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30 November 1970
SUPERSEDING
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(See 6.7)

MILITARY SPECIFICATION

REGULATORS, LINE VOLTAGE, SINGLE PHASE, 400 HERTZ A.C. NAVAL SHIPBOARD

1. SCOPE

1.1 Scope. This specification covers general requirements for single phase, 400 Hertz (Hz) alternating current (a.c.) line voltage regulators intended for shipboard application. The single-phase regulators shall operate in a three-phase bank when connected in a four-wire wye circuit with or without a grounded neutral, or in a delta circuit.

1.2 Classification. The continuous load capacity of the three-phase bank shall be limited by the maximum line current rating of the single-phase equipment. Equipments shall be of the following ratings as specified (see 6.1):

115 volt system - Equipments are rated at 115 volts (V) root-mean-square (RMS) and the following maximum continuous output line currents:

75 amperes RMS
150 amperes RMS
225 amperes RMS

440 volt system - Equipments are rated at 440V RMS and the following maximum continuous output line currents:

20 amperes RMS
40 amperes RMS

2. APPLICABLE DOCUMENTS

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

SPECIFICATIONS

MILITARY

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-E-2036 - Enclosures For Electric and Electronic Equipment, (Naval Shipboard).
MIL-P-15024 - Plates, Identification - Information and Marking For Identification of Electrical, Electronic and Mechanical Equipment.
MIL-M-15071 - Manuals, Technical Equipment and Systems Content For.
MIL-O-16485 - Ohmmeters, Insulation-Resistance-Indicating, Portable.
MIL-I-16923 - Insulating Compound, Electrical, Embedding.
MIL-E-17555 - Electronic and Electrical Equipment and Associated Repair Parts; Preparation For Delivery.
MIL-S-19500 - Semiconductor Devices, General Specification For.
MIL-I-45208 - Inspection System Requirements.
MIL-T-55164 - Terminal Boards, Molded Barrier, Screw and Stud Types and Associated Accessories, General Specification For.

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MIL-M-81203 - Manual, Technical, In-Process Reviews, Validations and Verification Support of.

STANDARDS

MILITARY

MIL-STD-108 - Definition of and Basic Requirements for Enclosure for Electric and Electronic Equipment.
MIL-STD-167 - Mechanical Vibrations of Shipboard Equipment.
MIL-STD-198 - Capacitors, Selection and Use of.
MIL-STD-199 - Resistors, Selection and Use of.
MIL-STD-470 - Maintainability Program Requirements (For Systems and Equipments).
MIL-STD-471 - Maintainability Demonstration.
MIL-STD-701 - Lists of Standard Semiconductor Devices.
MIL-STD-740 - Airborne and Structureborne Noise Measurements and Acceptance Criteria of Shipboard Equipment.
MIL-STD-761 - Electric Power, Alternate Current, For Shipboard Use, Characterization and Utilization of.
MIL-STD-785 - Requirements for Reliability Program (For Systems and Equipments).

PUBLICATIONS

MILITARY

NAVSHIPS 0967-312-8010 (Formerly NAVSHIPS 94324) - Maintainability Design Criteria Handbook for Design of Shipboard Electronic Equipment.

(Copies of specifications, standards, drawings, and publications required by contractors 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 Qualification. The line voltage regulators (see 6.4.1), furnished under this specification shall be a product which is qualified for listing on the applicable qualified products list at time set for opening of bids (see 4.3 and 6.2).

3.2 General requirements. The equipment shall be in accordance with MIL-E-917. If any requirement specified herein conflicts with the requirements of MIL-E-917, the requirements of this specification shall govern.

3.2.1 Vibration. The equipment shall withstand the type I vibration test of MIL-STD-167.

3.2.2 Shock. The equipment shall withstand the high-impact shock tests for grade A, class I, type A, lightweight equipment as specified in MIL-S-901.

3.2.3 Airborne noise. For all conditions of operation specified herein, the equipment shall conform to the acceptance limits specified for grade B equipment as specified in MIL-STD-740.

3.2.4 Radio frequency and low-frequency noise interference. Equipment shall be designed and constructed so that any generation of radio interference shall be at a minimum. Filters shall not be used unless specifically approved in each instance by the Naval Ship Engineering Center (NAVSEC).

3.2.5 Inclined operation. Equipment shall give no change in operation when inclined at an angle of 45 degrees from the vertical in any direction.

3.2.6 Mounting. The equipment shall be designed for bulkhead mounting with wiring compartment at the top. When the equipment is mounted in three-phase banks, a space of 4 inches measured horizontally along the width dimension shall be allowed between adjacent units for ventilating purposes. The equipments shall be mounted vertically and shall be free from obstructions to natural draft ventilation. The minimum clear space between the bottom of each equipment and the deck or other solid obstacle that would limit ventilation shall be 6 inches. Equipment shall be provided with means for lifting or handling, which may consist of mounting channels for engagement in a sling. Mounting brackets shall extend horizontally along the width dimension at the rear of the enclosure. The equipment shall be designed for mounting by four bolts in a rectangular pattern. Each equipment shall be equipped with cable entrance provisions which shall permit the passage of external cabling through the side panels to the input-output terminal board positioned in the wiring compartment. All mounting provisions shall be arranged for easy access and adjustment of mounting screws or bolts without the use of special tools and without disassembly of equipment. 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 Service (DCAS)).

3.2.7 Enclosure. Each equipment shall be provided with a dripproof protected enclosure constructed in accordance with MIL-E-2036. The term "dripproof protected", when applied to the equipments specified herein, shall be in conformance with the definitions of MIL-STD-108, with respect to degree of enclosure and environmental protection. Enclosure and framework shall be constructed of steel or aluminum or a combination of both. All enclosures shall be of the dead front type. Sufficient space and accessibility shall be provided in the cable compartment for effecting connection of single-phase units in three-phase banks. In order to facilitate installation and maintenance of the equipment, ready accessibility shall be provided for routing of shipboard cabling to the input-output terminal board and shipboard adjustment of cable drop compensation parameters. Variable resistors (or potentiometers) necessary to permit individual adjustment of the required degree of resistive and inductive components of cable drop compensation (see 3.3.4) shall be mounted on the input-output terminal board within the wiring compartment of the equipment enclosure to afford ready availability of these adjustments to maintenance personnel.

3.2.8 Insulation. Insulation shall be class B, F, H or N as specified in MIL-E-917 and shall be that which will result in minimum size and weight with optimum performance. Potting compounds, if used, shall be in accordance with type B, C or D of MIL-I-16923.

3.2.9 Terminals and connections. Equipment shall be completely wired internally and to terminals provided for external connections Terminals provided for external connections shall take cable connections up to 150 percent current rating of the equipment and shall be arranged on a terminal board located to provide ready accessibility for making connections. The terminals for external wiring shall be located in wiring compartments as specified in 3.2.6. Protective shields, as necessary, shall be furnished to protect exposed terminals or mounting boards within the equipment from damage due to penetration of the enclosure by moisture or foreign objects. Test points shall be provided for all control circuits for making measurements of voltage, current, and resistance as necessary for troubleshooting. All tests points shall be available at terminals arranged on a terminal board located in a readily accessible position within the equipment enclosure. Terminal lugs shall be provided for all leads except for the main power input and power output leads. All terminal lugs installed by the manufacturer shall be of solderless type, approved by NAVSEC. All connections using wire larger than 4000 circular mils (cm.) shall be provided with efficient locking devices to prevent their becoming loosened by shock or vibration. Terminal boards shall be in accordance with MIL-T-55164 (with insulation as specified in MIL-E-917) except (a) where the terminal board is integral and considered a part of another approved part, and (b) where the application rating or space configuration makes their use impractical. Terminals shall be provided with contact surfaces of areas and materials that will ensure the operation and freedom from oxidation of contact surfaces when the equipment is operated continuously in local temperatures of 110° centigrade (C.) as experienced by the terminal lugs. Threaded surfaces of bolts and studs shall not be utilized for current carrying contacts. Where wire smaller than 2000 cm is involved and the size of a part does not allow for the installation of screw type terminals, soldered connections will be permitted. All such connections shall be in accordance with MIL-E-917.

3.2.10 Wiring. All wiring in the equipment shall be of sufficient capacity for rated duty of the equipment and shall be in accordance with MIL-E-917. Identification markings shall correspond to lead numbers of the wiring diagram. All wiring and sleeving used in the equipment shall have insulation with temperature rating sufficiently high to provide for operation and life with ambient temperatures equal to the maximum surface temperatures of the adjacent equipment parts.

3.2.11 Resistors. Resistors shall be selected from MIL-STD-199. For applications which require resistors of ratings or characteristics other than those listed in MIL-STD-199, the contractor shall obtain approval from NAVSEC in accordance with MIL-E-917.

3.2.12 Capacitors. Capacitors shall be selected from MIL-STD-198. For applications which require capacitors of ratings or characteristics other than those listed in MIL-STD-198, the contractor shall obtain approval from NAVSEC in accordance with MIL-E-917.

