielectric strength..... (4.6.5)
(d) Line current balance (polyphase only)..... (4.6.4)
(e) Overspeed..... (4.6.6)
(f) Brake performance (stopping revolutions and static holding torque only). (4.6.22.1, 4.6.22.2)
(g) High ambient temperature... (4.6.7.1)
Low ambient temperature. (4.6.7.2(a))
(h) Starting..... (4.6.9)
(i) Fungus..... (4.6.18)
(j) Interference..... (4.6.17)

MOTOR NO. 2

(a) Examination of product..... (4.6.1)
(b) Performance..... (4.6.2)
(c) Dielectric strength..... (4.6.5)
(d) Line current balance (polyphase only)..... (4.6.4)
(e) Overspeed..... (4.6.6)
(f) Brake performance (stopping revolutions and static holding torque only) (4.6.22.1, 4.6.22.2)
(g) Acceleration..... (4.6.10)
(h) Operating position..... (4.6.8)
(i) Salt spray..... (4.6.15)
(j) Explosion-proof (aeronautical, when specified)..... (4.6.21)
(k) Thermal protection, methods II and III (when specified). (4.6.19.1.2, 4.6.19.1.3)
(l) Interference..... (4.6.17)

MOTOR NO. 3

(a) Examination of product..... (4.6.1)
(b) Performance..... (4.6.2)
(c) Dielectric strength..... (4.6.5)
(d) Line current balance (polyphase only)..... (4.6.4)
(e) Overspeed..... (4.6.6)
(f) Low ambient temperature. (4.6.7.2(b))
(g) Shock..... (4.6.11)
(h) Brake performance..... (4.6.22)
(i) Vibration..... (4.6.12)
(j) Humidity..... (4.6.14)
(k) Interference..... (4.6.17)

MOTOR NO. 4

(a) Examination of product..... (4.6.1)
(b) Performance ..... (4.6.2)
(c) Dielectric strength ..... (4.6.5)
(d) Line current balance (polyphase only)..... (4.6.4)
(e) Overspeed..... (4.6.6)

(f) Brake performance (stopping revolutions and static holding torque only) (4.6.22.1, 4.6.22.2)
(g) Fluid resistance (when specified) ..... (4.6.20)
(h) Life ..... (4.6.13)
(i) Sand and dust resistance ..... (4.6.16)
(j) Thermal protection, methods I and II (when specified) . (4.6.19.1.2)
(k) Interference ..... (4.6.17)

4.3.2.1 *Disassembly and inspection.* At the conclusion of the preproduction inspections, the motors will be disassembled and inspected for excessive wear and defects.

4.4 Quality conformance inspections. Each motor shall be subjected to:

(a) Examination of product ..... (4.6.1)
(b) Load test ..... (4.6.3)
(c) Line current balance (polyphase only) ..... (4.6.4)
(d) Dielectric strength ..... (4.6.5)
(e) Thermal protection—short time test only (when thermally protected) ..... (4.6.19)
(f) Brake performance—stopping revolutions (motors with stopping devices only) ... (4.6.22.1)

4.5 Test conditions. Unless otherwise specified, each test in this section shall be made under the following conditions.

4.5.1 *Loading.* The motor shall be coupled to a suitable loading device capable of loading the motor over the rated load and speed range. The rotational axis of the motor shall be horizontal. Rated torque shall be computed from rated horsepower and rated speed and used as the index of loading. Reversible motors shall be tested in each direction of rotation.

4.5.2 *Ambient.* The ambient temperature shall be 25° ±15° C unless higher or lower ambients are specified in the applicable MS or detail specification.

4.5.3 *Altitude.* The test shall be run at approximately sea level altitude.

4.5.4 *Location of load.* The load for the motor shall be so located that it will not appreciably affect the ambient temperature.

4.5.5 *Warmup.* Prior to each test, the continuous-duty motor shall be operated at rated load for sufficient time to reach a substantially constant temperature, as specified in 4.6.2.1. Intermittent-duty motors are rated at 25° C with no temperature rise, and no warmup is required.

4.5.6 *Voltage measurement.* The input voltage shall be measured at the terminals of the motor.

4.5.7 *Input power.* Category C ac electric power shall be in accordance with MIL-STD-704 and as specified on the detail specification or MS.

