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MIL-M-17556(SHIPS)
30 April 1953
Used IN LIEU OF
MIL-M-2511(in part)
23 October 1950

MILITARY SPECIFICATION

MOTOR, DIRECT-CURRENT, FRACTIONAL HP

(SHIPBOARD USE)

1. SCOPE

1.1 Scope.- This specification covers fractional horsepower, corrosion resistant, direct current, motors for shipboard use.

1.2 Classification.- Motors covered by this specification shall be of the following services (see 6.2).

Service A.
Service C.

2. APPLICABLE SPECIFICATIONS, STANDARDS, DRAWINGS, AND PUBLICATIONS

2.1 The following specifications, standards, and drawings, of the issue in effect on date of invitation for bids, form a part of this specification:

SPECIFICATIONS

FEDERAL

HH-I-538 - Insulation, Electrical, Pasted-Mica.
NN-B-591 - Boxes, Fiberboard, Wood-Cleated (for Domestic Shipment).
NN-B-601 - Boxes, Wood-Cleated-Plywood, for Domestic Shipment.
NN-B-621 - Boxes, Wood, Nailed and Lock-Corner.
NN-B-631 - Boxes, Wood, Wirebound (for Domestic Shipment).
QQ-M-161 - Metals, Antifriction, Casting and Ingots.
QQ-A-601 - Aluminum-Base-Alloys: Sand Castings.
QQ-I-666 - Iron, Malleable; Castings.
LLL-B-631 - Boxes; Fiber Corrugated (for Domestic Shipment).
LLL-B-636 - Boxes; Fiber, Solid, (for Domestic Shipment).

MILITARY

MIL-P-14 - Plastic-Materials, Molded and Plastic Parts, Molded; Thermosetting.
MIL-P-79 - Plastic-Materials, Laminated, Thermosetting Rods and Tubes.
JAN-P-103 - Packaging and Packing for Overseas Shipment - Boxes, Wood-Cleated, Solid-Fiberboard.
JAN-P-105 - Packaging and Packing for Overseas Shipment - Boxes, Wood, Cleated, Plywood.
JAN-P-106 - Packaging and Packing for Overseas Shipment - Boxes, Wood, Nailed.
MIL-B-107 - Boxes, Wood, Wirebound (Overseas Type).
JAN-P-108 - Packaging and Packing for Overseas Shipment - Boxes, Fiberboard (V-Board and W-Board), Exterior and Interior.
MIL-P-116 - Preservation; Methods of.
JAN-P-132 - Packaging and Packing for Overseas Shipment - Crates; Unsheathed, Wood, Nailed (for Maximum Net Load of 2,500 Pounds).
JAN-P-139 - Packaging and Packing for Overseas Shipment - Plywood, Container Grade.
MIL-B-233 - Boxes, Repair Parts.
JAN-E-251 - Electrical-Equipment: Rotation, Connections, and Terminal Markings for.
JAN-W-583 - Wire, Magnet.

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MILITARY (cont'd.)

MIL-I-631 - Insulation, Electrical, Synthetic-Resin Composition, Nonrigid.
JAN-P-690 - Puller: Bushing, Bearing, and Gear Installing and Removing.
MIL-I-695 - Insulation, Electrical, Paper (Slot-Cell).
MIL-W-806 - Wire, Armature-Banding, Steel, Tinned.
MIL-B-892 - Bronze, Phosphor, Rolled or Drawn; Bars, Plates, Rods, Sheets, and Strips.
MIL-N-894 - Nickel-Copper-Alloy; Wrought.
MIL-S-901 - Shockproof-Equipment, Class HI (High-Impact): Shipboard Application Tests for.
MIL-E-917 - Equipment, Electric Power Basic Requirements for (Naval Shipboard Use).
MIL-A-958 - Aluminum Base-Alloy, Permanent-Mold Castings (Marine Service).
MIL-D-963 - Drawings: Production (for Electrical and Mechanical Equipment for Naval Shipboard Use).
MIL-P-997 - Plastic-Material, Laminated, Thermosetting, Electrical-Insulating: Sheets, Glass Cloth, Silicone Resin.
JAN-W-1085 - Washers, Iron and Steel.
MIL-V-1137 - Varnish, Insulating (Electrical).
JAN-F-1148 - Fiber, Insulating.
MIL-W-1165 - Washers, Brass.
MIL-E-2036 - Enclosures for Electrical and Electronic Equipment (Naval Shipboard Use).
MIL-G-2765 - Gaskets, Oil-Resisting (Sheet, Strip and Molded).
MIL-W-3065 - Wire Armature Banding, Nonmagnetic, Iron-Chrome-Nickel-Alloy.
MIL-I-3190 - Insulation, Electrical, Sleeving, Flexible, Treated.
MIL-I-3505 - Insulation, Electrical, Coil and Slot, High-Temperature.
MIL-B-3742 - Brushes, Electrical Contact and Carbon Plate, Electrical Contact Brush.
MIL-L-10547 - Liners, Case, Waterproof.
MIL-I-15024 - Identification Plates, Information Plates and Marking Information for Identification of Electrical, Electronic, and Mechanical Equipment.
MIL-P-15037 - Plastic Materials, Laminated, Thermosetting, Sheets, Glass-Cloth Melamine-Resin.
MIL-R-15137 - Repair Parts for Electrical and Mechanical Equipment (Naval Shipboard Use).
MIL-A-15130 - Aluminum-Base-Alloy: Die-Castings.
MIL-P-15424 - Packaging of Hand Tools: General Specification for Domestic and Overseas Preservation.
MIL-G-15719 - Grease, High-Temperature, Electric Motor, Ball Bearing.
MIL-W-16072 - Wire, Magnet, High-Temperature.
MIL-B-16261 - Bronze, Bearing, Castings.
MIL-P-16295 - Preservation, Packaging, Packing, and Marking of Electric Machines Having Rotating Parts (Includes Associated Repair Parts).
MIL-O-16485 - Ohmmeter, Insulation-Resistance-Indicating.
MIL-I-16910 - Interference Measurement, Radio, Methods and Limits; 13 Kilocycles to 1000 Megacycles.
MIL-A-17129 - Aluminum Alloy Casting: Sand, Resistant to Salt Water.
MIL-I-17166 - Iron Castings; Nodular Graphite (Ductile Iron) (for Shipboard Applications).
MIL-F-17292 - Format for List of Repair (Spare) Parts for Shipboard Mechanical and Electrical Equipment.

NAVY DEPARTMENT

General Specifications for Inspection of Material.
42B5 - Bearings, Ball.
42B10 - Bearings, Roller.

STANDARDS

MILITARY

MIL-STD-129 - Marking of Shipments.

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DRAWINGS

BUREAU OF SHIPS
9000-S6301-73441 - Standards for Pump Motors.
9000-S6301-73459 - Standards for General Purpose Motors.

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

2.2 Other publications.- The following publications, of the issue in effect on date of invitation for bids, unless otherwise stated, form a part of this specification:

CONSOLIDATED FREIGHT CLASSIFICATION COMMITTEE
Consolidated Freight Classification - Ratings, Rules and Regulations.

(Application for copies should be addressed to the Consolidated Freight Classification Committee, 202 Chicago Union Station, Chicago 6, Ill.)

AMERICAN TRUCKING ASSOCIATION, INC.
Motor Freight Classification Rules.

(Application for copies should be addressed to the Issuing Officer, American Trucking Association, Inc. 1424 16th St. N.W., Washington 6, D.C.)

AMERICAN STANDARDS
Z24.7 - Apparatus Noise Measurement.

(Application for copies should be addressed to American Standards Association, 70 East 45th Street, New York 17, New York).

3. REQUIREMENTS

3.1 Definitions.- The following definitions shall apply to the various technical terms wherever such terms appear in this specification.

3.1.1 Continuous duty.- Continuous duty motors shall be rated at the load in horsepower that can be carried continuously at the ambient temperature specified (see 3.2.6.1) without exceeding allowable temperature rises (see table V).

3.1.2 Speed regulation.- Speed regulation is the change in speed, expressed as percent of speed at rated load, when the load is reduced gradually from the rated value to zero with constant applied voltage and field rheostat setting.

3.1.3 Constant-speed motor.- A constant-speed motor is one of which the normal speed of operation is constant or practically constant; for example, a shunt motor.

3.1.4 Multispeed motor.- A multispeed motor is one which can be operated at any one of two or more definite speeds, each being practically independent of the load.

3.1.5 Adjustable-speed motor.- An adjustable-speed motor is one the speed of which can be varied gradually over a considerable range, but when once adjusted remains practically unaffected by the load.

3.1.6 Base speed of adjustable-speed motor.- The base speed of an adjustable-speed motor is the lowest speed obtained at rated load and rated voltage at the temperature rise specified in the rating.

3.1.7 Varying-speed motor.- A varying-speed motor is one the speed of which varies in considerable degree with change in load, ordinarily decreasing when the load increases, such as a series motor.

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3.1.8 Adjustable varying-speed motor.- An adjustable varying-speed motor is one the speed of which can be adjusted gradually, but when once adjusted for a given load, will vary in considerable degree with change in load.

3.1.9 Front (of motor).- The front of a motor is the end opposite the coupling.

3.1.10 Back (of motor).- The back of a motor is the end which carries the coupling or driving pulley.

3.1.11 Shunt-wound motor.- A shunt-wound motor is one in which the excitation is derived from a voltage source practically independent of the variation load current. The field is usually connected in parallel with the armature circuit. If a light series winding is added to prevent a rise in speed with increase of load, the motor is termed stabilized shunt-wound.

3.1.12 Series-wound motor.- A series-wound motor is one in which the field circuit and armature circuit are connected in series.

3.1.13 Compound-wound motor.- A compound-wound motor is one which has two separate field windings; one, usually the predominating field, connected in parallel with the armature circuit, and the other connected in series with the armature circuit.

3.1.14 Efficiency.- The efficiency of a motor is the ratio of the useful power output to the total power input.

3.1.15 Direct measured efficiency.- The output is determined by direct measurement of torque and speed.

3.1.16 Conventional efficiency.- The output is determined by subtraction of the component losses from the input.

3.1.17 Thermal protector (inherent overheating protective device).- A thermal protector is a protective device which is responsive to motor current and temperature whose purpose, when applied to a motor, is to protect the motor against excessive overheating due to overload or failure to start.

3.1.18 Fractional horsepower-motor.- A fractional horsepower motor is one built in a frame of a size smaller than 203 as shown on Drawings 9000-S6301-73441 or 9000-S6301-73459.

3.2 General design.-

3.2.1 Ambient temperatures.- Motors shall be designed for the following ambient temperatures as specified (see 6.2):

40°C.	65°C.
50°C.	Special.

3.2.2 Audible noise.- Motors shall operate without objectionable audible noise at all loads and speeds within the service range.

3.2.3 Voltage.- Motors shall be designed for the following voltages as specified (see 6.2):

115
230
Special

3.2.4 Voltage limitation.- Except for submarine service (see 3.7.1) motors shall operate successfully at rated load with voltage not more than 10 percent above or below rated voltage, but not necessarily in accordance with the standards of performance established for operation at rated voltage.

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3.2.5 Winding and speed.- The rated speed in r.p.m. or rated speed range in r.p.m. shall be specified (see 6.2). Except for submarine service (see 3.7.2), the winding and speed classification of motors shall be one of the following, as specified (see 6.2):

Shunt (or stabilized shunt) constant-speed.
Shunt (or stabilized shunt) adjustable.
Shunt (or stabilized shunt) multispeed.
Compound, varying speed.
Compound, varying multispeed.
Series, varying speed.
Series, adjustable varying-speed.
Series, varying multispeed.

Stabilized shunt need not be specified in the contract or order, since the method of obtaining stability is at the option of the manufacturer.

3.2.6 Duty.- The duty of motors shall be continuous, intermittent, varying, or short-time as specified (see 6.2).

3.2.6.1 Continuous duty.- Continuous duty motors shall be rated at the load in horsepower that can be carried continuously at the ambient temperature specified (see 6.2) without exceeding allowable temperature rises (see table V).

3.2.6.2 Intermittent duty.- Intermittent duty motors shall be rated at the horsepower load and for the time duration which will permit operation of the motor definitely at the cycle of load and rest specified (see 6.2) without exceeding the allowable temperature rises (see table V). Where intermittent operation is involved and no definite operating cycle can be given, a short-time duty motor of sufficient rating to meet the estimated load requirements shall be furnished.