3.2.12.1 The rise above ambient of the temperature measured on the case of capacitors used for a.c. applications shall be limited to 15°C. at the most severe conditions of application. Capacitors may be of non-standard type, subject to NAVSEC approval (see 3.2.12), provided that the above temperature rise limitations are met and the capacitors are designed for 40,000 hours operation at 85°C. and the maximum operating voltage.

3.2.13 Semiconductor devices. Semiconductor devices shall be silicon types and shall be selected from MIL-STD-701. For applications which require semiconductor devices of ratings or characteristics other than those listed in MIL-STD-701, the contractor shall obtain approval from NAVSEC as required by MIL-E-917. Application of semiconductor devices shall be as specified by MIL-E-917.

3.2.14 Transformers and reactors. The fabrication and thermal capabilities of transformers and reactors shall be in accordance with MIL-E-917 with respect to:

(a) electrical insulation
(b) treatment and processing of insulation
(c) selection of material such as magnet wire, impregnation varnish and core laminations.

3.2.15 Insulation resistance. The insulation resistance of all circuits shall be not less than 10 megohms when measured with all circuits deenergized at room temperature (23°C.).

3.2.16 Dielectric strength. All equipment shall be so designed and constructed as to withstand for a period of 1 minute a dielectric test voltage between separate circuits and to ground as specified in 4.5.19.2.

3.2.17 Thermal design. Equipment design shall be such as to permit continuous operation in accordance with 3.3, without exceeding the limiting temperatures corresponding to the class of insulation materials employed in the equipment or temperature ratings assigned to power semiconductors.

3.2.18 Ventilation. The equipment shall be cooled by natural convection without use of fans. This shall be accomplished by construction of enclosures and arrangement of parts to give a chimney-effect, natural draft. The dimensions of the equipment shall include any necessary allowance for air intake and discharge.

3.2.19 Size and weight. The maximum size and weight of each single-phase equipment shall be as specified in table I. Dimensions are overall including screw heads and all protrusions except for mounting straps (see 3.2.6).

Table I - Size and weight requirements.

Maximum line current rating (amperes)		Maximum dimensions, inches			Max. weight (pounds)
115V units	440V units	Height	Width	Depth	
75	20	24	26	12	150
150	40	26	28	15	200
225	-	28	30	18	225

3.2.20 Painting. Painting shall be in accordance with MIL-E-917 except that only one coat of gray enamel need be applied. Marks or scratches made due to handling during fabrication and testing shall be repainted by either complete repainting of equipment or by touch-up method.

3.3 Design and construction.

3.3.1 Operation. Operation shall be accomplished by means of static parts, such as saturable core reactors, buck-boost transformers, silicon controlled rectifiers, semiconductor devices, transistors, resistors and capacitors. Thyratron, gas or vacuum tubes, tap changing adjustable auto-transformers, rheostat, or contactors shall not be used. Each equipment of a specific rating and design shall be for use as a single-phase unit or as three identical units connected in a three-phase bank. No adjustment, other than compensation for output line voltage drop, shall be required to put the equipment into performance at the time of installation. Output voltage compensation capability (see 3.3.4) shall be furnished in all equipments. Control of the equipments shall be accomplished by means of devices mounted within the basic equipment enclosure. The equipment shall be designed for continuous duty under either single-phase or three-phase application. Equipments shall operate in accordance with 3.3.2 when wired into a three-phase configuration with forward or reversed phase rotation (see 6.4.22). Each equipment shall be designed with provisions for local sensing and remote sensing.

3.3.2 Operational configuration. The equipment shall be capable of regulating output voltage (see 6.4.28), according to the following modes of operation:

(a) Internal (or local) sensing and regulation of output voltage at the terminals of the equipment.
(b) Remote sensing and regulation of voltage directly at the load or other remote point (output voltage compensation not used).
(c) Internal (or local) sensing of output voltage at the terminals of the equipment with provision for output voltage compensation (see 3.3.4) for single phase and three phase wye operation.

3.3.2.1 When connected in a three-phase 115V four-wire wye system, the equipments shall regulate each line-to-neutral output voltage within the specified steady-state regulation band.

3.3.2.2 When connected in a three-phase 115V or 440V delta system, the equipments shall maintain output line-to-line voltages within the specified steady-state voltage regulation band.

3.3.3 Voltage regulation (steady-state).

3.3.3.1 RMS output voltage shall remain regulated without adjustment for all conditions specified in table II. Steady-state output voltage shall be regulated within the following bands, corresponding to mode of equipment operation:

(a) ± 0.5 percent of rated voltage for operational modes specified in (a) and (b) of 3.3.2.
(b) ± 1.0 percent of rated voltage for operational mode specified in 3.3.2(c).

3.3.3.2 Steady-state voltage regulation performance shall be as specified for each operational mode of 3.3.2, when equipments are connected in a three-phase delta configuration under the conditions of unbalanced line current specified in table II and input line-to-line voltages are successively set at the following values:

Percent of rated input voltage

Phase AB	Phase BC	Phase CA
95	100	105
105	95	100
100	105	95

3.3.3.3 Steady state voltage regulation shall be as specified for each operational mode of 3.3.2, when equipments are wired into a three phase four wire wye system, under the conditions of unbalanced line current specified in table II and input line-to-neutral voltages are set successively at the following values:

Percent of rated input voltage

Phase A-N	Phase B-N	Phase C-N
95	100	105
105	95	100
100	105	95

Table II - Electrical operation characteristics.

Identification plate ratings, Maximum continuous output Line current, RMS amperes:	
115V system	75, 150, 225
440V system	20, 40
Ratings, KVA per phase	(See 6.5)
Rated voltages (RMS)	115 volts, single phase 115 volts, line-to-line (three-phase delta) 115 volts, line-to-neutral (three-phase wye, four wire) 440 volts, single phase 440 volts, line-to-line (three-phase delta)
Input voltage, steady-state band	+ 5 percent of rated voltage
Input/output frequency, steady-state	400 Hz + 1/2 percent
Output load variation	No load to rated full load, single-phase No load to rated full load, three phase balanced
Output power factor	0.75 lagging to unity
Output load unbalance (maximum)	
Three-phase wye (four wire)	10 percent of rated output line current in one line Rated output line current in remaining two lines
Three-phase delta	20 percent of rated output line current in one line 80 percent of rated output line current in remaining two lines
Ambient temperature	+ 23°C. to + 50°C.

3.3.4 Output voltage compensation (three-phase, four-wire wye system). Each equipment shall be designed to provide means for output voltage compensation covering a minimum range extending from zero to plus 7.07 percent of rated output voltage at rated full load to compensate for voltage drop in the cabling between the equipment and the connected load. The compensation shall be provided in the form of separate resistive compensation and inductive compensation, each to be independently adjustable over a range from zero to 5 percent of rated voltage at rated full load. The degrees of resistive and inductive compensation respectively shall be individually adjustable by means of variable resistors internal to the equipments but accessible and available for necessary adjustment aboard ship. Any regulation error introduced by the specified output voltage compensation shall be constrained to permit the RMS output voltage at the end of the load cable to remain regulated within plus or minus 1 percent of rated voltage over a load range extending from no load to rated full load. The requirements on magnitude of output voltage compensation and permissible regulation error specified herein shall be satisfied when equipments are operated in a three-phase four-wire wye system (with grounded neutral) under conditions of balanced load or unbalanced load as follows:

20 percent rated load on one phase; rated full load on remaining two phases.

3.3.4.1 Compensation shall be linear as a function of load as required to meet the performance requirements of 3.3.4. Compensation circuitry and parts shall be so designed that no combination of adjustments shall cause the regulator terminal output voltage to exceed 110 percent of rated voltage at any load.

3.3.5 Input/output voltage transient effect. If an undervoltage or overvoltage transient of maximum amplitude equal to 5 percent of rated peak voltage is superimposed upon the steady-state input voltage, the peak transient occurring in the output voltage shall not exceed 8 percent of rated peak output voltage. The output voltage shall recover to, and remain within, the steady-state regulation band specified in 3.3.3 within 0.1 second after the input voltage has recovered to the specified 5 percent steady-state band. The superimposed transient may be induced from any input voltage value within the plus or minus 5 percent steady-state voltage band.

3.3.6 Output voltage transient. When equipments operated in accordance with 3.3.2(a) are subjected to the step changes in load specified in 4.5.8.2, the maximum transient excursion occurring in the output voltage shall not exceed by more than 5 percent of rated peak voltage the peak magnitude of the input voltage transient. Operation of the equipments shall be such that the input voltage prior to and following the load changes of 4.5.8.2 lies within the plus or minus 5 percent steady-state regulation band. The output voltage shall recover to, and remain within, the prescribed plus or minus 0.5 percent steady-state regulation band within 0.1 second after the input voltage has recovered to the specified plus or minus 5 percent steady-state band. No sustained oscillations shall develop.