4.5.8 *Simulation of actual installation.* Wherever practicable, for environmental tests, the test setup should simulate the installation in service, i.e., connection of the motor to the gear box, screw jack, pump, etc.

4.6 Inspection methods.

4.6.1 *Examination of product.* Each unit shall be examined to determine compliance with all requirements of this specification not covered by tests.

4.6.2 *Performance.*

4.6.2.1 *Heating, speed.* Provision shall be made for determining frequency, speed, input voltage and current, input watts, and output torque. While the motor is cold, the resistance and temperature of the stator winding shall be determined for use in calculating the final stator winding temperature rise after operation at rated load. A temperature measurement may be made by thermocouple on the frame or stator winding structure in order to determine when the temperature has leveled off prior to taking a final resistance reading on the stator winding. The motor shall be considered to have reached its continuous operating condition in the case of continuous-duty motors, when the rate of rise of stator winding temperature above the then existing ambient is no more than 1° C within 15 minutes, and for intermittent-duty motors, when the difference between the maximum rises at the end of successive duty cycles is no more than 1° C. The ability of the motor to deliver rated torque under the following conditions for continuous or rated duty cycle operation shall be demonstrated. The final temperature of the motor shall not be cause for rejection, provided the motor meets all other requirements of the specification. When specified, the temperature of exposed parts shall be limited to a maximum

of 390° F and shall not be exceeded for any temperature-altitude condition within requirements of this specification:

(a) Rated frequency, rated voltage.
(b) Minimum frequency, maximum steady-state voltage.
(c) Maximum frequency, minimum steady-state voltage.
(d) For polyphase motors only, minimum frequency on all phases, rated voltage on one phase, maximum steady-state voltage on all other phases.

Unless otherwise stated in the applicable MS or detail specification, the frequency limits specified in MIL-STD-704 shall be assumed. For intermittent-duty motors, minimum and maximum steady-state voltages shall be 98 and 124V, respectively. For continuous-duty motors, minimum and maximum steady-state voltages shall be 102 and 124V, respectively.

At the option of the procuring activity, a 1-hour test run under (b), (c), or (d) specified above, may be performed in addition to the above tests.

4.6.2.2 *Speed.* At the completion of the heat run at rated input voltage and frequency, the motor speed shall be within 5 percent of the rated speed specified by the applicable MS or detail specification.

4.6.2.3 *Efficiency.* At rated voltage, frequency, and torque, the speed, input watts, and input current shall be determined. The efficiency shall be not less than that shown by the applicable MS or detail specification. A minimum of 60 percent efficiency should be a design objective.

4.6.2.4 *Calibrated.* The motor with rated voltage applied, shall be subjected to tests to determine compliance with the range of speed-torque requirements shown on the applicable detail specification or MS. Line current, speed, horsepower, efficiency, power factor, and watts input shall be shown graphically, using values of torque as the abscissa.

4.6.2.5 *Power factor.* At rated voltage, frequency, and torque, the speed, input watts, and input current shall be determined. The power factor shall be not less than that shown by the applicable MS or detail specification. A minimum of .60 power factor should be a design objective.

4.6.3 *Load test.*

4.6.3.1 *Continuous-duty motors.* Continuous-duty motors shall be tested at rated voltage, frequency, and torque for input current and speed after running for a sufficient time to attain at least 80 percent of normal temperature rise obtained under standard test conditions (4.5). Unless otherwise specified in the applicable MS or detail specification, the motor speed shall not differ from the rated speed by more than 5 percent. The input current shall be of such value that the motor meets the efficiency and power factor requirements of the applicable MS or detail specification. Room temperature tests may be run if correlated with the normal temperature rise test.

4.6.3.2 *Intermittent-duty motors.* Intermittent-duty motors shall be tested at rated voltage, frequency, and torque for input current and speed with the temperature of the motor as near 25° C. as practicable. Unless otherwise specified in the applicable MS or detail specification, the motor speed shall not differ from the rated speed by more than 5 percent. The input current and watts shall be of such value that the motor meets the efficiency and power factor requirements of the applicable MS or detail specification.

