MIL-M-19160C(SHIPS)
30 September 1970
SUPERSEDING
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(See 6.5)

MILITARY SPECIFICATION

MOTOR-GENERATOR, 60-HERTZ A.C. TO 400-HERTZ A.C., SHIPBOARD SERVICE

1. SCOPE

1.1 This specification covers 60 Hertz (Hz) alternating current (a.c.) to 400-Hz a.c., general purpose motor-generator power supplies for Naval shipboard use on surface ships.

2. APPLICABLE DOCUMENTS

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

SPECIFICATIONS

FEDERAL

FF-B-171 - Bearings, Ball, Annular, (General Purpose).
QQ-I-666 - Iron Castings, Malleable.
GGG-P-781 - Puller, Mechanical Puller Attachment, Mechanical and Puller Set, Mechanical.

MILITARY

MIL-I-631 - Insulation, Electrical, Synthetic-Resin Composition, Nonrigid.
MIL-B-857 - Bolts, Nuts and Studs.
MIL-S-901 - Shock Tests, H.I. (High-Impact); Shipboard Machinery, Equipment and Systems, Requirements for.
MIL-E-917 - Electric Power Equipment, Basic Requirements for (Naval Shipboard Use).
MIL-D-1000 - Drawings Engineering and Associated Lists.
MIL-D-1000/2 - Drawings, Engineering and Associated Lists.
MIL-I-1361 - Instrument, Auxiliaries, Electrical Measuring: Shunts, Resistors, and Transformers.
MIL-E-2036 - Enclosures for Electric and Electronic Equipment, Naval Shipboard.
MIL-C-2212 - Controllers, Alternating-Current, Naval Shipboard.
MIL-Q-9858 - Quality Program Requirements.
MIL-M-9868/1 - Microfilming of Engineering Documents, 35MM, for Naval Ship Systems.
MIL-M-15071 - Manuals, Technical: Equipment and Systems Content Requirements for.
MIL-S-15083 - Steel Casting.
MIL-R-15109 - Resistors and Rheostats, (Naval Shipboard).
MIL-M-16034 - Meters, Electrical-Indicating (Switchboard and Portable Types).
MIL-I-16104 - Indicators, Synchronization.
MIL-E-16298 - Electric Machines Having Rotating Parts and Associated Repair Parts: Packaging of.
MIL-C-17361 - Circuit Breakers, Air, Electric, Insulated Enclosure (Shipboard Use).
MIL-E-17555 - Electronic and Electrical Equipment, Accessories and Repair Parts; Packaging and Packing of.
MIL-C-17588 - Circuit Breaker (Automatic - ALB) and Switch, Toggle (Circuit Breaker, Non-Automatic - NLB), Air, Insulated Enclosure, 125 Volts and Below, AC or DC, Naval Shipboard.
MIL-G-18709 - Grease, Ball and Roller Bearing.
MIL-W-19088 - Wattmeters, Switchboard Type, 4-1/2 Inch.
MIL-V-23151 - Voltmeter, Expanded Scale Switchboard Type (Naval Shipboard Use).
MIL-I-24137 - Iron Castings, Modular Graphitic (Ductile Iron) and Modular Graphitic (Corrosion Resisting, Austenitic, Low Magnetic Permeability) (for Shipboard Application).

FSC 6125

MILITARY (Cont'd)
MIL-H-46855- Human Engineering Requirements for Military Systems, Equipment and Facilities.
MIL-M-81203 - Manual, Technical, In-Process Reviews, Validation, and Verification Support of.

STANDARDS

MILITARY
MIL-STD-195 - Marking of Connections for Electric Assemblies.
MIL-STD-415 - Test Points and Test Facilities for Electronic Systems and Associated Equipment, Design Standard for.
MIL-STD-470 - Maintainability Program Requirements (for Systems and Equipments).
MIL-STD-471 - Maintainability Demonstration.
MIL-STD-740 - Airborne and Structureborne Noise Measurements and Accceptance Criteria of Shipboard Equipment.
MIL-STD-761 - Electric Power, Alternating Current for Shipboard Use Characteristics and Utilization of.
MIL-STD-785 - Requirements for Reliability Program (for Systems and Equipments).

HANDBOOKS

MILITARY
MIL-HDBK-217 - Reliability Stress and Failure Rate Data for Electronic Equipment.
MIL-HDBK-472 - Maintainability Prediction.

PUBLICATIONS

NAVY DEPARTMENT
NAVSHIPS 94324 - Maintainability Design Criteria Handbook for Design of Shipboard Electronic Equipment.
0969-019-7000 - Electronic Test Equipment Application Guide.

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

2.2 Other publications. The following document forms a part of this specification to the extent specified herein. Unless otherwise indicated, the issue in effect on date of invitation for bids or request for proposal shall apply.

UNIFORM CLASSIFICATION COMMITTEE
Uniform Freight Classification Rules

(Application for copies should be addressed to the Uniform Classification Committee, 202 Union Station, 516 West Jackson Boulevard, Chicago, Illinois 60606.)

3. REQUIREMENTS

3.1 Definitions. The definition of terms used in this specification shall be in accordance with 6.2.

3.2 Performance requirements.

3.2.1 The motor generator shall be designed to the following characteristics:

(a) Motor:
(1) Voltage - 440 volts.
(2) Phase - Three.
(3) Speed - 1200 revolutions per minute (rpm).
(4) Slip - With rated full load applied to the generator, the motor slip shall not exceed 2 percent at minus 10 percent rated motor voltage.
(5) Frequency - 60 Hz.
(6) Type - Squirrel cage induction.
(7) Voltage and frequency variation- The motor shall be capable of operating satisfactorily with an input voltage variation of plus or minus 10 percent and an input frequency variation of plus or minus 5 percent.

(b) Generator:
(1) Kilowatt ratings (kw) - 0.5, 1.5, 3, 5, 10, 15, 30, 60, 100, 200, or 300, as specified (see 6.1).
(2) Speed - 1200 rpm.
(3) Output voltage - 120 or 450 volts, as specified (see 6.1).
(4) Phase - Three phase.
(5) Frequency - 400 Hz.
(6) Power factor - 0.8.
(7) Field poles and shoes - Not required to be individually removable, replaceable or adjustable.
(8) Rotating field type - Unless otherwise specified (see 6.1).

3.2.2 Duty. Motor generators and control equipment shall be designed for satisfactory operation over the range of no load to full load when operating on the input voltage and frequency range specified in 3.2.1(a)(7).

3.2.3 Ambient temperature. The motor generators and all associated control equipment shall be designed for operation in an ambient temperature of 50°Centigrade (C).

3.2.4 Shock. Motor generators and all associated control equipment shall be capable of withstanding the high impact shock test as specified for Grade A, hull or deck mounted as specified (see 6.1), class I, medium or heavy weight (as applicable), type A equipment of MIL-S-901.

3.2.5 Insulation resistance. The insulation resistance when connected in accordance with 4.6.5 shall be not less than 50 megohms for motor generators and 10 megohms for associated control equipment.

3.2.6 Grounding. Equipment shall be designed to operate satisfactorily from an ungrounded ship's power system, but accidental grounding of this system shall not cause maloperation. Design and construction shall be such that all exposed metal parts are at ground (ship's hull) potential at all times, however none of the circuits of the equipment furnished shall be tied to ground. The output of the motor generator power supply shall also be designed as an ungrounded system; however, the equipment shall be designed to perform in accordance with the requirements of this specification in the event of single failure to ground and when operating with loads which may have high impedance circuits to ground such as may be caused by electromagnetic suppression networks.

3.2.7 Mode of operation. The equipment shall be required to operate with the voltage regulator in automatic only.

3.2.8 Source of excitation power. Generator excitation shall be obtained from the rectified output of a rotating brushless exciter mounted on the motor generator shaft. The field of the brushless exciter shall be energized from a static voltage regulator supplied from either rectified 400 Hz generator output, rectified 60 Hz input or a combination of both. When 400 Hz is used, a relay may be used to provide initial power from the 60 Hz source on start up. No relays shall be used to provide power to obtain the specified short circuit characteristics.

3.2.9 Voltage regulation. Voltage regulation shall be achieved by a completely static regulator and exictation system. The voltage regulator shall be capable of maintaining the mean voltage of the three phases within plus or minus 1/2 percent of rated voltage for any preset value within the range specified in 3.2.11 under the following conditions or any combination thereof:

(a) Load varying between no load and rated load.
(b) Load power factor varying between 0.8 lagging and unity.
(c) Variation of input voltage and frequency within the range specified in 3.2.1(a)(7).
(d) Variation of equipment temperature from cold as specified ambient to full load rise at specified ambient.
(e) Unbalanced generator load of 15 percent of rated current at any power factor between rated and unity.

3.2.10 Voltage deviation and recovery. The time to return and stay within plus or minus 0.5 percent of the rated value of the steady state voltage shall not exceed 0.5 second following change in an 0.8 p.f. load from no load to half load, from half load to full load, from full load to half load and from three-fourths load to one-fourth load. The maximum voltage dip or rise shall not exceed 9 percent of rated value during the load changes specified herein.

3.2.11 Regulated voltage adjustment. Provisions shall be made to adjust the regulated voltage within the range of 5.0 percent above and below rated voltage in steps of not more than 0.2 percent of rated voltage at any load from no load to 100 percent of rated load at rated power factor.

3.2.12 Harmonic content. From no load to full load, the r.m.s. value of the sum of all of the harmonics in the output voltage wave shall not exceed 3 percent of the r.m.s value of the rated output voltage. The r.m.s. value of any single harmonic shall not exceed 2 percent of the r.m.s. value of the rated output voltage. Harmonics of 0.1 percent or less, of the r.m.s. value of the rated output voltage may be disregarded in the determination of the harmonic content of the output voltage wave.

3.2.13 Amplitude modulation. Amplitude modulation of the output voltage of the generator when operating with its intended voltage regulator shall not exceed 1 percent of the peak to peak voltage. This requirement shall apply for any loads between no load and rated load and at any power factor between 0.6 (lagging) and unity.

3.2.14 Line unbalance. The difference between line voltages shall be not greater than 5 percent of rated voltage on application of a single phase load of 15 percent rated current at any power factor between 0.8 and unity to any line of the generator which is already loaded with a balanced three phase load of 75 percent of rated current.

3.2.15 Voltage balance. The difference between line voltages at the output terminals of the power supply (load side of circuit breaker) shall be not greater than 0.5 percent of rated voltage at no load or for any balanced three phase current up to rated current at any power factor between 0.8 and unity.

3.2.16 Generator short circuit ratio. The generator short circuit ratio shall be not less than 0.6.

3.2.17 System short circuit performance. The motor generator and control shall produce short circuit current as follows:

(a) $I^2t = 1100$.

Where:
I = Sustained steady state generator output current (per unit value).
t = Time in seconds.

(b) The minimum value of generator short circuit current shall be three per unit.
(c) The peak value of short circuit current shall not exceed 11 per unit.

The requirements specified herein shall be met under the following three phase short circuit condition:

Initial load	Control	Generator field temperature
No load	Automatic	Hot

Hot field temperature shall be equivalent to normal full load rise obtained from the heat run plus the specified ambient temperature (50°C.). The design of the motor generators and control equipment shall be such that it can withstand a short circuit current of the magnitude required without damaging the equipment. Upon removal of the short circuit, rated voltage shall be automatically restored. No relays shall be used to provide excitation to obtain the short circuit characteristics specified herein.

3.2.18 Parallel operation. Parallel operation when required (see 6.1) shall be provided as follows:

(a) The equipment shall be designed so that up to three motor generators and control equipment of identical design will operate in parallel in accordance with the requirements specified herein. Parallel operation shall be accomplished by cross-current compensation of the voltage regulators.

3.2.18.1 Parallel operation performance. The maximum difference in kilovar (kvar) supplied by generators operating in parallel shall not exceed the following limit under any load condition between 20 and 100 percent of rated load. This requirement shall also apply for input voltage and frequency variation specified in 3.2.1(a)(7), variation in equipment temperature from ambient to full load rise, and variation in power factor between 0.8 lagging and unity.

(a) The maximum difference in kvar supplied by the generators in parallel shall not exceed 10 percent of kvar rating of one of the generators.

3.2.19 Dielectric strength. The motor generator and associated control equipment shall be capable of withstanding a dielectric strength test (see 4.6.6) of twice the normal voltage of the circuit plus 1,000 volts for 1 minute.

3.3 Detailed requirements.

3.3.1 General. Equipment covered by this specification shall conform to MIL-E-917 unless otherwise specified herein. The equipment shall form a complete power supply consisting of a motor generator and its associated control equipment.

3.3.2 Reliability. To meet the needs of the Naval service, it is imperative that reliability of operation be considered of prime importance in the design and manufacture of the equipment. The supplier shall employ all reasonable methods possible in the process of manufacture to assure quality and maximum reliability. In order to insure high equipment reliability under all service conditions to avoid marginal applications and provide adequate safety factors, it may be necessary to derate certain parts from their rated values when applying them to equipment circuits. The design shall include all possible features which will result in reliable and stable operation with minimum need for adjustment and alignment, and with Mean-Time-Between-Failures (MTBF) not less than 2500 hours for the entire motor generator and associated control system.

3.3.2.1 Equipment failure is defined as occurring when either the equipment ceases to function or its performance degrades below the requirements of this specification.

3.3.2.2 The MTBF shall be predicted in accordance with MIL-HDBK-217 (see 6.4). The section "How to Make a Reliability Prediction Based on Stress Factors and Part Populations" shall be used for the method of prediction and report format. The most critical items shall be identified in reliability prediction in accordance with MIL-STD-785 (see 6.4).

3.3.2.3 Failure rate data used shall be as given primarily in MIL-HDBK-217 (see 6.4). Failure rate data from other sources or estimated failure rates, if necessary, shall be submitted to the procuring activity for approval prior to use. In the event other sources than quoted herein are used for failure rates derivation, detailed substantiation shall be given. No acceleration factors shall be used unless justified by special quality assurance controls and justification submitted.

3.3.2.4 Stress levels shall be calculated from design data in accordance with MIL-HDBK-217 (see 6.4). The operating electrical and thermal stress levels shall be obtained during the tests of 4.6.19 and 4.6.20. The stress levels obtained by test shall be compared to the application ratings (maximum stress levels allowed) given by part or unit vendors and the calculated stress levels using tabular form. Where parts are found by test or calculation to be stressed beyond the application rating (maximum stress level) necessary design changes shall be made and stress level tests shall be repeated. Where the test and calculated values differ by more than 10 percent a second stress calculation shall be made on that part to determine cause of discrepancy.

3.3.2.5 The contractor shall submit the Reliability Predictions and definition of failure in terms of actual equipment configuartion to the procuring activity for approval.

3.3.3 Maintainability. The contractor shall establish the maintainability program which shall be integrated with the equipment design engineering program. The maintainability program shall be consistent with the type and complexity of equipment, and shall contain but shall not be limited to the following:

(a) Maintainability program plan.
(b) Maintainability analysis and corrective action system.

3.3.3.1 The maintainability shall be defined in terms of Geometric-Mean-Time-To-Repair ($MTTR_G$). $MTTR_G$ for the equipment shall be 2 hours maximum. Equipment repair time (ERT) for any one item shall not exceed 6 hours.

3.3.3.2 The contractor shall define in the Maintenance Program Plan how he will develop and conduct the maintainability program to meet the quantitative requirements. He shall compute $MTTR_G$ predictions and submit them to the procuring activity for approval.

3.3.3.3 The $MTTR_G$ shall be predicted in accordance with MIL-HDBK-472 (see 6.4), maintainability prediction procedure II. The failure rates used shall be the same as used for the reliability prediction. Wherever the expected life of the part or unit is shorter than the expected life of the equipment, the replacement of the part or unit shall be scheduled in the preventive maintenance section of the technical manual for the equipment so as to prevent equipment failures due to wear out of its parts.

3.3.3.4 Preventive maintenance shall be simplified so as to reduce the need for highly skilled maintenance personnel. The complexity of maintenance shall be reduced by providing adequate accessibility, and clearance, and by providing for interchangeability of like units and parts. All essential parts shall be interchangeable physically and electrically with corresponding repair parts without selective matching, drilling, filing, or use of undue force.

3.3.3.5 Corrective maintenance downtime shall be reduced by designing for rapid and positive detection of malfunction or degradation (implementation of indicators, test points, and so forth), ease of fault correction, and rapid positive verification of correction.

3.3.3.6 Equipment shall be subjected to a maintainability demonstration test. Sample size of corrective maintenance actions shall be 20, sample selection in accordance with the "Task Selection" appendix, "Corrective maintenance sample selection" table of MIL-STD-471 (see 6.4). $MTTR_G$ shall be computed by the following formula:

$$\log MTTR_G = \frac{\sum_{i=1}^{20} (\log M_{ci})}{20}$$

where M_{ci} is the repair time of corrective maintenance action "i".

3.3.3.6.1 A maintenance test plan shall be prepared and submitted to the procuring activity for approval before the tests commence. The plan shall define in detail the maintainability actions to be performed during the test. The plan shall provide for random selection of failure events to be chosen at the time of the test.

3.3.3.6.2 A report of the maintainability test shall be prepared by the contractor and submitted to the procuring activity.

3.3.3.7 Data collection. The contractor shall establish and maintain a data collection system covering failure modes and effects, analysis, and corrective action throughout all stages of development, production and testing of the equipment. Any failure that occurs shall be thoroughly analyzed and recorded in the log book. The corrective action shall be implemented and design review shall be initiated as necessary to improve the reliability and maintainability of the equipment and to meet the quantitative requirements. All failures and actions taken shall be reported to the procuring activity in two reports: (a) prior to first delivery and (b) with the last equipment delivered.