3.3.7 Output voltage modulation. Calculated on a peak basis, any amplitude modulation present in the output voltage of a regulator equipment shall not exceed 1/2 percent of rated peak voltage when the regulator is connected to a power source which exhibits less than 0.2 percent modulation, as determined by operating the source into a passive load having the same KVA loading effect as the regulator equipment

3.3.7.1 Output voltage modulation gain. When the steady-state input voltage is amplitude modulated at an RMS amplitude equal to 2, 5, or 10 percent of rated RMS voltage and at a frequency ranging from 1 to 100 Hz superimposed upon the steady-state 400 Hz. waveform, the maximum amplitude of the resulting output modulation in the steady-state output voltage waveform shall not exceed 150 percent of the corresponding input modulation when wye connected regulator equipments are operated at rated input voltage, within the plus or minus 5 percent steady-state band, and rated frequency.

3.3.7.1.1 Modulation gain shall be confined to 180 percent when regulator equipments are interconnected in three phase delta banks and operated under the conditions specified in 3.3.7.1.

3.3.8 No load input excitation current characteristics. Each equipment shall exhibit a no load input current excitation characteristic which shall remain within the constraints on amplitude and slope specified in 3.3.8.1 and 3.3.8.2.

3.3.8.1 No load excitation current (steady-state). Under any steady-state operating condition, within an input voltage range extending from an undervoltage 12.5 percent below rated RMS voltage to an overvoltage point 10 percent above rated RMS voltage, the no load, or excitation, (regulator input line current), expressed as percent of rated full load output line current, shall be confined to the limits specified below:

(a) Single-phase or three-phase wye (4-wire):
2% for 150 ampere and 225 ampere regulators;
4% for 75 ampere regulators;
6% for 20 ampere and 40 ampere regulators
(b) Three-phase delta:
3.5% for 150 ampere and 225 ampere regulators;
7% for 75 ampere regulators;
10.5% for 20 ampere and 40 ampere regulators.

3.3.8.1.1 Leading component of excitation current. Within the input voltage range of 3.3.8.1, the leading component of input line current shall not exceed 1.5 percent of maximum rated output line current, for single-phase or three-phase four-wire wye connection, and 3 percent of maximum rated output line current for three-phase delta operation.

3.3.8.1.2 The limits on no load input current specified in 3.3.8.1 shall apply after the first 10 cycles of input current following equipment energization.

3.3.8.2 No load excitation current (dynamic). No load input excitation current shall remain within the constraints specified in 3.3.8.1 when steady-state input voltage is sinusoidally modulated at a peak amplitude equal to 2, 5, or 10 percent of rated peak voltage and at a frequency ranging from 1 to 100 Hz, superimposed upon the steady-state voltages specified in 3.3.8.1.

3.3.8.3 No load input current slope. When the equipment is energized at no load, any tendency to exhibit a characteristic of increasing input current with decreasing input voltage shall not exceed 0.9 percent (of rated current) increase for each increment of 4.5 percent (of rated voltage) decrease. This characteristic shall be met for any increment in input voltage over the range extending from 12.5 percent below rated voltage to 10 percent above rated voltage under both steady-state and dynamic input conditions as specified in 3.3.8.1 and 3.3.8.2

3.3.9 Output voltage buildup. The output voltage of the equipment shall build up to a point corresponding to 85 percent of rated RMS voltage within 35 millisecond (ms) after energization of the equipment. After reaching the 85 percent voltage value, the output voltage shall continue to increase, approaching a point within a plus or minus 0.5 percent band about rated RMS voltage. Steady-state operation conforming to the voltage regulation requirements of this specification shall be attained within 250 ms after energization. In no event shall the output voltage overshoot rated voltage by more than 10 percent, after 35 milliseconds following energization. Build-up of output voltage shall occur as specified under any load condition within the rating of the equipment.

3.3.10 Waveform distortion.

3.3.10.1 Harmonic distortion. When equipments are operated in accordance with 4.5.10.1 under any condition of output load and load power factor specified in table II, the RMS summation of all harmonic components present in the output voltage waveform produced by the equipment shall not exceed 3 percent of rated RMS voltage; no individual output harmonic shall exceed 2 percent of rated RMS voltage.

3.3.10.2 Deviation factor. Waveform deviation factor shall not exceed 5 percent whenever equipments are operated in accordance with table II and 3.3.2(a).

3.3.11 Efficiency.

3.3.11.1 KVA. KVA efficiency of each equipment shall be at least 80 percent at any load between 60 percent load and rated full load, at 0.75 lagging and unity power factors.

3.3.11.2 KW. KW (power) efficiency of each equipment shall be at least 90 percent at any load between 60 percent load and rated full load, at 0.75 lagging and unity power factors.

3.3.12 Endurance. The equipment shall withstand the test of 4.5.16.

3.4 Repair parts. Onboard repair parts, based on the total number of identical parts or sets of parts furnished for each ship, shall be supplied as specified in table III. This table includes parts for a complete line voltage regulator.

3.4.1 Irreplaceable parts. If any part listed in table III forms part of an assembly or sub-assembly and is not normally a replaceable part of the assembly, then the complete assembly shall be furnished in lieu thereof as a repair part.

3.4.2 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 III - Quantities of onboard repair parts to be furnished per ship.

Parts required	Identical parts installed per ship							
	1	2	3	4	5-8	9-20	21-50	51-100
Capacitors each size and type	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
Transformers	1	1	1	1	1	2	3	4
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
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

3.5 Diagrams and identification plates.

3.5.1 Connection diagram. Each equipment shall contain a diagram of electrical connections with each terminal and lead designated to correspond to markings as shown on the equipment. In addition, a schematic circuit diagram and description of operation shall be included. All diagrams and instruction sheets shall be subject to approval of NAVSEC and shall be secured and protected in accordance with MIL-E-2036.

3.5.2 Identification and information plates. Identification plates shall be furnished and installed on all parts of the equipment and on the completed equipment. Information plates shall be furnished and installed on the complete equipment. Plates and marking of part assemblies such as rectifiers and similar items shall comply with the applicable referenced specifications. Identification of other parts such as transformers and reactors shall be made by use of identification plates or by stamping or stenciling the required following minimum data:

(a) Manufacturers name and identification number as shown on applicable drawing.
(b) Title of part (that is, transformer, reactor, and similar items).
(c) Federal stock number, if available.

If stamping or stenciling is done it shall be applied and protected in such a manner as to be completely legible during full life of the equipment. Identification and information plates of the equipment shall be either type A, B or C in accordance with MIL-P-15024. Black enamel shall be used for filling markings on metal plates. The size of plates shall be as approved by NAVSEC with identification plates conforming to standard dimensions of MIL-P-15024. All plates shall be furnished as part of the equipment and shall be attached to that part of the equipment which will not ordinarily be renewed during its normal service life in a position that is readily accessible where they can be read at all times without danger to personnel. The identification plate for the equipment shall indicate the following data:

LINE VOLTAGE REGULATOR

TYPE: SPR_____LINE AMPERES AC

PHASE: Single phase frequency_____Hz

INPUT:_____VOLTS AC

OUTPUT:_____VOLTS AC

AMBIENT: 50°C. YEAR_____

CAT. NO.:_____SERIAL NO.:_____

FSN:_____CONTRACT:_____

DWG. NO.:_____ACCEPTANCE STAMP

MANUFACTURERS NAME_____

The information plates for the complete assembly shall indicate properly marked wiring diagrams showing connections for single-phase or three-phase use of the regulators in either a delta or wye system.

3.5.3 Drawings. Drawings shall conform to types II and III, categories A, G, and E, form 2 requirements of MIL-D-1000 and MIL-D-1000/2 and as specified herein (see 6.1). Type II drawings shall be presented on sheets of the same size and shall not be smaller than 17 by 22 inches and not larger than 28 by 40 inches. Sheet sizes smaller than 28 by 40 inches shall be used only when all of the required drawing data for each designated category is furnished complete on one sheet. Type III drawings shall be prepared in accordance with the format shown on figure 1.

3.5.3.1 Category A, design evaluation. Category A drawings shall contain the following minimum data:

(a) List of material excluding items of hardware.
(b) List of onboard repair parts and tools in table form as shown on figure 1.

at an angle of 45 degrees from the vertical in any direction.

(c) A table of insulation indicating the location, class of insulation, insulation material and applicable specifications and remarks.

(d) A table or list of units such as transformers, rectifier stacks, resistors, capacitors, and similar items giving piece number, type, and rating of each. This data is a supplement to the list of material where space normally does not permit complete listing of part rating. Ratings shall include both manufacturer's rating and the specific application rating.

(e) Outline dimensional drawings of units such as transformers, reactors, transformer and reactor cores, rectifier stacks, capacitors and similar items except for those parts which have received separate qualification approval under applicable part specifications in which case the parts shall be identified by making reference to the letter of agency approval and the test report number.