4.6.4 *Line current balance.* For polyphase motors, the maximum difference in line currents shall be no greater than 10 percent of the minimum steady-state current when measured at rated load and balanced terminal voltage. For motors with electric brakes or clutches utilizing less than the number of phases in the stator winding, the percent current difference shall not exceed that shown on the detail specification or MS.

4.6.5 *Dielectric strength.*

4.6.5.1 *General.* While the motor is hot as the result of testing, it shall be subjected to and withstand the following test voltage at approximately 60 cps, applied between windings and between each winding and frame, for the time specified below. The ground shall be disconnected from the motor frame. For this test, all windings permanently connected together are to be considered one winding.

(a) 1,250V (rms) for 1 minute, or
(b) 1,500V (rms) for 1 second

Capacitors may be disconnected for this test.

4.6.5.2 *Capacitors.* Capacitors shall be subjected to and shall withstand for 1 second, a dc test voltage of twice the maximum peak voltage in service, or a minimum of 500V, whichever is greater.

4.6.6 *Overspeed.* This test shall be made while the motor is hot as the result of testing and shall be made at no load and at a speed 20 percent above the speed obtained at minimum specified operating load and maximum frequency for the type of power specified by the detail specification or MS. The motor shall demonstrate its ability to operate under overspeed conditions for 5 minutes or one duty cycle, without mechanical failure or impaired electrical performance.

4.6.7 *Extreme temperature operation.*

4.6.7.1 *High ambient temperature.* While inoperative, the motor shall be soaked for 24 hours at the maximum ambient temperature indicated for sea level operation by the curve on MS33543 applicable to the class of motor being tested. While at this temperature, the motor shall be operated at rated output torque as follows:

(a) Continuous-duty motors without thermal protection shall operate satisfactorily at rated torque for 1/2 hour.
(b) Intermittent duty motors without thermal protection shall operate satisfactorily at rated torque for six duty cycles or an accumulation of 1/2 hour of cycles, whichever is longer.
(c) Continuous-duty motors with thermal protection shall operate satisfactorily at 115 percent rated torque for 1/2 hour without tripping the thermal device.
(d) Intermittent-duty motors with thermal protection shall operate satisfactorily at 115 percent rated torque for six duty cycles or the accumulation of 1/2 hour of cycles, whichever is longer, without tripping the thermal device.

4.6.7.2 *Low ambient temperature.* While inoperative, the motor shall be soaked for 72 hours at the minimum ambient temperature specified for sea level operation on MS33543. At the end of this period and while at this temperature, minimum steady-state input voltage of 98V for intermittent-duty motors, and 102V for continuous-duty motors, and maximum frequency in accordance with MIL-STD-704 shall be applied to the input circuit. This input circuit to the motor shall incorporate an impedance of such magnitude that the voltage drop, caused when the steady-state, locked rotor line current flows, results in a motor terminal voltage equal to the minimum steady-state terminal voltage under locked rotor as defined by 6.4. The motor shall start with 150 percent rated output torque within 2.0 seconds and operate as follows (higher or lower starting torques and higher or lower temperatures may be specified by the applicable MS or detail specification):

(a) Continuous-duty motors shall operate satisfactorily for 1/2 hour.
(b) Intermittent-duty motors shall operate satisfactorily for six duty cycles or the accumulation of 1/2 hour of cycles, whichever is longer.

Operation shall be considered satisfactory during the above tests if, within 2.0 seconds after application of voltage, the speed is within 30 percent of rated speed and the motor shows no evidence of damage on completion of test.

4.6.8 *Operating position.* During the course of other tests, it shall be ascertained that the operation of the motor in any position does not adversely affect power output, heating, lubrication, and other operating characteristics.

4.6.9 *Starting.*

4.6.9.1 *Starting current.* At 25° C. temperature, no load, and with rated voltage and frequency applied at the motor terminals, the ratio of maximum starting peak line current to peak full-load line current shall not exceed the percentage shown on figure 1. Starting current shall be measured with an oscillograph, or other suitable instrument after the first cycle. The measured starting current shall be corrected to rated voltage in direct proportion to the reduction of voltage. As defined by MIL-STD-704, the starting current shall, so far as is practicable, not load the aircraft power system in such a manner as to unduly disturb the system voltage.

This current should be kept to the lowest limit practicable consistent with the other design parameters.