3.3.3.8 The control equipment shall be designed to permit easy installations and to keep maintenance requirements to a minimum, both in level of skills and in number of personnel required to maintain the equipment. The equipment shall also be designed so that it can be maintained by replacement of easily removed parts, modules, or subassemblies. The design shall follow design for maintainability considerations in MIL-STD-470 (see 6.4) and NAVSHIPS 94324 (see 6.4).

3.3.3.9 Human engineering requirements. Human engineering requirements shall be in accordance with MIL-H-46855 (see 6.4).

3.3.3.10 Test equipment. The motor generator shall be so designed as to be capable of being maintained, aligned, calibrated, and repaired with the aid of the following test equipment:

(a) Clamp-on volt-ammeter - 0 to 600 amp and 0 to 600 volts a.c. range, FSN: 1N6625-284-0855 or 1N6625-879-1231, MTN: CV-633 or AN/USM-33.
(b) Multimeter - 0 to 4000 volts d.c., 0 to 800 volts a.c., 0 to 16 amps d.c. and 0 to 200 megohm range; FSN: 1N6625-684-3082; MTN: AN/USM-123; G.E. Simpson Model 269 or equivalent.
(c) Oscilloscope - FSN: F6625-787-0309, MTN: AN/USM-117.
(d) D.c. milliammeter - 0 to 150 ma range; FSN: 2N6625-945-2759; MTN: CV-931-4904-003.
(e) A.c. voltmeter - 0 to 600 volts range, FSN 1N6625-184-5337; MTN: MR71W600ADVV in accordance with MIL-M-16034.
(f) An isolated variable voltage d.c. power supply 0 to 35 volts (0 to 3 amp capacity).

Contractors desiring to utilize test equipment other than specified herein, shall submit to the procuring activity with justification, the necessity for using such test equipment, prior

to the start of manufacture of the equipment. Test equipment required for maintenance not listed herein, in the Portable Test Equipment list for Electric Plant, or in Publication 0969-019-7000 shall be furnished by the contractor with the motor generator.

3.3.3.11 Plan for use. Unless otherwise specified (see 6.1), reliability and maintainability calculations shall be based on average operating time of 4 days per week or 139 days per year. System characteristics shall be as specified for type II power of MIL-STD-761. Loads shall be considered to vary between one-quarter, one-half and full load steps changing at 1 hour intervals.

3.3.4 Enclosures. The motor generators and control equipment shall be furnished in dripproof protected 12 degree enclosures in accordance with MIL-E-2036.

3.3.5 Insulation class. Insulation shall be class B, C, F or H in accordance with MIL-E-917, as selected by the manufacturer.

3.3.5.1 If insulation classes are mixed within a motor generator, the thermal rating of the lesser temperature class of insulation shall not be exceeded.

3.3.6 Heating. The motor generators and control equipment shall be so designed that the temperature rises do not exceed those shown in table I when tested in accordance with 4.6.20.2.

Table I - Maximum permissible temperature rise (°C.) (based on 50°C ambient - continuous rated load).

Name of part [3/]	Insulation class			
	B	F	H	C [1/]
Bearings	60	60	100	
Coils - measured by thermocouple or thermometer	60	85	120	
Measured by resistance	70	95	140	
Cores and mechanical parts adjacent to insulation	60	85	120	
Air-within 1/2 inch of meters	15	15	15	
Capacitors - Air within 1/2 inch of case	35	35	35	
Rectifiers - selenium [2/]	25	25	25	
Rheostats and resistors:				
Bare resistor material	375	375	375	
Resistor embedding material	300	300	300	
Bolted connections and terminal studs:				
Not plated	50	50	50	
Silver plated	65	65	65	
Contact:				
Solid	70	70	70	
Solid, silver faced	80	80	80	

1/ Maximum temperature depends on class of insulation used.

2/ Silicon rectifiers, voltage reference elements, voltage regulator elements and transistors - permissible temperature rise on these parts is dependent upon operating conditions. Maximum permissible case temperature shall be shown on the equipment drawing (see 3.7).

3/ Where no measurement method is indicated, thermometer or thermocouple method is used.

3.3.7 Material restrictions. The minimum requirements for materials to be used shall be as shown in table II.

Table II - Minimum material requirements.

Item	Material	Specification	Limitations
Caps and cartridge	Steel	See Note 1	
Ball bearing end brackets, terminal boxes, covers, housing, vee rings, shells, drip covers baffles, hand hole as access covers	Malleable iron	QQ-I-666	
	Nodular graphitic iron	MIL-I-24137	
Eye bolts	Steel		
Fans	Steel	See Note 1	
	Aluminum		
Grease	Petroleum	MIL-G-18709	Bearings operating at 110°C and below
Springs	Steel carbon		Cadmium plated and baked after forming
	Steel corrosion resistant		
	Copper-beryllium		
Shaft	Steel		Tensile strength not less than 75,000 p.s.i. and elongation not less than 20 percent in 2 inches
Spider and quills	Steel	See Note 1	

Note 1 - Unless otherwise shown in table II, steel parts may be cast, fabricated, wrought or forged. Cast steel shall be in accordance with grade B of MIL-S-15083, except that radiographic and magnetic particle examination will not be required.

3.3.8 Lifting provisions. Motor generators, control panels, and separately mounted control units weighing over 150 pounds shall be provided with eyebolts or other suitable means for hoisting and handling.

3.3.9 Identification and information plates. The identification and information plates shall be attached to the part of the machinery or equipment which will not ordinarily be renewed during its normal service life. These plates shall be located where they can be read at all times without danger to personnel. Identification plates and information plates shall be made of brass, nickel-copper-alloy or corrosion resistant steel. The markings shall be etched, stamped, engraved, metal-photo on anodized aluminum or cast in such a manner as to produce permanent and durable markings to last the anticipated life of the equipment. All etchings, engravings or stampings shall be not less than 0.003 inch deep. The characters on cast plates shall be raised to at least 0.03 inch. All engraved stamped or direct etched markings shall be filled with black paint enamel or lacquer (see 3.4.23 and 3.5.5.10 for details of information to be shown on the identification plates).

3.4 Motor generator.

3.4.1 General. The motor generator shall be of the two bearing type with the motor and the generator rigidly coupled together in such a manner that the combined unit will be capable of maintaining proper alignment without dependence upon the supporting structure of the ship, and shall not require any additional structural bedplate. The rotating elements of the motor and generator shall be mounted on a single one piece shaft.

3.4.2 Mounting. The motor generator shall be designed for horizontal deck mounting. The size of the mounting bolts shall be selected by the manufacturer in accordance with table III and the following:

(a) Mounting bolts shall be no less than grade 2 of MIL-B-857.
(b) Minimum bolt size shall be 3/4 inch.
(c) Maximum bolt size shall be 1-1/2 inches.
(d) Mounting bolt holes shall be round.
(e) Bolt hole diametrical clearance shall be 1/32 inch for 3/4 inch bolts and 1/16 inch for bolts over 3/4 inch.

Table III - Maximum weights and dimensions.

Rating	Control arrangement	Maximum Motor Generator Unit Dimensions and Weights				Maximum Control Cabinet Dimensions and Weights				Maximum motor Generator Mounting Dimensions	
		Length	Width 1/	Height 2/	Weight	Depth 3/	Width	Height 2/	Weight	Length	Width
kw.		Inches	Inches	Inches	Pounds	Inches	Inches	Inches	Pounds	Inches	Inches
5	A	36	20	22	900	12	28	36	300	18	15
5	B	36	20	22	900	12	28	36	300	18	15
10	A	42	24	24	1200	12	28	36	300	21	18
10	B	42	24	24	1200	12	28	36	300	21	18
15	A	44	24	26	1500	12	28	36	300	22	18
15	B	44	24	26	1500	12	28	36	300	22	18
30	A	50	28	28	2200	12	28	36	300	25	21
30	B	50	28	28	2200	12	28	36	300	25	21
60	A	60	34	30	3300	12	28	36	300	30	25
60	B	60	34	30	3300	12	28	36	300	30	25
100	A	64	36	32	4500	16	28	48	500	32	27
100	B	64	36	32	4500	16	28	48	500	32	27
200	A	80	46	46	8500	16 16	28 28	48 48	500 500 5/	As required 4/	
200	B	80	46	46	8500	16 16	28 28	48 48	500 500 5/	As required 4/	
300	A	86	46	46	9500	16 16	28 28	48 48	500 500 5/	As required 4/	
300	B	86	46	46	9500	16 16	28 28	48 48	500 500 5/	As required 4/	

1/ Includes terminal box.

2/ Does not include removable lifting provisions.

3/ Does not include guard rail.

4/ 200 and 300 kw motor generators shall have six mounting bolt holes. Length between holes shall be equal and physically located about the center of gravity of the motor generator.

5/ Motor starter cabinet.

3.4.3 Dimensions and weight. The motor generators shall be as light as possible consistent with specified performance and design. The maximum dimensions and weight shall be as shown in table III.

3.4.4 Airborne noise. Motor generators shall be designed to produce minimum airborne noise. The airborne noise limits, instrumentation and measurements shall be in accordance with MIL-STD-740 and the following:

(a) Grade - Grade D equipment.
(b) Operating condition - No load to full load at input voltage specified herein.

3.4.5 Internally excited vibration.

3.4.5.1 Mechanical balance. Motor generators shall be balanced at any load in the operating range. Windings not in mechanical symmetry shall have dummy coils. In general, the proper mechancial balance shall be effected by the use of balance weights securely attached (if bolts are used, corrosion-resistant bolts and locknuts shall be required), removal of material, securely welded steel weights, or by metal carried in a receiver in such a manner as to preclude its breaking loose.

3.4.5.2 Balance limits. The maximum allowable amplitude in inches shall be as shown in table IV.

Table IV - Mechanical balance.

Weight of motor generators	Maximum allowable peak to peak amplitude
	Balance
pounds	Inch
Up to 350	0.0005
From 351 to 800	.00075
From 801 to 2,000	.001
From 2,001 and up	.0015

3.4.6 Bearings.

3.4.6.1 Radial, single row, both races extended, sealed, cartridge type, type 120 in accordance with FF-B-171 shall be used up to and including size 315. Size 316 and larger shall be single shielded, type 111, class 2. When cartridge type 120 bearings are used, a plate bearing the warning "DO NOT LUBRICATE" shall be secured to the end brackets.

3.4.6.2 Series. Ball bearings shall be of medium series.

3.4.6.3 Mounting diameters and tolerances. The shaft, shoulder, housing, and housing shoulder diameters shall be in accordance with the values shown in table V.

Table V - Bearing shaft, shaft shoulder, housing and housing shoulder diameters.

Bearing	Shaft diameter		Shaft shoulder diameter	Housing diameter		Housing shoulder diameter
	Minimum	Maximum	Minimum	Minimum	Maximum	Maximum
305	0.9844	0.9847	1.140	2.4409	2.4416	2.280
306	1.1812	1.1815	1.340	2.8346	2.8358	2.620
307	1.3781	1.3785	1.590	3.1496	3.1503	2.940
308	1.5749	1.5753	1.813	3.5433	3.5442	3.310
309	1.7718	1.7722	2.000	3.9370	3.9379	3.660
310	1.9686	1.9690	2.270	4.3307	4.3316	4.000
311	2.1655	2.1660	2.468	4.7244	4.7253	4.380
312	2.3623	2.3628	2.688	5.1181	5.1191	4.750
313	2.5592	2.5597	2.968	5.5118	5.5131	5.190
314	2.7560	2.7565	3.156	5.9055	5.9068	5.560
315	2.9529	2.9534	3.380	6.2992	6.3005	5.940
316	3.1497	3.1502	3.550	6.6929	6.6942	6.250
317	3.3466	3.3472	3.840	7.0866	7.0879	6.620
318	3.5434	3.5440	4.060	7.4803	7.4817	7.000
319	3.7403	3.7409	4.290	7.8740	7.8754	7.380
320	3.9371	3.9377	4.488	8.4646	8.4660	7.940

3.4.6.4 Bearing pre-load washers or springs. The use of bearing pre-load washers or springs or both are preferred. Washers and springs up to sizes 312 shall be secured in the housing to preclude their falling out of the end bracket during repairs and maintenance of the motor generator.

3.4.6.5 Mounting. The bearings shall be mounted as follows:

(a) Fixed free method - When the bearings are secured to the shaft by means of locknuts and lockwashers, the following requirements shall apply: One end bearing shall be fixed axially in the housing by suitable housing and end cap shoulders. The axial movements of the shaft shall be not more than 0.010 inch for size 310 and smaller bearings and 0.015 inch for bearings larger than size 310.

(b) Opposed shoulder method - When the opposed shoulder method is used, the following information shall be submitted to the procuring activity:
   (1) The initial end play required (to compensate for thermal expansion differentials between shaft and housing).
   (2) The method used to measure end play.

3.4.6.6 Heat stablization. Bearings operating above 110°C shall be heat stabilized so that their dimensions do not increase more than 0.0001 inch per inch of diameter during 2500 hours at 149°C.

3.4.6.7 Housing construction. The bearing housing shall be constructed to permit ready removal of the end bracket without the necessity of removing the bearings from the shaft. The housing shall have sufficient metal to permit redrilling and bushing.

3.4.6.8 Removal of bearing. The design shall be such as to permit removal of the ball bearing by pulling on the inner ring of the bearing with one of the tools contained in a "complete" Naval shipboard set of tools specified in GGG-P-781.

3.4.7 Fans. Fans shall be keyed to the shaft to prevent rotation and shall be secured in a manner to prevent axial displacement of the fan along the shaft. Shoulders, lockwashers and nut, sleeves or clamping bolts (in the case of split fan) may be used. Shrink rings or press rings may be used where the fans do not have to be removed from the shaft during disassembly of the motor generators. Locked set screws may be used only where closed end key seats or woodruff keys are used.

3.4.8 Cores.

3.4.8.1 Mounting. Cores shall be secured to the shaft, spider, or frame so as to prevent their axial and rotational displacement under operational or test conditions. A pin through the shaft is not an acceptable means of preventing axial displacement. Welding shall not be used to secure the core or quill to the shaft. The use of spiders constructed of individual flutes welded to the shaft is acceptable when preheat and stress relieving procedures satisfactory to the procuring activity are employed. Press or shrink fits without keys shall be approved by the procuring activity.

3.4.8.2 Accessibility. To remove or insert the rotor it shall be unnecessary to remove any stationary windings or remove any of the motor generator mounting bolts.

3.4.9 End brackets. An accurately machined shoulder joint shall be provided between the frame and the end brackets. End brackets shall be secured to the frame by not less than four hexagon-head bolts. Resilient gaskets shall not be placed between any bearing support member and the frame. Openings of adequate size and number shall be provided so as to give easy access to and a direct view of the rotating rectifiers. The enclosing covers (handhole or access-hole covers) shall be readily removable. The engaging bolts or locking devices shall be attached to the frame, the end bracket, or the cover as the design permits, in such a manner as to prevent the bolts or locking devices from being misplaced or dropped into the machine during repair operations.

3.4.10 Feet. Feet shall be machined on the mounting surfaces and shall be either cast integral with, bolted or welded to the frame and shall be provided with round holes for holding-down bolts.

3.4.11 Shaft. The motor generator shaft shall be one piece.

3.4.12 Field poles and shoes. Field poles and shoes may be an integral part of the complete rotor or stator lamination and need not be individually removable. The method of securing rotating field poles to the shaft or spider shall result in a factor of safety of not less than 2.0, based on the elastic limit of the material and the rated speed of the motor generator.

3.4.13 Field coils. Field coils shall be thoroughly insulated from adjacent conducting and grounded parts. All coils shall be completely one-half lap wrapped with tape before the varnish dip and bake. All field coils in the same machine shall be readily interchangeable. The coils shall be so secured that they cannot become loosened or damaged by vibration, or produce vibration by a slight shifting in the coils position.

3.4.14 Coil connections. All coil connections shall be made on the exterior end of the generator.

3.4.15 Excitation requirements. The motor and generator design, construction, assembly, and quality control exercised shall be such that the ampere turn requirements for the motor and generator at any load do not differ more than plus or minus 10 percent from the design or nominal value.

3.4.16 Stray field reduction. To reduce the stray magnetic field the motor generator shall incorporate the following:

(a) Stray magnetic fields caused by electrical circuits shall be kept to a minimum by making the area of electrical current loops as small as possible and arranging adjacent loops so that their fields will be in opposition. Current loops shall enclose no magnetic material unless essential for proper performance of equipment. All motor and generator windings and connections shall be balanced for ampere-turns around the shaft to eliminate stray fields insofar as possible. Each circuit, which makes even part of a turn around the machine shall return on itself back to the starting point, with conductors for the forward and reverse currents arranged at the same end of the machine and as close as adequate insulation permits. All connections shall be as short as possible.

3.4.17 Electromagnetic interference. The equipment shall be designed to ensure a minimum amount of electromagnetic interference.

3.4.18 Terminal boxes. Terminal boxes shall be provided and shall be securely bolted or welded to the frame. The boxes shall not have any openings but shall be suitable for the drilling and installing of cable clamps or stuffing tubes by the installing activity. Terminal boxes not readily removable from the motor generator shall be provided with removable plates for the purpose of drilling as specified herein. Gaskets shall be furnished under all terminal box covers; removable plates; and between the box and motor generator frame, if the box is bolted to the frame.