3.2.6.3 Varying duty.- Varying-duty motors shall be rated at the horsepower load and for the time duration which will permit operation of the motor indefinitely at the cycle of varying loads specified (see 6.2) without exceeding allowable temperature rises (see table V). Unless otherwise specified in the contract or order, varying-duty motors shall be capable of operating at 1/4 load until temperature stabilizes followed by full rated load for the specified period.

3.2.6.4 Short-time duty.- Short-time duty motors shall be rated at the horsepower load which, starting at the ambient temperature, can be carried constantly for the period specified (see 6.2) without exceeding allowable temperature rises (see table V).

3.2.7 Enclosure.- Enclosures shall conform to Specification MIL-E-2036. Except for submarine service (see 3.7.3), motors shall be of the following enclosures as specified (see 6.2):

Open	Watertight
Protected	Watertight fan-cooled
Dripproof	Totally enclosed
Dripproof protected	Totally enclosed fan-cooled
Splashproof	Explosionproof
Splashproof protected	Explosionproof fan-cooled
Spraytight	Submersible (15 foot)
Spraytight fan-cooled	Submersible (50 foot)

3.2.8 Standard horsepower sizes.- Motors shall be furnished in the following standard horsepower sizes as specified (see 6.2):

1/20	1/6	1/3	3/4
1/12	---	1/2	---
1/8	1/4	---	---

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3.2.9 Overspeed.- Except for submarine motors (see 3.7.4) motors other than varying speed shall withstand without injury, continuous speeds of 125 percent of maximum no-load speed. Varying speed motors that have no definite no-load speed shall withstand a continuous speed of not less than 200 percent of the rated full-load speed of the driven auxiliary except that where the maximum speed of the auxiliary under normal operating conditions exceeds 200 percent of rated full-load speed, the motor shall withstand this maximum speed.

3.2.10 Permissible variation from rated speed.- The variation of the actual motor speed at rated voltage and load from rated speed shall not exceed the tolerances required for satisfactory operation of the driven auxiliary. Unless closer tolerances are required for satisfactory operation of the driven auxiliary, the variation of the actual speed at rated load, rated voltage, at normal operating temperature, and for both directions of rotation from rated full-load speed shall not exceed 7.5 percent. Where shunt fields are internally connected for one direction of rotation, these requirements apply for the normal direction of rotation only.

3.2.11 Speed regulation.-

3.2.11.1 Motor speed regulation shall be positive; that is, it shall decrease to at least a slight extent with increase of load. Motors having a full-load or overload speed greater than the no-load speed, at corresponding temperatures, will not be accepted.

3.2.11.2 Constant speed.- The speed regulation of constant speed, continuous-duty motors at normal operating temperatures shall not exceed the following:

Frame size	Percent of full-load speeds	
	Shunt	Compound
11N and smaller	25	35
15N	20	30
17N	15	25
18N	12	20

3.2.11.3 Adjustable speed.- The speed regulation of adjustable speed motors at normal operating temperatures shall not exceed 18 percent.

3.2.11.4 The speed regulation of varying-speed motors shall not exceed the amount specified (see 6.2).

3.2.11.5 Where the safe satisfactory operation of the driven auxiliary requires a speed regulation which is closer than the values specified in 3.2.11.2, 3.2.11.3, and 3.2.11.4, the needs of the driven auxiliary shall determine the permissible speed regulations in the particular case.

3.2.11.6 Change in speed due to heating.- The change in motor speed from rated load cold to rated load hot, based on rated load speed hot shall not exceed the following percentages:

Class A insulation

Open: 10 percent Others: 15 percent

Class B and class H insulation

All enclosures - 15 percent

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3.2.12 Insulation resistance.- The insulation resistance, when corrected to 25°C., shall be not less than the following:

Armature circuit (class A insulated) - 12 megohms.
Armature circuit (class B insulated) - 25 megohms.
Field circuit (class A insulated) - 25 megohms.
Field circuit (class B insulated) - 50 megohms.

3.2.13 Dielectric strength.- Motors shall withstand dielectric test voltages of not less than 60 cycles per second as follows:

Motors 1/2 hp. and less, rated 250 volts and less	900	1 minute
All others:		
Quantities of 100 or less	1000 plus twice rated voltage	1 minute
Quantities greater than 100, for motors rated 250 volts or less	1200 plus 2.4 rated voltage	1 second

3.2.14 Mechanical balance.- Motors shall be balanced at any load and speed in the operating range. Windings not in mechanical symmetry shall have dummy coils. In general, the proper mechanical balance shall be effected by the use of balance weights attached by non-corrodible bolts securely locked, drilling out of material, securely welded steel weights, or by babbitt carried in a receiver in such a manner as to preclude its breaking loose. Balancing by the use of solder on the banding wire is permissible subject to the following limitations:

(1) Peripheral speed not to exceed 6,500 feet per minute at rated load.
(2) All armature cores to be balanced before the windings are inserted.
(3) Only tinned banding wire is to be used.
(4) The solder not to cover an arc of more than 25 percent of the circumference of the armature measured on the banding wire unless satisfactory to the bureau or agency concerned. Where the manufacturer pre-balances the armature and takes care in placing the windings in the slots to reduce unbalance due to axial misalignment of the coils, this value may be increased to 33 percent if satisfactory to the bureau or agency concerned.
(5) Thickness of solder over banding wire not to exceed 3/32 inch, and in no case to extend past the center of the air gap.

When tested as specified in 4.1.4.6.1, the maximum allowable amplitude in inches of motors rated 5000 r.p.m. and less shall be as shown in table I. Unless otherwise specified in the contract or order, the degree of balance shall be "standard" in accordance with table I. Motors rated more than 5000 r.p.m. shall be as approved by the bureau or agency concerned.

Table I - Maximum allowable amplitude.

Maximum allowable total amplitude		
Standard balance	Precision balance	Super-precision balance
Inch	Inch	Inch
0.001	0.0005	0.0002

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3.2.15 Field coils.- Field coils shall be thoroughly insulated from adjacent, conducting and grounded parts and shall be so secured that they cannot become loosened by vibration. As far as practicable, field coils of the same type shall be interchangeable.

3.2.16 Frame.- The frame shall be of rigid construction. The feet need not be machined and the holes for holding-down bolts may be either drilled or slotted.

3.2.17 End brackets (explosionproof and explosionproof fan-cooled, excluded).- An accurately machined shoulder joint shall be provided between the frame and the end brackets. When so specified, the design of the end brackets shall provide for, and the accuracy of machining shall be such as to permit, the rotation of the bearings through 90 degrees or 180 degrees in either direction to allow for bulkhead or underside suspension of the motor. Resilient-gaskets shall not be placed between any bearing support member and the frame. In the case of spraytight and watertight motors, the contact surfaces between the enclosing covers and the motor frame shall be free from fins, burrs, or other imperfections detrimental to watertightness, and shall be provided with gaskets suitably secured and treated with graphite on the contact surface to present sticking. All sheet packing shall be securely attached to the covers.

3.2.17.1 General.- The end brackets shall be secured by not less than two machine screws or through bolts of suitable size and strength. These machine screws or through bolts may be furnished with either screw-driver slots or hexagon-head screws.

3.2.18 Shafts.- Unless otherwise specified in the contract or order, shaft extensions 5/8 inch diameter and larger shall have a keyway for a 3/16 inch by 3/16 inch key; shaft extensions less than 5/8 inch diameter shall have a 3/64 inch flat.

3.2.19 Bearings.-

3.2.19.1 Type of bearings.- Bearings shall be of the ball, sleeve or roller type as specified (see 6.2).

3.2.19.2 Ball bearings.-

3.2.19.2.1 General.- When ball bearings are used, they shall be in accordance with Specification 42B5.

3.2.19.2.2 Axial end play.- The requirements of Specification 42B5 shall be conformed to in respect to the installation of ball bearings in a motor. The axial movement of the shaft shall be not more than 0.030 inch nor less than 0.010 inch including bearing end play, when the application does not require the end play to be minimized.

3.2.19.2.3 Seals.- The housing shall provide for a close-clearance metallic (non-rubbing) seal on both sides of the bearings to prevent the leakage of oil or grease along the shaft. This is in addition to bearing shields, the deflecting flanges or slingers required on the shaft. Friction type seals may be used to supplement the close-clearance metallic seal on motors for certain applications; for example, submersible motors. Such sealing arrangements shall, however, be satisfactory to the bureau or agency concerned. Washers of felt or other suitable material may be used in combination with either grooves, labyrinths, or slingers if satisfactory to the bureau or agency concerned.

3.2.19.2.4 Housing construction.- The bearing housing shall be so constructed as to permit ready removal of the end bracket without the necessity of removing the bearings.

3.2.19.2.5 Addition of grease lubricant.- Where grease lubrication is used, the correct amount of lubricant shall be added to the motor before the motor leaves the place of manufacture.

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3.2.19.2.6 Single shielded or single sealed.-

3.2.19.2.6.1 Grease cups.- Compression cups shall be used where grease is a means of lubrication.

3.2.19.2.6.2 Drain plugs.- Where grease cups are used, drain plugs shall be supplied at the bottom of the bearing housing and, in general, shall be located at the same end of the bearing as the filling connection.

3.2.19.2.6.3 Grease pipes.- Extension grease pipes shall be provided for all grease cups and drain plugs when needed, to provide ready accessibility for these fittings. All burrs and scales shall be removed from the inside of the grease pipes.

3.2.19.2.6.4 Pipe plugs for grease openings.- A blind pipe plug, for use when the grease cups and pipes are not being used, shall be provided for each grease opening. (Note: Grease cups and pipes will be assembled on the motor for relubricating operations only.)

3.2.19.3 Sleeve bearings.-

3.2.19.3.1 Lubrication of sleeve bearings.- Sleeve bearings shall be lubricated by employing oil rings, oil wick, wool yarn, or other means satisfactory to the bureau or agency concerned.

3.2.19.3.1.1 Oil rings.- The number of oil rings shall be such that no ring is required to distribute lubricant for an axial distance greater than 3 inches on either side of the ring. The inside diameter of the oil ring shall be not less than twice the diameter of the shaft. Rings shall have a true circular shape and shall be of uniform cross-section. The cross-section shall preferably be that of a truncated cone with the base on the shaft. Rings shall be machined all over and shall have all corners rounded. The finish shall be smooth and free from flaws. Split oil rings shall not be used.

3.2.19.3.1.2 Bearing housing.- The housing shall be designed to permit the oil rings to rotate freely up to the maximum degree of inclination. The rings shall not rub or strike against the sides or ends of the oil reservoir, and shall not show a pronounced irregularity of movement. A means shall be provided to prevent the rings from being thrown out of place when the vessel is permanently listed, rolling or when subject to shock. The housing shall provide for a close-clearance metallic seal on both sides of the bearings to prevent the leakage of oil along the shaft. This is in addition to the deflecting flanges or slingers required on the shaft. Provision shall be made to insure against the suction of oil vapor into the interior of the motor. Provision shall also be made for observation of the oil rings while the motor is running. These openings shall be made oiltight by a cover secured by screw plugs or other suitable means. Any conventional filler may be used.

3.2.19.4 Roller bearing.- When roller bearings are used, they shall conform to Specification 42B10.

3.2.20 Armatures.- The laminations shall be properly insulated from each other. The spacers used for ventilation shall be mechanically rigid, and shall be secured so as to prevent their coming loose due to vibration in service. In the assembly of the cores, care shall be taken to remove all burrs or projecting laminations in the slot portion of the core which might result in injury to the coils. The laminations shall be clamped together in such a manner as to insure that the assembled core is "tight" at the top of the teeth. Provisions shall be made to prevent axial displacement of the core along the shaft. A pin through the shaft is not an acceptable means of preventing axial displacement. Keys, knurling of the shaft or other means satisfactory to the bureau or agency concerned shall be provided to prevent rotation of the core on the shaft.

3.2.20.1 Armature windings.- The coils shall be securely retained in the slot by wedges, wire banding, or other method satisfactory to the bureau or agency concerned.

3.2.20.2 Equalizer connections.- Equalizer connections shall be supplied on all lap-wound armatures of motors having four or more main poles.

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3.2.21 Commutators.-

3.2.21.1 General.- The commutator shall be secured rigidly to the shaft or spider by keying or other method satisfactory to the bureau or agency concerned which will positively secure the commutator in such a manner as to prevent either rotational or axial motion of the commutator relative to its support under operating or test conditions.

3.2.21.2 Copper segments.- The copper segments shall be securely retained in such manner as will prevent their relative displacement as a result of centrifugal forces and the stresses imposed by repeated expansion and contraction in service. The segments, when worn to the full extent of the allowable wearing depth specified in table II, shall be of ample section to operate satisfactorily.