(f) Sectional views describing provisions for mounting of power transformers, reactors and semi-conductors heat sinks internal to the equipment enclosure, such as brackets and channels, adequate to illustrate the mechanical relationship between part mounting and overall cabinet structure.

(g) Transformer and reactor data:
  (1) Core material and core or lamination form and size (including stack height). If core boxes are used, the material and size of the box should be given.
  (2) Winding data including number of turns, taps, wire size and specification type designation, insulation, method of impregnation and treatment, and d.c. resistance at a specified temperature.
  (3) If potted, the method of potting and potting compound should be identified.
  (4) Identification as to where used.

(h) Semiconductor data:
  (1) General information including the name of semiconductor manufacturer, manufacturer's identification number, salient ratings, circuit application, number of semiconductors per equipment.
  (2) Describe physical mounting and heat sinking of power semiconductors and voltage reference diodes.

(i) Voltage surge suppressors:
  (1) Identify manufacturer's technical data bulletin.
  (2) Provide the following rating data:
    a. Stack RMS voltage (steady-state).
    b. Stack clamping voltage.
    c. Peak discharge current (corresponding to clamping voltage).
    d. Polarization (polarized or non-polarized).
    e. Maximum energy at rated clamping voltage for single pulse current.
    f. Maximum pulse duration for repetitive pulses at line frequency and amplitude equal to clamping voltage.
    g. Maximum operating temperature.

(j) Operating characteristic curves for magnetic amplifiers and saturable reactors:
  (1) Plot of gate winding current versus control winding ampere turns.
  (2) Schematic diagram of test circuit.

3.5.3.2 Category G, installation. Category G drawings shall contain the following information:

(a) Manufacturer's name and catalog number or equivalent identification of the equipment.

(b) List of descriptive data of the equipment including:
  (1) Applicable specification and exceptions.
  (2) Complete rating showing (a) input voltage, frequency, regulation, and number of phases, (b) output voltage, regulation and current from zero to full load, (c) efficiency at one-half and full load, (d) degree of output voltage compensation.
  (3) Duty.
  (4) Shock classification.
  (5) Enclosure classification.
  (6) Ventilation.
  (7) Type of load.
  (8) Ambient temperature.
  (9) Temperature limits (when specified).
  (10) Weight of equipment.
  (11) Notation of the corrosion-resistant treatment of all hardware.
  (12) Special features.

(c) Finish, including method of treatment of enclosure for paintings, color, and applicable specification of paint.
(d) Sketch showing method of mounting of equipment enclosure, indicating size and location of mounting holes and position of brackets or mounting supports, and illustrating significant structural members of enclosure.
(e) Detailed dimensioned sketch, with terminal markings, of all terminal boards for input and output connections.
(f) Location of center of gravity of equipment shown in at least two views of the enclosure.
(g) Outline of equipment showing overall and principal dimensions of front view, side view, top view and sectional views as necessary, to show approximate mounting arrangement and location of parts of the list of material. Parts shall be flagged by item or piece number. Views shall show identification and information plates with data to appear thereon.
(h) Cable entrance provisions.
(i) Air intake and discharge openings with statement of minimum ventilation clearances.
(j) Wiring compartment. Showing provisions for cable access and position of output voltage compensation adjustments.
(k) Required interconnections and cabling within three-phase banks of equipment necessary to obtain correct delta and four-wire wye systems.

3.5.3.3 Category H, maintenance. Category H drawings shall contain the following minimum data:

(a) Schematic electrical diagram arranged in simplified form. Magnetic amplifier circuits shall show all windings in location with their respective cores but with circuitry to the control windings shown remote from the cores to avoid long and indirect runs. Control windings in the circuit schematic shall be shown in symbols or notation designating the direction of magnetic effect. All parts and windings shall be identified by appropriate symbols corresponding to their identification in the description of operation.
(b) Wiring diagram indicating markings of all terminals, leads, and all parts with wire sizes shown for all connections. Each lead shall be shown by number designation. The wiring diagram shall show parts and wiring in the approximate same physical location with respect to one another as mounted in the equipment.
(c) Description of operation, description of all adjustments and a general theory of operation.

3.6 Technical manuals. Technical manuals shall be furnished as specified (see 6.1), and shall conform to type II of MIL-M-15071. The text of technical manuals shall be specific for the particular equipment covered. General information may be added in supplement to required specific information (that is, general magnetic amplifier theory of operation) when considered desirable by the manufacturer and when approved by NAVSEC.

3.6.1 Arrangement. Arrangement of the text shall be as follows:

(a) Cover
(b) Title page
(c) General data
  (1) Title description of line voltage regulator.
  (2) Navy type designation.
  (3) Federal stock number.
  (4) Dimensions.
  (5) Weight (without packing).
  (6) Salient design characteristics.
  (7) Manufacturers type and catalog number.
  (8) Safety notices.
(d) Table of contents, listing all divisions and primary and secondary subdivisions (such as chapters, sections, and others) with corresponding page numbers.
(e) List of illustrations, photographs, and drawings.
(f) Introduction.
  (1) General description.
  (2) Input requirements and output rating.
(g) Operating instructions.
(h) Principles of operation.
  (1) Explanation of basic theory governing the functions performed by power regulating parts and control circuits which define buck-boost effects within equipment.

(2) Block diagram showing necessary signal flow to achieve voltage regulated operation of power stage;
(3) Simplified illustrations and schematic diagrams to supplement explanatory text;
(4) Significant operational characteristic curves, such as transfer curves for magnetic amplifiers, saturable reactors and power magnetics of specialized design.
(5) Voltage and current signal waveforms internal to regulator control circuitry; correct phase relationship of trigger pulses and gating signals with respect to A.C. line voltage, indicating instantaneous excursions, reference levels and time base.

(i) Installation instructions.
(1) Precautions.
(2) Preparation for use after storage.
(3) Mounting.
(4) Electrical connections.
(5) Adjustment of output voltage compensation resistors (see 3.3.4).
(6) Tests, including insulation resistance measurements, necessary to verify suitability for shipboard installation;
(7) Test data, including data on steady-state no load excitation current for single-phase equipment (see 3.3.8.1).

(j) Maintenance, corrective.
(1) Proper adjustment of resistive and reactive voltage compensation potentiometers.
(2) Simple voltage regulation tests requiring measurement of peak and RMS output voltage.
(3) Resistance measurements and continuity checks.
(4) Troubleshooting techniques, involving observation of symptoms, diagnosis of faults and corrective action; sequence of steps required to isolate faults.
(5) Signal tracing and measurement of significant voltages, currents and waveforms; necessary trimming adjustments.
(6) Adjustment of output voltage.
(7) Removal of replaceable trays or modules to facilitate troubleshooting and repair.
(8) Description of test instruments required to troubleshoot equipments, and admonitions or precautions on proper use of instruments.

(k) Maintenance, preventive.
(1) Visual inspection for broken leads, heat damaged parts, dirt and contaminants.
(2) Proper procedure for cleaning interior of equipment to accomplish safe and nondestructive removal of dirt and deposits; precautions on use and handling of cleaning solvents.

(l) Parts identification in form of list based on provisioning technical documentation defining recommended complement of onboard repair parts.
(m) Reduced size master drawings of line voltage regulator.
(n) Photographs (include a sufficient number of photographs of both external and internal views of the equipment to show construction details and location of parts. Parts shall be flagged.)
(o) Definitive list of test equipment, indicating instrument, manufacturer and model designation, necessary to troubleshoot shipboard installed equipments and to reproduce test data required by item (i)(7).

3.6.2 Manual validation plan. The manufacturer shall prepare, revise as appropriate and follow a validation plan for the technical manual as specified in MIL-M-15071 (see 6.6). The validation plan shall provide for Government verification. Validation of maintenance procedures shall be accomplished in accordance with MIL-T-81203 prior to equipment delivery.

3.7 Maintainability. The equipment shall be designed so that it can be maintained by easy replacement of subassemblies. The design shall conform to the design-for-maintainability requirements of MIL-STD-470 (see 6.6) and Publication NAVSHIPS 94324. The Geometric-Mean-Time-To-Repair ($MTTR_G$) shall be 1 hour and shall be demonstrated in accordance with MIL-STD-471 (see 6.6).