3.4.19 Terminal boards.

3.4.19.1 Generators having a rating of 10 kw or less. A lead clamp shall be provided for the terminal leads. The terminal leads shall not be attached to the end brackets but shall be attached to the frame instead and shall extend to at least 6 inches beyond the point of support. The methods of fastening shall be such that no strain from the outside can come upon the connections within the generator frame. The use of unclamped rubber bushings is not a suitable method of securing such leads. The end of each generator lead shall be fitted with a connector of either the solder or the solderless type which shall be satisfactory to the procuring activity. Terminal lead holes in the generator frames shall have all edges rounded to prevent injury to lead insulation. The leads shall be enclosed in a terminal box which shall be solidly attached to the generator frame. A gasket shall be placed between the terminal box and the frame. The joints of the terminal box shall be of dripproof construction.

3.4.19.2 Generators having a rating greater than 10 kw. All motor generator leads shall terminate at a terminal board within the terminal box. The terminal board shall be securely mounted within the terminal box in such a manner as to permit connection of the internal leads to the back of the board and the external leads to the front of the board. Terminal studs shall be secured to the boards in a manner to prevent turning of the studs when tightening or loosening the nuts used to secure lead connectors. Terminal identification corresponding to the lead identifications specified in MIL-STD-195 shall be permanently marked on the front of the terminal board.

3.4.20 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 generator frame, terminal box, piping or cable clamps.

3.4.21 Securing terminal leads. Leads shall be secured to prevent their coming in contact with moving parts or being chafed by contact with stationary parts. Leads shall not be secured to end brackets or in any other manner which would prohibit ready removal of the end brackets or rotating assembly. Terminal leads shall be secured to the terminals on the terminal board by means of solderless connnectors and jam nuts or lock washers or nuts to prevent the connectors from loosening under shock or vibration.

3.4.22 Lead identification. All motor and generator leads shall be permanently marked in accordance with MIL-STD-195. In order to achieve standard marking of all leads, all motor generators shall rotate clockwise when facing the generator end. The direction of rotation shall be permanently marked on the frame of the motor generator by means of an instruction plate stating "rotation" with an arrow in the direction of the rotation.

3.4.23 Identification plate markings. A separate plate for the motor and the generator or a single larger plate may be furnished. The minimum data to be marked on the identification plate (or plates) shall include the following:

(a) Major unit name (that is a.c./a.c. motor generator).
(b) Federal stock number.
(c) Manufacturer's name and serial number.
(d) Technical manual number.
(e) Contract number and year of manufacture.
(f) Blank space for inspector's official acceptance stamp.
(g) Salient design characteristics of motor, namely, horsepower, phase, voltage, current, speed, class of insulation and maximum ambient temperature.
(h) Salient design characteristics of generator, namely, kw., power factor, voltage, current, frequency, number of phases, class of insulation and maximum ambient temperature.

3.4.24 Permanent marking.

3.4.24.1 Magnet frame. The manufacturer's name, serial number and the Federal stock number (where available) shall be stamped underneath the identification plate in the solid metal of the magnet frame.

3.4.24.2 Rotating element. The rotating element shall be marked with the manufacturer's serial number and Federal stock number (where available) shall be stamped on the shaft.

3.5 Control equipment.

3.5.1 General. Control equipment requirements in addition to those which affect the combined system performance and the detailed requirements of 3.3 shall be as specified herein.

3.5.2 Arrangements. Control equipment shall be furnished in either one of the following arrangements as specified (see 6.1).

(a) Arrangement A.
(b) Arrangement B.

3.5.2.1 Arrangement A. When control arrangement A is specified, the following equipment shall be furnished:

(a) Motor starter or circuit breaker (see 3.5.4.7).
(b) Motor starter overload relay reset pushbutton.
(c) Voltage regulator.
(d) Generator circuit breaker.
(e) Voltmeter for a.c. generator output.
(f) Ammeter for a.c. generator output.
(g) Wattmeter for a.c. generator output.
(h) Regulated voltage adjusting rheostat.
(i) Motor starter start-stop pushbutton.
(j) Synchroscope (when paralleling is specified (see 3.5.4.12 and 6.1)).

For motor generators 100 kw and less, items (a) through (i) shall be located in a single bulkhead mounted control cabinet. Fo motor generators above 100 kw, items (a) through (c) shall be located in one bulkhead mounted control cobinet; items (d) through (j) shall be located in a second bulkhead mounted control cabinet.

3.5.2.2 Arrangement B. When control arrangement B is specified, the following equipment shall be furnished:

(a) Motor starter.
(b) Motor starter overload relay reset pushbutton.
(c) Voltage regulator.
(d) Regulated voltage adjusting rheostat.
(e) Motor starter start-stop pushbutton.

For motor generators 100 kw and less, items (a) through (e) shall be located in a single bulkhead mounted control cabinet. For motor generators above 100 kw, items (a) and (b) shall be located in one bulkhead mounted control cabinet; items (c), (d) and (e) shall be located in a second bulkhead mounted control cabinet.

3.5.2.3 Test points. Test points in accordance with MIL-STD-415 shall be provided for the voltage regulator. Sufficient test points shall be brought out to a jack board in order to monitor equipment operation while performing all facets of equipment trouble shooting. These test points shall also be capable of being utilized during normal operation without adversely affecting system performance. Test points for voltage readouts shall not be utilized if a voltmeter is installed for continuous readings. The test points shall be readily accessible for use by service personnel. Each circuit point shall be clearly identified. In addition to individual jacks for each point, the points may also be connected through a selector switch or switches to a single jack.

3.5.3 Enclosures.

3.5.3.1 Mounting. All control equipment enclosures shall be designed for bulkhead mounting. Mounting holes shall be round and have a diametrical clearance of 1/16 inch. Mounting bolts shall be not less than 5/8 inch in diameter. The enclosure shall not be supported from more than one plane.

3.5.3.2 Dimensions and weights. The control equipment enclosures shall be as light and compact as possible, while consistent with specified performance and design. The dimensions of all bulkhead mounted cabinets shall not exceed the dimensions shown in table III.

3.5.3.3 Enclosure face. When control arrangement A is furnished, all instruments, switches, rheostats, circuit breakers, and other parts needed for normal control of the equipment shall be mounted on the front of the panel. The automatic voltage adjusting control is not considered a normal adjustment and shall not be mounted on the front of the control panel, but at a readily accessible location within the panel. The meters shall be mounted at the top of the panel.

3.5.3.4 Accessibility. All parts which require servicing, repair, replacement, or periodic adjustment during the life of the equipment shall be readily accessible through the front of the panel or enclosure. Accessibility shall be obtained by providing hinged full doors. Wherever practicable, subassemblies shall be utilized in the design of the equipment in order to reduce the time required for service and maintenance, for example, separate assemblies for the voltage detector and individual amplification stages.

3.5.3.5 Positioning devices. The hinged door shall be provided with stops and positioning devices to automatically stop it in its open positions and to prevent its moving from those positions due to gravity or ship motion. Its full open position shall be at least enough to permit unimpeded access and shall minimize obstruction of working or passage areas. Intermediate stops shall be provided when added convenience for maintenance will result.

3.5.3.6 Internal temperature. The design of the equipment enclosure and the placement and selection of parts shall be such that no part will be exposed to a higher operating temperature than the maximum rated temperature for the part.

3.5.3.7 Heating. Circuit design shall not require the use of heaters to obtain proper operation with varying ambient temperature or the variation in temperature rise within the enclosure due to heating of parts under different operating conditions.

3.5.3.8 Guard rails. All deck mounted control panels shall be provided with vertical grab rods located so that an operator will have means of support while operating the panel. The rods shall be of smooth hardwood, or other non-conductive material supported with a sufficient number of brackets to provide adequate support for personnel under all operating conditions of the ship. The rods shall not interfere with the opening of the doors nor shall their removal be required to open the door. The rods shall not interfere with operation of the equipment and shall not extend more than 6 inches from the front of the panel. The rail shall be capable of resisting a force of 400 pounds applied at any point on the rail without permanent distortion or damage to the rod or supporting means.

3.5.3.9 Operating and maintenance instructions. A reduced size copy of abbreviated operating instructions, complete schematic diagram of the system and wiring diagram shall be laminated in plastic and stowed in the control equipment panel or enclosure. The diagram printing process shall be such that fading of the recorded information will not occur. The diagrams and instruction sheets shall be either mechanically attached to enclosure doors or stowed in racks in the enclosure in such a manner as not to interfere with operation of the equipment.

3.5.3.10 Ventilation. Forced draft ventilation shall not be used.

3.5.4 Parts and subassembly requirements.

3.5.4.1 Parts and subassembly mounting. In order to prevent the possibility of displacement of parts and subassemblies due to shock and vibration, the use of slotted mounting bolt holes is prohibited. The holes shall be round with a minimum diametrical clearance over the mounting bolt diameter. In no case shall the diametrical clearance be greater than 1/16 inch. Parts and subassemblies previously approved as a qualified product shall be mounted in a manner similar to the way they were mounted when subjected to the HI shock and vibration tests during their qualification testing.

3.5.4.2 Part and terminal markings. All parts and terminals shall be marked with the identifying designations shown on master drawings. Wherever practicable, the designations shall be in accordance with MIL-STD-195. The identifying designations may be made by metal stamping, engraving, silk screening, stenciling, or rubber stamping; however, silk screening, stenciling, or rubber stamping may not be used on terminal boards.

3.5.4.3 Adjustable circuit elements. The number of adjustable circuits shall be kept to an absolute minimum and limited to those adjustments required by maintenance personnel. When 100 percent adjustable resistors are used, a fixed series resistor shall be employed to protect circuitry from overload due to improper adjustment of the variable resistor. A complete description and instructions for such adjustment shall be included in technical manuals.

3.5.4.4 Mechanical stability. All controls of the equipment shall be so designed that when the equipment is properly installed and whether operating or nonoperating, the setting, position, or adjustment of any control shall not change due to normal service conditions.

3.5.4.5 Adjustment locking devices. Adjustment locking devices, where used, shall be capable of retaining the controls in any given setting within the range of control under shock and vibration. The locking and unlocking action shall be easily and quickly accomplished with the equipment energized and shall not affect the setting of the control. When in the unlocked position, the locking device shall not interfere with the normal operation of the control. Where vernier controls are used, the locking device shall operate on both main and vernier controls.

3.5.4.6 End stops. Each control which is not capable of an unlimited degree of motion without damage shall be provided with positive end stops to limit the degree of motion of the control to that within its normal excursion or within its range of calibration. Where flexible control shafts are employed, end stops shall be provided on the driving end of the shaft.

3.5.4.7 Motor starter. Motor generator starting shall be accomplished in accordance with the following:

(a) Applications requiring the use of size 4 controllers or smaller shall use controllers in accordance with MIL-C-2212.
(b) Applications requiring the use of size 5 controllers or greater shall use controllers in accordance with MIL-C-2212 or circuit breakers in accordance with MIL-C-17361.

3.5.4.7.1 Motor controllers shall be as required by the application and shall meet the requirements of MIL-C-2212 and the following:

(a) Operation shall be magnetic.
(b) Low voltage protection and overload protection with hand reset shall be provided.

3.5.4.7.2 Circuit breakers when used for starting shall be type AQB with electric closing attachment and under voltage protection in accordance with MIL-C-17361. The trip unit shall provide thermal protection required by MIL-C-2212. If such protection cannot be obtained with circuit breakers only, overload relays in accordance with MIL-C-2212 shall be used. Instantaneous trip shall have an "M" calibration.

3.5.4.7.3 Master switches shall be in accordance with MIL-C-2212.

3.5.4.8 Voltage regulator. The voltage regulator and excitation system shall be designed to meet the system performance requirements specified in 3.2 when operating with its intended motor generator and as follows:

(a) Type - static. That is, one which does not employ vibrating contacts, carbon piles, electron tubes or mechanically-moving parts such as relays and

tachometers. This restriction does not apply to switching devices required to start the motor generator or to sychronize and interconnect the motor generators for parallel operation. Sliding contact variable resistors and rheostats other than those varied only by manual means will not be permitted. The required performance shall be obtained through circuits using transformers, reactors, magnetic amplifiers, diodes, transistors, rectifiers, resistors and capacitors which control the field of the rotating brushless exciter.

(b) Circuit controlled. The specified performance requirements shall be met by controlling the generator main fields from the rectified output of the brushless exciter.

(c) Votage control. The voltage regulator shall provide for generator output voltage build-up upon starting as specified in 3.2.8. Overvoltage limitation shall be provided as a part of the voltage regulator to protect the equipment against overvoltage due to loss of sensing or failure of parts or circuitry. The overvoltage limiting circuit shall sense the generator terminal voltage and limit it to 135 percent of the rated voltage.

(d) Compensation for parallel operation. The reactive load division circuits provided to meet the parallel operation requirements specified in 3.2.18.1 shall be automatically energized through auxiliary contacts on the generator circuit breaker so that generators being brought on will automatically be parallel with the generator (or generators) already on the line when its circuit breaker is closed. The reactive load division circuits shall be adjustable to compensate for differences in reactive load sharing characteristics of the generators. The adjusting means shall be located on the inside of the voltage regulator enclosure.

3.5.4.9 Generator circuit breakers. Generator circuit breakers, when required in 400 Hz outputs (see 3.5.2.1), shall be type ALB conforming to MIL-C-17588 for generator full load currents up to and including 100 amperes; or type AQB conforming to MIL-C-17361 for generator full load currents above 100 amperes. Circuit breakers shall be equipped with a 115-volt d.c. shunt trip device and an auxiliary switch. ALB-5 circuit breakers rated at 125 volts shall be satisfactory for 450 volt applications where the interrupting capacity of the breaker is greater than the maximum current available in the system.

3.5.4.10 Voltmeter. The voltmeters when required (see 3.5.2.1) shall be 4-1/2 inch 250 degree scale switchboard type conforming to MIL-V-23151. The meter shall be suitable for operating directly from the generator output and not require potential transformers.

3.5.4.11 Ammeter. The ammeters when required (see 3.5.2.1) shall be 4-1/2 inch 250 degree scale switchboard type conforming to MIL-M-16034. The meter scale shall have a red line scale mark at rated amperes. The meter full scale range shall be selected such that rated amperes fall within approximately 60 to 80 percent full scale range.

3.5.4.12 Synchroscopes. Synchroscopes, when required (see 3.5.2.1), shall be the 4-1/2 inch switchboard type in accordance with MIL-I-16104.

3.5.4.13 Instrument transformers. Instrument transformers where used shall conform to MIL-I-1361.

3.5.4.14 Reverse power protection. The shunt trip on the generator circuit breaker shall be electrically interlocked with the motor controller or input circuit breaker in such a manner that de-energizing the motor controller or input circuit breaker will result in the activation of the shunt trip on the generator circuit breaker.

3.5.4.15 Wattmeters. Wattmeters when required (see 3.5.2.1) shall be 4-1/2 inch, 250 degree scale switchboard type in accordance with MIL-W-19088.

3.5.5 Wiring and connections.

3.5.5.1 Harnessing. All wiring shall be neatly formed into groups which shall be laced with nonflammable (glass) cord or nylon ties and supported or clamped in a manner which will prevent chafing of the insulation due to vibration and shock. The clamps shall be made of non-flammable material. Where metal is used, it shall be covered with a non-flammable material to prevent chafing of the wire insulation. There shall be no splices in the wire and all connections shall be made at the terminal studs of the devices or at terminal blocks. The wire groups running from the hinged doors shall be formed and clamped so that sharp bends do not occur with the panel in either the open or closed position.

3.5.5.2 Slack. Sufficient slack shall be provided so as not to impair movement or put undue stresses on the wire or parts in those places where movement of parts may be expected. Slack shall also be provided to prevent undue stresses on terminal connections due to shock or vibration. When wire terminals are used, sufficient slack shall be provided for at least two replacements of the part in the event that the wires are damaged or have to be clipped at the terminals during disassembly.

3.5.5.3 Cable entrance provisions. Removable cable entrance plates shall be provided both top and bottom of each control panel so that the necessary cables can be brought into the enclosure. The top plate shall be provided with a gasket.

3.5.5.4 External cable connections. External cable connections to the equipment shall terminate at a terminal board accessibility located near the bottom cable entrance and shall be accessible from the front of the enclosure. Where calibrated shunt leads are required, they shall terminate on the instrument studs. Excess length of calibrated shunt leads shall be neatly coiled and secured so as not to interfere with access to other equipment. Circuitous routing of wiring shall be avoided.

3.5.5.5 Insulation protection. Wherever wires are run through holes in metal partitions, the holes shall be equipped with grommets for mechanical protection of insulation. Care shall be exercised in the running of wires to insure that they are not carried over or bent around any sharp corner or edge.

3.5.5.6 Studs. Studs of potted parts shall be so designed and fastened to the insulating strip or plate (or the enclosure itself if this conforms to insulation requirements) as not to cause any degradation in the moisture excluding property of the enclosure by the normal soldering and resoldering of external leads to the studs.

3.5.5.7 Wire end connectors. The ends of each wire (except for pigtail leads or parts requiring solder connections) shall be connected to the part studs or to terminal boards by means of solderless connectors of a type approved by the procuring activity or by forming a wire around the part stud and retaining the wire loop in a cup or crimped washer. The strands of the wire loop shall be secured together by soldering. All nuts, bolts and screws used for electrical connections shall be secured by a locking device, however a locking device need not be provided where solderless connectors for conductors below 4000 circular mils are used. Quick disconnect connectors shall not be used.