Table II - Wearing depth of copper segments.

Commutator diameter (inches)	Permissible reduction in diameter
	Inch
1 and under	1/16
Over 1 and up to 4 and including 1-1/2	1/8
Over 1-1/2 and up to and including 2	3/16
Over 2	3/8

3.2.21.3 Connections.- The connections to the windings shall be effectively soldered, and, if separate risers are used, they shall be mechanically and electrically connected to the commutator bar in a manner satisfactory to the bureau or agency concerned.

3.2.21.4 Sealing.- After the assembly of the commutator all crevices or joints at each end between the bars and the retaining flanges shall be completely filled up and sealed over with high-grade, flexible, baking insulating varnish in such manner as to prevent the entrance of moisture, oil, carbon, or copper dust, or other deleterious substances at these points, likewise, the creepage parts from the ends of the copper bars to the metal flanges shall be given a heavy, durable coating of flexible, baking insulating varnish as a protection against short circuits and ground at these points.

3.2.21.5 Mica undercutting.- The mica insulation between bars shall be undercut on all motors. The undercutting shall be accomplished by removing all mica between bars to form a groove not to exceed 3/64 inch in depth.

3.2.21.6 Curing.- All commutators shall be cured at higher than operating temperatures and shall be of such thoroughly solid construction throughout as will insure that they will hold their shape in service and obviate the necessity of frequently dressing the commutators on account of high bars or flat spots.

3.2.22 Brush holders.-

3.2.22.1 Brush stop.- Means shall be provided to prevent brushes form being thrown out of their brush holders as a result of shock or from being displaced to such a position that they may bind in their brush holders and not return to their normal operating position. Such means shall consist of positive stops or other devices satisfactory to the bureau or agency concerned and shall not interfere with the normal functioning of the brushes. They shall not unduly complicate replacement of the brushes, require the use of a special design of brushes, or result in cumbersome or intricate design of brush holders.

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3.2.22.2 Adjustability.- The brush holders shall be of a type which will permit satisfactory operation with the motor running in either direction. Except where cartridge type brush holders are used, the installation shall be such that the angular position of all brush holders may be adjusted. The construction shall also provide for maintaining the spacing of the various holders at all times during adjustment. Means shall be provided to prevent loosening and shifting of brush holders under vibration and spring pressure.

3.2.23 Terminal boxes and terminal box covers.- Except for motors of 1/4 horsepower or less, terminal boxes shall be provided and shall be either cast or fabricated as an integral part of the frame or securely bolted or welded to the frame. The use of pipe nipples where they are necessary or where motors are to be used in inaccessible locations shall be satisfactory to the bureau or agency concerned.

3.2.24 Connections and terminals.-

3.2.24.1 Securing connections.- All connections liable to become loosened by vibration shall be provided with locking devices satisfactory to the bureau or agency concerned. Connections and leads shall be secured in a reliable manner to prevent their coming in contact with moving parts or being chafed by contact with stationary parts. All excess solder shall be removed from soldered connections.

3.2.24.2 Field connections.- In general, and where practicable, all field connections shall be made on the commutator end.

3.2.24.3 Terminal leads.- All terminal leads shall be of flexible, stranded cable or wire. An insulating sleeve or other suitable means shall be provided to prevent abrasion of the lead insulation by metallic edges of the motor frame, terminal box, piping, or lead clamp. Unless satisfactory to the bureau or agency concerned, terminal leads shall be in accordance with table III.

Table III - Size of terminal leads.

Frame size of motor	Minimum size of terminal leads
	Circular mils
1/3 hp. at 1725 r.p.m. and smaller	2600
Larger than 1/3 hp. at 1725 r.p.m.	3500

3.2.24.4 Securing terminal leads.- The leads shall be secured by a lead clamp or by anchoring them to the motor windings so that no strain is placed on the end connections. Where a lead clamp is provided, the terminal leads shall be attached to the frame and not to the end brackets. The method of securing shall be such that stress from outside the motor is not transmitted to electrical connections inside the motor. The use of unclamped, friction rubber grushings is not a satisfactory method of securing terminal leads.

3.2.25 Frame and armature marking.- The manufacturer's serial number shall be stamped (or otherwise permanently marked) in the solid metal of the frame underneath (covered by) the main identification plate. The part number, or other information sufficient to completely identify the armature, shall be stamped (or otherwise permanently marked) on the shaft or rotor core. The marking of armatures and field coils shall identify the manufacturer and the style and type of motor.

3.3 Interchangeability.- All similar parts, including repair parts, of corresponding apparatus furnished on the same order or built to the same drawings, shall be strictly interchangeable without the necessity of further machining, selective assembly or hand fitting of any kind.

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3.4 Repair parts.- Each repair part shall be suitable for immediate use in replacing originally installed parts in any identical motor, and the operation of the motor in which such repair parts are installed shall be within the performance limits of the original machine. In general, the design shall be such that no special tools are required; however, where the design and construction is such as to require the use of special tools for their proper maintenance, such tools shall be furnished. The requirements of Specification MIL-R-15137 shall apply.

3.4.1 Repair parts boxes.- Where specified in the contract or order, repair parts and tools for onboard shall be furnished in repair parts boxes conforming to type M of Specification MIL-B-233.

3.4.2 Shipping of onboard repair parts.- Unless otherwise specified in the contract or order, repair parts shall be inspected and shipped at the same time as the motor. Separate inspection and shipment will be satisfactory only when an acceptable schedule of shipment of the repair parts has been arranged between the manufacturer and the ordering activity.

3.4.3 Stock repair parts.- Quantities of stock repair parts (that is, parts required to replace onboard repair parts or those required for repair of a motor but not specified as onboard) and their stock numbers shall be determined in accordance with Specification MIL-R-15137.

3.5 Drawings.- Master drawings and certification data shall conform to Specification MIL-D-963. The approval activity for master drawings shall be the bureau or agency concerned. The approval activity for certification data shall be the ordering activity.

3.5.1 Master drawings.- (See 3.6.1.11 and 3.6.2.6.)

3.5.2 Certification data sheet.- In addition to the data required by Specification MIL-D-963, certification data shall include the following information:

(a) Horsepower, voltage, current, speed, type of winding and whether of a special type such as close coupled.

3.6 Requirements applicable to individual services.-

3.6.1 Service A.-

3.6.1.1 Materials.-

3.6.1.1.1 General.- Service A motors shall conform to Specification MIL-E-917. The class of insulation shall be as specified (see 6.2).

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3.6.1.1.2 Material restrictions. - Cast iron, semisteel, ebony asbestos, wood, porcelain, and cardboard shall not be used as materials of construction. The minimum requirements for materials to be used are as specified in table IV.

Table IV - Minimum material requirements for service A motors.

Item	Limitations	Material	Remarks
Armature	All sizes	Steel	
Flanges	All sizes	Nodular graphitic iron	Specification MIL-I-17166
Armature quills and spiders	All sizes	Steel	----------
Ball bearings	All sizes	----------	Specification 42B5
Ball bearings caps and cartridges	----------	Steel[1]	----------
	All sizes	Malleable iron	Grade I, type A, Specification QQ-I-666
----------	All sizes	Nodular graphitic iron	Specification MIL-I-17166
Brush holders	All sizes	Steel	Treated for corrosion-resistance
		Brass	
----------	All sizes	Nodular graphitic iron	Specification MIL-I-17166
Brush studs	All sizes	Steel	Treated for corrosion-resistance
		Brass	
Brushes	All sizes	----------	Specification MIL-B-3743
Coil spacers or separators inside slot	All sizes	Plastic	Type GMG, Specification MIL-P-15037
Collector rings	All sizes	Brass	----------
		Bronze	----------
Collector ring insulation	All sizes	Mica	Specification MH-I-538 or MIL-I-3505
Cores	All sizes	Steel[1]	Non-aging, low hysteresis
----------	----------	Plastic	Mineral filled type, Specification MIL-P-14
----------	----------	Steel	----------
Covers, part	----------	Malleable iron	Grade I, type A, Specification QQ-I-666
----------	----------	Aluminum	Specification MIL-A-17129
----------	All sizes	Nodular graphitic iron	Specification MIL-I-17166
----------	----------	Malleable iron	Grade I, type A, Specification QQ-I-666
----------	----------	Steel[1]	----------
----------	----------	Aluminum	Specification MIL-A-15153 or MIL-A-17129

[1]Unless otherwise specified in table IV, steel parts may be cast, fabricated, wrought, or forged.

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Table IV - Minimum material requirements for service A motors (cont'd.).

Item	Limitations	Material	Remarks
----------	All sizes	Nodular	Specification MIL-I-17166
Fans	All sizes	Steel[1]	----------
----------	All sizes	Nodular	Specification MIL-I-17166
Frames	----------	Steel[1]	----------
----------	All sizes	Nodular graphitic iron	Specification MIL-I-17166
Gaskets	All sizes	----------	Specification MIL-G-2765
Grease	Bearing total temperatures of 90°C. and below	Petroleum	Specification MIL-L-15719
----------	Bearing total temperatures above 90°C.	Silicone	Specification MIL-G-15719
Grease cups and pipes	All sizes	Steel	Treated for corrosion
Ground insulation	All sizes	Fish paper varnished cloth	Specification MIL-I-695
----------	----------	Glass cloth	Specification MIL-I-3505
----------	----------	Pasted mica	Specification HH-I-538
Insulation between commutator bars	All sizes	Mica	Specification HH-I-538
Lead and connection insulation	All sizes	Synthetic resin sleeving	Specification MIL-I-631
----------	----------	Varnish cloth sleeving	Specification MIL-I-3190
----------	----------	Silicone rubber glass sleeving	----------
Lead clamp insulation	----------	----------	Type GMG, Specification MIL-P-15037
Oil rings	All sizes	Brass	----------
Spacers and coil separators	All sizes	----------	Type GSG, Specification MIL-P-997
----------	----------	----------	Type GMG, Specification MIL-P-15037
Shafts	----------	Steel[1]	Commercial, except where close-coupled pumps may require corrosion-resistant material.
Sleeve bearings	All sizes	Bronze	Specification MIL-B-16261, grade III

[1]Unless otherwise specified in table IV, steel parts may be cast, fabricated, wrought, or forged.

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Table IV - Minimum material requirements for service A motors (cont'd.).

Item	Limitations	Material	Remarks
----------	----------	Babbitt	
		Antifriction	Specification QQ-M-161
Springs	All sizes	Phosphor	Specification MIL-B-892
----------	----------	Bronze	----------
----------	----------	Steel	Treated for corrosion-resistance
Terminal boxes and terminal box covers	All sizes	Steel[1]	
		Malleable iron	Grade I, type A, Specifications QQ-A-601, QQ-I-666
----------	----------	Aluminum	Specification MIL-A-15153
----------	All sizes	Nodular graphitic iron	Specification MIL-I-17166
Terminal boards	All sizes	Plastic	Mineral filled type Specification MIL-P-14:
----------	----------	----------	Type GMG - Specification MIL-P-15037
----------	----------	----------	Type GSG - Specification MIL-P-997
Varnish, insulation	All sizes	Classes A & B	Type CB, Specification MIL-V-1137
----------	----------	Class H Silicone	----------
----------	----------	Steel	----------
V-rings and shells	All sizes	Fiber	----------
Washers and bushings, insulating	All sizes	Mica or pressed mica plate	Specification HH-I-538
----------	----------	Plastic	Mineral filled type, Specification MIL-P-14
			Type GMG - Specification MIL-P-79, MIL-P-15037
Washers, metallic	All sizes	Iron & steel	Specification JAN-W-1085
----------	----------	Brass	Specification MIL-W-1165
Wedges	All sizes	Steel or brass	----------
Wedges, flat	All sizes	Plastic	Type GMG, Specification MIL-P-15037
----------	----------	----------	Type GSG, Specification MIL-P-997
Wedges, formed	All sizes. To be used only where wedge cannot be made in a flat sheet		
		Fiber	Specification JAN-F-1148

[1]Unless otherwise specified in table IV, steel parts may be cast, fabricated, wrought, or forged.

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Table IV - Minimum material requirements for service A motors (cont'd.).