3.8 Reliability and maintainability program. A prerequisite to listing of equipment on the Qualified Products List shall be the submittal of a Reliability and Maintainability Plan covering all equipment that will be supplied against this specification. The plan shall be submitted to NAVSEC for approval. MIL-STD-785 (see 6.6) and MIL-STD-470 (see 6.6)

shall be used as guidelines in preparing the Reliability and Maintainability Program. The minimum plan shall include the following:

(a) Define the equipment covered by the program plan.
(b) List the Military specifications which govern the equipment furnished under this plan, such as MIL-R-23098, MIL-E-917, and others.
(c) Describe the inspection system which will be followed.
(d) Indicate the system which will be used to insure reliability of suppliers' and subcontractors' products.
(e) Describe training to be provided to manufacturing personnel to permit these personnel to keep pace with improved methods and materials.
(f) Identify personnel responsible for the Reliability and Maintainability Program.
(g) Indicate that design reviews will be conducted, identifying personnel involved and stating frequency of review sessions. Reviews shall include these topics:
    (1) Reliability
    (2) Design
    (3) Value engineering
    (4) Safety engineering
    (5) Standardization of parts
    (6) Means of reducing maintenance
    (7) Improvements in methods and materials
    (8) Inspection procedures
(h) Indicate the system which will be used to improve parts reliability and maintainability fo equipment.
(i) Describe techniques which will be used in determining equipment mean-time-between-failure (MTBF) and $MTTR_G$. Attach data which is currently available on equipment MTBF and $MTTR_G$.
(j) Indicate life-cycle cost estimates and cost effectiveness studies which have been, and will be, performed.
(k) Include a copy of the Technical Manual Preventive Maintenance Form.

3.9 Data collection. The contractor shall establish and maintain a data collection system covering all failures and part replacements throughout all states of development, production and testing of the equipment. Any failure that occurs and its effect on the performance of equipment and system shall be analyzed and recorded in a log book which shall be maintained on all production units. All failures and corrective actions taken shall be reported to NAVSEC.

3.10 Workmanship. All metal surfaces shall have a smooth finish and all details of manufacture, including the preparation of parts and accessories, shall be in accordance with the best practice for high quality electrical equipment. Particular attention shall be given to neatness and thoroughness of soldering, wiring, inpregnation of windings of transformers and reactors, marking of parts, plating, lacquering, riveting, clearance between connections, ruggedness, and suitability of enclosure.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order, the supplier is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified 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 Inspection system. The inspection system which the supplier is required to maintain, as provided in the inspection clause of the contract or order, shall be in accordance with MIL-I-45208 (see 6.6).

4.2 Classification of inspection. The inspection and testing of the equipment shall be classified as follows:

(a) Qualification tests (see 4.3).
(b) Quality conformance tests (see 4.4).
    Group A
    Group B
    Group C

4.3 Qualification tests.[1/] Qualification tests shall be conducted at a laboratory satisfactory to the Naval Ship Engineering Center. Qualification tests shall consist of the tests specified in table IV.

4.3.1 Prior to qualification tests. Prior to test authorization, the manufacturer shall submit detailed drawings containing all information as required to determine complete compliance with requirements of applicable specifications. Manufacture of equipment for tests should not begin until receipt of manufacturing drawing approval by NAVSEC (except for prototype breadboard samples which may be built anytime by the manufacturer to prove certain operating features and circuitry).

4.3.2 Qualification approval (115 volt equipments). To obtain approval for all ratings of the equipment for 115 volt operation, the contractor shall submit four identical equipment units corresponding to the following rating on a per phase basis for qualification testing in accordance with table IV:

115 volts
400 Hz
225 amperes

4.3.2.1 Qualification approval (440 volt equipments). To obtain approval for all ratings of the equipment for 440 volt operation, the contractor shall submit four identical equipment units corresponding to the following rating on a per phase basis for qualification testing in accordance with table IV:

400 volts
400 Hz
40 amperes

4.3.3 Qualification approval (single rating). To obtain approval for a single rating of the equipment, conforming to a particular voltage and current rating, the contractor shall submit four sample units representing the class of equipment for qualification testing in accordance with table IV.

Table IV - Qualification and quality conformance tests.

Test	Qualification[1/]	Quality conformance tests			Reference paragraph	
		Group A[2/]	Group B[2/]	Group C[2/]	Requirement	Test
General examination	X	X	X	X	3.10	4.5.1
Effectiveness of enclosure	X	-	-	X	3.2.7	4.5.2
Creepage and clearance	X	-	-	X	3.2	4.5.3
Insulation resistance	X	X	-	X	3.2.15	4.5.4
Heating	X	-	-	X	3.2.17	4.5.5
Airborne noise	X	-	-	X	3.2.3	4.5.6
Voltage regulation performance, steady-state	X	X	-	X	3.3.3	4.5.7
Input voltage transient	X	-	-	X	3.3.5	4.5.8.1
Output voltage transient	X	-	-	X	3.3.6	4.5.8.2
Output voltage build-up	X	-	-	X	3.3.9	4.5.8.3
Output voltage modulation	X	-	X	X	3.3.7	4.5.7.4
Output voltage modulation gain	X	-	-	X	3.3.7.1	4.5.12
No load input excitation current	X	-	-	X	3.3.8	4.5.13

See footnotes at end of table

1/ Application for Qualification tests shall be made in accordance with "Provisions Governing Qualification SD-6" (see 6.2 and 6.2.1).

Table IV - Qualification and quality conformance tests. (cont'd.)

Test	Qualification[1]	Quality conformance tests			Reference paragraph	
		Group A[2]	Group B[2]	Group C[1]	Requirement	Test
Slope of no load input excitation current versus input voltage	X	-	-	X	3.3.8.3	4.5.13.3
Waveform distortion	X	-	-	X	3.3.10	4.5.10
Phase balance	X	-	-	X	3.3.3.2	4.5.11
Inclined operation	X	-	-	X	3.2.5	4.5.14
Efficiency	X	-	X	X	3.3.11	4.5.15
Endurance test	X	-	-	-	3.3.12	4.5.16
Vibration	X	-	-	X[3]	3.2.1	4.5.17
Shock	X	-	-	X[3]	3.2.2	4.5.18
Dielectric strength	X	X	-	X	3.2.16	4.5.19
Weight and size	X	-	-	X	3.2.19	4.5.20
Reliability	X	-	-	-	3.8	4.5.22
Maintainability	X	-	-	-	3.7	4.5.21

[1] Group C and Qualification testing shall be conducted under the phase conditions specified in table V.

[2] Tests shall be conducted as single-phase equipment during Group A and Group B testing.

[3] See 4.4.1.3.

Table V - Phase conditions for Group C[1] and qualification tests.

Test	Phase condition		
	phase	3 phase delta	3 phase wye[1]
General examination	X	-	-
Effectiveness of enclosure	X	-	-
Creepage and clearance	X	-	-
Insulation resistance	X	-	-
Heating	-	X	-
Airborne noise	X	-	-
Voltage regulation performance steady-state	X	X	X
Input voltage transient	X	X	-
Output voltage transient	X	X	-
Output voltage build-up	X	X	-
Output voltage modulation	X	X	-
Output voltage modulation gain	X	X	-
No load input excitation current	X	X	-
Slope of no load input excitation current versus input voltage	X	X	-
Waveform distortion	X	X	-
Phase balance	-	X	-
Inclined operation	X	-	-

See footnote at end of table.

Table V - Phase conditions for Group C[1/] and qualification tests. (cont'd.)

Test	Phase condition		
	1 phase	3 phase delta	3 phase wye[1/]
Efficiency	X	X	-
Endurance test (Qualification test only)	-	X	-
Vibration	X	-	-
Shock	X	-	-
Dielectric strength	-	X	-
Weight and size	X	-	-
Reliability	X	-	-
Maintainability	X	-	-

1/ With the exception of voltage regulation performance (steady-state), 3 phase wye operation is not required during Group C tests.

4.4 Quality conformance test. Quality conformance testing shall consist of the group A, B, and C tests of table IV.

4.4.1 Sampling.

4.4.1.1 Group A. Each production unit shall be subjected to the Group A tests of table IV to determine conformance with this specification.

4.4.1.2 Group B. Each equipment selected in accordance with table VI shall be subjected to the Group B tests specified in table IV to determine conformance with this specification. If the number of defective equipments in any sample exceeds the acceptance number for that sample, the lot represented by the sample shall be rejected.

4.4.1.2.1 Rejected lots. If an inspection lot is rejected, the supplier may replace it with a new lot, rework it to correct defects, or screen out the defective units, and again inspect it. Such lots shall be sampled in accordance with tightened inspection sample sizes specified in table VI. Reinspected lots shall be kept separate from new lots and shall be clearly identified as reinspected lots. Acceptance criteria of 4.4.1.2 shall apply.

4.4.1.2.2 Inspection lot. All equipment of the same specific design and type offered for delivery at one time shall be considered a lot for purposes of quality conformance inspection and testing.

Table VI - Acceptance and rejection criteria for Group B tests.