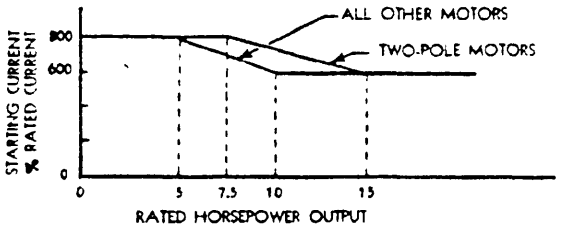

FIGURE 1. *Maximum allowable starting current*

4.6.9.2 *Minimum torque position.* With the motor at approximately 25° C, the minimum and maximum locked torque position of the rotor shall be determined. The variations in the locked torque position shall not deviate more than ±20 percent of the mean locked rotor torque.

4.6.10 *Acceleration.* The motor shall be mounted on a centrifuge. The centrifuge shall then be operated at a speed that will produce an acceleration of 10g; the motor shall start at no load and run satisfactorily during the test. The motor shall then be rotated 180 degrees about an axis perpendicular to the axis of the centrifuge arm, and the test repeated. The motor shall be mounted on the centrifuge in four additional positions such that the accelerating force is applied in both directions through each of the remaining axes of the motor. For each position of the motor, the centrifuge shall be operated at a speed that will produce an acceleration of 10g. The acceleration of 10g in each test shall be stabilized and maintained for not less than 1 minute. After completion of this test the motor shall pass the test specified in 4.6.3.

4.6.11 *Shock.* The motor shall be mounted using its own mounting provisions and subjected to a shock test in accordance with Procedure V of MIL-E-5272, except that the test specified for "Equipment crash-safety" shall not be required. The shock testing machine shall be in accordance with MIL-STD-202, or other approved equipment. Following this test, the motor shall pass the test specified in 4.6.3.

4.6.12 *Vibration.* The motor shall be subjected to vibration test in accordance with Procedure XII of MIL-E-5272. During the entire test, the motor shall be operated at no load. The "on" time for intermittent-duty motors shall be in accordance with the rated duty cycle. Following this test, the motor shall pass the test specified in 4.6.3. Continuous-duty motors shall start and operate at no load during this test.

4.6.13 *Life.* The motors shall be so instrumented that the bearing, stator winding, and other hot spot or critical temperature readings can be checked or recorded. The motor shall be operated for 1,000 hours at rated input voltage, rated frequency, and rated output torque at its specified duty cycle with the exception of the simulated altitude-temperature runs. Reversible, intermittent-duty motors shall be alternately operated in each direction at the rated duty cycle. Following this test, the motor shall pass the load test specified in 4.6.3. No maintenance of any kind shall be allowed during this test.

Simulated altitude-temperature runs shall be conducted as follows:

(a) Sea level altitude shall be utilized.

(b) Temperature data obtained during the altitude chamber runs shall be duplicated by varying any or all of the following:

(1) Input voltage

(2) Input frequency

(3) Loading

(4) Modification of air flow through or over the unit

(5) Any other condition required to accomplish the desired result.

4.6.13.1 Class B motors shall be operated as specified in table I.

4.6.13.2 Class A motors shall be operated as specified in table II.

4.6.14 *Humidity.* The motor shall be subjected to humidity test Procedure I of MIL-E-5272. Immediately following this test, the motor shall pass the test specified in 4.6.3 at room temperature.

4.6.15 *Salt spray.* The motor shall be subjected to a 50-hour salt spray test in accordance with Procedure I of MIL-E-5272. During this test, the motor shall be operated as follows:

(a) Continuous-duty motors shall be operated at no load with voltage or frequency adjusted to give approximately rated speed for 10 periods of 15 minutes duration with a minimum nonoperating

period of 45 minutes between running periods.

(b) Intermittent-duty motors shall be operated at no load with voltage or frequency adjusted to give approximately rated speed for 10 duty cycles (a maximum of 15 minutes running time per cycle) with a minimum nonoperating period of 45 minutes between running periods.

Following the test, the motor shall be washed and dried for 15 to 20 hours, and shall then pass the test specified in 4.6.3 at room ambient temperature.