Item	Limitations	Material	Remarks
Wire, armature banding	All sizes	Steel, carbon	Specification MIL-W-608
----------	All sizes	Steel, corrosion-resisting	Specification MIL-W-3068
----------	Motors 1/4 hp. and less	----------	----------
Wire, electric, round	All sizes	Copper	Specification JAN-W-583
Wire, electric, rectangular	----------	----------	Specification MIL-W-16072
	Motors larger than 1/4 hp.		
Wire, electric round	Type C, sizes 4 to 40 incl. only	Copper	Specification JAN-W-583, integral sizes only
Wire, round	Type C2, sizes 0 to 38 incl. only	Copper	Specification JAN-W-583, integral sizes only
Wire, round	Type R2, sizes 8 to 40 incl. only	Copper	Specification JAN-W-583, integral sizes only
Wire, round	Type R4, sizes 15 to 23 incl. only	Copper	Specification JAN-W-583, integral sizes only
Wire, round	Type AV, sizes 4 to 25 incl. only	Copper	Specification JAN-W-583, integral sizes only
Wire, round	Type GV, sizes 8 to 25 incl. only	Copper	Specification JAN-W-583, integral sizes only
Wire, round	Type GV, sizes 27, 28, 29, 30 and 33 only	Copper	Specification JAN-W-583, integral sizes only
Wire, round	Type GV2, sizes 8 to 25 incl. only	Cooper	Specification JAN-W-583, integral sizes only
Wire, round	Type GH, sizes 14 to 30 incl. only	Copper	Specification MIL-W-16072 integral sizes only
Wire, round	Type GH, sizes 32, 34 and 36 only	Copper	Specification MIL-W-16072 integral sizes only
Wire, round	Type G2H, sizes 11 to 26 incl. only	Copper	Specification MIL-W-16072 integral sizes only
Wire, rectangular	----------	Copper	Specification JAN-W-583,
Wire, rectangular	Type R4, 50 x 187, 60 x 200, 60 x 240 or 80 x 170 mils only	Copper	Specification JAN-W-583,
Wire, rectangular	Types AV and G2V, 64 x 325, 80 x 325, 258 x 258, or 289 x 289 mils only	Copper	Specification JAN-W-583,
Wire, rectangular	Type AV, 258 x 365 mils only	Copper	Specification JAN-W-583
Wire, rectangular	Type G2V, 65 x 115 or 182 x 182 mils only	Copper	Specification JAN-W-583
Wire, rectangular	Type G2H, 24 x 65, 40 x 80, 90, 95, 100 or 125, 52 x 62, 50 x 80, 110, 120, 200, 300 or 310, 57 x 82, 65 x 115 or 240; 45 x 180; 54 x 160; 72 x 72; 80 x 110, 185, 235, 295 or 320; 51 x 180 or 258; 60 x 200 or 240; 75 x 155, 200 or 215; 102 x 125; 114 x 114, 55 x 245; 96 x 150 or 245; 70 x 250; 85 x 206; 90 x 200; 130 x 150; 88 x 243; 82 x 324; 105 x 285; 182 x 182; 135 x 275; 162 x 162; 130 x 250; 200 x 375 mils	Copper	Specification MIL-W-16072

Alternate wire sizes.- Types C, C2, R2, R4, AV, GV and G2V of Specification JAN-W-583 and types GH and G2H of Specification MIL-W-16072 of sizes other than those in table V may be used provided the design is such as to permit rewinding with a type and size listed in table IV and having an equivalent or higher temperature rating.

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3.6.1.1.3 The number of impregnations for each design of motor shall conform to the minimum requirements of the manufacturer's detail insulation drawings as approved by the cognizant bureau or agency for that specific design. In any case, there shall be not less than three complete independent impregnations of any electrical winding. One impregnation shall be defined as one complete cycle of treating and curing (such as one immersion and one baking) by a recognized method. However, the brushing or spraying method, shall not be considered as one of the required impregnations unless it is applied as the final coat of varnish. All insulated windings shall receive at least two of the required impregnations after the windings have been installed on the corresponding motor subassemblies. Except as otherwise specified hereinafter, all insulated electrical windings shall receive at least one of the required impregnations before assembly on machine parts. Impregnation before assembly on machine parts will not be required for windings where the method of installation is such as to make this preliminary impregnation impractical. In such cases, all required impregnations shall be made after the windings are installed on the machine parts.

3.6.1.2 Temperature limits.- The motors shall be so designed as not to exceed the values of maximum permissible temperature rises specified in table V. The methods of temperature measurements specified in table V shall apply.

Table V - Maximum permissible temperature rises.

Part	40°C. amb.			50°C. amb.			65°C. amb.		
	A	B	H	A	B	H	A	B	H
1. Coil windings except shunt field									
a. Open									
Thermometer	40	60	---	30	50	---	15	35	---
Resistance	50	75	140	40	65	130	25	50	115
b. Protected, dripproof, drip-proof protected, splash-proof and splashproof protected									
Thermometer	50	70	130	40	60	120	25	45	105
Resistance	60	85	145	50	75	140	35	60	120
c. Others									
Thermometer	55	75	135	45	65	125	30	50	110
Resistance	65	85	145	50	75	140	35	60	125
2. Shunt field windings									
a. Open									
Thermometer	40	60	---	30	50	---	15	35	---
Resistance	60	70	---	50	60	---	35	45	---
b. Motors listed under 1b									
Thermometer	50	70	130	40	60	120	25	45	105
Resistance	70	90	150	60	80	140	45	65	125
c. Others									
Resistance	70	90	---	60	80	---	45	65	---

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Table V - Maximum permissible temperature rises (cont'd.).

Part	40°C. amb.			50°C. amb.			65°C. amb.		
	A	B	H	A	B	H	A	B	H
3. Commutators and collector rings									
a. Open - Thermometer	55	--	---	45	--	---	30	--	--
b. Motors listed under 1b thermometer	65	85	---	55	75	---	40	60	--
c. Others - Thermometer	65	85	---	55	75	---	40	60	--
4. Miscellaneous parts as brush holders, brushes, pole tips, etc., other than those whose temperatures affect the temperature of the insulating material may attain such temperatures as will not injure the motor in any respect.									
5. Bearings - Thermometer	50	50	110	40	40	100	25	25	85

Note.- Where two methods of temperature determination are indicated, the method to be used shall be optional with the contractor.

With but few exceptions, the values applicable to windings in table V are determined by the following "hottest spot" allowances, based on the "hot spot" temperatures in Specification MIL-E-917 and applicable to the various types of motor construction and methods of temperature measurement:

Motor enclosure	Method of measurement	Class of insulation A	B	H
Open	Method 1 (thermometer)	25	30	40
	Method 2 (resistance)	15	15	20
Protected, dripproof, dripproof protected, splashproof and splash-proof protected.	Method 1	15	20	30
	Method 2	5	10	15
Totally enclosed, fan-cooled	Method 1	10	15	25
	Method 2	5	5	10
Others	Method 1	10	15	25
	Method 2	0	5	10

Where motors are required to deliver 125 percent load for a period of 2 hours, the temperature rises shall not exceed the corresponding values in table V by more than 15°C.

3.6.1.3 Shock resistance.- The motors shall be capable of withstanding the high-impact shock test specified in Specification MIL-S-901

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3.6.1.4 Methods of attaching fans to shaft.-

3.6.1.4.1 General.- Where fans are not an integral part of the shaft, one of the following methods shall be used in attaching fans to the shaft:

(a) A key and a nut with keyed lock washer.
(b) A key, shaft shoulders and rings or tubing.
(c) A long key tack welded to the fan and secured in a closed-end key seat.
(d) A Woodruff key with a locked set screw secured on the key. The design shall be such that the set screw will not produce unbalance.

3.6.1.4.2 In the case of motors having no ball bearings between the fan and the rotor core, it will be satisfactory to use one of the following methods:

(a) A knurled shaft and press fit between the shaft and fan.
(b) A key and a press or shrink fit between the fan and shaft.

3.6.1.5 Radio noise.- The design of the motors shall be such as to minimize the generation of radio interference. Where suppression harnesses are required to reduce radio noise to the limits specified (see 6.2) impedance coils and capacitors designed for suppression purposes shall be satisfactory to the bureau or agency concerned, and shall be capable of withstanding high impact shock test in accordance with Specification MIL-S-901.

3.6.1.5.1 Noise suppression devices, where required, shall be readily removable for replacement purposes.

3.6.1.5.2 When specified (see 6.2) the following requirements shall apply: At rated speed and voltage and at any load from zero to full load, radio noise in the frequency spectrum from 150 kilocycles to 400 megacycles shall not exceed the limits in microvolts as specified in Specification MIL-I-16910.

3.6.1.6 Type of bearings.-

3.6.1.6.1 Ball bearings.- Ball bearings shall be of the following types, as specified (see 6.2).

(a) Double sealed, double row width, single row.- Where these bearings are used, a plate bearing the warning "Do not lubricate" shall appear near the bearing.
(b) Single shielded or single sealed.

3.6.1.6.2 Heat stabilization.- Bearings operating above 90° C. shall be heat stabilized so that their dimensions do not increase more than 0.0001 inch per inch of operation during 2500 hours at 149° C.

3.6.1.7 Terminal markings.- Motor leads shall be permanently marked with designating letters which correspond to the markings shown on the diagram of connections for the motor and for the controller used therewith. Terminal markings shall be in accordance with Specification JAN-E-251.

3.6.1.8 Direction of rotation.- Where a nonstandard direction of rotation (see Spec. JAN-E-251) is specified, motors shall be marked in a permanent manner to indicate the direction of rotation.

3.6.1.9 Identification plates.-

3.6.1.9.1 General.- Identification plates shall be attached to the part of the machinery or equipment which will not ordinarily be renewed during its normal service life, and be located in a readily accessible position where they can be read at all times without danger to personnel. These plates shall be in accordance with type A, B, C or D of Specification MIL-I-15024 except that aluminum alloy and plastic materials will not be permitted.

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3.6.1.9.2 Identification plate markings.- The minimum data to be marked on the identification plate for motors shall include the following items:

(a) Manufacturer's name, identification symbols, serial number, bureau or agency concerned drawing number of assembly drawing, Government contract number, date (year) of manufacture.
(b) Salient design characteristics, namely, horsepower, voltage (nominal voltage and voltage range shall be given for submarine service), current, type of winding and speed.
(c) Blank space for Government inspector's official stamping.
(d) Where motors rated for intermittent duty, short-time, or varying duty are capable of operating continuously at some decreased rating, that continuous rating shall also be shown on the identification plate. If there is no continuous rating, it shall be so stated.
(e) Class of insulation.
(f) Government stock number.
(g) Government contract number.

3.6.1.10 Quantity of onboard repair parts and tools.-

3.6.1.10.1 Repair parts.- Unless otherwise specified in the contract or order, repair parts, based upon the total number of motors of each size and design furnished for each vessel on a contract or order, shall be supplied as follows:

3.6.1.10.1.1 For motors of 1/4 horsepower and less at speeds of 1,700 r.p.m. and higher repair parts shall be furnished as shown in table VI.

Table VI - Repair parts for motors 1/4 horsepower and less.

Item No.	Name of part	Quantities to be furnished		
		1 to 5 identical motors per vessel	6 to 20 identical motors per vessel	21 or more identical motors per vessel
1	Brushes sets	4	8	12
2	Motor, complete	1	1	1

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3.6.1.10.1.2 For motors larger than 1/4 horsepower, repair parts shall be furnished as shown in table VII.

Table VII - Onboard repair parts for motors larger than 1/4 horsepower.

Item No.	Repair parts applicable to the motors installed	Quantities to be furnished per vessel		
		1 to 5 identical motors per vessel	6 to 20 identical motors per vessel	21 or more identical motors per vessel
1	Armatures complete with shaft:			
	(a) For close-coupled pumps	1	1	1
	(b) For submarines	0	0	0
	(c) Other applications		(see 6.2)	
2	Bearings, or bearing linings, sets (sleeve bearings shall be complete oil rings if used)	1	2	3
3	Brushes, sets:			
	(a) Commutator	4	8	12
	(b) Collector ring	3	4	5
4	Brush-rigging insulation sets:			
	(a) Commutator	1	1	1
	(b) Collector ring	1	1	1
5	Brush holders, sets (complete with springs):			
	(a) Commutator	1	1	1
	(b) Collector ring	1	1	1
6	Brush holder springs:[1]			
	(a) Commutator	3	4	5
	(b) Collector ring	3	4	5
7	Bearing lubricant seals, sets	3	4	5
8	Field coils, each size and type:			
	(a) For submarines	0	0	0
	(b) Other applications	1	1	2
9	Special tools[2]	1	1	1
	Additional repair parts required for gear-in head motors (gear end only)			
10	Sets of gears	As specified in the contract or order.[3] (See 6.2.)		