Lot size	Sample size		Acceptance number defectives	Rejection number defectives
	Normal inspection	Tightened inspection		
1 to 5	All	All	-	-
6 to 8	5	6	0	1
9 to 15	7	9	0	1
16 to 25	8	10	0	1
26 to 40	10	12	0	1
41 to 65	12	14	0	1
66 to 110	15	18	1	2
111 to 180	20	24	1	2
181 to 300	25	30	1	2
301 or more	Not less than 10 percent	Not less than 15 percent		

Figure 1 - Controller, rotor

4.4.1.3 Group C. Three sample units of each specific equipment rating shall be selected at random for the Group C tests of table IV on the first production contract or order for that specific equipment rating after QPL approval. Thereafter, every 18 months, the specific equipment rating shall be subjected to the Group C tests of table IV except for shock and vibration. A Group C 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, NAVSEC may require that any or all of the Group C tests be made on a particular equipment to demonstrate that it conforms to this specification. Three copies of Group C test reports shall be prepared by the manufacturer, and forwarded to NAVSEC. Group C test results shall be reported in any convenient form providing all test data is complete and arranged in the same sequence as the sequence of test procedure. Photographs shall be used in reports wherever any noticeable damage occurs as an aid in explaining extent of damage and method of correction.

4.4.1.4 Repair parts. Resistance readings at room temperature shall be made upon the windings of all repair transformers, reactors, and resistors and the values checked against the values obtained for the same part in the applicable equipment. If the resistance readings differ by more than 5 percent from those of the applicable equipment, the repair parts shall be rejected. All transformers, reactors, resistors, and rectifier stacks shall be subjected to the dielectric test specified in 4.5.19.

4.5 Test procedures.

4.5.1 General examination. Each equipment shall be subjected to a thorough examination to ascertain that the material, workmanship, and design are in conformance with this specification. The fit of parts shall be observed with particular reference to the interchangeability of such parts as are likely to require replacement during the normal service life of the equipment. Specific observation shall be given to the following:

(a) All wiring shall be checked for layout, and proper identification.
(b) All terminals shall be checked for proper marking.
(c) Wire connections (soldered and unsoldered) shall be checked for security.
(d) Arrangement and layout of parts shall be checked for conformance with applicable approved drawings.
(e) Miscellaneous hardware, mounting supports and brackets shall be checked for proper corrosion resistant material or treatment in accordance with MIL-E-917.

4.5.1.1 Repair parts. All repair parts shall be subjected to a careful examination to ascertain that the materials, workmanship, and finish are first class in every respect and that they conform fully to the manufacturer's drawings as approved by NAVSEC. The principal object of this examination shall be to determine if the repair parts are exact duplicates of those used in the equipment. If there is reason to doubt the ready interchangeability of the repair parts with the original equipment parts, a demonstration of such interchangeability shall be performed.

4.5.2 Effectiveness of enclosure. The equipment enclosure shall be tested in accordance with MIL-E-2306 to determine conformance with 3.2.7.

4.5.3 Creepage and clearance. Creepage and clearance distances shall be demonstrated by actual measurement to be in accordance with MIL-E-917.

4.5.4 Insulation resistance. Insulation resistance measurement shall be made to determine conformance with 3.2.15. The measurement of insulation resistance shall be made with all circuits of equal voltage above ground connected together. Circuits or groups of circuits of different voltage above ground shall be tested separately. Insulation resistance shall be measured with an insulation-resistance-indicating meter conforming to type GC of MIL-O-16485. The time of test voltage application shall be not less than 60 seconds. Measurements shall be made at room (+ 23°C.) ambient temperature with all circuits at that ambient temperature. The relative humidity and ambient temperature shall be recorded.

4.5.5 Heating.

4.5.5.1 Conditions. Heating tests shall be performed in accordance with the operational configuration of 3.3.2(a), at any combination of conditions specified in 3.3.3.2 that produces maximum temperature rises. Tests shall be conducted at 50°C. ambient temperature. Photographs, drawings or descriptive text shall be used to illustrate the location of temperature measuring probes on the various power magnetic parts and semiconductor devices. Conformance with 3.2.17 shall be demonstrated.

4.5.5.2 ounting of equipment. Heating tests shall be made only with the equipment embled and mounted in the manner for which it is designed. Barriers sha acent to the enclosure, 2 inches from the back and each side. Temperature e taken on all coil windings (including power transformers and reactors) and

4.5.5.3 erature measurements. The method of temperature measurement shall be either ter method or embedded detector method in accordance with MIL-E-917. eter method is used the true temperature rise shall be determined by addi temperature gradient to the indicated temperature rise. The temperature e predetermined prior to assembly of equipment by taking measurements of maxi of the parts under rated application load by both the resistance method ter method. The difference in measurements between the thermometer methtance method shall be the value of temperature gradient. When the embedded is used the true temperature rise shall be considered the indicated tem f the detector element giving the maximum value.

4.5.5.4 conductor devices and voltage reference devices, a thermocouple shall be affi or flange of the device with a small quantity of oil putty. The temperatil not exceed the maximum case temperature permitted for the device under of voltage and current or power dissipation existing within the equipment temperature shall be obtained from appropriate curves or charts in Military ssued under MIL-S-19500 or device manufacturer's commercial specificatione or may be calculated by subtracting the product of case to junction therd power dissipation from the maximum allowed junction temperature. Therm lues shall be obtained from charts in appropriate Military specificationfacturer's commercial specifications. Power dissipation may be calculated product of instantaneous voltage and instantaneous current over one cycle in periodic circuits or the product of voltage and current in continuous cir obtained from appropriate curves in Military specifications or device manu sheets. The temperature measurements outlined above shall demonstrate tmiconductors and voltage reference diodes have been applied in accordance and that device operation is consistent with assigned ratings, as specified pecifications issued under MIL-S-19500, or defined by commercial specificandard devices approved in accordance with MIL-E-917.

4.5.5.5 t. The heating test shall be continued until the temperature rise of partsserved during testing have attained a steady final value. The time durationss than 4 hours.

4.5.5.6 eria. The maximum permissible temperature (not spot temperature) as specified the class of insulation used and the maximum rated temperature assigned to tductors shall not be exceeded.

4.5.5.7 ment. The ambient or room temperature shall be measured as specified in ns of two or more thermometers placed at different points around and one equipment and at a distance of 3 to 6 feet from the enclosure. The thermometerted in oil filled cups not less than 1 inch in internal diameter and 2 inhall be protected from drafts and from heat radiation from the equipment und sources.

4.5.5.8 n determining temperature rise, no correction shall be made for barometrimidity.

4.5.6 AThe equipment shall be examined for airborne noise performance in accordance rocedures of MIL-STD-740 to determine conformance with 3.2.3. The prescribeall be completed on an equipment operated as a single-phase unit without ompensation at rated input voltage and frequency. At the stated operatthe equipment shall be tested successively at no load and full load, atd unity power factor.

4.5.7 Vn. Equipment shall be tested as specified in 4.5.7.1 through 4.5.7.4 underof voltage, frequency, ambient temperature and load within the specified The output voltage shall remain within the specified regulation limits withoutoltage regulation tests shall be conducted under the conditions specified in

Table VII - Conditions of line voltage, load, frequency and temperature.

Condition numbers	Load	Power factor	Input voltage	Frequency	Ambient temperature (Degrees C.)
	(Balanced)		(Balanced)		
1	No load	-	Rated -5%	Rated	23
2	No load	-	Rated	Rated	23
3	No load	-	Rated +5%	Rated	23
4	10% load	Unity	Rated -5%	Rated	50
5	10% load	Unity	Rated	Rated	50
6	10% load	Unity	Rated +5%	Rated	50
7	20% load	0.75 lagging	Rated -5%	Rated -1/2%	50
8	20% load	0.75 lagging	Rated	Rated -1/2%	50
9	20% load	0.75 lagging	Rated +5%	Rated -1/2%	50
10	40% load	Unity	Rated -5%	Rated +1/2%	50
11	40% load	Unity	Rated	Rated +1/2%	50
12	40% load	Unity	Rated +5%	Rated +1/2%	50
13	60% load	0.75 lagging	Rated -5%	Rated	23
14	60% load	0.75 lagging	Rated	Rated	23
15	60% load	0.75 lagging	Rated +5%	Rated	23
16	80% load	Unity	Rated -5%	Rated -1/2%	23
17	80% load	Unity	Rated	Rated -1/2%	23
18	80% load	Unity	Rated +5%	Rated -1/2%	23
19	Full load	0.75 lagging	Rated -5%	Rated	50
20	Full load	0.75 lagging	Rated	Rated +1/2%	50
21	Full load	0.75 lagging	Rated +5%	Rated -1/2%	50
22	Full load	Unity	Rated -5%	Rated	23
23	Full load	Unity	Rated	Rated	23
24	Full load	Unity	Rated +5%	Rated	23

4.5.7.1 Group A. The test for steady-state voltage regulation shall be performed in accordance with condition Nos. 1, 2, 3 and 22, 23, and 24 of table VII. Output voltage shall be measured at the output terminals of each equipment employing internal sensing without output voltage compensation.

4.5.7.2 Group C and qualification tests. The equipments shall be tested in accordance with the following procedure to determine conformance with 3.3.3.