TABLE I. *Operation of class B motors*

Hours	Altitude (ft.)	Temperature, ±5° C
100	Sea level	25
100	Sea level	120
5	35,000	−55
5	35,000	50
5	65,000	−55
5	65,000	25
200	Sea level	25
95	Simulated 35,000	Simulated −55
95	Simulated 35,000	Simulated 50
45	Simulated 65,000	Simulated −55
45	Simulated 65,000	Simulated 25
300	Sea level	25

TABLE II. *Operation of class A motors*

Hours	Altitude (ft.)	Temperature, ±5° C
100	Sea level	25
5	35,000	−55
5	35,000	25
5	50,000	−55
5	50,000	−10
100	Sea level	25
195	Simulated 35,000	Simulated −55
195	Simulated 35,000	Simulated 25
95	Simulated 50,000	Simulated −55
95	Simulated 50,000	Simulated −10
200	Sea level	25

4.6.16 *Sand and dust resistance.* The motor shall be subjected to sand and dust test Procedure I, part I of MIL-E-5272. The motor shall be located in the test chamber in any position. The test cycle shall be composed of 30-minute operative (no load) and 90-minute inoperative periods. Following this test, the motor shall pass the test specified in 4.6.3 at room ambient temperature.

4.6.17 *Interference.* The motors shall be tested for interference in accordance with MIL-I-6181. Conducted and radiated measurements shall be within the limits specified in MIL-I-6181.

4.6.18 *Fungus.* The motor shall be subjected to fungus resistance test Procedure I of MIL-E-5272. Service covers and inspection plates shall be removed prior to the treatment with the spore suspension and then reinstalled after the spores have been introduced within the motor proper. Immediately following the test, the motor shall pass the test specified in 4.6.3 at room ambient temperature.

4.6.19 *Thermal protection.*

4.6.19.1 *Direct acting thermal protection tests.*

4.6.19.1.1 *Tests for method I thermal protection—motor No. 4.*

4.6.19.1.1.1 *Mounting.* Unless otherwise specified in the detail specification or drawing, the motor mounting method shall thermally isolate the motor sufficiently to prevent conduction to or from adjacent metallic structures.

4.6.19.1.1.2 *Running overload test.* The motor and thermal protector combination shall provide 115 percent of rated torque for 1 hour at maximum ambient, rated voltage and frequency, without a nuisance trip for continuous-duty motors. The motor is then to be over loaded until the protector trips; no smoke or toxic fumes shall occur. Intermittent-duty motors shall be operated at room ambient and rated load until the protector trips; no smoke or toxic fumes shall occur. If no protector trip occurs prior to stabilization of frame temperature, the test shall be repeated in the maximum specified ambient.

4.6.19.1.1.3 *Locked rotor test.* With the rotor locked at room ambient and rated voltage and frequency applied to the motor terminals, the motor and thermal protector combination shall withstand one locked rotor protector interruption without the occurrence of smoke or toxic fumes.

4.6.19.1.2 *Tests for method II thermal protection—motor Nos. 2 and 4.*

4.6.19.1.2.1 *Mountings.* Unless otherwise specified by the detail specification or drawing, the motor mounting method shall thermally

isolate the motor sufficiently to prevent conduction to or from adjacent metallic structures.

4.6.19.1.2.2 *Running overload test—motor No. 4.* The motor shall be operated at 150 percent of rated torque in the maximum specified ambient at rated voltage and frequency until the input power has been completely interrupted by the protective system. During the test, no flame shall be visible and no external part of the motor, prior or subsequent to operation of the protective system, shall exceed 200° C., unless otherwise specified in the detail specification or drawing. If power interruption does not occur at 150 percent of rated torque within 2 hours, a load torque greater than 150 percent of rated torque may be utilized.

If the motor input power was not interrupted by a protective device, the test shall be repeated on motor No. 1 after completion of all other tests on motor No. 1.

4.6.19.1.2.3 *Locked rotor test—motor No. 2.* The motor rotor shall be locked while at room ambient, and rated voltage and frequency shall be applied to the motor terminals until the input power is completely interrupted by the motor protective system. During the test, no flame shall be visible and no external part of the motor, prior or subsequent to operation of the protective system, shall exceed 200° C, unless otherwise specified in the detail specification or drawing. When an explosion-proof test requirement is specified, the above test shall be conducted in the explosive atmosphere specified in the detail specification or drawing. No explosion, external to the motor, shall occur. If the motor power was not interrupted by a protective device, the test shall be repeated on motor No. 3 after all other scheduled tests on motor No. 3.