[1] When brushes are supplied with springs as a part of each brush it is not necessary to furnish springs as a separate item.

[2] A tool for removing the ball bearings need not be furnished when the ball bearing can be removed by pulling on the inner race with one of the tools contained in a "complete" Naval shipboard set of tools specified in Specification JAN-P-690.

[3] If any gear is not readily removable from its shaft, the shaft shall also be furnished as a repair part.

3.6.1.10.2 Repair parts for radio noise suppression equipment shall be as specified (see 6.2).

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3.6.1.11 Master drawings.- Master drawings shall conform to the requirements of Specification MIL-D-963, shall contain the following minimum data:

(a) Schematic wiring diagram of motor windings, with directions covering connections for operating clockwise or counterclockwise rotation.
(b) An assembly end and side view showing all parts of the motor identified with piece numbers in the list of materials. The assembly side view shall show a longitudinal section of the motor above the centerline. The assembly end view shall show a transverse quarter section above the centerline. These assembly views shall show the following information:
  (1) Bearing housing construction, fits and tolerances.
  (2) Sectional view of commutator, brush-rigging and brushes indicating brush rake (angle with respect to commutator), design and materials of all brush-rigging and brush holder stud insulation, and methods of supporting brush-rigging, brush holders, brush holder studs and brushes against excessive deflection due to high-impact shock. If necessary for clarity, a separate detail shall be included on the drawing.
  (3) Method of retaining commutator, sleeve rings, and armature core to shaft.
  (4) Sectional view of shunt field and series field if used.
  (5) Baffles.
  (6) Method of attaching terminal box to frame.
  (7) Method of bringing cables out of frame into terminal box and the method of protecting these cables against chafing at sharp metallic corners.
  (8) Method of clamping motor leads in the terminal box to prevent strain on internal connections and method of protecting lead insulation against abrasion by the clamp.
  (9) Dimensions, drilling and tapping of terminal box, and the number of size of cover bolts. For submarine application (see 3.7.5).
  (10) All overall dimensions including mounting, and shaft extensions key.
  (11) Direction of mounting.
  (12) Direction of air flow.
  (13) Lifting means.
  (14) All details required by this specification and not covered in the foregoing enumeration.
(c) A detailed working drawing of the shaft.
(d) Design requirements, guaranteed performance (load, efficiency, amperes).
(e) Armature diameter and core length.
(f) Commutator diameter, length, wearing depth, depth of undercutting of mica segments, minimum distance to ground.
(g) Government and manufacturer's brush grade, Government form number, number of brushes per stud, number of studs and grade of brush and manufacturer.
(h) Number of main poles and nominal air-gap.
(i) Table of armature winding data and insulation of coils, including the following information:
  (1) Number of slots.
  (2) Number of commutator segments.
  (3) Number of single coils.
  (4) Conductor copper.
  (5) Conductor insulation and Government specification.
  (6) Turns in series per coil.
  (7) Feet of wire per coil.
  (8) Total weight of copper in armature (pounds).
  (9) Insulation of coils.
(j) Development of armature winding. A partial diagram is sufficient, showing dummy coils if any.
(k) Dimensioned cross-sectional view of armature slot.
(l) Treatment of wound armature. Number of dips, bakes, and Government type of varnish.

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(m) Table of field winding data for all fields, including the following information:
  (1) Conductor copper.
  (2) Conductor insulation.
  (3) Conductors in parallel.
  (4) Turns per coil.
  (5) Feet of wire per coil.
  (6) Pounds of wire per coil.
(n) Cross-sectional view of fields.
(o) Treatment of field coils. Number of dips, bakes and Government type of varnish.
(p) Table of insulation materials showing material used and applicable Government specifications
(q) Periodic test data:
  (1) Table of temperature conditions, coverload and full load currents containing the following:
    Time, line volts and amperes, shunt volts, field amperes, speed, temperature readings, rise while running, maximum rise after shutdown, of armature coils, core, commutator, front head, read head location of thermometers.
  (2) Resistances, both cold and hot of the following:
    Armature, shunt field, series field and commutating field.
  (3) Field rheostat resistance while hot vs. r.p.m.
  (4) Speed regulation, all speeds, hot and cold, and percentages of change.
  (5) Full load losses, including I^2R fields, I^2R armature, field rheostat other losses, and the total of all.
  (6) Minimum air gaps, inches, by poles, main and commutating.
  (7) Weight of armature and weight of complete motor in pounds. This data may be included in any convenient location but not in the performance tables.
(r) A note identifying replacement bearings by Government bearing number. If there is no suitable Government standard bearing, all suitable replacement bearings shall be identified by manufacturer's names and manufacturers' identification numbers.
(s) A note identifying the type and class of the applicable Government puller specified in Specification JAN-P-690.
(t) The following additional insulation data which shall be included on each master drawing or on a separate master drawing previously approved by the bureau or agency concerned. If the data are shown on a separate master drawing covering insulation practice for a number of motors, the Bureau drawing of the insulation master drawing shall be referred to on each applicable motor master drawing. These additional data, together with the information required by 3.6.1.11 (b) to 3.6.1.11 (l), inclusive, shall completely describe all insulation used, indicating the materials, thicknesses, forms, sequence of winding and insulating operations, number of layers and amount of overlapping of tape applications, limitations (limiting voltages and mechanical conditions), treatment schedules (number and types of dipper to be used, temperature and duration of baking treatments, vacuum and pressure employed during impregnation). These additional data shall contain complete detailed information on each type of wound assembly (main field coils, commutating field coils, armature and commutator assembly) including:
  (1) Conductor strand and turn insulation.
  (2) Coil insulation including slot and end turn insulation of each armature coil, ground insulation, coil turn separators, coil banding insulation, and support pads between coils and armature spider or pole piece.
  (3) Commutator insulation, including insulation between bars, insulation between bars and shell, insulation creepage distances.
  (4) Sketches for each type of winding, showing a cross-section of the winding with relative location and identification, by piece numbers, of insulating materials shown.

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(5) Other sketches and data as necessary to show method of manufacture (insulation and forming) of each winding. These sketches shall show such details as the direction and overlap of the various tape windings on strands, conductors, turns and coils, the distance that armature coil slot insulation and slot armor extend beyond the armature iron, and the original and final shape of conductors and coils before and after each insulating process.

(6) Each sketch under (4) and (5) above shall be identified as to the design of motor and the type of winding. (For example, "Class B coil insulation for armatures of small d.c. motors with partially closed slots and random-wound coils.") The sketches should contain a table of standard and alternate insulating materials, identified by piece numbers and giving applicable specifications.

(7) Method of bringing out and insulating leads from each coil.

(8) Slot sections, showing details of slot wedges, slot armor, coil spacers, slot tubes.

(9) Sketches showing in detail how field coils are assembled, insulated and supported on the pole pieces, insulation between shunt and series coils, and method of preventing excessive relative motion between the various conductors and windings when subjected to high-impact shock.

(u) Government specification, size and quantity applicable to motor terminal lugs.

(v) Stock number for motors.

3.6.1.12 Standardization.- Unless otherwise specified in the contract or order, motors shall be in conformance with the standardization requirements shown on Drawing 9000-S6301-73459 or 9000-S6301-73441 as applicable.

3.6.2 Service C.-

3.6.2.1 General.- Protection against corrosion and methods of impregnation shall conform to Specification MIL-E-917. Insulation varnish shall conform to Specification MIL-V-1137.

3.6.2.2 Radio noise.- If specified (see 6.2), the requirements of 3.6.1.5 shall apply.

3.6.2.3 Temperature limits.- Temperature limits shall conform to table V.

3.6.2.4 Magnet wire.- The magnet wire for motors larger than 1/4 hp. at 1725 r.p.m. shall be of such size as to permit rewinding with any of the types listed in table IV.

3.6.2.5 Repair parts.- The requirements of 3.6.1.10 shall apply.

3.6.2.6 Master drawings.- Master drawings for service C motors shall contain the following minimum data:

(a) An outline drawing giving dimensions, clearance holes, tapped holes and bolts, the armature diameter, core length, commutator diameter, commutator length, diametrical wear depth and mica undercut depth.

(b) The armature winding data which shall include the number of single coils, size of conductor, type of conductor insulation, number of turns in series per coil, feet of wire per coil, and the total weight of copper in windings.

(c) A schematic diagram of armature windings.

(d) Diagram of slot insulation.

(e) Field winding data of shunt, series or commutating field as applicable, including the following: Size of conductor copper, type of conductor, insulation, number of conductors in parallel, number of turns per coil, feet of wire per coil and weight of wire per coil.

(f) Sectional sketch through main field coils.

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(g) Elevation of commutating field coils.
(h) Insulation treatment of main and commutating field coils.
(i) Insulation materials.
(j) Manufacturer's brush grade and Government brush grade and form number.
(k) Number of brush holder studs, and number of brushes per stud.
(l) Performance test of series wound motors at 50, 75, and 10 percent load including line volts, line amperes, r.p.m. and efficiency with rheostat settings remaining unchanged. Performance test of other motors at 0, 25, 50, 75, and 100 percent load including line volts, line amperes, field volts, field amperes, r.p.m. and efficiency with rheostat settings remaining unchanged.
(m) Weight of complete motor in pounds.
(n) Government specification, size and quantity applicable to motor terminal lugs.
(o) Stock number for motors.
(p) List of items normally furnished as repair parts and tools.

3.7 Motors for submarine service.- Motors for submarine service shall be in accordance with 3.1 to 3.6.1 inclusive except as follows:

3.7.1 Voltage limitation.- The rated voltage and voltage range of motors for submarine service shall be as specified in the contract or order (see 6.2).

3.7.2 Winding and speed.- The winding and speed classification shall be one of those listed under 3.2.5 or shall be special as specified (see 6.2).

3.7.3 Enclosure.- The enclosure shall be one of those listed under 3.2.7 or shall be special as specified (see 6.2).

3.7.4 Overspeed.-

3.7.4.1 For motors not requiring a field rheostat.- Motors not requiring a field rheostat shall withstand without injury a continuous speed equal to 110 percent of the warm-no-load speed attained under the conditions specified in 4.1.4.10.2.2.

3.7.4.2 For motors requiring a field rheostat.- Motors requiring a field rheostat shall withstand without injury the no-load speed attained under the conditions specified in 4.1.4.10.2.2.

3.7.4.3 Motors not having a definite no-load speed.- The requirements of 3.7.4.1 shall apply.

3.7.4.4 Overspeed trip device.- An overspeed trip device shall be employed if specified (see 6.2). Motors requiring overspeed trip devices need not comply with 3.7.4.1. The overspeed trip device shall be set at the r.p.m. considered by the manufacturer to be a safe r.p.m. but in no case shall permit the motor to run at an r.p.m. greater than 125 percent rated r.p.m. at the highest voltage rating of the motor.

3.7.5 Terminal boxes.- Terminal boxes shall not be drilled or tapped by the contractor. This requirement shall be indicated on the master drawing (see 3.6.1.11 (b) (9)).

3.7.6 Repair parts boxes.- Repair parts boxes shall not be furnished.

3.7.7 Banding wire.- Banding wire shall not be used to secure coils in slots.

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4. SAMPLING, INSPECTION, AND TEST PROCEDURES

4.1 Service A. -

4.1.1 Sampling. -

4.1.1.1 Sampling procedure for selective tests (at the place of manufacture). - Motors shall be selected by the Government inspector in accordance with table VIII. The inspector may at his discretion require these tests to be made on additional motors if the routine tests show large variations from the accepted design and performance.

Table VIII - Sampling for selective tests.

Number of motors on order	Minimum number of motors to be tested (tests in table IX)
1 to 4	1
5 to 8	2
9 to 25	3
26 to 40	4
41 to 65	5
66 to 110	6
111 to 180	8
181 to 300	10

4.1.1.2 Sampling procedure for periodic tests (at the place of manufacture). - The first motor of a design and size offered for delivery on a contract or order shall be subjected to the specified periodic tests in addition to the routine and selective tests. Thereafter, one motor of identical design and size shall be selected during each calendar year during which such motors are offered for delivery. If the Government inspector is satisfied that the motors conform to the requirements of this specification, he may waive the subsequent periodic tests. The subsequent periodic shock tests shall be waived in all cases except where there has been a change in design which affects the shockproof characteristics. A periodic test will be required after any change in design which affects the performance characteristics. If routine and selective test data reveal variations beyond a normal manufacturing tolerance, the Government inspector may require that any or all of the periodic tests be made on a particular motor to demonstrate that it conforms to this specification.