3.5.5.8 Soldering connections. Pigtails (wire leads which are permanently affixed to a part), studs (soldering posts which are permanently fixed to a part), soldering lugs (projections which solder to ends of wires to facilitate attachments to solderless connections), and soldering terminals (items which are attached to the chassis, or insulating boards, strips, or posts to serve as solder junctions for two or more wires or leads) come under this heading. All soldering studs, lugs, and terminals shall be notched or otherwise provided with means for mechanically securing the wire or lead prior to the application of solder. All solder terminations shall be completely plated with tin or silver. All solder type studs and terminals shall be sturdily designed and shall be constructed of materials which will render them suitable for repeated soldering and unsoldering operations without breaking or loosening. All solder type studs shall be mounted in such manner as to preclude their loosening or rotation due to soldering operations or from strains due to attached wires or leads. No more than three wires, including wires from parts, shall terminate at any one terminal.

3.5.5.9 Wire identification. All wires shall be marked at each end by stamping the wire number on the wire terminal or on an insulated sleeve which shall be slipped over the wire close to the terminal. The sleeving shall fit tightly over the wire or over the round portion of the terminal to prevent the sleeving from sliding on the wire and to insulate the terminal. Sleeving shall be type F, form U, grade a, class II, category 1, white, in accordance with MIL-I-631. Markings shall be permanently stamped on the sleeving in such a manner as to remain legible after repeated handling and exposure to grease.

3.5.5.10 Identification and information plates.

3.5.5.10.1 Identification plates. Identification plates shall be furnished on each piece of control equipment which is separately mounted. When the control equipment is mounted in a common control panel, identification plates shall be furnished on the outside of the complete unit as well as on major individual subassemblies within the enclosure such as voltage regulators, motor controllers, circuit breakers, and so forth. The minimum data to be marked on the plate shall include the name of the unit, manufacturer's name, manufacturer's serial numbers, Federal stock number, drawing number, contract number, year of manufacture, rating data, a blank space for the inspector's official acceptance stamp and identification to associate the equipment with its parent equipment (such as, for use with 10 kw, 440 Vac/450 AC MG FSN).

3.5.5.10.2 Information plates. The function of each control and indicator on the face of the panel as well as the function of each internal adjustment, connector and test point, within the enclosure shall be indicated by means of information plates adjacent to the device.

3.6 Repair parts. Onboard repair parts, based on the total number of identical parts or sets of parts furnished for each ship on a contract or order, shall be supplied as shown in table VI. This table includes parts for the complete motor generator set, including auxiliary devices such as the voltage regulator, motor starter, and so forth, and takes precedence over repair part requirements in individual referenced specifications.

3.6.1 Irreplaceable parts. If any part shown in table VI forms part of an assembly or subassembly and is not normally a replaceable part of the assembly, then the complete assembly shall be furnished in lieu thereof as a repair part.

3.6.2 Matched parts. Where matching of parts is required in the equipment, the matched set of parts shall be considered one part and furnished as such if required as a repair part.

Table VI - Quantities of onboard repair parts to be furnished per ship.

Parts required	Identical parts, or sets of parts, installed per ship							
	1	2	3	4	5-8	9-20	21-50	51-100
Bearing, sets	1	1	1	1	2	3	4	5
Capacitors, each size and type	1	1	1	1	2	3	4	5
Circuit breaker trip element if AQB type breaker is furnished, or complete circuit breaker if if ALB type is furnished	1	1	1	1	2	3	4	5
Contacts for rheostats and motor controller (except for overload devices), sets	1	1	1	1	2	3	4	5
Overload heaters for motor controller, sets	1	1	1	1	2	3	4	5
Rectifiers, each size and type	1	2	3	3	4	6	7	8
Resistors, each size and type	1	1	1	1	2	3	4	5
Rheostats, each size and type (if springs and contacts are not replaceable)	1	1	1	1	2	3	4	5
Saturable reactors only if the reactors contain magnet wire of less than 1000 circular mils cross-sectional area complete set (or four, whichever is less)	1	1	1	1	1	2	3	4
Shunt coils for motor controller	1	1	1	1	1	2	3	4
Springs for rheostats and motor controller (except for overload devices), sets	1	1	1	1	2	3	4	5
Switches, each size and type	1	1	1	1	2	3	4	5
Transistors, each size and type	1	2	3	3	4	6	7	8
Voltage regulator diodes	1	2	3	3	4	6	7	8
Voltage reference diodes	1	2	3	3	4	6	7	8
Fuses	3	6	8	8	10	12	12	12
Printed wiring (plug-in assemblies) (tuned and adjusted), each size and type	1	2	3	4	5	6	7	8

3.7 Drawings.

3.7.1 General requirement. Drawings shall be in accordance with MIL-D-1000 and as specified herein:

3.7.2 Kind of drawings. Drawings shall be type II in accordance with MIL-D-1000/2 and the following:

(a) Preliminary drawings.
(b) Final drawings.

3.7.2.1 Preliminary drawings. These drawings which shall be submitted for approval shall be either blue prints, blue line prints or equal and shall contain the information required by 3.7.3.3 through 3.7.3.5.

3.7.2.2 Final drawings. Final drawings shall be either microfilms, tracings, or direct reading diazotype prints of the approved preliminary drawings in accordance with MIL-D-1000/2 and MIL-M-9868/1. Where microfilms are furnished, one full size non-reproducible copy of each drawing shall also be furnished.

3.7.3 Drawings required. The following drawings shall be furnished:

(a) Motor-generator drawing (two sheets maximum).
(b) Control panel drawing exclusive of motor controller, circuit breaker and rheostats (five sheets maximum).
(c) Motor starter drawing (as required).
(d) Voltage regulator drawing (five sheets maximum).
(e) Installation drawing (one sheet maximum).

3.7.3.1 When separately mounted control equipment is furnished in lieu of a complete control panel (see 3.5.3.2), a "Motor-generator power supply system" drawing shall be furnished in lieu of the control panel drawing. This drawing shall consist of a schematic diagram for the complete system conforming to 3.7.3.3(f), an interconnection diagram for all parts and subassemblies of the system conforming to 3.7.3.3(d) and part data as required by 3.7.3.3(b) for all items for which separate master drawings are not furnished. Units which may be necessary to make a complete system but are not furnished by the contractor (such as circuit breakers, rheostats, and so forth) shall also be described and shown in the schematic and wiring diagrams and a note added to indicate that they were not furnished by the contractor.

3.7.3.2 When a complete control panel is furnished, the voltage regulator drawings shall be counted as part of the five sheets required for the control panel.

3.7.3.3 Motor-generator drawing. Information to be shown on the motor-generator master drawing shall be as follows:

(a) Descriptive data.
  (1) Identification: Manufacturer's type, class or model number.
  (2) Reference specification: A statement as follows: "The A.C./A.C. motor-generators shown hereon conforms to Specification MIL-M-19160___dated___with the following exceptions: (State none or list all exceptions as applicable.)"
  (3) Guaranteed performance: Overall efficiencies at 1/4, 1/2, 3/4 and full load.
  (4) Motor generator classification:
    a. Enclosure
    b. Speed
    c. Ambient temperature
    d. Mounting.
    e. Duty
    f. Insulation class.
  (5) Motor classification:
    a. Horsepower, voltage, speed, full load current, phase and frequency.
    b. Stator core diameter, core length and nominal air gap.
    c. Rotor core diameter, core length.
  (6) Generator classification:
    a. Kw rating, voltage, phase, power factor, frequency current, excitation current and voltage (no load and full load) and insulation class.
    b. Generator constants:
      1. Short-circuit ratio (minimum calculated value only).
      2. Transient reactance (maximum calculated value only).
      3. Subtransient reactance (minimum calculated value only).
      4. Open-circuit transient time constant (calculated value).
      5. Synchronous reactance (calculated value).
      6. Negative sequence reactance.
    c. Stator core diameter, core length, nominal air gap.
    d. Rotor core diameter, core length.
  (7) Shaft, bearings and lubrication:
    a. Shaft material.
    b. Type of bearings.
    c. Type of lubrication.
    d. Note identifying the type and class of the applicable Military standard bearing puller and adapter (see GGG-P-781).
  (8) Weights:
    a. Weight of complete motor generator.
    b. Weight of rotor.

(b) Motor winding data:
  (1) Stator:
    a. Winding data of stator, including:
      1. Number of poles
      2. Type of connection.
      3. Number of slots.
      4. Number of coils.
      5. Winding pitch in slots.
      6. Turns in series per coil.
      7. Conductor circular mils or size, form (round or rectangular), and developed length.
      8. Conductor insulation and specification.
      9. Resistance between terminal in ohms @ 25°C.
      10. Weight of copper in pounds.
    b. Insulation materials and their dimensions and applicable requirements of the following:
      1. Slot cell.
      2. Spacer.
      3. Top wedge.
      4. "U" wedge (where used).
      5. Insulation between phases.
      6. Insulation on coil extension.
      7. Insulation on coil leads and connections.
      8. Complete stator, specification and grade of varnish.
      9. Lead wire.
    c. Cross sectional view of slot showing details of slot wedges, slot armor, coil spacers and slot tubes.
    d. A schematic wiring diagram.
    e. Table of all insulation material indicating type of material, form, thickness, applicable specification and indicate where used. Materials listed in this table need not be repeated in the basic list of materials.
  (2) Rotor - Number of bars, bar material and size, size of end ring and material of end ring.

(c) Generator winding data:
  (1) Armature winding data to include type of winding, number of slots, number of coils per slot, turns per coil, pitch of coil, size of conductor insulation (specification and type) feet of wire per coil, weight of copper per coil, resistance of wound armature in ohms at 25°C.
  (2) Armature, winding diagram, facing connection end.
  (3) Cross sectional view of armature slot showing coils and all insulation.
  (4) Cross sectional view of field poles showing coils and all insulation.
  (5) Dimensional plan and end view of each type of armature and field coils. Dimensions before and after forming shall be shown.
  (6) Field winding data to include size and shape of conductors, conductor insulation (specification and type), turns per coil, feet of wire per coil, number of conductors in parallel and resistance per coil in ohms at 25°C.
  (7) Field coil connection diagram.
  (8) Table of all insulation material indicating type of material form, thickness, applicable specification and indicate where used. Materials listed in this table need not be repeated in the basic list of materials.

(d) The following additional insulation data shall either be shown on each motor-generator master drawing or may be shown on a separate insulation procedure master drawing showing the various processes, procedures and methods used by the manufacturer. If the latter is selected, the motor-generator master drawing shall reference the applicable portions of the insulation procedure master drawing.
  (1) Sequence of all winding and insulating operations and applicable specifications for all material used.
  (2) Tape application including type, number of layers, amount of overlay, and so forth.
  (3) Sketches as necessary to completely describe all operations.
  (4) Ground insulation, slot cell insulation, phase insulation, coil spacers and separators, end turn insulation, insulation under banding wire, support pads, distance that slot cell insulation extends beyond laminations, alternate materials, slot wedges, method of bringing out and insulating leads from each coil, method of securing windings, and so forth.

ical characteristics of the basic type shall be indicated by the

(5) Varnish treatment schedules including type of varnish, impregnation methods, time cycles, and baking temperatures for wound coils prior to installation as well as treatments for completed subassemblies.

(e) Test reports. The periodic test report number or numbers and date used to obtain design approval shall be referenced on the drawing.

(f) Construction details.

(1) An assembly drawing showing a side and two end views with all parts of the motor generator identified with piece numbers in the list of materials. The side view shall show a longitudinal section of the motor-generator above the centerline of the shaft. The end views shall show quarter sections (or more if necessary) of the motor and generator. These assembly views shall be drawn so that they will be legible when the drawing is reduced to technical manual size. The assembly views shall show all information as indicated herein. Separate detail views of subassemblies shall be provided where the sectional views do not clearly show the information required.

(2) Method of securing all rotating elements to the shaft. This includes bearing inner races, fans, rotating diodes, armatures, rotating field assemblies, spiders, spacers, sleeves, and so forth. The drawing shall clearly indicate the method used to prevent both axial and rotational movement of all items secured to the shaft. Where interference fits are used to prevent axial movement, the inner and outer diameters and tolerance, shall be indicated.

(3) Method of securing all stationary elements to the motor generator frame. Details furnished to be the same as indicated for 3.7.3.3(f)(2).

(4) Bearing housing construction, fits and tolerances. Bearing fits and tolerances may be indicated in tabular form.

(5) Baffles and screen guards and method used to attach them to the end brackets or frames.

(6) Method of attaching terminal box to frame.

(7) Method of bringing cables out of frame into terminal box and method of protecting these cables against chafing at sharp metallic corners.

(8) Method of securing the motor and generator leads to the terminal boards in the terminal box.

(9) Overall dimensions of terminal box, and the number and size of cover bolts.

(10) A detailed working drawing of the shaft including dimensions, finishes and tolerances.

(11) Sectional view of assembly showing direction of rotation, design of rigging for rotating diodes and method of supporting the rigging to withstand high impact shock. The materials of the rigging shall be indicated in the list of material.

(12) Direction of air flow through the frame.

(13) Lifting means provided.

(14) All overall dimensions including mounting and maintenance clearances.

3.7.3.4 Control equipment drawing. The control panel and voltage regulator, master drawings shall include the following information as applicable. The motor starter and field rheostat drawings shall include information as required by MIL-C-2212 and MIL-R-15105, respectively.

(a) Descriptive data for the equipment.

(1) Type of equipment: Control panel voltage regulator and motor starter.

(2) Manufacturer's identification: Type, class and model number.

(3) Reference specification: A statement that the equipment conforms to Specification MIL-M-19160___dated___with the following exceptions: (State none or list exceptions)

(4) Equipment classification (as applicable).

a. Type of equipment.
b. Enclosure.
c. Shock classification.
d. Ambient temperature.
e. Electrical characteristics: Input and output voltages, currents, number of phases, frequencies, and so forth.
f. Mounting.
g. Ventilation.
h. Weight of complete assembly or part where furnished separately.
i. Insulation class.
j. Special features.

(5) Test report: The periodic test report number or numbers and date to obtain design approval shall be referenced on the drawing.

(b) Parts design data.

(1) Transformers, reactors and magnetic amplifiers.

a. Core material.

b. Winding data including the number of turns, tape, wire size and type, terminal identification, d.c. resistance between terminals at 25°C, nominal voltage between terminals, volt - amp ratings for transformers, and current ratios for current transformers.

c. Part designation as assigned in the elementary schematic diagram and part number used in the list of material.

d. Complete material details including applicable specifications for materials used. Details of core boxes, layer and coil insulation, ground insulation, method of impregnation and treatment, potting methods and materials, terminal boards, grommets and leads shall be included.

(2) Resistors. Type, resistance, voltage rating, standard, Military type number, type of mounting, type of terminals, type of adjusting band, and any other special data which may be necessary for ordering exact duplicates from the resistor manufacturer.

(3) Rheostats. Nominal diameter number of plates connection, voltage rating, current rating (both ends, number of steps and part designation).

(4) Capacitors. Style, capacitance, voltage rating, standard Military type number and part designation. Also indicate the maximum ac (peak and rms) and dc (average) voltages which will be applied to the capacitor in the application and the condition at which these maximum voltages occur (transient load conditions, 50 percent rated current and so forth). If dry electrolytic capacitors are used add the following drawing note:

"It is to be noted that these electrolytic capacitors deform and may become instable when stored or left idle for extended period of time."

(5) Current switches.

a. Type, number of position, position marking, voltage rating, current rating, contact arrangement, number of poles, position tabulation and part designation.

b. Chart showing contact position for each switch.

(6) Semiconductor devices. Each device shall be identified in the list of material by manufacturer's part or drawing number to permit direct ordering (JEDEC number is adequate). Also provide mounting details and application (not device capability) data as follows:

a. Rectifiers using silicone diodes.

1. Circuit symbols and piece number.
2. Maximum reverse voltage peak and rms (complete rectifier circuit).
3. Maximum load current d.c. amperes (complete circuit).
4. Maximum diode case temperature at design ambient-use for diodes rated against core temperature.
5. Maximum ambient temperature directly adjacent to diodes-use for diodes rated against ambient temperature-no cooling plates.
6. Cooling plate size, thickness and material where so mounted.
7. Air velocity if forced cooled (linear feet per minute.)
8. Circuit (for example single phase bridge, and so forth.)
9. Total diodes in circuit.
10. Diodes in series per arm.
11. Diodes in parallel per arm.
12. Description of insulation hardware if insulated from a cooling plate.

b. Rectifiers using selenium cells (in stacks or cartridges).