4.6.19.1.3 *Test for method III thermal protection—motor No. 2.*

4.6.19.1.3.1 *Running overload test.* After conclusion of the explosion-proof test, if specified, the motor and thermal protector combination shall provide 115 percent of rated torque for 1 hour at maximum ambient, without a nuisance trip for continuous duty motors. The load shall then be increased to 150 percent of rated torque and the protector shall trip within 5 minutes and not reset within a period equal to twice the time required to trip at 150 percent of rated torque. Cyclical tests, by means of the thermal protector, shall be continued for 25 hours with the load set at 150 percent of rated torque. Intermittent-duty motors shall be subjected to cyclical tests for 25 hours at maximum ambient, rated voltage and frequency, and with the load set at rated torque.

4.6.19.1.3.2 *Locked rotor test.* After conclusion of the running overload test, the motor shall be submitted to locked rotor operation at rated voltage and frequency for 25 hours at room ambient. Following this test, the motor shall pass the test specified in 4.6.3 at room ambient temperature.

4.6.19.2 *Indirect acting thermal protection tests.* The motor and protector signal element shall be subjected to the tests specified in 4.6.19.1.1, 4.6.19.1.2, or 4.6.19.1.3, as appropriate, according to the method of protection specified and motor duty.

4.6.19.3 *Short time.* For quality conformance inspections, motors furnished with thermal protective means shall be given a functional test by a suitable method after the device has been installed in the motor to check proper installation and operation of the protector.

4.6.20 *Fluid resistance.* Fluid-resistant motors shall be mounted in a manner simulating that in the actual application and tested under the following conditions:

(a) The fluid specified by the detail specification or MS shall be allowed to drip on and flow over the motor at the rate of 1/2 pint per hour.

(b) Unless otherwise specified by the detail specification or MS, the fluid temperature shall be between 55° and 65° C.

(c) At no load with terminal voltage adjusted to give approximately rated speed, continuous-duty motors shall be operated for 48 hours and intermittent-duty motors shall be operated for 6 duty cycles, following each 12 hours of exposure, for 4 periods of operation.

(d) After this test, the motor shall be cleaned and dried externally, and shall then withstand 600V rms at approximately 60 cps, for 1 minute, successively impressed between each circuit and all other circuits and metal parts grounded together. The motor shall

then pass the test specified in 4.6.3 at room ambient temperature.

4.6.21 *Explosion-proof (aeronautical).* Explosion-proof motors shall be subjected to one of the following test procedures as specified by the applicable detail specification or MS:

(a) Procedure I: Motors which are required by the applicable detail specification or MS to be explosion-proof in accordance with the purpose of Procedure III of MIL-E-5272, shall be subjected to the test outlined in Procedure III, except that the test shall be conducted at sea level conditions only.

(b) Procedure II: Motors which are required by the applicable detail specification or MS to be explosion-proof in accordance with the purpose of Procedure IV of MIL-E-5272, shall be subjected to the test outlined in Procedure IV, except that the test shall be conducted at sea level conditions only. The tests shall be made using two different explosive mixtures; one resulting in maximum pressure, and the other in maximum duration of flame.

4.6.22 *Brake performance.*

4.6.22.1 *Stopping revolutions.* Motors with stopping devices shall be instrumented to determine revolutions of coast after the motor is deenergized, and shall be equipped with the inertia load specified by the applicable detail specification or MS. The motor shall be operated at rated speed with no load other than the inertia load specified by the applicable specification or MS. Voltage may be reduced to obtain the required speed. Upon removal of the voltage, the revolutions of coast shall fall within the value specified by the applicable specification or MS. For testing during production, revolutions of coast may be determined by other means if correlated with results obtained by the inertia load, rated voltage method.

4.6.22.2 *Static holding torque.* The output shaft of motors equipped with stopping devices shall be subjected to 200 percent rated torque while the motor is deenergized. The motor shaft shall not creep. Other values of holding torque may be specified by the applicable specification or MS. When required by the detail specification or MS, the above test procedure shall be applicable while the motor is being subjected to vibration frequency test Procedure XII of MIL-E-5272 at room ambient temperature. During this test, the torque producing device shall be connected so it will not add to the effective mass of the motor.