4.1.2 Inspection (at the place of manufacture). -

4.1.2.1 Motors. - Each motor shall be subjected by the Government inspector to a thorough examination to ascertain that the material, workmanship, and design are in conformance with this specification. The fit of parts shall be observed with particular reference to the interchangeability of such parts as are likely to require replacement during the normal service life of the motor.

4.1.2.2 Repair parts. - All motor repair parts shall be subjected to a careful examination to ascertain that the materials, workmanship, and finish are first-class in every respect and that they conform fully to the manufacturer's approved drawings. The principal object of this inspection shall be to determine if the repair parts are exact duplicates of those used in the motor. If the Government inspector has reason to doubt the ready interchangeability of the repair parts with the original motor parts he may require a suitable demonstration of such interchangeability.

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4.1.3 Tests. - Motors shall be tested at the manufacturer's plant in the presence of the Government inspector. Those tests that require assembly with driven auxiliary for which the motor is designed may be conducted at either the plant of the auxiliary manufacturer or the motor manufacturer. It shall be the responsibility of the prime contractor to insure that tests required on assembled units are made. The manufacturer shall make, previous to tests to be witnessed by the Government inspector, sufficient tests to insure that the design of the motor conforms in all respects to this specification. To prevent delays, not more than two tests shall be made; the second test shall be made within such time after the first test as stipulated by the Government inspector. Failure to make the necessary repairs or remedy defects within that time shall be considered sufficient cause for the final rejection of the motor. Tests shall be performed as shown in table IX. The standard factory test record form (NIS-21) shall be used.

Table IX - Routine, selective, and periodic tests.

Description of test	Applicable test paragraph		
	Routine test	Selective tests	Periodic tests
Material	4.1.4.1	--------	---------
Lubrication	4.1.4.4	--------	---------
Audio noise By ear	4.1.4.5.1	--------	---------
By instrument	---------	--------	4.1.4.5.2
Mechanical balance:			
Where bearings are of standard grade (by instrument)	---------	4.1.4.6	---------
Where bearings are of standard grade (by hand)	4.1.4.6	4.1.4.6	---------
Where bearings are above standard grade (by instrument)	---------	4.1.4.6	---------
End play (sleeve bearing motors)	4.1.4.7	--------	---------
Speed regulation	4.1.4.8	--------	---------
Commutation	4.1.4.9	--------	---------
Overspeed	4.1.4.10	--------	---------
Insulation resistance (cold)	4.1.4.13	--------	---------
Dielectric strength	4.1.4.14	--------	---------
Effectiveness of enclosure	---------	4.1.4.15	---------
Overload and heat run	---------	4.1.4.16	---------
Insulation resistance (hot)	---------	4.1.4.17	---------
Radio noise (subsequent tests waived)	---------	--------	4.1.4.19
Weight	---------	--------	4.1.4.20
Change in speed due to heating	---------	4.1.4.18	---------
Efficiency	---------	--------	4.1.4.21
Inclined operation	---------	--------	4.1.4.22
Shock (subsequent tests waived)	---------	--------	4.1.4.23
Explosionproof tests (subsequent tests waived)	---------	--------	4.1.4.23
Either:			
(1) Air-gap measurements	---------	4.1.4.2	---------
(2) Resistance (cold)	4.1.4.3	--------	---------
Or:			
(1) Full-load input data	4.1.4.12	--------	---------
(2) No-load input data	4.1.4.12	--------	---------
(3) Resistance (cold)	---------	--------	4.1.4.3

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4.1.3.1 Routine tests. -

4.1.3.1.1 Each motor shall be subjected by or under the supervision of the Government inspector to the routine tests specified in table IX, to determine conformance with the requirements of this specification. Nonconforming motors shall be individually rejected.

4.1.3.1.2 Repair parts. -

4.1.3.1.2.1 Coil tests. - **Resistance readings at ordinary room temperature shall be made upon all repair field coil windings and the results checked against the values obtained for the coils of the motors. If the resistances are materially different from those of the motor coils, the repair coils shall be rejected. All repair coils shall be submitted to a dielectric test.**

4.1.3.1.2.2 Armature tests. - The tests on repair armatures shall comprise those routine tests normally made on the motor itself. Any armature that has been routine tested in the frame of any motor of the size and design on order may be designated as the repair armature. In the case of repair armatures on subsequent contracts or orders for which suitable frames are not available at the place of manufacture, the following tests shall be made:

(a) General inspection. - The armature shall be subjected to a thorough examination to ascertain that the material workmanship, dimensions, and design are in conformance with specified requirements.
(b) Dynamic balance. - The armature shall be dynamically balanced.
(c) Insulation resistance. - The requirements of 4.1.4.17 shall apply.
(d) Dielectric strength. - The requirements of 4.1.4.14 shall apply.

4.1.3.2 Selective tests. - Each sample motor selected in accordance with 4.1.1.1 shall be subjected to the selective tests specified in table IX. If any sample is found not to conform to this specification, the lot which it represents shall be rejected. A rejected lot may be resubmitted for selective tests provided the manufacturer, after being informed of the reasons for rejection, has inspected or tested each motor in the lot for deficiencies noted and has removed all nonconforming motors.

4.1.3.3 Periodic tests. - Each sample motor selected in accordance with 4.1.1.2 shall be subjected to the periodic tests specified in table IX.

4.1.3.4 Test reports and records. - Records of periodic tests, verified and attested by the Government inspector, shall be included on and made a part of the finished plans of the motor. In instances where the finished drawings do not include such data, this information shall be recorded on standard Navy forms. Where such data are compiled on standard Navy forms, these forms shall be either carbon-backed, inked, or otherwise prepared so that they may serve as master copies from which reproductions can be made by blueprinting or a similar process. Only one master copy shall be prepared and forwarded to the Naval shipyard, shipbuilder, or design activity responsible for compiling the "Record of Electrical Auxiliaries with Performance Data". Copies of the master type test data shall not be made or distributed to any other Naval activity, contractor or shipbuilder, except that one copy shall be furnished to the Government inspector responsible for conducting the tests. Routine test data and selective test data recorded at time of tests on motors other than periodic-tested motors shall be retained by the Government inspector and shall not be distributed to other activities, except when specifically requested.

4.1.4 Methods of test. -

4.1.4.1 Material tests. - While it is not the intention of this specification, in general, to require that all the material used in the construction of motors be tested in accordance with the requirements of specifications referred to in each individual case, the Government inspector shall require such material tests whenever, in his judgment, it is necessary to ascertain that the quality of a material is at least equal to the material specified herein and covered by the referenced specifications, or as shown on the manufacturer's approved drawings.

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4.1.4.2 Air-gap measurements.-

4.1.4.2.1 Motors having a rating of 1/4 horsepower and below need not be checked for air-gap uniformity.

4.1.4.2.2 For motors having a rating above 1/4 horsepower, the uniformity of the air-gap shall be determined by ascertaining that the rotor turns freely in the assembled motor, when wound with a wire spaced spirally around the rotor periphery. For this test, the diameter of the wire shall be 70 percent of the nominal air-gap of the motor.

4.1.4.3 Resistance.- The resistance of the windings and the temperature at which they are measured shall be taken and recorded.

4.1.4.4 Lubrication.- The effectiveness of the lubricating system with the motor in its normal position shall be observed during the progress of the other tests, or by special test, as the circumstances may warrant. The oil rings of sleeve bearing motors shall turn freely and there shall be no foaming of the oil. Navy approved lubricants similar to those required for service operation shall be used. It shall be demonstrated that the motor lubrication is satisfactory, that the specified limitations of the bearing temperatures have not been exceeded, and there is no suction of lubricant into the electrical windings under any operating condition. The test report shall indicate that such tests have been made.

4.1.4.5 Audible noise.-

4.1.4.5.1 Routine and selective tests.- Observation shall be made of motor noise during the progress of testing to determine that the motor is free from any degree of noise comparably greater than that inherent in the given type and size of motor.

4.1.4.5.2 Periodic tests.- Measurements shall be made in accordance with the procedure specified in American Standard "Apparatus Noise Measurement" Z24.7 - 1950 with the following exceptions:

(a) The airborne noise level of each motor shall be measured with the "flat" weighting network at a distance of 12 inches.
(b) Observers or reflecting surfaces, other than the floor when necessary, shall be not less than 3 feet from either the microphone or the motor being measured.
(c) In cases where the measurements cover a range of 10 db or more, as in the case of motors producing a highly directional noise, the individual readings at each microphone location shall be reported and summarized in terms of power average together with the maximum and minimum values.

4.1.4.6 Mechanical balance.-

4.1.4.6.1 By instrument.- The mechanical balance of the completely assembled motor (and any special attachments such as brakes, and overspeed switches), shall be measured. Motors having a varying speed, but no definite no-load speed shall be tested at not less than 100 percent above the rated full-load speed of the driven auxiliary whichever is higher. The method of test shall be as follows:

(a) Place the motor on an elastic mounting so proportioned that the up and down natural frequency shall be at least as low as one-quarter of the operating speed of the motor. To accomplish this, it is required that the elastic mounting be deflected downwards at least by the amounts shown below due to the weight of the motor. The deformation of the mounting shall in no case be more than 1/2 the original height of the elastic element.

Revolutions per minute:	Compression Inch
900	1
1,800	1/4
3,600	1/16
7,200	1/64

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(b) A reliable peak vibration indicator shall be employed.
(c) The amplitude of vibration shall be measured on the bearing housing in the direction giving the maximum amplitude, with the motor running, the axis of the shaft in normal position and at normal voltage. If the shaft extension has a keyway, the motor shall be balanced with 1/2 a standard key in the keyway; that is, a key of full length, flush with the top of the keyway.

4.1.4.8.2 By hand.- The balance shall be checked by "touch" without the necessity of mounting on an elastic base.

4.1.4.7 End play.- Horizontal sleeve-bearing motors shall be tested for "end play" while running by alternately pressing and releasing the rotor shaft at each end. To insure floating of the shaft, there shall be at least 1/64 inch end play in either direction. The armature shall not oscillate and bump the bearing end. The longitudinal mechanical and electric centers shall coincide.

4.1.4.8 Speed regulation.-

(a) With the motor operating at rated load, and with rated voltage applied, the speed in revolutions per minute shall be observed and recorded. The motor shall be immediately disconnected from the lead as by the throwing off of the driving belt or unloading a dynamometer, and another set of readings taken. The difference between the full-load speed and the no-load speed shall be expressed as a percentage of the full-load speed.
(b) In the case of adjustable-speed motors the test for speed regulation shall be made at the highest speed rating.

4.1.4.9 Commutation.- For motors with cartridge-type brush holders which are permanently located, the Government inspector shall see that the brush holders are equally spaced and set for the correct commutating zone, that the brushes are fully seated, and the commutator has a smooth surface.

4.1.4.9.1 If the motor is provided with commutating poles, the Government inspector shall ascertain that practically sparkless commutation is attained by correct commutating pole field strength and not by brush shift from the neutral or by commutating pole shunts. Brush shift from neutral or the use of shunts across the commutating pole field terminals are not acceptable. Proper correction of strength requires a change in the commutating pole air-gap or the commutating winding.

4.1.4.9.2 The observation of commutation will not, in general, require any special tests as such, but will usually be made in conjunction with and during the progress of other tests. Specific observation of the commutation shall be made at approximately 150 percent load at rated voltage for one-half hour or for the time necessary to heat the commutator to a temperature approximately 10 degrees above the total commutator temperature, rated ambient temperature plus rise, permitted in table V, whichever, is shorter. Specific observation of commutation shall also be made at rated load, at rated voltage. Readings of volts and amperes shall be taken. The test report shall indicate that commutation noise, and vibration were observed. After shutdown, the brushes and commutator shall be checked to determine whether there has been excessive wear, pitting, or other injuries.

4.1.4.9.3 The commutation shall be observed at the same speed, within permissible variations, in both directions of rotation, except for motors whose operation will be in one direction only.

4.1.4.10 Overspeed.- Each motor shall be subjected to the following overspeed test for a period of not less than 5 minutes. The Government inspector shall check for noise, balance, and smoothness of running during the test, for loose solder, and for evidence of distortion, injury or noticeable change in the condition of the commutator bars, balance weights, fan windings, or any part after shutdown.

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4.1.4.10.1 Motors except submarine motors. - The overspeed tests shall be made at a speed not less than 25 percent above the maximum no-load speed of the motor. On varying speed motors which do not have a definite no-load speed the test shall be made at not less than 100 percent above the rated full-load speed of the driven auxiliary or at the maximum normal operating speed of the driven auxiliary, whichever is higher. Motors used for across-line starting and where both ends of the shunt field are internally connected need not be subjected to the overspeed tests.