(a) The equipments shall be interconnected to form three-phase, four-wire wye systems and investigated under the following mode of regulation:
(1) Using the operational configuration specified in 3.3.2(a), output line-to-neutral voltages shall be measured at the regulator terminals under condition Nos. 7 through 12, 16 through 18, 20 and 21 of table VII.
(2) Using the operational configuration specified in 3.3.2(c), output line-to-neutral voltages shall be measured at the load under condition Nos. 4, 7, 10, 13, 16, 19 and 22 of table VII. The equipments shall be adjusted for maximum output voltage compensation.
(3) Repeat test specified in (a)(1), except that: input line-to-neutral voltages shall be unbalanced as specified in 3.3.3.3, and unbalanced load shall be imposed in accordance with table II.
(4) Repeat test specified in (a)(2), except that output load shall be unbalanced as permitted by 3.3.4.

(b) The equipment shall be tested in a three-phase delta system under the following modes of regulation:
(1) Using the operational configuration specified in 3.3.2(b), output line voltages shall be measured at the load under Condition Nos. 1 through 6, 13 through 15, 19, and 22 through 24 of table VII.
(2) Using the operational configuration specified in 3.3.2(a), output line-to-line voltages shall be measured at the regulator equipment terminals under condition Nos. 4, 7, 10, 13, 16, 19 and 22 of table VII.

4.5.7.3 Readings shall be taken and recorded on input voltage and frequency, input current, power factor at regulator input terminals, ambient temperature, output voltage and output current for all of the specified conditions. Curves shall be plotted of output voltage versus output current for each specified voltage regulation test run of table VII.

4.5.7.4 Output voltage modulation. Peak and RMS values of input and output modulation voltages shall be recorded during the voltage regulation test specified in 4.5.7.2(b)(1). A calibrated oscilloscope and camera attachment shall be employed to observe and record instantaneous input and output waveform modulation. Oscillograms of input and output voltage waveforms shall be prepared in such a manner as to scale and quality as to ensure readable and permanent traces. Voltage readings and oscillograms shall demonstrate that any amplitude modulation occurring in the output voltage is confined to the limits specified in 3.3.7.

4.5.8 Transient voltage regulation. The test for input voltage transient, output voltage transient and output voltage build-up performance, shall be conducted with the equipment operated under the operational configuration of 3.3.2(a); voltage measurements shall be performed at the output terminals of the equipments.

4.5.8.1 Input voltage transient. The equipments shall conform to the requirements of 3.3.5 when tested as follows:

(a) A set of equipment wired in a three-phase four-wire wye system shall be operated on a steady-state basis in accordance with Condition Nos. 3, 14 and 22 of table VII. An undervoltage transient of 5 percent (of rated peak voltage) shall be simultaneously induced in each line-neutral input voltage at any point of the cycle.
(b) The set of equipments shall be operated in a three-phase delta configuration in accordance with the steady-state conditions specified by Condition Nos. 3, 14 and 22 of table VII. An over-voltage transient of 5 percent (of rated peak voltage) shall be simultaneously induced in each input line voltage on phases AB, BC and CA at any point of the cycle.

4.5.8.2 Output voltage transient. The equipments shall conform with 3.3.6. when tested as follows:

(a) Input and output line-neutral voltage excursions shall be recorded for three-phase four-wire wye systems in accordance with the following test sequence:
(1) The equipments shall be subjected to a balanced step increase in load from 10 percent load to rated full load accomplished in a single step, starting with the steady-state conditions specified for Condition No. 4 in table VII. This test shall be repeated for steady-state conditions No. 5 and 6 specified in table VII. The equipments shall be subjected to a balanced step decrease in load from rated full load to 10 percent load, starting with the steady-state conditions specified for Condition No. 19 in table VII. This test shall be repeated for steady-state conditions No. 20 and 21 specified in table VII.
(2) Phase AN, BN and CN line-to-neutral input voltages conforming to 3.3.3.2 shall be applied to equipments operated under the unbalanced load condition specified by table II. The equipments shall be subjected to a single-phase step increase in load from 10 percent load to rated full load on the lightly loaded phase.
(b) Repeat the tests specified in 4.5.8.2(a) except that the equipments shall be connected in three-phase delta for measurement of line-to-line voltage transients on phases AB, BC and CA, and step change in load on lightly loaded phase shall extend from 20 percent load to rated full load.

4.5.8.3 Output voltage build-up. The equipments shall be energized at Condition Nos. 1 and 22 of table VII. Waveform traces obtained on the basis of this test shall demonstrate conformance with 3.3.9.

4.5.8.4 Record voltage transients occurring at input and output terminals of the equipments, and recovery time to steady-state conditions for input and output line-to-line voltages (for delta) and line-to-neutral voltages (for wye). Oscillograms of voltage waveforms shall be prepared and submitted to NAVSEC to demonstrate that the equipments conform with 3.3.5, 3.3.6, and 3.3.9.

4.5.9 Electrical measurement instrumentation. Indicating meters used for measurement of voltage throughout the prescribed tests shall have an accuracy of one-fourth percent or better, voltage and current excursions shall be recorded by means of oscillograms to determine conformance with specified transient performance requirements. Voltage measurements shall be taken with true RMS instruments where significant waveform distortion is encountered. Hewlett Packard Model 302A Wave Analyzer, or equal, shall be utilized for measurement and evaluation of waveform distortion (see 4.5.10). Instrumentation used in recording voltage and current transients and waveform modulation shall consist of the following:

(a) String type oscillographs similar or equivalent in accuracy and response time to Consolidated Electro-Dynamic Corporation model CEC 5-124; or
(b) Oscilloscope and camera combinations similar or equivalent to Tektronix 560 Series instruments and camera attachments. Pen and ink type recorders shall not be used unless specifically approved by NAVSEC. Specific test equipment used in performance of measurements and examinations specified herein shall be documented in the test reports with respect to manufacturer, type and salient response characteristics.

4.5.10 Waveform distortion.

4.5.10.1 Harmonic. The harmonic content of the output voltage waveforms of the equipments shall be measured during the voltage regulation test of 4.5.7.2(a)(1), (b)(2) and phase balance test of 4.5.11. The equipments shall be energized by a source which exhibits less than 1 percent total harmonic distortion when supplying a resistive load equal to the regulator equipment rating. Insertion of the regulator into the circuit involved in the tests of 4.5.7.2 and 4.5.11 shall not cause the total input harmonics to increase by more than 2 percent or cause any single harmonic to increase by more than 1 percent. The operatine condition which produces the most significant harmonic distortion of the steady-state waveform shall be identified and reported. When the conditions of maximum harmonic content have been determined, the percentage content of each RMS harmonic component shall be recorded up to the forty-first harmonic of the steady-state voltage waveform. The recorded test values shall not exceed the maximum percentages specified in 3.3.10 for single harmonic components and total harmonic content present in output voltage waveforms.

4.5.10.2 Deviation factor. Equipments shall be operated in accordance with 3.3.2(a) and tested at conditions No. 2, 14 and 23 of table VII. Input and output voltage waveforms shall be observed on an oscilloscope at each specified condition of operation. Scope observations of waveform shall demonstrate that equipments conform to 3.3.10.2. Source characteristics shall be consistent with 4.5.10.1.

4.5.11 Phase balance. Equipments shall be connected in three-phase delta. Unbalanced line-to-line input voltages shall be impressed on the three-phase bank of equipments, in succession, in accorance with the sequence of unbalanced RMS voltages specified in 3.3.3.2. A unity power factor delta connected load shall be imposed on the bank of regulators. Loading effect shall be such as to demand 20 percent of rated output line current in one line and 80 percent of rated output line current in the remaining two lines. Equipment operation shall be in accordance with 3.3.2(a). The three-phase delta configuration shall be tested for voltage balance at equipment output terminals. Output line-to-line voltages shall be measured to determine conformance with 3.3.3.2. Repeat this test for 0.75 lagging power factor loads.

4.5.12 Output voltage modulation gain. With rated RMS input voltage applied to the equipments in accordance with Condition Nos. 2, 5, 14 and 23 of table VII, the input voltage waveform shall be modulated, during separate tests, by a modulation voltage of amplitude equal to 2, 5 and 10 percent of rated voltage from a variable frequency source. Modulation frequency shall be gradually increased over the range 1 to 100 Hz. As the frequency of the modulation voltage is varied over the indicated range, any frequency at which the amplitude of the output modulation voltage reaches a peak shall be noted and recorded. If such peaking is observed as modulation frequency is raised from 1 to 100 Hz, the modulation gain of the equipments shall be measured at the frequency where the amplitude of modulation of the output voltage has reached a peak and shown a definite decrease with further increase of frequency. In the event that multiple peaks occur, the highest value of output modulation voltage shall apply. The amplitudes of the input and output voltage waveform modulations shall be recorded by means of calibrated modulation detection and waveform analysis

instrumentation. A plot of RMS output voltage modulation gain versus modulation frequency shall be prepared for each specified test. Any output voltage modulation gain exhibited by the equipments shall be confined to the limits specified in 3.3.7.1.