1. Circuit symbol(s) and piece number.
2. Maximum a.c. voltage applied to the rectifier circuit.
3. Maximum d.c. load current through rectifier circuit.
4. Maximum cell temperature (shall not exceed 75°C.).
5. Cell dimensions (3 by 3 inches, 5 by 6 inches, and so forth).
6. Air velocity if forced cooled (linear feet per minute).
7. Rectifier circuit (single phase bridge, and so forth).
8. Total stacks or cartridges used in circuit.
9. Stack or cartridge circuit (if different from rectifier circuit).
10. Cells in series per arm of stack or cartridge.
11. Cells in parallel.

c. Voltage regulator diodes.
1. Circuit symbol(s) and piece number.
2. Range of actual voltage levels which circuit will accept (with or without circuit adjustment) from regulator diodes and still give required equipment performance_____volts to_____volts.
3. Regulation (including temperature error) permitted in an installed regulator diode under all conditions of operation (assume equipment is initially adjusted for optimum performance) ± _____mv.
4. Maximum level of steady-state average reverse current through regulator diode (steady-state shall be considered any time in excess of 30 seconds): _____ma.
5. Maximum transient reverse current under any operating condition____ma for____sec duration and___frequency of occurrence.
6. Maximum ambient temperature at diode (no cooling plate).
7. Maximum core temperature of diode (complete for diodes rated against case temperature).
8. Cooling plate size, thickness and material where used.
9. Air velocity if forced cooled (linear feet per minute).
10. Total diodes in circuit.
11. Diodes in series per circuit element (complete where more than one circuit element is used in the voltage regulator such as in a bridge type regulator circuit).
12. Description of insulation hardware if insulated from a cooling plate.

d. Voltage reference diodes (see regulator diodes also).
1. Circuit symbol(s) and piece number.
2. Range of reference voltage levels which circuit will accept (with or without circuit adjustment) from the voltage reference diode(s):____volts to_____volts.
3. Error permitted in an installed voltage reference diode under all conditions of operation: ± ____millivolts.
4. Circuit design current through voltage reference
(a) Nominal or average value:_____ma
(b) Regulation about nominal value: ± _____ma.
5. Maximum ambient temperature (include internal heat rise above outside design ambient): ____a.
6. Number of voltage reference elements in series: ____(operation in parallel is not permitted).

e. Transistors:
1. Circuit symbol(s) and piece number.
2. Maximum collector to emitter voltage _____volts.
3. Maximum collector to base voltage _____volts.
4. Maximum collector current _____ma.
5. Maximum base current _____ma.
6. Maximum collector power dissipation ____mw.
7. Maximum ambient temperature (include internal heat rise at transistor at 50°C. design ambient _____°C.
8. Maximum core temperature of transistor at 50°C equipment design ambient and any condition of required equipment operation _____°C. (Where rating is based on case temperature).
9. Cooling plate size, thickness and material where so mounted.
10. Description of insulating hardware if insulated from a cooling plate.

(7) Meters: Scale, range and red line rated marking.
(8) Circuit breakers: Type, frame size, thermal element rating, instantaneous trip calibration, and any special features which may have been provided.
(9) Motor controllers: Type, size, protection features, overload heater rating and any other special features which may have been provided or minor deviations from the master drawing from the motor starter.

(c) Schematic diagram:
(1) A schematic diagram of the complete system to clearly represent the operation of the equipment. The following features shall be incorporated:
a. Each part, such as resistors, capacitors, and so forth shall be identified by symbol (R for resistors, T for transformers, L for reactors, and so forth).
b. In addition to the part designation, the numerical value of all resistances, capacitances and inductances shall be noted adjacent to the part.

c. Identification of all terminals shall be shown.
d. A brief description of theory of operation of the system to enable the approval authority to understand the circuitry.
e. Simplicity in reading and understanding the operation of the system shall be stressed throughout.

(d) Wiring diagram:
(1) A wiring diagram for each of the major subassemblies and interconnection of the subassemblies. The following features shall be incorporated in the drawing:
a. All parts shall be shown in correct relation to physical location within a particular enclosure.
b. Terminals of all assemblies and subassemblies shall be clearly shown and marked.
c. Designation of parts shall conform to those assigned in the schematic diagram. Also, the piece numbers corresponding to those shown in the list of material shall be indicated.
d. Wire size, type, applicable specifications, and type of terminals shall be shown in tabular form.
e. Lead identification.
f. Continuous lines to represent leads between terminals or leads need not be drawn if the lead identification used clearly indicates the termination point of each lead.

(e) Construction details:
(1) Two representative views of each enclosure showing the following:
a. Overall dimensions of the enclosure.
b. Drilling and mounting dimensions.
c. Outline of all parts, subassemblies and assemblies contained in each enclosure identified with item or piece number corresponding to item or piece number contained in the list of material.
d. The parts need not be drawn in detail nor to scale but shall represent general configuration of the part and show its general location in the enclosure.
e. Details of construction showing cable entrance provisions; door stop and positioning device; guard rails; captive bolts; gaskets; and other details as applicable.
f. Outline drawing of parts or assemblies furnished separately (not mounted in an enclosure) to show critical dimensions including mounting dimensions.

3.7.3.5 Installation drawings. Data to be shown on these drawings shall be as follows:

(a) Dimensional outline of all major assemblies (motor generator, control panel, and so forth), showing overall and principle dimensions in sufficient detail to establish the limits of space in all directions required for installation, operation and servicing, exclusive of space required for personnel. Include the amount of clearance required to permit opening doors and hinged panels; clearances required for withdrawal of parts and subassemblies such as end brackets, rotating assemblies, and so forth, for the motor-generator and chassis for the control equipment panels; clearances for cable access, and clearances for ventilation. Also indicate the location of meters and operating controls on control equipment panels so that the panels may be located at a convenient operating height.
(b) Weight of each enclosure and separately furnished assembly.
(c) Center of gravity of all major assemblies.
(d) A block diagram of all major assemblies showing interconnection between these assemblies. Terminal identification, as well as maximum current rating of each cable should be shown.

3.8 Technical manuals. The dimensions of the manual shall be 11-5/8 inches high and 8-3/4 inches wide. Technical manuals shall conform to type II of MIL-M-15071 and shall consist of the following:

(a) Front material.
(1) Cover.
(2) Approval and procurement record page.
(3) List of effective pages.
(4) Table of contents.
(5) List of figures.
(6) List of tables.
(7) List of drawings.

(b) Chapter 1 - General information.
(1) Section 1 - General data.
Parts list.
Characteristic of each part (motor generator, voltage, regulator, and so forth).
(2) Section 2 - Introduction.
Brief description of equipment furnished, its basic parameters, function and so forth.
(c) Chaper 2 - Detailed description.
(1) Section 1 - Motor generator.
Detailed description of major parts or assembly.
Photograph.
(2) Section 2 - Voltage regulator.
Block diagram of assemblies (voltage reference, bias, mag amp and so forth) and explanation of each.
Photograph (door closed).
(d) Chapter 3 - Principle of operation.
(1) Section 1 - Voltage regulator.
Schematic diagram of various assemblies of the voltage regulation with explanation of function of each part.
(e) Chapter 4 - Installation.
(1) Section 1 - Installation instruction.
(2) Section 2 - Check out before start up.
(f) Chapter 5 - Operating instructions.
(1) Section 1 - Safety precautions.
(2) Section 2 - Start up.
(3) Section 3 - Manual operation.
(4) Section 4 - Automatic operation.
(5) Section 5 - Parallel operation.
(6) Section 6 - Shut down.
(g) Chapter 6 - Maintenance.
(1) Section 1 - Preventive maintenance.
Routine inspection and care of equipment.
(2) Section 2 - Corrective maintenance.
Open loop test.
Trouble shooting charts.
Tables showing points of measurements of voltage, current, resistance and so forth.
Adjustments after repair.
Test instruments required for trouble shooting and adjusting after repair.
(h) Chapter 7 - Parts identification.
(1) Section 1 - Introduction.
(2) Section 2 - Parts tabulation (photograph of control panel (door open) with subassemblies and major parts indicated by arrow and symbol).
(i) Chapter 8 - Test data.
(1) Section 1 - Heat runs, voltage regulation, parallel operation, harmonic content, no load saturation curve transient response, resistance at 25°C, insulation resistance (cold), locked rotor voltage, current and watts, fault current and voltage oscillograms, voltage dip and rise.
(j) Chapter 9 - Drawings. Reduced size prints of approved motor generator, control equipment and installation master drawings.
(k) Chapter 10 - Appendix.
(1) Motor controller insert.
(2) Circuit breaker insert.

3.8.1 Maintenance procedures shall be validated and verified in accordance with MIL-M-81203 (see 6.4). All maintenance actions described in the manual shall be identified as to the level at which the work or action can be performed (SHIP, TENDER, or YARD). This can be determined by considering the tools, lifting facilities, space, instrumentation and skilled personnel needed to perform the action. This shall be listed in the preliminary manual when submitted for approval. The approving activity will then classify each action as to level of the facility capable of performing the action. This shall then be included into the final manual.

3.9 Workmanship. Workmanship shall be first class in every respect.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order, the supplier is responsible for the performance of all inspection require-

ments as specified herein. Except as otherwise specified in the contract or order, the supplier may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

4.1.1 Quality program. The supplier shall provide and maintain a quality program acceptable to the Government for supplies and services covered by this specification. The quality program shall be in accordance with MIL-Q-9858 (see 6.4).

4.2 In-process inspection. The supplier shall perform in-process inspection of processes, materials, parts, subassemblies, assemblies and finished machines to demonstrate conformance with applicable drawings and specifications. The supplier's in-process inspection shall include the applicable items of inspection contained in the Appendix herein, selected in accordance with the design, manufacturing methods and sequence of operations. In-process inspection procedures, measuring gauges, instruments and written records shall be acceptable to the inspector.

4.2.1 Test reporting. Test results shall be recorded by the supplier on test forms prepared by the supplier and approved by the inspector. Provision shall be made for recording of all required data. Each test report form shall be identified by the number of this specification and by the particular test requirement paragraph number and its title. When oscillograms are required, each trace shall be identified as to the circuit measurement involved and its calibration shall be indicated to permit ready use without reference to associated documents.

4.3 Sampling.

4.3.1 Sampling procedures for routine tests. All motor generators on the contract or order shall be subjected to the routine tests shown in table VII. The tests shown therein shall be performed on completely assembled units. Nonconforming equipment shall be individually rejected.

Table VII - Routine and periodic tests.

Description of test	Applicable test paragraph		Test to be conducted while motor-generators and control equipment are operating together as a complete system	Test which may be conducted on motor-generator alone	Test which may be conducted on control equipment alone
	Routine tests	Periodic tests			
Creepage and clearance	4.6.1	4.6.1		X	X
Enclosure	4.6.2	4.6.2		X	X
Weight		4.6.3		X	X
Resistance at 25°C.	4.6.4	4.6.4		X	
Insulation resistance (cold)	4.6.5	4.6.5		X	X
Dielectric	4.6.6	4.6.6		X	X
Airborne noise	4.6.7.2	4.6.7.1		X	
End play	4.6.8	4.6.8		X	
Inclined operation		4.6.9		X	
Internally excited vibration	4.6.10	4.6.10		X	
No load saturation curve for generator		4.6.11		X	
Synchronous impedance curve		4.6.12		X	
Shock		4.6.13	X		
Regulated voltage adjustment range and steps		4.6.14	X		
Automatic voltage regulation	4.6.15.2	4.6.15.1	X		
Frequency regulation	4.6.16	4.6.16	X		
Transient response of voltage regulator (deviation and recovery time)	4.6.17	4.6.17	X		

Table VII - Routine and periodic tests (Continued).

Description of test	Applicable test paragraph		Test to be conducted while motor-generators and control equipment are operating together as a complete system	Test which may be conducted on motor-generator alone	Test which may be conducted on control equipment alone
	Routine tests	Periodic tests			
Parallel operation (kvar sharing)		4.6.18	X		
Short circuit characteristics		4.6.19	X		
Rated load heating		4.6.20.2	X		
Resistance (hot)		4.6.4		X	
Insulation resistance (hot)		4.6.21	X		
Efficiency at full, 3/4, 1/2 and 1/4 load		4.6.22	X		
Harmonic analysis		4.6.23	X		
Amplitude modulation		4.6.24	X		
Line unbalance		4.6.25	X		
Voltage balance		4.6.26	X		
Starting tests		4.6.27		X	
Part ratings	4.6.28			X	X
Repair parts		4.6.29			

4.3.2 Sampling procedure for periodic tests. The first motor generator power supply of each design and size offered for delivery shall be subjected to the periodic tests shown in table VII. Thereafter one periodic test on identical equipment will be required every 12 months. If a motor generator sample does not meet performance requirements under periodic tests, that motor generator and those of the same design and lot shall be rejected. After the design has been modified and the revisions incorporated into the sample, the sample may be resubmitted for tests. A periodic test shall be required after any change in design which affects the performance characteristics. If routine test data reveals variations beyond a normal manufacturing tolerance, the inspector may require that any or all of the periodic tests be made on a particular motor generator to demonstrate that it conforms to this specification.

4.4 Test reports. All test data shall be approved by the cognizant inspector prior to the shipment of the equipment. Upon approval, one file copy of all test periodic data shall be forwarded to the procuring activity. This data shall be bound into 9 by 11-1/2 inch binders. The cover and title page shall give sufficient information to identify the equipment. A table of contents shall be included and list each test required by table VII. No special test format will be required. However, each test shall be prefaced by the name of the test and applicable test paragraph as indicated in table VII. The data submitted shall be copies of the actual data taken on the test floor and not retyped data. The forms used shall allow sufficient columns to make instrument corrections and necessary calculations. The inspector shall sign the cover sheet of the test report and note thereon the number of test sheets verified. Wherever practical, the final results of the test shall be listed adjacent to the specification requirement for that test.

4.5 Special provisions.

4.5.1 Periodic tests. The shock test and weight measurement need only be conducted on the first unit of a given design.

4.5.2 Routine tests. Routine tests which require that the motor generator and controls be operated together may be conducted as follows:

(a) Use one motor generator to test all control units.
(b) Use one set of controls to test all motor generators.
(c) Test any motor generator and any set of controls together.

The motor generator and control which is used for the complete periodic test shall not be used in the routine testing of any of the other units.

4.6 Methods of tests. Test procedures shall be as specified herein.

4.6.1 Creepage and clearance. Creepage and clearance distances between current carrying parts in the motor generator and control equipment shall be measured to determine compliance with MIL-E-917.

4.6.2 Enclosure. Acceptability of the enclosure shall be determined by visual examination or measurements to determine compliance with 3.3.4.

4.6.3 Weight. The weight of the complete motor generator, complete rotating element of the motor generator, complete control panel (or each individual control equipment enclosure and switchboard mounted units in the case of separately mounted control equipment) shall be measured and recorded.

4.6.4 Resistance (cold and hot). The resistance of all motor and generator windings shall be measured when the equipment is at same ambient temperature and both resistance and ambient shall be recorded. The resistance of the windings measured after the rated load heat run (see 4.6.20.2) and the calculated temperature for this resistance shall be recorded adjacent to the cold resistances on the test report.

4.6.5 Insulation resistance (cold). This test shall be made before the dielectric tests. Prior to the application of the test voltage, all circuits shall be thoroughly discharged by shorting them to the frame and the motor generator may be disconnected from the control equipment. The test voltage shall be applied between all electrically isolated circuits (motor generator as well as control equipment) and between each circuit and ground. Circuit diagrams shall be carefully studied prior to conducting this test to ascertain that circuits which may be isolated by transformer are not inadvertently neglected. When testing between the circuits and ground, all circuits of the control equipment and the motor generator may be tied together so that only one test voltage need be applied to each, the motor generator and the control equipment providing that the insulation resistance when tested in this manner shall be as specified in 3.2.5. Insulation resistance shall be measured with an insulation resistance indicating instrument. The time of test voltage application shall be not less than 60 seconds. The temperature of the circuits at the time of the test shall be measured and recorded. Insulation resistance measurements shall be corrected to 25°C. Unless otherwise specified (see 6.1), 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.

4.6.6 Dielectric tests.

4.6.6.1 General. The dielectric test shall be made after all other tests have been completed. The dielectric test shall be made on the completely assembled motor generator and control equipment and not upon individual parts within the motor generator or control equipment. An exception is made in the case of repair parts which require dielectric tests.

4.6.6.2 Points of application. The test voltages of a magnitude as specified in 3.2.19 shall be successively applied between each electric circuit and all other electric circuits and metal parts. No parts, however, in an assembled unit shall be subjected to a dielectric test voltage higher than that test voltage required for that part. When the unit test voltage is higher than that required for an individual part, that part shall be disconnected from the circuit. 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 of the motor generator.

4.6.7 Airborne noise.

4.6.7.1 By instrument (for periodic test). Airborne noise measurements shall be made in accordance with MIL-STD-740 with the motor generator operating at rated load and nominal input voltage to determine compliance with 3.4.4.

4.6.7.2 By observation (for routine tests). Observation shall be made of motor generator noise during the progress of testing to determine that the motor generator is free from any degree of noise comparably greater than that inherent in a motor generator of the same rating and design. If any objectionable noise is detected the inspector may require a test by instrument as specified in 4.6.7.1 to ascertain that the unit meets the requirements of 3.4.4.

4.6.8 End play. The end play of all motor generator rotating elements shall be measured to determine compliance with 3.4.6.5.

4.6.9 Inclined operation. The motor generator only need be tested for inclined operation. The angle of inclination shall be as follows:

(a) Shaft inclined 15 degrees, generator end low.
(b) Shaft inclined 15 degrees, motor end low.

The motor generator shall be run at no load for a period of not less than 30 minutes at each of the positions of inclination as specified herein. 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.

4.6.10 Internally excited vibration test. Each motor generator shall be tested to determine compliance with 3.4.5.2. This test shall be conducted after the motor generator has been operated at rated load. After balancing, the unit shall be completely assembled and, mounted elastically at a natural frequency less than one-quarter of the rotational frequency of the unit. To accomplish this, the minimum static deflection of the mounting shall be determined as shown on figure 1. In no case shall the deflection exceed one-half the original height of the elastic element. Measurements shall be made on the bearing housing and in the direction giving the maximum vibration when the motor generator is operating at rated load. Test data submitted for each machine shall include a description of the test set up including compression of elastic mount, instruments used, location of readings taken, actual instrument readings, and any corrections or calculations made. This test shall also be run as part of the post shock tests of the unit which was HI shock tested in order to ascertain that the HI shock test has not affected the unit in such a manner that the equipment does not meet the post shock internally excited vibration limits of 4.6.13(b)(6). Failure to meet the internally excited vibration limit after shock shall be considered as cause for rejection of the equipment.