4.1.4.10.2 Submarine motors. -

4.1.4.10.2.1 For motors not requiring a field rheostat. - The overspeed test shall be made at the speed 10 percent above the maximum no-load speed of the motor at maximum voltage.

4.1.4.10.2.2 For motors requiring a field rheostat. - The overspeed tests shall be made at the speed attained under the following conditions:

(a) Sufficient resistance shall be added to the field circuit to increase the field rheostat resistance to 110 percent of the rated value of the field rheostat designed to be used with the motor. This additional 10 percent increase in resistance is to allow for the variation in the manufacture of field rheostats.
(b) Sufficient additional resistance shall then be added to the field circuit so as to increase the speed of the motor to 110 percent of the speed attained after the conditions in (a) above have been complied with.

4.1.4.10.2.3 Motors not having a definite no-load speed. - The requirements of 4.1.4.10.1 shall apply.

4.1.4.11 No-load input data. - The no-load input data test shall consist of taking a no-load input reading with rated voltage applied at the motor terminals. Where the armature of the motor is supported by the bearings of the driven auxiliary, this test may be conducted with the motor driving the auxiliary. Readings of voltage, amperes and speed shall be taken and recorded. The motor shall be run for a sufficient period of time to allow bearing losses to become constant before any readings are taken.

4.1.4.12 Full-load input. - The full-load input test shall consist of taking full-load input readings with rated voltage applied at the motor terminals. Readings of speed, volts and amperes shall be taken and recorded.

4.1.4.13 Insulation resistance tests. - This test shall be made before the dielectric tests. Prior to the application of the test voltage, the windings of the motor shall be thoroughly discharged by connecting the windings to the frame. Separate measurements shall be made on the stator and armature windings. Circuits of equal voltage above ground shall be connected together. Circuits or groups of circuits of different voltage above ground shall be separated. Insulation resistance shall be measured with an insulation-resistance-indicating meter conforming to type GC of Specification MIL-G-1045. The time of test voltage application shall be not less than 60 seconds. The temperature of the motor windings at the time of the test shall be measured and recorded. Insulation resistance measurements shall be corrected to 25°C. Unless otherwise specified in the contract or order, corrections shall be made on the basis of insulation resistance doubling for each 15°C. decrease in temperature. The relative humidity at the time of the test shall be measured and recorded.

4.1.4.14 Dielectric tests. -

4.1.4.14.1 General. - The dielectric test shall be made after all other tests have been completed. If the insulation resistance of the windings is known to be lower than specified, due to dirt or moisture or damage to windings, this shall be remedied before the application of the dielectric test voltage. The dielectric test shall be made on the completely assembled machine and not upon individual parts. An exception is made in the case of repair parts which require dielectric tests for example, repair coils and repair armatures. In the case of motors using capacitors, the dielectric test on the motor may be made with the capacitor disconnected. The capacitor shall be given a separate dielectric test according to the rating of the capacitor used.

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4.1.4.14.2 Measurement of test voltage.- The measurement of the voltage used in dielectric tests shall be made by the voltmeter method whereby the instrument derives its voltage from the high-volt circuit either directly or by means of a voltmeter coil placed in the testing transformer, or through an auxiliary ratio transformer. In any case, if the capacitance of the machine to be tested is such as to cause wave distortion, the testing voltage shall be checked by a crest-voltage meter. If the crest-voltage meter is calibrated in crest volts, its reading shall be reduced to the corresponding root-mean-square sinusoidal value by multiplying by 0.707.

4.1.4.14.3 Points of application.- The test voltage shall be successively applied between each electric circuit and all other electric circuits and metal parts grounded. The test voltage shall be applied in such a manner as to preclude the possibility of pitting the bearings in case of insulation failure. Voltage need not be applied between stationary and rotating windings.

4.1.4.15 Effectiveness of enclosure.- Motors shall be tested as specified in Specification MIL-E-2036.

4.1.4.16 Overload and heat run test.-

4.1.4.16.1 Overload tests.-

4.1.4.16.1.1 At 150 percent rated load.- The overload test shall be made at 150 percent rated load only on continuous-duty integral horsepower motors in accordance with the following: Start with motor cold and record temperature at end of run. Temperature rises shall not exceed those specified for continuous operation at rated load. The conditions of test shall be as follows:

Rated motor load - 150 percent.
Voltage - rated.
Time - 10 minutes.

4.1.4.16.1.2 At 125 percent rated load.- Where the motor of motor-generator sets is required to have a 25-percent overload, the overload test shall be made immediately following the rated load heat run. The conditions of test shall be as follows:

Rated motor load - 125 percent.
Voltage - rated.
Time - 2 hours.

The permissible temperature rises specified in 3.6.1.2 shall not be exceeded.

4.1.4.16.2 Heat-run test.- The heat run test shall be made on integral and fractional horsepower continuous duty motors in accordance with the following:

Rated motor load - 100 percent.
Voltage - rated.
Time - until all temperatures are constant.

The heat-run may be made immediately following the overload test. Motor load may be obtained by maintaining the current torque or watts input corresponding to rated motor horsepower output.

4.1.4.16.3 Details of temperature tests, correction to shutdown.-

4.1.4.16.3.1 Normal load heat-runs on continuous-duty motors shall be continued until constant temperatures have been attained in all parts of the motor. For motors having several continuous ratings the heat-run shall be taken with the rating giving the highest temperature rises. In cases where this cannot be determined beforehand the motor shall be tested separately for each rating. It shall be considered that constant temperatures have been reached when at least four consecutive readings taken at 10-minute intervals show no increase in the temperature of any part of the motor.

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4.1.4.16.3.2 The duration of the temperature test of a motor with a short-time or overload requirement shall be the time specified for that rating. Intermittent and varying duty motors shall be tested at the specified duty cycle. In lieu thereof, the motors may be tested as short-time duty motors of sufficient rating to meet the actual load requirements. The manufacturer shall submit to the bureau or agency concerned evidence that the short-time duty rating used for test purposes is equivalent to the required duty cycle.

4.1.4.16.3.3 Wherever possible, temperature measurements shall be taken during the progress of the heat-run as well as after shutdown. The highest figures thus obtained shall be adopted as the observable temperatures.

4.1.4.16.3.4 Whenever sufficient time has elapsed between the instant of shutdown and the time of the final temperature measurement to permit the temperature to fall, suitable corrections shall be applied so as to obtain as nearly as possible the temperature at the instant of shutdown.

4.1.4.17 Hot insulation resistance.- The insulation resistance and the temperature at which it is measured shall be taken and recorded immediately following the heat-run (see 4.1.4.13).

4.1.4.18 Change in speed due to heating.-

4.1.4.18.1 Starting with the motor at approximately room temperature and under rated voltage and load conditions, the speed in revolutions per minute shall be observed and recorded at the earliest practicable moment before the field and armature resistances have materially changed in value.

4.1.4.18.2 After the machine temperatures have attained their approximate normal operating values, and with the rated load and voltage applied to the motor, the speed in revolutions per minute shall again be observed and recorded.

4.1.4.18.3 The difference between the full-load cold and full-load hot speeds shall be expressed as a percentage of the full-load hot speed. It shall not exceed the maximum percentage specified herein.

4.1.4.18.4 The difference between the rated-load hot speed and rated speed shall be expressed as a percentage, plus or minus depending upon whether it is greater than or less than rated speed.

4.1.4.19 Radio noise tests.-

4.1.4.19.1 General.- The tests shall be conducted in accordance with Specification MIL-I-16910.

4.1.4.19.2 Ambient noise.- The contractor shall conduct the radio noise tests in a screened room or other location where the ambient noise level is not more than 20 percent of the maximum permissible radio noise values specified for the motor under test. Ambient noise measurements shall be made and recorded with the motor at stand-still and with the noise meter connected for conducted noise, and if required by the contract or order (see 6.2), radiated noise.

4.1.4.19.3 Conducted noise measurements.- Conducted noise tests shall be made with the noise meter connected in turn from each a.c. motor terminal to ground and in accordance with Specification MIL-I-16910.

4.1.4.19.4 Radiated noise measurements.- Radiated noise tests, when required, shall be made in accordance with Specification MIL-I-16910.

4.1.4.19.5 Power source shielding.- Under all conditions of motor loading, unshielded power leads of adequate voltage and current capacity shall be provided in each motor line. These leads shall be 15 feet plus or minus 6 inches in length measured between the motor terminals and the power terminals. These leads shall be spaced approximately 1/2 inch apart and shall be extended in a straight line to their maximum practicable length. Other methods of inserting impedance shall be used only if satisfactory to the bureau or agency concerned. Necessary filters shall be inserted at the power end of the 15-foot unshielded power leads.

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4.1.4.19.6 Test conditions.- Conducted noise and radiated noise measurements shall be made at no load and full load at rated voltage and frequency and at the following approximate frequencies in megacycles per second:

0.15	1.6	10	40	90	200
0.18	2.0	12	45	95	220
0.20	2.4	14	50	100	250
0.24	2.8	16	55	110	280
0.28	3.2	18	60	120	320
0.32	3.6	20	65	130	350
0.35	4.0	24	70	140	375
0.60	5.0	28	75	150	400
1.0	6.0	32	80	160	
1.4	8.0	35	85	180	

4.1.4.19.7 Test records.- A record of radio noise tests indicating ambient noise, conducted noise and, when required, radiated noise measurements and the date and location of tests shall be included in the motor test records.

4.1.4.20 Weight.- The weight of motors shall be taken and recorded.

4.1.4.21 Efficiency.-

4.1.4.21.1 Unless otherwise specified in the contract or order, the efficiency is understood to be at rated load. In general, the efficiency shall be the directly measured efficiency as determined by dynamometer. If test facilities are limited and the efficiency cannot be measured by the foregoing method, the conventional efficiency will be acceptable. The manufacturer shall state definitely in the test records if other than the directly measured efficiency is given. A curve of efficiency plotted against horsepower output shall be made a part of the test record. The efficiency shall be determined for 1/4, 1/2, 3/4, 4/4, and 5/4 rated load. Total losses at rated output shall be segregated as follows:

I^2R fields.
I^2R armature.
Core, friction, windage, and brush drop losses.
Field rheostat.
Miscellaneous.

4.1.4.21.2 Copper losses.- The I^2R loss shall depend on the measured current and the resistance of the windings. For conventional efficiency the resistance of the windings shall be corrected to 75°C. For the directly measured efficiency those losses shall be based on the "hot" resistance of the windings at the temperature of the windings under actual operating conditions.

4.1.4.21.3 Field rheostat losses.- Field rheostat losses shall be included in the losses of the motor.

4.1.4.21.4 Miscellaneous losses.- When a separately driven blower supplies air to a single motor, the power required to drive it shall be charged against the motor; but when one or more separately driven blowers supply air through a single duct to two or more motors, the power required to drive the blower or blowers shall be charged against the plant or station and not against the single motor.

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4.1.4.22 Inclined operation.-

4.1.4.22.1 The inclination tests for horizontal motors shall, in general, cover the following test positions:

For sleeve-bearing motors:
Shaft inclined 15 degrees, front end low.
Shaft inclined 15 degrees, rear end low.
Shaft horizontal, motor base tilted 15 degrees to the right.
Shaft horizontal, motor base tilted 15 degrees to the left.
For ball-bearing and roller-bearing motors:
Shaft inclined 15 degrees, front end low.
Shaft inclined 15 degrees, rear end low.

4.1.4.22.2 Under each of the positions of inclination specified in 4.1.4.22.1 the motor shall be run for a period of not less than 30 minutes. This test may be made on the combined motor-driven auxiliary. The combined motor-driven auxiliary shall be run at not less than its maximum service speed, and the driven auxiliary need not be loaded. During the progress of these tests it shall be ascertained that the mechanical balance is as good as it was in the normal horizontal position, that there is no pounding or grinding at the bearings, and that the lubrication is satisfactory. If the motor is provided with oil-ring lubrication, it shall be ascertained that the rings do not rub or strike against the sides or ends of the oil well, that they do not "dance" or show pronounced irregularity of movement, and that the shaft does not sling oil into the motor.