4.6.22.3 *Brake life.* The life of the brake shall be determined by cycling at no load with the voltage adjusted to produce rated speed with connected inertia load as specified by the applicable detail specification or MS. Reversible motors shall be operated in alternate rotations. If the voltage required is such as to cause improper operations of the brake, the circuit may be modified to obtain normal operation of the brake. A cycling rate shall be used which will not result in exceeding the temperature of the windings obtained during the heating test. At the completion of the number of cycles specified by the detail specification or MS, the motor shall meet the requirements of 4.6.22.1 and 4.6.22.4.

4.6.22.4 *Brake operating voltage.* At 98V, 420 cps, no load, the motor shall start and operate without malfunction of the brake. The motor shall be operated at 98V, 420 cps, no load and the circuit momentarily interrupted; the output shaft shall resume rotation. A different operating voltage and frequency may be specified by the applicable detail specification or MS.

4.7 Inspection for delivery. The motors shall be inspected to determine that the preservation, packaging, packing and marking are in accordance with section 5.

5. PREPARATION FOR DELIVERY

5.1 Packaging, packing, and marking. All items of the equipment shall be preserved, packaged, packed, and marked in accordance with MIL-E-16298 for the level of shipment specified in the contract or order.

6. NOTES

6.1 Intended use. This specification covers the requirements of ac motors for use in aircraft 115/200V, 400 cycle, ac systems, to drive various aircraft accessories.

6.2 Ordering data. Procurement documents should specify:

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

(b) Class of motor desired (see 1.2).
(c) Data requirements (see 3.2).
(d) Installation instructions, handbooks, or manuals, when required (see 3.11).
(e) Required level of packaging and packing and special marking requirements (see section 5).

6.3 Definitions.

6.3.1 *Ambient temperature.* Ambient temperature will mean the temperature of air surrounding the unit in normal, free convection (velocity below 50 fpm).

6.3.2 *Continuous duty.* Continuous duty is a requirement of service that demands operation at substantially constant load for an indefinite period.

6.3.3 *Intermittent duty.* Intermittent duty is a requirement of service that demands operation for alternate intervals, (a) load and part or no load, (b) load and rest, or (c) load, part or no load, and rest; such alternate intervals being definitely specified as the duty cycle.

6.3.4 *Operating time.* When a definite operating time is specified in the specification, it shall be continuous in the case of continuous-duty rated motors, or be composed of no load or specified minimum load, and load and rest periods in the case of intermittent rated motors. For example: If 1 hour of operation were required of a motor whose duty cycle was 1 minute under full load and 9 minutes rest, then six cycles would be equivalent to 1 hour of operation.

6.4 The following method will be utilized to compute the minimum steady-state terminal voltage under the locked rotor condition at start (see 4.6.7.2). MIL-STD-704 defines the minimum steady-state voltage of 98V for intermittent-duty equipment or 102V for continuous-duty equipment and includes the voltage drop resulting from one per unit full-load line current. For each additional unit of full-load line current, assume a line drop of 4V for each unit of full-load line current for continuous-duty motors and 7V for intermittent-duty motors.

EXAMPLE

(Intermittent-duty motor)
Steady-state, full-load line current = 2 amp.
Steady-state, locked rotor line current = 10 amp.

Per unit line current $= \frac{10}{2} = 5$ per unit

Minimum terminal voltage under locked rotor $= 98 - 7(5 - 1) = 70$V

6.5 Sample detail requirements format. The data referenced in 3.5.2 is contained in the following sample format:

AIRCRAFT ELECTRIC MOTOR DETAIL REQUIREMENTS
(FOR USE ON A 115/200V, 400 CYCLE, AC SYSTEM)