4.6.11 Generator no load saturation curve. Sufficient data to plot a no load saturation curve for the generator shall be obtained. A copy of this curve shall be included in the test records. Points for this curve shall be taken as follows: Four below 60 percent of rated voltage; one between 60 and 90 percent; one at rated voltage; and three between rated voltage and full field excitation. Readings shall always be taken with increasing values of field current and when it is necessary to reduce the field, it shall be reduced to zero and then increased to the desired value. Data recorded for each point shall consist of field voltages and currents, speed, generator voltage (each of the three phases and average of the three phase voltages), motor input voltage and motor input current. The motor generator shall be operating at rated speed and with rated voltage applied to the motor during this test.

4.6.12 Synchronous impedance curve. Sufficient data to plot a synchronous impedance curve for the generator shall be obtained. A copy of this curve, which may be plotted on the same sheets as the saturation curve, shall also be included in the test records. Six readings from 150 percent rated current shall be recorded.

4.6.13 High impact shock test. The test shall be as specified in MIL-S-901 and as specified herein:

(a) General. The motor generator and control equipment shall be energized during the test; and may be tested simultaneously or separately. All equipment or parts shall be mounted on the shock machine in a manner simulating the actual installation on board ship. The weight designation of the shock test shall be as required by the combined weight of the equipment being tested. When motor generators are tested at a 30 degree inclination on the medium weight shock test machine, the centerline of the shaft shall be parallel to the inclination.
(1) If tested separately, the following procedures are acceptable:
a. The motor generator may be energized by a source other than its intended control equipment.
The speed of the motor and the generator voltage, or average of the three phase voltages shall be recorded before and after each blow. No adjustments or change in input or output shall be made between blows.
b. The voltage regulator and static exciter may be tested with a simulated load rather than controlling its intended motor generator. Data shall be recorded before and after each blow to demonstrate the equipments' ability to meet the regulation requirements of 3.2.9.

(b) Failure to perform principal function. Any of the following failures shall be considered as cause for rejection of the equipment:
(1) Breakage of any parts.

(2) Appreciable distortion or dislocation of any parts such as mounting feet, poles, coils, and bearings.
(3) A value of insulation resistance of the motor generator or any of the control equipment (corrected to 25°C) less than that permitted by 3.2.5.
(4) Objectionable noise. Any noticeable increase or decrease in noise of the motor generator when operating at rated speed shall be investigated and its cause determined. However, if disassembly is required for this check, it shall be made during the test specified in 4.6.7.
(5) Low dielectric strength. The motor generator and control equipment shall be operated to obtain approximately rated temperature rise of iron and windings, then disconnected from its load and its source of power and a dielectric strength test made to check the condition of insulation. This dielectric strength test shall be made in accordance with MIL-E-917 except that it shall be made with an applied voltage equal to 65 percent of that specified.
(6) Failure to meet twice the internally excited vibration limit specified in 3.4.5.2 after completion of the shock test.
(7) A shift in regulated voltage of more than plus or minus 0.25 percent.
(8) Failure to meet the voltage regulation test specified in 4.6.15.2 after completion of the shock test.
(9) The equipment shall be operated at full load for 2 hours and its overall performance checked. Any noticeable increase in heating, or other abnormal operation noted and investigated to determine its cause.
(10) Failure to pass inspection. After all the checks and tests of 4.6.13(b) (1) through (9) have been conducted, the motor generator and control equipment shall be disassembled and thoroughly inspected for damage. The extent of disassembly need be only to the point where the condition of the various parts can be easily observed.

(c) Disposal of shock-tested equipment.
(1) Equipment which has been subjected to the high impact shock test and has failed to perform any of the principal functions specified herein will not be acceptable, either in whole or any of the parts.
(2) Equipment which has been subjected to the high impact shock test and has successfully performed all the principal functions specified herein will be acceptable under a contract or order providing that ball bearings are replaced in the motor generator.

(d) The number of generators to be tested. Unless otherwise specified in the contract or order, one motor generator of the longest core length in each diameter and of similar construction shall be shock tested.

If the manufacturer desires, he may submit a motor generator frame of less than the longest core length for the shock test. However, satisfactory compliance with the shock requirements will only determine conformance of motor generators having a core length equal to or less than the core length of the motor generator tested.

(e) Shock extension.
(1) Motor generator shock test approval may be extended from the longest core length (same outside diameter and similar construction) to a motor generator of a shorter core length. The manufacturer shall submit a letter of request together with the drawings of each unit. Upon receipt of the procuring activity approval, the manufacturer shall note on the master plan the test number and date of original shock test, the inspector's approval letter, serial number and date of a statement of shock extension including the procuring activity approval letter.
(2) The extension of shock test from one control panel and voltage regulator or both to another shall be based on comparison of size, weight, and distribution of parts. The manufacturer shall submit a letter of request together with the drawings of each unit. Drawing notation shall be as specified in 4.6.13(e)(1).

4.6.14 Regulated voltage adjustment range and steps. The tests for compliance with 3.2.11 shall be conducted as follows:

(a) With rated voltage applied to the motor and the generator operating at no load under automatic operation.
(1) Record the maximum and minimum voltage adjustment.
(2) Record the voltage for three consecutive steps for at least five points over the range specified.

(b) Repeat (1) and (2) of (a) herein for rated load at rated power factor.
(c) With the maximum and minimum input voltages specified in 3.2.2 applied to the equipment the maximum and minimum limits of adjustability shall be recorded.

4.6.15 Automatic voltage regulation.

4.6.15.1 Periodic test.

(a) The test shall be started with the rotating and control equipment at room temperature.
(b) Start the equipment with nominal voltage and frequency applied to the motor and with no load on the generator. Adjust the average voltage to rated. No further adjustment shall be made to the automatic voltage or any part of the regulators during the remainder of this test. The first set of readings shall be taken within 2 minutes after the equipment is energized. The generator voltage and current (or each of generator phase voltages, average of the phase voltages, and each of three output line currents), kw output, speed, frequency (may be computed from speed if suitable meter is not available), generator field voltage and current and motor input voltage and current (each line) shall be the minimum data recorded for each set of readings taken during the tests. Repeat for input variations of 3.2.1(a)(7).
(c) Apply full load to the generator and permit the equipment to reach its full load temperature rise before proceeding with the remaining parts of this test. A set of readings shall be taken every 30 minutes during warmup.
(d) A set of readings shall be recorded for each of the tests shown in table VIII.

Table VIII - Automatic voltage regulation test conditions.

Percent of rated kw load	Power Factor of Load (Lagging)	Motor input voltage (see 3.2.2)	Test no.
0	-	Min. (minimum)	1
		Nom. (nominal)	2
		Max. (maximum)	3
25	0.8	Min.	4
		Nom.	5
		Max.	6
	1.0	Min.	7
		Nom.	8
		Max.	9
50	0.8	Min.	10
		Nom.	11
		Max.	12
	1.0	Min.	13
		Nom.	14
		Max.	15
75	0.8	Min.	16
		Nom.	17
		Max.	18
	1.0	Min.	19
		Nom.	20
		Max.	21
100	0.8	Min.	22
		Nom.	23
		Max.	24
	1.0	Min.	25
		Nom.	26
		Max.	27
75	0.8	Min.	28
		Nom.	29
		Max.	30
	1.0	Min.	31
		Nom.	32
		Max.	33

Table VIII - Automatic voltage regulation test conditions. (Cont'd)

Percent of rated kw load	Power Factor Load (lagging)	Motor input voltage (see 3.2.2)	Test no.
50	0.8	Min.	34
		Nom.	35
		Max.	36
	1.0	Min.	37
		Nom.	38
		Max.	39
25	0.8	Min.	40
		Nom.	41
		Max.	42
	1.0	Min.	43
		Nom.	44
		Max.	45
0	-	Min.	46
		Nom.	47
		Max.	48

Percent of rated current (one phase)	Generator terminal connection	Power factor of load (lagging)	Motor input voltage (see 3.2.2)	Test no. 1/
15	$T_1 - T_2$	0.8	Nominal	49
15	$T_1 - T_2$	1.0	Nominal	50
15	$T_2 - T_3$	0.8	Nominal	51
15	$T_2 - T_3$	1.0	Nominal	52
15	$T_3 - T_1$	0.8	Nominal	53
15	$T_3 - T_1$	1.0	Nominal	54

1/ The generator shall be loaded with a three phase, 75 percent rated, 0.8 power factor load before the single phase 15 percent rated current load is applied during tests 49 through 54.

The manufacturer may conduct any number of tests, in any sequence for a kw load. The tests shall be conducted in order of ascending and descending load as shown in table VIII.

Tests 49 through 54 may be taken before or after tests 1 through 48, or interspersed with tests 16 through 21 and tests 28 through 33.

(e) All voltages or the average phase voltages recorded during the above tests shall be within the limits specified in 3.2.9.

4.6.15.2 Routine test. This test shall be conducted in accordance with 4.6.15.1, except that only the following tests will be conducted in the order listed:

Test No.
3
22
47
17
23
41
51
15

4.6.16 Frequency regulation. The motor-generator speed shall be recorded at no load and with rated full load applied to the generator to determine compliance with 3.2.1(a)(4). Motor slip shall also be recorded with 440 volts applied to the motor.

4.6.17 Voltage deviation and recovery time. With the generator operating at no load and with rated voltage applied to the motor, a 50 percent balanced three phase load at 0.8 power factor shall be suddenly applied in one step. This test shall be repeated removing this same load from a generator which was initially carrying rated load at rated power factor. Oscillograms shall be taken to determine compliance with 3.2.10. The voltage

trace shall be adjusted so as to have no less than 3 inches peak to peak displacement for rated voltage. The film speed shall be such as to give approximately 8 cycles per inch, and sufficient film used to record continuous operation from at least 0.5 second before the instant of load application or removal to at least 4 seconds of operation after the instant of application or removal of load. This test may be conducted concurrent with the voltage regulation test of 4.6.15.

4.6.18 Parallel operation. The parallel operation test shall be conducted as follows: With each motor generator connected to the same power supply, and the voltage regulator in automatic operation, adjust the control equipment so that rated voltage is obtained and the kw and kva loads of each generator are equal for a combined load of 25 percent. No further adjustment of the control equipment shall be made of the remainder of the test. The total load shall then be varied from 25 to 100 percent of combined kw and kva rating of the parallel generators at approximately rated power factor in three approximately equal steps and back to 25 percent load in the same manner. The actual difference in kw and kvar expressed in percentage of kva rating of one power supply shall be computed and recorded.

4.6.19 Short circuit characteristics. The sustained short circuit current shall be measured by means of an ammeter and oscillograph to determine compliance with 3.2.17. When computing the I^2t value the steady state current measured with the ammeter shall be used, the time shall start when the current reaches its steady state value. When the circuit breakers are furnished by the contractor, the test shall be conducted with the circuit breaker locked in to prevent tripping during the test. There shall be no evidence of smoking, burning or burning odor as a result of this test. The voltage shall automatically return to within the regulation band limits when the short circuit is removed. Oscillograms of the fault current and voltage shall be taken.

4.6.20 Heating tests.

4.6.20.1 General. All heating tests on the motor generator and control equipment shall be conducted at the same time. Simulated heating tests will not be permitted on the control equipment or motor generator. All heating tests shall be made on a production model. During heating tests of the control equipment the enclosure doors shall be closed. In those cases where the loading of control circuitry may be greater at some low or intermediate load point than it is at rated load or overload, additional tests will be required to demonstrate that no parts are overheating at the lower loads.

4.6.20.2 Rated load heating test. The equipment shall be operated at rated load at rated power factor and with nominal voltage applied to the motor until the temperature has stabilized in all parts. However, in no case shall the duration of the test be less than 4 hours. During the first 3 hours, temperature measurements shall be made and recorded at 30 minute intervals. After that readings shall be made and recorded at 15 minute intervals. It shall be considered that stabilized temperatures have been reached, when at least four consecutive readings not differing by more than 2 degrees are taken at 15 minute intervals. After shutdown, temperature rises of the rotating elements shall be determined in accordance with 4.6.20.4.3, and rise by resistance measurements made in accordance with 4.6.20.4.4. Maximum temperature rises recorded shall be within the limits shown in table I.

4.6.20.3 Data to be recorded. The following data shall be the minimum recorded for each reading taken during the heating tests:

(a) Motor input voltage and current.
(b) Output power (measured on load side of generator circuit breaker).
(c) Output phase voltages and line currents.
(d) Power factor.
(e) Room ambient.
(f) Air temperature at a minimum of four locations within the control equipment enclosures.
(g) Temperature of air entering and leaving all enclosures.
(h) Thermometer or thermocouple readings for all heat producing parts.

The temperature rise of all parts shall be determined by one of the methods shown in table I; however, the temperature rise of all motor and generator windings which have a resistance of 1.0 ohm or more shall be determined by the rise in resistance method. Where shutdown temperature of rotating elements (for windings less than 1 ohm) are taken in accordance with 4.6.20.4.3., extrapolation curves need not be included in the test report.

FIGURE 11. Example of part identifying number.

4.6.20.4 Measurement methods. Measurement methods used in the heating tests shall be as specified herein. Detailed procedures of method I (thermometer) and method II (resistance) shall be as specified in MIL-E-917. In determining temperature rise, no correction shall be made for barometric pressure, humidity, or for any differences in heat transfer characteristics between the test ambient temperature and the specified 50°C. ambient temperature.

4.6.20.4.1 Ambient temperature. The ambient temperature shall be measured by means of two or more thermometers placed at different points around each the motor generator and control equipment (total four minimum). The thermometers shall be placed at a distance of 3 to 6 feet from the equipment and at a height level with the mid point of the equipment. The ambient temperature thermometers shall be protected from drafts, and from heat radiation, from equipment under test or outside sources. They shall be inserted in heavy oil filled cups of not less than 1 inch in external diameter and 2 inches in height. The value to be adopted for the ambient temperature during the tests shall be the mean of the readings of the several thermometers, placed as specified herein, taken at four equal intervals of time during the last quarter of the test. A motor generator power supply may be tested at any convenient ambient temperature above 10°C, but the conditions in the testing room shall be such that the ambient temperature will not vary greatly during test. A variation of 10°C, or more, during a period of 6 hours, or proportional change for runs of shorter durations shall in no case be exceeded. If the ambient temperature is very irregular during the run or changes rapidly at the end, the test shall be repeated.

4.6.20.4.2 Potted assemblies. The temperature rise of all encapsulated or potted assemblies shall be determined by embedding thermocouples in the samples to be used for this test.

4.6.20.4.3 Rotating elements. The temperature rise of generator rotating field or armature windings shall be determined as follows: On shutdown, preheated thermometers (preheated to a temperature approximately equivalent to the temperature rise permitted for the applicable part plus the room ambient at the time) shall be placed on the respective parts in accordance with method I procedures of MIL-E-917. Every precaution shall be taken to reduce to a minimum the period of time elapsing between the stopping of the machine and the application of the thermometers. A curve shall be plotted with temperature readings as ordinates and time as abscissa. The curve shall be extrapolated back to the instant of shutdown. The temperature at the instant of shutdown shall be recorded and the temperature rise determined. This rise shall be in accordance with the limits shown in table I. In addition, the temperature rise of all rotating windings which have a resistance greater than 1.0 ohm shall be determined by method II of MIL-E-917.

4.6.20.4.4 Stationary elements of motor generator. The temperature rise of motor and generator stationary coils, laminations or field poles and the outer races of both bearings shall be measured by method I of MIL-E-917. In addition, the temperature rise of all coils which have a resistance greater than 1.0 ohms shall be measured by method II of MIL-E-917 shutdown.

4.6.20.4.5 Qualified Products List (QPL) items. QPL items such as rheostats, resistors, circuit breakers, motor starters, capacitors, circuit breakers, instruments, and instrument transformers have previously been tested and are satisfactory when used within their rating and provided there is no excessive rise in air temperature within the complete control equipment enclosure. When all of the control equipment is integrated within a single enclosure, the rise of all transformer coils, motor controller coils, resistors, rheostats, case temperatures of capacitors, and air temperature within 1/2 inch of all instruments shall also be measured by method I of MIL-E-917 during the heat runs and be within the limits shown in table I.

4.6.20.4.6 Other parts. The temperature rise of parts not covered by 4.6.20.4.1 through 4.6.20.4.5 shall be measured as follows:

(a) Transformer windings, magnetic amplifier windings, and so forth, method I of MIL-E-917.

(b) Semiconductor devices. The ambient temperature of semiconductor devices shall be measured by method I of MIL-E-917 within 0.5 inch of the device on the low temperature side (side from which air starts passage over device). The case or cell temperature required for selenium rectifiers and other semiconductor devices relying upon a cooling fin or other surface to dissipate heat from the case to the ambient shall be measured by placing a thermocouple in direct contact with the case (on center cell near through bolt or stud of a selenium rectifier stack). Position on the case shall be on the high temperature side of the case. In no instance

shall the thermocouple be placed on the cooling fin or other heat dissipating surface. The selenium cell or plate is an exception since the rectifying junction is distributed across the cell.