4.1.4.22.3 Vertical motors shall be tested by inclining them to an angle of 15 degrees from their normal position, in any direction (that direction which imposes the most severe condition, if there is any dissymmetry) and for a period of 30 minutes. If desired, this test may be made on the combined unit used for the special operating test. Vertical motor-driven auxiliaries shall be tested by inclining them to an angle of 15 degrees from their normal horizontal position, in each of four different directions; namely, (a) forward, (b) backward, (c) to the right, and (d) to the left. Observations shall be made as specified in 4.1.4.22.2 for horizontal motors and motor-driven auxiliaries.

4.1.4.22.4 The suitability of motor-driven auxiliaries for operation when a vessel is rolling 45 degrees to either side shall be determined by inspection of design.

4.1.4.23 High-impact shock test.- The tests shall be as specified in Specification MIL-S-901. The features of the test shall be as follows:

(a) The required type of shock test.- Type A.
(b) The weight designation of the shock test.- As required by the motor. If the motor shaft in application will be required to support a heavy weight such as a clutch-type coupling or fan impeller, the shock tests shall be conducted with the motor shaft so loaded.
(c) Principal functions of the equipment or apparatus.- Motive power for various auxiliaries.
(d) A definition of "failure to perform principal functions".-
(1) Breakage of any parts, including mounting bolts.
(2) Appreciable distortion or dislocation of any parts such as mounting feet, poles, coils, brushes, and bearings.
(3) A value of insulation resistance (corrected to 25°C.) less than that permitted by 3.2.12.
(4) A mechanical unbalance of more than two times the value of unbalance specified in 3.2.14.
(5) A bearing temperature rise in excess of that permitted in table IV.

(4) Turns per coil

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(6) Objectionable noise.- Any noticeable increase or decrease in noise of the motor when operating at rated speed should be investigated and its cause determined. However, if disassembly is required for this check, it should be made during the test specified in 4.1.4.23 (d) (8).

(7) Low dielectric strength. The motor shall be operated to obtain approximately rated temperature rise of iron and windings, then disconnected from its load or from its source of power and a dielectric strength test made to check the condition of the insulation. This dielectric strength test shall be made in accordance with 4.1.4.14 except that it shall be made with an applied voltage equal to 63 percent that specified in 4.1.4.14. Under these conditions, insulation failures shall be cause for rejection.

(8) Failure to pass inspection. The motor shall be disassembled following checks 4.1.4.23 (d) (1) to 4.1.4.23 (d) (7), inclusive, and inspected thoroughly for damage. The extent of disassembly need be only to the point where the condition of the motor can be easily observed. The effects of the shocks and subsequent check tests on the structure, bearings, and insulation shall be carefully observed and recorded.

(e) Acceptable method of mounting on shock-testing machine.- The mounting adapters shown on the following figures of Specification MIL-S-901 shall be used:

(1) Figure 4 C for motors to be tested on the shock-testing machine for light weight equipment.

(2) Figure 7 A for motors to be tested on the shock-testing machine for medium weight equipment.

(f) Exceptions to Specification MIL-S-901.- None.

(g) Place at which shock test will be conducted.- At the manufacturer's plant. Where a manufacturer is unable to conduct these tests at his own plant, he may arrange to have them conducted at a commercial laboratory, or Government laboratory suitably equipped to conduct tests. Where shock tests are conducted at a Government laboratory, a copy of the applicable master drawing shall accompany the motor.

(h) Number of motors to be tested.- Unless otherwise specified in the contract or order, one motor of the longest core length in each diameter and of similar construction out of each group of enclosures listed below, shall be shock-tested:

Group 1:
- Open
- Protected
- Dripproof
- Dripproof protected
- Splashproof protected

Group 2:
- Spraytight
- Watertight
- Totally enclosed

Group 3:
- Spraytight fan-cooled
- Watertight fan-cooled
- Totally enclosed fan-cooled

Group 4:
- Explosionproof

Group 5:
- Explosionproof fan-cooled

Group 6:
- Submersible, all degrees

If the manufacturer desires he may submit a motor frame of less than the longest core length to the shock test. However satisfactory conformance with the shock requirements will give approval only to motors having a core length equal to or less than the core length of the motor tested.

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(i) Disposal of shock-tested motors.

(1) Motors which have been subjected to the high-impact shock test and have failed to conform to the requirements will not be acceptable, either in whole or any of the parts.

(2) Motors which have been subjected to the high-impact shock test and have successfully passed this test shall be considered acceptable provided the post-shock tests specified hereinafter are satisfactorily passed and provided the mechanical corrective measures specified hereinafter are satisfactorily met. Continuous duty motors shall be subjected to a full-load heat run test of 2 hours duration intermittent, varying and short-time duty motors shall be subjected to a heat run test corresponding to but not exceeding the specified rating of the motor. All motors shall be given an insulation resistance test and a dielectric strength test in accordance with 4.1.4.16.2, 4.1.4.13, and 4.1.4.23 (d) (7), respectively. Mounting flanges connecting directly to the driven auxiliary shall be replaced in the event of minor deformation. Minor deformations affecting alignments, including alignments with the auxiliary, shall be corrected. Minor deformations shall be defined as those which do not cause unqualified rejection of the design under the high-impact shock test but which are in excess of the dimensional tolerances specified on the applicable motor drawings. A "substandard" plate will not be required.

4.2 Service C.-

4.2.1 Sampling and inspection for service C motors shall be as specified in 4.1.1 and 4.1.2. Tests shall be as specified in 4.1.3 but limited to only those tests listed in table X. No periodic tests will be conducted.

Table X - Routine and selective tests.

Description of test	Applicable test paragraph	
	Routine test	Selective test
Material	4.1.4.1	-------
Lubrication	4.1.4.4	-------
Mechanical balance (by hand)	4.1.4.6	4.1.4.6
Insulation resistance (cold)	4.1.4.13	-------
Dielectric strength	4.1.4.14	-------
Effectiveness of enclosure	--------	4.1.4.15
Air-gap measurements	4.1.4.2	--------
Resistance (cold)	4.1.4.3	--------

4.3 Inspection procedures.- For Naval purchases, the general inspection procedures shall be in accordance with General Specifications for Inspection of Material.

5. PREPARATION FOR DELIVERY

5.1 Preservation and packaging.-

5.1.1 For domestic shipment - immediate known use.- When specified in the contract or order, cleaning, preservation and packaging shall be in accordance with the manufacturer's standard practice.

(c) Stock number for motor

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5.1.2 For domestic shipment and storage or overseas shipment.-

5.1.2.1 Motors shall be preserved and unit packaged in accordance with Specification MIL-P-16298.

5.1.2.2 Repair parts and tools shall be preserved and packaged in accordance with Specifications MIL-P-16298 and MIL-P-15424, as applicable. Items not specifically covered therein shall be preserved and packaged in accordance with Specification MIL-P-116.

5.2 Packing.-

5.2.1 For domestic shipment - immediate known use.- When specified in the contract or order, the equipment and accessories packaged as specified in 5.1.1 shall be packed in accordance with the Consolidated Freight Classification Rules or Motor Freight Classification Rules, whichever may be applicable. The gross weight of wood boxes shall not exceed 200 pounds; of fiberboard 90 pounds.

5.2.2 For domestic shipment and storage.-

5.2.2.1 Equipment.- Unless otherwise specified in the contract or order, the motors shall be packed in accordance with Specification MIL-P-16298 as specified for domestic storage therein.

5.2.2.2 Repair parts and tools.- Unless otherwise specified in the contract or order, repair parts and tools shall be packed in snug fitting wood cleated fiberboard, cleated plywood, nailed wood, wirebound, corrugated or solid fiberboard boxes conforming to Specification NN-B-591, NN-B-601, NN-B-621, NN-B-631, LLL-B-631 or LLL-B-636, respectively. Fiberboard boxes shall conform to the special requirements of the applicable box specification. Closure of the fiberboard boxes shall conform to the appendix of the applicable container specification. The gross weight of wood and wood cleated boxes shall not exceed 200 pounds; fiberboard boxes shall conform to the weight limitations of the applicable specification.

5.2.3 For overseas shipment.-

5.2.3.1 Equipment.- When specified in the contract or order, the motors shall be packed for overseas shipment in accordance with Specification MIL-P-16298.

5.2.3.2 Repair parts and tools.- Unless otherwise specified in the contract or order, repair parts and tools shall be packed in snug fitting wood cleated fiberboard, wood cleated plywood, nailed wood, wirebound or fiberboard boxes conforming to Specification JAN-P-103, JAN-P-105, style 2, 2-1/2 or 3 of Specification MIL-P-106, MIP-B-107 or JAN-P-108 (exterior grade), respectively. Plywood shall conform to type A or B, condition 1 of Specification JAN-P-139. Boxes shall be lined with a sealed waterproof caseliner conforming to Specification MIL-L-10547 and appendix thereto. Shipping containers shall be closed and strapped in accordance with the appendix of the applicable container specification. The gross weight of wood boxes shall not exceed 150 pounds; of fiberboard, 70 pounds. Caseliners will not be required when fiberboard boxes conforming to Specification JAN-P-108 are used.

5.3 Onboard repair parts boxes.-

5.3.1 When onboard repair parts boxes are specified in the contract or order, onboard repair parts shall be snugly packed in metal or wood repair parts boxes conforming to type M or type W of Specification MIL-B-233 and shall be overpacked in shipping containers conforming to Specification JAN-P-132.

5.3.2 An index list of repair parts and tools conforming to Specification MIL-F-17292 shall be secured to the cover within each box.

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5.4 Technical publications.- Instruction books, pamphlets and handbooks, as applicable, shall be packaged in accordance with method IC-3 of Specification MIL-P-116. When specified in the contract or order, one or two copies of the instruction book shall be packed in the shipping container holding the main unit. Packing lists shall indicate which container contains the instruction book. Bulk quantities of the instruction book shall be packed in shipping containers in the same manner as specified in 5.2.2 or 5.2.3.

5.5 Marking.- In addition to any special marking required by the contract or order, unit and intermediate packages and exterior shipping containers shall be marked in accordance with Standard MIL-STD-129, and in addition, shall include the electrical and mechanical operational characteristics or ratings (as applicable).

6. NOTES

6.1 Intended use.- Motors covered are all types of fractional horsepower motors, intended for shipboard use. Service A motors are intended for applications where they are essential to the Military effectiveness of a ship. Service C motors are intended for applications where they are not essential to the Military effectiveness of a ship.

6.2 Ordering data.- Procurement documents should specify the following:

(a) Title, number, and date of this specification.
(b) Service (see 1.2).
(c) Ambient temperature (see 3.2.1).
(d) Rating (volts must always be stated; horsepower or torque requirements, either or both, may be specified) (see 3.2.3 and 3.2.8).
(e) Winding and speeds (see 3.2.5).
(f) Duty (specified time of duty cycle) (see 3.2.6).
(g) Enclosure (see 3.2.7).
(h) Explosive, if other than gasoline vapor, for explosionproof motors (see 3.2.7).
(i) Speed regulation for varying speed motors (see 3.2.11.4).
(j) Type of bearings (see 3.2.19.1 and 3.6.1.6.1).
(k) Bearing, and grade if ball or roller bearings are required (see 3.2.23).
(l) Insulation (see 3.6.1.1).
(m) Maximum permissible temperature, and temperature rises, for class C insulation (see 3.6.1.1.1).
(n) Whether suppression harnesses and specific radio noise limits are required (see 3.6.1.5).
(o) Repair sets of gears and spare noise suppression equipment for services A and C motors (see 3.6.1.10).
(p) Whether for domestic or overseas shipment.
(q) Driven auxiliary with which motor is to be used.
(r) Nonstandard direction of rotation if required.
(s) For submarine service only:
  (1) Rated voltage and voltage range (see 3.7.1).
  (2) Winding and speed classification (see 3.7.2).
  (3) Enclosure, including details for special enclosures (see 3.7.3).
  (4) Whether an overspeed trip device is required (see 3.7.4.4).
(t) If metal or wood repair boxes are required (see 5.3).
(u) Whether for domestic shipment - immediate use; for domestic shipment and storage; or for overseas shipment (see 5.1 and 5.2).

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6.3 Reduction of audible noise.- As a means of reducing audible noise, special attention should be given the following:

Magnetic:
(1) Number of slots per pole pitch.
(2) Number of slots magnetically under one pole.
(3) Slot frequency as a function of natural frequency of the frame.
(4) Skew of slots or pole tips.

Mechanical:
(1) Elimination of brush chatter.
(2) Stiffeners of brush rigging.
(3) Aerodynamic design of the ventilating or cooling system.
(4) Mechanical balance.

6.4 Motors formerly covered by service D of Specification MIL-M-2511 are now covered by NEMA standards.

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