A. APPLICATION (DESCRIBE BRIEFLY, AND INDICATE WHETHER CLASS A OR B)

B. DESIGN DETAILS:

(1) OUTPUT:..... HORSEPOWER, AT .....RPM
(2) TERMINAL VOLTAGE ...../..... VOLTS
(3) DUTY CYCLE:.....(CONTINUOUS OR INTERMITTENT: IF INTERMITTENT SPECIFY CYCLE)
(4) PHASES:.....
(5) RATED FULL-LOAD CURRENT PER PHASE ..... AMPERES
(6) MAXIMUM WEIGHT: MOTOR ..... POUNDS
(7) MINIMUM EFFICIENCY: ..... PERCENT
(8) MINIMUM POWER FACTOR: .....
(9) MAXIMUM FULL-LOAD LINE CURRENT UNBALANCE ..... PERCENT. (APPLICABLE ONLY WHEN NUMBER OF PHASES UTILIZED IN INTERNAL STOPPING DEVICE IS LESS THAN NUMBER OF PHASES UTILIZED IN MOTOR.)
(10) ENCLOSURE: .....
(11) MOUNTING FLANGE AND DRIVE:
.....MS33568
.....MS33569
.....MS33570
.....MS33571
.....OTHER.....
(12) MAXIMUM DIMENSIONS: LENGTH ..... INCHES.
DIAMETER ..... INCHES.
(13) SKETCH: MAY REPLACE ALL OR PART OF (11) AND (12) ABOVE AND MUST INDICATE METHOD OF MARKING ELECTRICAL CONNECTIONS TO MOTOR.

C. DESIGN OPTIONS: ALL OF THE FOLLOWING DESIGN FEATURES HAVE THE INDICATED REQUIREMENTS INCORPORATED IN THE GENERAL SPECIFICATION WHICH ARE AUTOMATICALLY EFFECTIVE UNLESS EXCEPTION IS TAKEN HEREIN.

(1) POWER: MIL-STD-704, CATEGORY .....
OPTION: ..... MIL-STD-704.
(2) STARTING TORQUE: 150 PERCENT FULL-LOAD TORQUE PER PARAGRAPH 4.6.7.2 OPTION: ..... PERCENT FULL-LOAD TORQUE

(3) STARTING CURRENT: 800 PERCENT PEAK LINE CURRENT MAXIMUM PER PARAGRAPH 4.6.9.1
OPTION: ..... PERCENT PEAK LINE CURRENT

(4) OPERATING LOCATION: NONPRESSURIZED SPACE AND CORRESPONDING TEMPERATURES AS DICTATED BY CLASS A OR CLASS B
OPTION: ..... SPECIFY ALTITUDE-TEMPERATURE COMBINATION

(5) ROTATION: CCW WHEN FACING END OPPOSITE OUTPUT SHAFT

(6) EMERGENCY TWO-PHASE OPERATION: NOT REQUIRED
OPTION: (A)..... MOTOR SHALL BE CAPABLE OF DELIVERING SPECIFIED REDUCED HORSEPOWER OUTPUT CONTINUOUSLY.
(B)..... MOTOR SHALL BE CAPABLE OF DELIVERING SPECIFIED MINIMUM STALLED TORQUE.
(C)..... MOTOR SHALL BE CAPABLE OF DELIVERING SPECIFIED MINIMUM RUNNING TORQUE.
(D)..... MOTOR SHALL BE CAPABLE OF DELIVERING A SPECIFIED HORSEPOWER OUTPUT FOR A SPECIFIED NUMBER OF OPERATIONAL CYCLES PRIOR TO FAILURE.
(E)..... OTHER:.....

(7) MINIMUM OPERATING LOAD: NO LOAD
OPTION: ..... PERCENT FULL-LOAD TORQUE

(8) USEFUL LIFE: 1,000 HOURS
OPTION: .....HOURS

(9) THERMAL PROTECTION: NOT REQUIRED
OPTION: METHOD ..... TYPE.....

(10) TERMINAL MARKING: IN ACCORDANCE WITH MIL-STD-195
OPTION: .....

(11) FLUID RESISTANCE: NOT REQUIRED
OPTION: ..... YES

(12) EXPLOSION-PROOF (AERONAUTICAL): NOT REQUIRED
OPTION:..... PROCEDURE:.....

(13) BRAKE: NOT REQUIRED
OPTION:..... (SPECIFY STOPPING REVOLUTIONS, SPEED FROM WHICH MOTOR MUST STOP, INERTIA LOAD, REQUIRED LIFE CYCLES, ETC.)

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