4.6.21 Insulation resistance (hot). Immediately following the heat run, measurements of insulation resistance shall be taken. (For details of test see 4.6.5).

4.6.22 Efficiency. The efficiency of the motor generator power supply shall be measured in automatic operation for 1/4, 1/2, 3/4, and full load. Motor input voltage and current (each line), kw input, field voltage and current for generator fields, generator voltage (each phase and average of the three phases), generator line currents measured at the generator terminals, output line current measured at the load side of the circuit breaker, load power factor kw output, generator frequency, and the calculated overall efficiency shall be the minimum data recorded for each load point. A detailed breakdown of losses will not be required. However, if an analysis is made for the contractor's own design files, a copy of the breakdown of losses shall be included in the test report. The data taken during 4.6.15 may be used to compute the efficiencies.

4.6.23 Harmonic analysis. A harmonic analysis shall be made with the equipment operating at no load, and full load unity power factor. All harmonics up to the fortieth harmonic shall be recorded. Harmonics of less than 0.1 percent may be disregarded in the determination of the total operation when the harmonic analysis is made.

4.6.24 Amplitude modulation. Amplitude modulation of the generator output voltage shall be measured to determine compliance with 3.2.13. This test shall be conducted with the controls in automatic with the generator voltage and frequency at rated value. The percentage of amplitude modulation shall be recorded for no load and full load unity power factor.

4.6.25 Line unbalance. The data recorded during tests 49 through 54 of 4.6.15 shall be used to determine compliance with the line unbalance requirements specified in 3.2.14. The maximum difference in phase voltages for each of the load points shall be computed and recorded. The voltage values used shall be measured at the output terminals of the power supply (load side of generator circuit breaker) and not at the generator terminals.

4.6.26 Voltage balance. The data recorded during tests 1 through 48 of the voltage regulation test of 4.6.15 shall be used to determine compliance with the voltage balance requirements specified in 3.2.15. The maximum difference in line voltages for each of the load points shall be computed and recorded. The voltage values used shall be measured at the output terminals of the power supply (load side of the generator circuit breaker) and not the generator terminals.

4.6.27 Starting tests. At the instant of start, the locked rotor voltage, current and watts of the motor shall be recorded.

4.6.28 Part ratings. The inspector shall ascertain that the rating of all parts such as resistors, rectifiers, capacitors, transformers, instruments, rheostats, and so forth, is as shown on the approved master drawing.

4.6.29 Repair parts. Repair parts shall be subjected to the following tests as applicable:

(a) Insulation resistance.
(b) Dielectric.
(c) Creepage and clearance.
(d) Materials.
(e) Resistance at 25°C.

5. PREPARATION FOR DELIVERY

(The preparation for delivery requirements specified herein apply only for direct Government procurements. For the extent of applicability of the preparation for delivery requirements of referenced documents listed in section 2, see 6.3.)

5.1 Domestic shipment and early equipment installation and for storage of onboard repair parts.

5.1.1 Basic equipment.

5.1.1.1 Preservation and packaging. Preservation and packaging which may be the supplier's commercial practice, shall be sufficient to afford adequate protection against corrosion, deterioration and physical damage during shipment from the supply source to the using activity and until early installation.

5.1.1.2 Packing. Packing shall be accomplished in a manner which will insure acceptance by common carrier at the lowest rate and will afford protection against physical or mechanical damage during direct shipment from the supply source to the using activity for early installation. The shipping containers or method of packing shall conform to the Uniform Freight Classification Rules or other carrier regulations as applicable to the mode of transportation and may conform to the suppliers commercial practice.

5.1.1.3 Marking. Shipment marking information shall be provided on interior packages and exterior shipping containers in accordance with the contractor's commercial practice. The information shall include nomenclature, Federal stock number or manufacturer's part number, contract or order number, contractor's name and destination.

5.1.2 Onboard repair parts. Onboard repair parts shall be preserved and packaged level A; packed level C and marked levels A and C respectively in accordance with MIL-E-17555.

5.2 Domestic shipment and storage or overseas shipment. The requirements and levels of preservation, packaging, packing and marking for shipment shall be specified by the procuring activity (see 6.1).

(5.2.1 The following provides various levels of protection during shipment and storage or overseas shipment, which may be required when procurement is made (see 6.1).

5.2.1.1 Preservation and packaging.

5.2.1.1.1 Level A.

5.2.1.1.1.1 Basic equipment. The basic equipment shall be preserved and packaged level A in accordance with MIL-E-16298. When the size and mounting arrangement of the basic equipment does not permit enclosure within a watervaporproof barrier as required in a method II package, packaging shall be accomplished by the alternate method specified in MIL-E-16298.

5.2.1.2 Packing.

5.2.1.2.1 Basic equipment.

5.2.1.2.1.1 Levels A and B. The basic equipment shall be packed level A or B as specified (see 6.1) in accordance with MIL-E-16298.

5.2.1.3 Marking. In addition to any special marking required by the contract or order, marking for shipment shall be in accordance with MIL-E-16298.

5.2.1.4 Repair parts and tools. Repair parts and tools shall be preserved, packaged, packed and marked for the level of shipment as specified (see 6.1) in accordance with MIL-E-16298.

5.2.1.5 Technical publications. Technical publications shall be packaged, packed and marked for the level of shipment as specified (see 6.1) in accordance with the applicable manual specification.

5.2.1.6 Drawings. Drawings shall be packaged, packed and marked for the level of shipment (see 6.1) in accordance with MIL-D-1000/2 (see 3.7.1).

5.3 Use of polystyrene (loose-fill) material.

5.3.1 For domestic shipment and early equipment installation and level C packaging and packing. Unless otherwise approved by the procuring activity (see 6.1), use of polystyrene (loose-fill) material for domestic shipment and early equipment installation and level C packaging and packing applications such as cushioning, filler and dunnage is

prohibited. When approved, unit packages and containers (interior and exterior) shall be marked and labelled as follows:

"CAUTION

Contents cushioned etc with polystyrene (loose-fill) material.
Not to be taken aboard ship.
Remove and discard loose-fill material before shipboard storage.
If required, recushion with cellulosic material bound fiber,
fiberboard or transparent flexible cellular material."

5.3.2 For level A packaging and level A and B packing. Use of polystyrene (loose-fill) material is prohibited for level A packaging and level A and B packing applications such as cushioning, filler and dunnage.

6. NOTES

6.1 Ordering data. Procurement documents should specify the following:

(a) Title, number and date of this specification.
(b) Whether generator size is 0.5, 1.5, 3, 5, 10, 15, 30, 60, 100, 200 or 300 kw (see 3.2.1(b)(1)).
(c) Whether generator voltage is 120 or 450 volts a.c. (see 3.2.1(b)(3)).
(d) If generator is other than rotating field type (see 3.2.1(b)(8)).
(e) Whether the motor generator and associated control equipment are to be full or deck mounted for shock test (see 3.2.4).
(f) Parallel operation, when required (see 3.2.18 and 3.5.2.1).
(g) Plan for use data if different from averages (see 3.5.3.11).
(h) Whether control equipment shall be arrangment A or arrangement B (see 3.5.2).
(i) If corrections are to be made other than on the basis of insulation resistance doubling for each 15°C. decrease in temperature (see 4.6.5).
(j) Preservation, packaging, packing and marking requirements other than those required by 5.1 (see 5.2).
(k) Level of preservation and packaging and level of packing required for repair parts, tools, publications and drawings (see 5.2.1.4, 5.2.1.5 and 5.2.1.6).

6.2 Definitions. For the purpose of this specification, the following definitions shall apply:

6.2.1 Rated condition. Rated condition is the characteristics assigned to a machine for a specified output rating such as speed, voltage, frequency and current.

6.2.2 Nominal rating. Nominal rating is the normal constant operating condition or characteristic assigned to a machine when a range of operating conditions or characteristics is specified.

6.2.3 Continuous duty. Continuous duty is the requirement of service that requires satisfactory operation at any constant load in the range of no load to full load for an indefinitely long time.

6.2.4 Total harmonic content. The total harmonic content of a complex wave is the total root mean square (r.m.s.) voltage remaining when the fundamental is removed.

6.2.5 Voltage modulation. Voltage modulation is the cyclic variation or random dynamic variations, or both, about an average of the a.c. peak voltage during a steady state electric-system such as caused by voltage regulation and speed variations. The modulation envelope is formed by a continuous curve connecting each sine wave peak to the successive sine wave peak.

6.2.6 Short-circuit ratio. The short-circuit ratio is the ratio of the field current at rated open circuit armature voltage and frequency to the field current required to produce rated armature current for a sustained symmetrical short circuit at rated frequency.

6.2.7 Synchronous impedance. The per unit direct axis synchronous impedance equals the ratio of the field current at rated armature current on sustained symmetrical short circuit to the field current at normal open circuit voltage on the air-gap line.

6.2.8 Air-gap line. The air-gap line is the extended straight line part of the no-load saturation curve.

6.3 Sub-contracted material and parts. The preparation for delivery requirements of referenced documents listed in Section 2 do not apply when material and parts are procured by the supplier for incorporation into the equipment and lose their separate identity when the equipment is shipped.

6.4 Management control documents. The following management control system documents should be included on DD Form 1660:

(a) MIL-STD-785 (see 3.3.2.2).
(b) MIL-HDBK-217 (see 3.3.2.2, 3.3.2.3 and 3.3.2.4).
(c) MIL-HDBK-472 (see 3.3.3.3).
(d) MIL-STD-471 (see 3.3.6).
(e) MIL-STD-470 (see 3.3.3.8).
(f) NAVSHIPS 94324 (see 3.3.3.8).
(g) MIL-H-46855 (see 3.3.3.9).
(h) MIL-M-81203 (see 3.8.1).
(i) MIL-Q-9858 (see 4.1.1).

6.5 CHANGES FROM PREVIOUS ISSUE. THE OUTSIDE MARGINS OF THIS DOCUMENT HAVE BEEN MARKED "¶" TO INDICATE WHERE CHANGES (DELETIONS, ADDITIONS, ETC.) FROM THE PREVIOUS ISSUE HAVE BEEN MADE. THIS HAS BEEN DONE AS A CONVENIENCE ONLY AND THE GOVERNMENT ASSUMES NO LIABILITY WHATSOEVER FOR ANY INACCURACIES IN THESE NOTATIONS. BIDDERS AND CONTRACTORS ARE CAUTIONED TO EVALUATE THE REQUIREMENTS OF THIS DOCUMENT BASED ON THE ENTIRE CONTENT AS WRITTEN IRRESPECTIVE OF THE MARGINAL NOTATIONS AND RELATIONSHIP TO THE LAST PREVIOUS ISSUE.

Preparing activity:
Navy - SH
(Project 6125-N130)

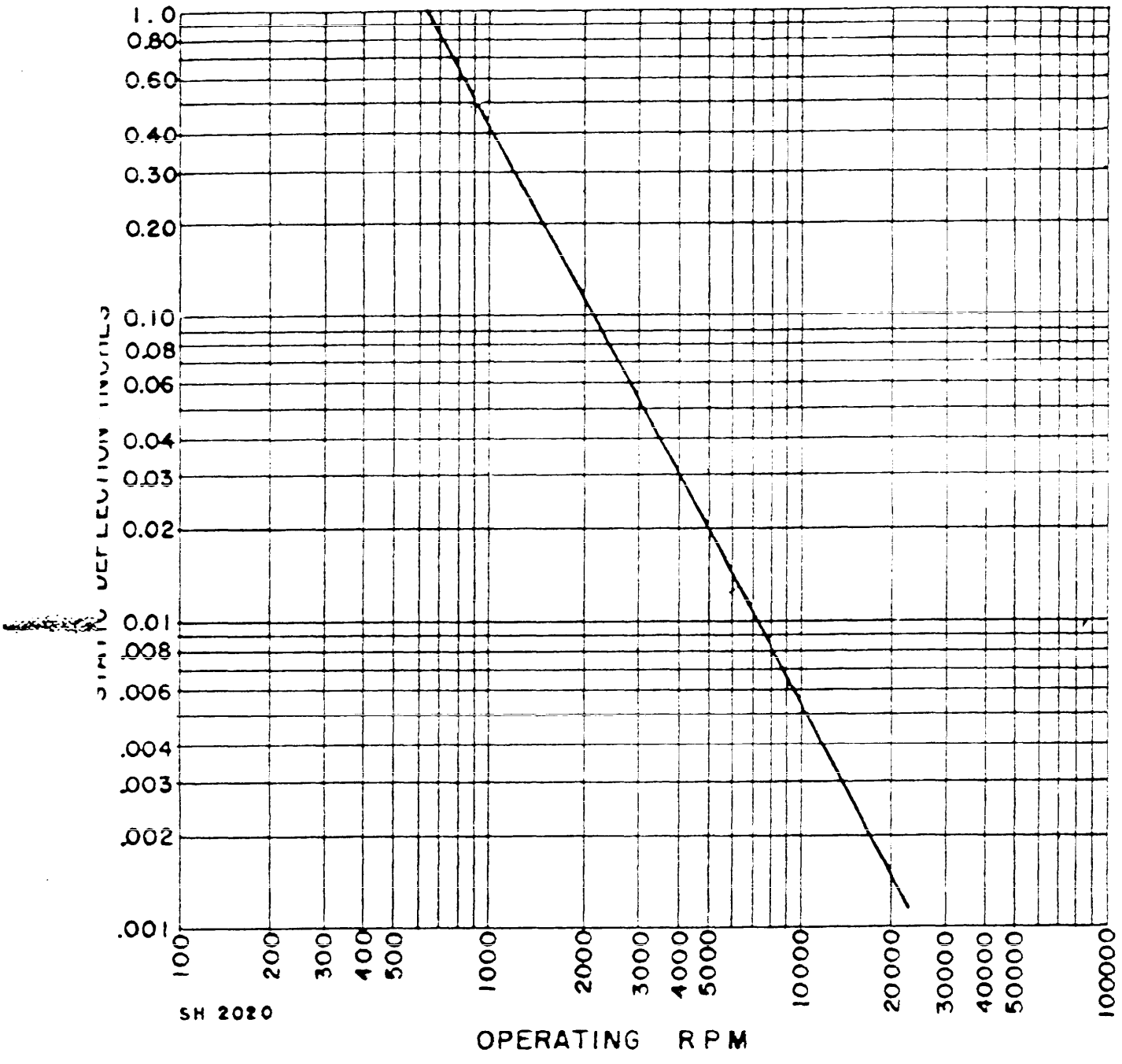

Figure 1 - Static deflection of elastic mounting for internally excited vibration test.

APPENDIX

INSPECTION CHECK LIST FOR IN-PROCESS INSPECTION

10. SCOPE

10.1 This appendix lists those items which shall be included in the in-process inspection of motor generators power supplies including control equipment furnished in accordance with this specification. This list is not an all inclusive list and additions and deletions as applicable can be made by the manufacturer subject to the approval of the inspector.

20 APPLICABLE DOCUMENTS

20.1 This section is not applicable to this specification.

30. REQUIREMENTS

30.1 To facilitate the in-process inspection procedure the manufacturer shall prepare a manufacturing flow chart showing the normal flow of material, parts, subassemblies, and assemblies through the manufacturing process. The manufacturer shall indicate on the flow chart the points at which the manufacturer conducts in-process inspection and these points shall be designated as inspection stations.

30.1.1 For each inspection station the manufacturer shall prepare an inspection check sheet listing the items inspected at that station. Where appropriate, a standard sketch shall be included in the check sheet showing dimensions to be checked and the allowable tolerances, finish requirements, and so forth. Space shall be left on the sketch or on the check sheet to record the results of dimensional, visual or other inspection. A column shall be included on the check sheet for the initials or stamp of the manufacturer's representative conducting the inspection. A space shall be left on the inspection check sheet for the inspector's initials or stamp. The inspection check sheet shall be suitably protected against damage or staining and will be physically attached to the item being inspected. When the unit is assembled, the inspection check sheet shall be attached to the unit or otherwise made available. The words "approved drawing" as used herein mean a required drawing (type I drawing), which is approved by the cognizant approval activity, or a manufacturer's shop drawing if needed to depict details for in-process inspection not shown on a required drawing. Manufacturer's shop drawings which agree with approved required drawings may also be used for in-process inspection. Inspection requirements are not to be waived or reduced by selection of drawings.

30.2 General inspection items. General inspection items shall be as follows:

(a) Material is as specified on approved drawing. Material was ordered in accordance with applicable material or parts specification and was inspected in accordance with the requirements of the material or parts specification.

(b) All welding is done by qualified welders and is in accordance with the approved drawing. There is no evidence of nonfusion, weld cracks, under-size welds, incomplete welds, heavy porosity, weld splatter or slag.

(c) All soldered connections are solidly bonded; there is no cold soldering, no rosin joints, no corrosive flux, no fractured joints, or excess solder. Satisfactory connections were made prior to soldering. Bolted connections include approved locking devices and are secured against vibration. Solderless connectors are properly crimped and the connector and crimping tool are proper size.

(d) Finished castings are as shown on approved drawing and are clean and free of molding sand, cracks, blow holes, splits and deformations. Sufficient material is allowed for machining. Casting defects have not been covered by unauthorized repairs.

(e) Machining is as shown on approved drawing. The surfaces, including mating surfaces, as applicable, are smooth, square and are free of burrs, sharp edges, tool marks, chatter marks, and scratches and damage due to handling. Surface finish is as shown on approved drawing, and there are no tool marks except those normally associated with the indicated surface finish. There are no flaws exposed as the result of machining.

... of each part (motor generator, voltage,

(f) No parts are Government surplus or have been previously used or reclaimed.
(g) All items including hardware (nuts, bolts, lockwashers, and so forth) are made of corrosion resistant material or are given a corrosion resistant treatment as specified in MIL-E-917.
(h) The inspector may require a coil or winding to be cut apart to see the extent of varnish treatment and filling if there is any question as to the effectiveness of varnish treatment used.
(i) All bolts, nuts, set screws and other fasteners are secured in a manner which will preclude loosening in service. All locking devices shall meet the requirements of MIL-E-917.
(j) Insulation creepage and clearance distances are in accordance with approved drawing. Creepage distances are not achieved by means of cemented or butt joints.

30.3 Motor generators.

30.3.1 Items to be inspected prior to assembly. Items to be inspected prior to assembly shall be as follows:

(a) Shafts.
(1) Items (a), (b), (e) and (f) of 30.2 apply.
(2) All dimensions, tolerances, keyways, fillets, shoulders, and surface finish are as shown on the approved drawing.
(3) Eccentricity tolerances including out of round for the bearing seats, bearing shoulder, and the seats for the rotating armatures or rotors are as shown on the approved drawing.
(4) After welding on appurtenances, shaft has been stress relieved as shown on the approved drawing.
(5) The shaft was not built up in any way to correct errors or reclaim material (unless specific case basis approval of the procuring activity is obtained in advance).
(6) All shoulders are square as shown on the approved drawing.
(b) Fans.
(1) Items (a), (b), (d), (e), (f), (g), (h), (i), and (j) of 30.2 apply.
(2) Fans, except those covered by 30.3.1(b)(5) are balanced.
(3) All dimensions and the number of blades are as shown on the approved drawing.
(4) The fan surfaces which move the air are free from any irregularities, surplus weld material or any other projections which may be a source of airborne noise.
(5) Fans which break down into several parts are indexed in a manner such that they can be assembled in one way only.
(c) End brackets and bearing housings, end caps and enclosures.
(1) Items (a), (b), (e) and (f) of 30.2 apply.
(2) Sufficient metal is available for drilling and tapping.
(3) All drilling, tapping and bolt centers are as shown on the approved drawing. Holes are clean, free of chips and are drilled straight. There are no burred threads. Holes are spot faced and are located so that edge distance is adequate in accordance with the approved drawing.
(4) All rust and grease is removed before painting. End brackets and enclosures fabricated and stored for periods prior to assembly were cleaned, and given a coat of primer or rust preventive before storing.
(5) The end brackets, except mating surfaces, such as bearing housings and rabbets, are cleaned, primed and painted on the inside surface prior to assembly. The inside of the frame is primed and painted if it did not receive at least two dips and bakes during the varnish treatment of the stationary electrical coils.
(6) Mating surfaces of brackets and frame are concentric as shown on the approved drawing.
(7) All dimensions, dimensional tolerances and concentricities are as shown on the approved drawing.
(8) Bearing housings have sufficient metal to permit redrilling and bushing of the housing.

30.3.2 Items to be installed during assembly.

(a) General.
(1) Items specified in 30.2 apply.
(2) All parts are interchangeable and no selective matching of parts is necessary.
(3) Assembly and disassembly of all equipment can be done without the use of special tools except as otherwise specified in the contract. Special tools are defined as those tools not listed in the Federal Supply Catalog. (Copies of this catalog may be consulted in the office of the Defense Contract Administration Office (DCAS)).

(b) Items to be checked during winding and assembly of rotating elements.
(1) Keys as shown on the approved drawing are used to prevent rotational movement of all rotating parts (such as spiders, rotors or armatures).
(2) When rotating parts are pressed on the shaft, the pressure required to press on these parts is as shown on the approved drawing.
(3) When rotating parts are shrink fitted on the shaft, the interference shrink fits of the parts are as shown on the approved drawing.
(4) Axial movement of all parts is prevented by the methods shown on the approved drawing.
(5) Fans are secured to the shaft as shown on approved drawing.
(6) Coil connections for rotating armature, a.c. generators and all equalizer connections are insulated adequately as shown on the drawing.
(7) Bearings are of the size and type as shown on the approved drawing.
(8) The inner races of ball and roller bearings are secured to the shaft by means of shaft shoulders, lock washers and nuts or by the opposed shoulder method as shown on the approved drawing.
(9) Lamination size and stacking are as shown on the approved drawing.
(10) Slot or ground insulation are as shown on the approved drawing.
(11) Slot or ground insulation extends beyond stacking as shown on the approved drawing.
(12) Wire size and type used are as shown on the approved drawing.
(13) Preformed coils formed in accordance with the dimensions shown on the approved drawing and given at least one varnish treatment with clear baking varnish before installation in the slots.
(14) Undue force is not required to put slot wedge in place and insulation is not damaged or pushed out of place as the wedge is inserted.
(15) Slot wedges are of material and size as shown on the approved drawing. Length of wedge exceeds length of slot as shown on approved drawing.
(16) Coils are not loose after the wedges are in place.
(17) The wedge size is proper for the size and shape of the slot and there is no possibility that the wedge will cock in the slot and slip out.
(18) Coil connections are adequately insulated as shown on the drawing.
(19) Coil support and phase insulation is as shown on the approved drawing. Phase insulation is inserted between the phase coils and is shaped to fit coil configuration.
(20) Coil extensions are insulated and secured as shown on the approved drawing.
(21) Insulation materials used are as shown on the approved drawing.
(22) Dimensions of wound coils are as shown on the approved drawing.
(23) Rotating field poles are secured as shown on the approved drawing.
(24) If steel wedges are used to secure rotating field poles, the wedges are securely driven and positive assurance is provided that they will not work loose.
(25) Insulation is cleaned off and unless self fluxing wire is used coil wire ends are tinned before making soldered connections. Connections are properly soldered. There is no evidence of cold solder joints. Commutator riser slots are filled with solder and any excess removed.
(26) Lead wires are of the type shown on the approved drawing.
(27) Windings are mechanically secured as shown on the approved drawing.
(28) When preformed coils are used, the coils are given one varnish treatment prior to insertion in the slots or on the poles and the completed winding assembly, including winding and pole, is given the varnish treatments with approved clear baking varnish. In the case where preformed coils are not used the complete assembly is given at least three varnish treatments.

(29) Type of varnish, treatment and baking time cycle, and baking temperatures are as shown on the approved drawing.
(30) The treated windings and coils are clean, smooth and glossy with good bonding and filling. Varnish seals are complete and show no signs of cracks or breaks. The completed windings have no air bubbles, air pockets, voids or dry spots on the surface and are not soft or sticky.
(31) There is no sign of excessive varnish buildup on one side of the winding assembly and lack of varnish buildup on the other side. The thickness of the varnish on the winding assembly shall be uniform over the entire surface of the windings.
(32) Lead wires are insulated from ground and secured to prevent them from moving due to centrifugal force. Length and arrangement of wires shall permit ready repair; there is no aimless wiring resulting in "rats nests". Wiring agrees with the approved drawing.
(33) No glyptal or non-approved type of varnish or paint was put on any of the rotating elements.
(34) Coils or windings are not nicked or damaged during handling and processing.
(35) All completed rotating elements (including bearings), are dynamically balanced. The type of balance weights and method of securing are as shown on the approved drawing. They are secured in a manner such that they will not loosen in service. Balance weights are not attached in the airstream of the fan.
(36) Mica is under cut to specified depth. Copper segments are not damaged.

(c) Items to be checked during winding and assembly of stationary elements.
(1) Items 30.3.2(b)(10) thru (23) inclusive, (26) thru (32) inclusive, (34) and (35).
(2) Complete stator assembly or stator core is secured to frame or frame spider as shown on approved drawing.
(3) Force required to press complete stator assembly or stator core into the frame or frame spider is as shown on the approved drawing.
(4) Axial movement of the stator within the frame is precluded by means shown on the approved drawing.
(5) All lead wires are insulated from ground and secured within the frame with a suitable clamp or fastening device.
(6) All lead wires pass through the frame, enter the terminal box and are secured in such a manner to prevent chafing or abrasion as shown on the approved drawing.
(7) Terminal lugs of the type shown on the approved drawing are provided on the leads. Terminal lugs are properly crimped and there are no cut wire strands.
(8) Terminal boxes are of the type and size shown and are secured in the manner shown on the approved drawing.
(9) All leads are properly marked as shown on the approved drawing. It is possible to differentiate motor leads from generator leads.
(10) All nuts, bolts, screws and other hardware are tight and provided with locking devices as shown on the approved drawing.
(11) Insulation material as shown on the approved drawing is placed between field coil and frame prior to securing the pole.
(12) Field pole coil is not unduly stressed while tightening pole securing bolts. Insulation is not damaged in the tightening process.
(13) Each field coil received at least three separate dips and bakes with an approved clear baking varnish either before or after assembly into the stator.
(14) All salient field coil connections were either soldered or bolted and a solid joint was made.
(15) All salient field coil connections are adequately insulated as shown on the approved drawing.
(16) Terminal board material is as shown on the approved drawing.
(17) Terminal studs are secured to the board in a manner to preclude turning when attaching external cables.

30.3.3 Items to be inspected during final assembly. Items to be inspected during final assembly shall be as follows:

(a) Items (a), (b), (c), (d), (e), (f), (g), (h), (i) and (j) of 30.2.
(b) End brackets properly match motor generator bearing housings and end caps. All holes align, there is no excess clearance, and no undue force is required to assembly parts.

(c) Coil ends do not protrude to a point where they may be damaged by assembly or removal of the end bracket and there is no possibility of interference with the rotating elements.
(d) Bearing outer races are secured in their housings as shown on approved drawing. The inside diameter of the retaining shoulders is within the dimensional tolerances shown on the approved drawing.
(e) There is no evidence of grease leakage past the close clearance non-rubbing seals into the motor generator or along the shaft.
(f) Spring washers, if used to provide preloading of the bearing, shall be selected and secured in the housing as shown on approved drawing.
(g) Seals of pre-lubricated bearings are not damaged and there is no evidence of grease leaking out of the bearing.
(h) Rotating diodes are properly secured to hub on shaft.
(i) Rotating voltage suppressors are properly secured.
(j) Terminals, connections and wiring of all parts in the rotating exciter assembly are securely tied down and protected.
(k) Air gaps have been adjusted to design value and are uniform within the limits shown on the approved drawing.
(l) Bearings have been lubricated with grease as shown on the approved drawing.
(m) Air baffles are securely attached and do not interfere with rotating elements.
(n) Lifting means is provided as shown on the approved drawing.
(o) Equipment enclosure is as shown on the approved drawing.
(p) Drain plugs are provided as shown on approved drawing.
(q) Entire exterior, other than identification plates or shaft extensions is painted in accordance with MIL-E-917.
(r) Identification and instruction plates are as shown on the approved drawing; contain all required information and are legible.
(s) Mounting feet are flat, square, and are as shown on approved drawing.
(t) The overall dimensions, mounting dimensions, and location of terminal boxes are as shown on the approved drawing.
(u) Friction type (rubbing) seals, are the type and are secured as shown on the approved drawing.
(v) Where high tensile bolts or screws such as socket head types, are used, provision is made to prevent replacement with a lower tensile strength bolt or screw. There are no slotted head bolts or screws used to secure end brackets to the housing. Thread-cutting screws (self tapping) are not used to secure any part of the motor generator.
(w) Spot facing is as specified in MIL-E-917.
(x) The motor generator, particularly the bearing housing, is clean and free of dirt, metal chips or other foreign materials.
(y) The weight of the complete unit is as shown on the drawing.
(z) Stationary lead wires do not contact rotating parts.

30.4 Control equipment.

30.4.1 Items to be inspected on major parts.

(a) The following items were ordered in accordance with the applicable specification as modified by the contract requirements; are of the size, type and rating shown on the drawing; and are Q.P.L. items.
  (1) Resistors and rheostats.
  (2) Instruments, instrument transformers, shunts and other associated accessories.
  (3) Motor starters and associated pushbuttons.
  (4) Circuit breakers.
  (5) Capacitors.
(b) The following items are not necessarily Q.P.L. items but are of the size, type and rating shown on the drawing.
  (1) Switches.
  (2) Rectifiers.
  (3) Molded terminal boards.
  (4) All laminated materials such as glass mica glass, glass silicon glass, used for terminal boards, sub panels, and so forth.
(c) All materials used in the construction of reactors, magnetic amplifiers, and transformers other than instrument transformers are as shown on the approved drawing and comply with the material requirements as shown on the approved drawing.
(d) All windings of reactors, magnetic amplifiers, and transformers other than instrument transformers were given a minimum of three varnish treatments or

one vacuum impregnation and bake followed by one dip and bake with an approved clear baking varnish in accordance with the procedures shown on the approved drawing.

(e) No black varnish, glyptal, paint, or other treatment was given to the insulation of reactors, magnetic amplifiers, and transformers other than instrument transformers after the last dip and bake with clear baking varnish.

(f) The resistance of all windings of all reactors, magnetic amplifiers, and transformers other than instrument transformers is as shown on the approved drawing. Ratio of turns is as specified on the approved drawing.

(g) The equipment enclosures are as shown on the approved drawing.

30.4.2 Items to be inspected on completed unit.

(a) All parts, subassemblies and assemblies are mounted as shown on the approved drawing.

(b) All parts which require servicing, repair, replacement, or periodic adjustment during the life of the equipment are readily accessible.

(c) All parts are marked with identifying symbols and these symbols agree with those used on the approved drawing.

(d) All terminals of all wiring leads and terminal boards are marked with identifying letters and numbers or both and this identification agrees with those used on the approved drawing.

(e) Wire used for interconnections is of the type and size shown on the approved drawing.

(f) All wiring is neatly formed into groups and laced with non-inflammable glass cord and supported or clamped in a manner which will prevent chafing of the insulation due to vibration and shock.

(g) Cable clamps used are of non-inflammable material.

(h) There are no splices in any of the wires.

(i) Wire groups from hinged doors and panels are formed and clamped in a manner that sharp bends do not occur with the panel or door in either the open or closed position.

(j) Sufficient slack in wiring is allowed so that the weight of the harness is not supported by the terminal connections and so that at least two replacements can be made if lugs are clipped off at the wire end.

(k) Cable entrance provisions are as shown on the approved drawing.

(l) Sufficient space is provided to bring external cables through these cable entrances, support them within the enclosure, and make connections at the appropriate terminals.

(m) Wherever wires run through holes in metal partitions or chassis grommets are provided for mechanical protection.

(n) Wires are not bent around sharp corners which may injure the insulation.

(o) All wires are connected by either bolted or soldered connections.

(p) All bolted connections are provided with locking devices.

(q) The soldered connections do not rely on the solder for mechanical strength. The wire was mechanically secured before soldering and the solder was used only to get a good electrical path.

(r) No more than three wires are soldered to any one terminal.

(s) Both ends of all wires are marked with designations as shown on the approved drawing.

(t) Hinged doors and panels do not bind when opening.

(u) A door stop and positioning device is furnished and functions satisfactorily.

(v) All identification and instruction plates are furnished as shown on the approved drawing.

(w) All information on identification and instruction plates is legible.

(x) A copy of the schematic and wiring diagram for the complete system as well as a copy of the operating instructions has been laminated in plastic and is stowed in a convenient location within the control panel.

(y) The location of the plastic laminated drawings and instructions is such that it does not interfere with convection air flow which may increase heating of parts. In those cases where the location is questionable, heat runs of the control panels are run with the diagrams in place.

(z) The overall and mounting dimensions of the equipment are as shown on the approved drawing.

(aa) The overall weight of the equipment is as shown on the approved drawing

(bb) The exterior and interior of the enclosure have been painted as shown on the approved drawing.

(cc) All controls operate smoothly throughout their range.

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SPECIFICATION ANALYSIS SHEET

Form Approved
Budget Bureau No. 119-R004

INSTRUCTIONS

This sheet is to be filled out by personnel either Government or contractor, involved in the use of the specification in procurement of products for ultimate use by the Department of Defense. This sheet is provided for obtaining information on the use of this specification which will insure that suitable products can be procured with a minimum amount of delay and at the least cost. Comments and the return of this form will be appreciated. Fold on lines on reverse side, staple in corner, and send to preparing activity (as indicated in reverse hereof).

SPECIFICATION

ORGANIZATION (Of submitter) | CITY AND STATE

CONTRACT NO. | QUANTITY OF ITEMS PROCURED | DOLLAR AMOUNT $

MATERIAL PROCURED UNDER A

☐ DIRECT GOVERNMENT CONTRACT ☐ SUBCONTRACT

1. HAS ANY PART OF THE SPECIFICATION CREATED PROBLEMS OR REQUIRED INTERPRETATION IN PROCUREMENT USE?

A. GIVE PARAGRAPH NUMBER AND WORDING.

B. RECOMMENDATIONS FOR CORRECTING THE DEFICIENCIES.

2. COMMENTS ON ANY SPECIFICATION REQUIREMENT CONSIDERED TOO RIGID

3. IS THE SPECIFICATION RESTRICTIVE?

☐ YES ☐ NO IF "YES", IN WHAT WAY?

4. REMARKS (Attach any pertinent data which may be of use in improving this specification. If there are additional papers, attach to form and place both in an envelope addressed to preparing activity)

SUBMITTED BY (Printed or typed name and activity) | DATE

DD FORM 1 APR 63 1426 REPLACES NAVSHIPS FORM 4863, WHICH IS OBSOLETE 0101-807-2000