4.5.13 No load input current characteristics.

4.5.13.1 Steady-state. The equipments shall be operated at no load. RMS input voltage shall be slowly varied in maximum increments of 4.5 percent of rated voltage over a range extending from an undervoltage 12.5 percent below rated voltage to an overvoltage 10 percent above rated voltage. No load RMS input current shall be plotted with respect to variation of RMS input voltage. No load input current points shall be defined in increments of 0.5 percent of rated current along the vertical axis (ordinate) measured from input current monitored at rated voltage. Input voltage points shall be defined in increments of 4.5 percent of rated voltage along the horizontal axis (abscissa) in order to determine points on the excitation curve. The rated voltage point shall be marked on the horizontal axis of the graph of current versus voltage. The specified input voltage increments shall be measured from the rated voltage point. RMS input current and input voltage shall also be recorded in the form of a table. The no load input current characteristic plotted during this test shall demonstrate conformance with 3.3.8.1 and 3.3.8.2.

4.5.13.2 Leading current component. The quadrature (90°) component of each no load input current of 4.5.13.1 shall be measured during the excitation test and recorded in terms of RMS amperes. A plot of leading current versus input voltage shall be made (lagging current when present shall be shown as negative leading current). The maximum leading current shall not exceed the limits of 3.3.8.1.

4.5.13.3 Dynamic. Steady-state RMS input voltage shall be slowly varied at no load over the range extending from a voltage value of 12.5 percent below rated voltage to a voltage value 10 percent above rated voltage. Modulation voltage of amplitude equal to 10 percent of rated RMS voltage shall be superimposed upon the initially applied steady-state 400 Hz waveform. Modulation frequency shall be swept from 1 to 100 Hz during each measurement of no load input current versus input voltage. The steady-state, 400 Hz input voltage, shall be raised from rated voltage to rated voltage plus 10 percent in maximum increments of 4.5 percent of rated voltage. Steady-state RMS input voltage shall then be returned to rated value, this 400 Hz voltage shall then be lowered to rated voltage minus 12.5 percent in maximum increments of 4.5 percent of rated RMS voltage. The specified modulation voltage shall remain superimposed upon the 400 Hz waveform during variation of steady-state input voltage. RMS input current shall be recorded and plotted in increments of 0.5 percent of rated output current and steady-state input voltage shall be recorded and plotted in increments of 4.5 percent of rated voltage. An excitation curve shall be plotted in accordance with the procedure of 4.5.13.1. This examination shall demonstrate conformance with 3.3.8.1 and 3.3.8.3.

4.5.13.3.1 The test of 4.5.13.3 shall be repeated for modulation voltages of amplitude equal to 2 and 5 percent of rated RMS voltage in order to verify conformance with 3.3.8.1.

4.5.14 Inclined operation. The equipment shall be tested for inclined operation by operating at full output load current with rated input voltage and frequency. Inclination of the equipment in the following positions shall not cause interruption of the output current from the equipment while operating and while not operating shall not cause any change from the non-operating condition:

(a) 45 degrees forward.
(b) 45 degrees backward.
(c) 45 degrees to the right side.
(d) 45 degrees to the left side.

4.5.15 Efficiency.

4.5.15.1 KVA efficiency. The KVA outputs and inputs of the equipments shall be measured at 60 percent load and 100 percent load, under conditions of unity and 0.75 lagging power factor loads with input voltage of 95, 100 and 105 percent of rated RMS value to determine conformance with 3.3.11.1.

4.5.15.2 KW efficiency. Input power furnished to the equipment and output power developed by the equipments shall be measured under the conditions of output loading and input voltage variation specified for testing of KVA efficiency to determine conformance with 3.3.11.2.

4.5.16 Endurance test. Equipments connected in a delta three-phase bank supplying the unbalanced load specified in 4.5.11 at the conditions of unbalanced steady-state input line voltages specified in 4.5.11 shall be operated for a period of 720 hours without occurence of part failure or operation which deviates from the requirements of this specification. After each 100 hours of operation, the load initially impressed on the lightly loaded phase of the three-phase delta bank in accordance with test sequence of 4.5.11 shall be increased in a single step from 10 percent load to rated full load. Unity power factor loads shall be impressed on the equipments. At each step application of single-phase load, the performance of the equipments shall be monitored to confirm operation in accordance with 3.3.6 and 3.3.3.2. The conditions of steady-state load imbalance specified in 4.5.11 shall then be restored. In the event of part failure during the prescribed test period, or evidence of equipment operation which departs from the performance specified in 3.3.3 and 3.3.6, the endurance test shall be discontinued and the cause of part failure or equipment maloperation shall be determined. The failed part shall be replaced and the entire 720 hour test program shall be repeated without regard to the duration of the test cycle preceding observation of part failure or equipment malfunction. The endurance test shall not be terminated until the equipments have demonstrated continuous operation for a period of 720 hours without failure of parts internal to the equipments. The causes of part failures observed during this test and any ensuing corrective action shall be reported to NAVSEC supported by recommendations on equipment design changes and improved part selection necessary to prevent recurrence of the failures detected during endurance testing.

4.5.17 Vibration. Vibration tests shall be conducted in accordance with the type I requirements of MIL-STD-167. The test features as specified for shock tests (see 4.5.18) shall apply also for vibration testing. The sample selected for vibration testing shall be the same sample selected for the high-impact shock tests.

4.5.18 Shock. The high-impact shock tests (electrical operation and mechanical damage) shall be conducted to determine conformance with 3.3.2. Test features shall be as follows:

(a) General. The completely assembled equipment shall be checked for specified electrical operation following the shock test. The equipment shall be energized and operated at full load during shock test. Regulator output voltage shall be monitored to ensure continuity of operation under shock blow impact. Upon completion of the shock test, steady-state voltage regulation shall be examined in accordance with table VII, Condition Nos. 22 through 24 to determine conformance with 3.3.3.

(b) Definition of failure to perform principal functions:
  (1) Breakage of any parts, including mounting bolts. Minor chipping of parts such as plastic knobs and cases and minor distortion of parts will be permitted where such chipping or distortion cannot in any manner impair operation of the equipment as specified.
  (2) Any distortion of parts, including enclosure and framework, which would prevent specified operation.
  (3) A value of insulation resistance lower than that specified in this specification (see 3.2.15).
  (4) Low dielectric strength. After shock tests the dielectric test shall be conducted at a voltage equal to 65 percent of the voltage specified in 4.5.19.2. Failure to pass this test shall be cause for rejection.
  (5) Failure to pass visual examination. The equipment shall be carefully examined after removing all removable panels and doors to ascertain any mechanical damage. Partial disassembly shall be performed to aid in determining any possible damage when requested by NAVSEC.
  (6) Interruption of equipment operation by tripping of a circuit breaker or blowing of a fuse placed in the a.c. line which supplies power to the regulator unit, as a direct effect of regulator maloperation caused by shock impact.
  (7) Failure to perform any electrical tests requested by NAVSEC during the following shock. No adjustment or replacement of damaged parts shall be permitted during shock tests unless specifically approved by NAVSEC.

(c) Mounting. The equipment shall be mounted on the shock machines in a manner simulating shipboard installations, in accordance with MIL-S-901 for bulkhead mounted equipment.

(d) Disposal of shock tested equipment:
  (1) Equipment which has been subjected to high-impact shock test under qualification tests shall be returned to the manufacturer for his disposal, or upon request of the manufacturer, for disposal by the Government.

(2) Equipment which has been subjected to high-impact shock test under Group C testing shall be accepted as a production unit of the contract or order only under the following conditions:

a. That any damaged parts are replaced.
b. That post shock electrical tests show conformance with specified performance. (The extent of electrical testing, after shock, for specified operation shall be as determined by NAVSEC in each instance and shall be dependent on the nature of required performance and inspection results of shock tests.)
c. That an identification plate is added identifying the unit as "high-impact shock tested".
d. That the unit is subjected to the same guarantee by the manufacturer as other production units.
e. That not more than one shock tested equipment per contract or order is being offered for acceptance following high-impact shock test.

4.5.19 Dielectric tests.

4.5.19.1 General. The dielectric test shall be in accordance with 4.5.19.1 through 4.5.19.4, shall precede shock and vibration testing, and shall be conducted again during post shock test of equipment (see 4.5.18(b)(4)). If the insulation resistance of the windings is known to be lower than specified, due to dirt, moisture or damage to windings, this shall be remedied before the application of the dielectric test voltage. The dielectric test shall be made upon the completely assembled equipment and not upon individual parts, except in the case of repair parts which require dielectric tests (see 4.4.1.4).

4.5.19.2 Test voltage. The frequency of the testing voltage shall be not less than 60 Hz and shall approximate a true sine wave. The value of test voltage shall be as follows and shall be applied continuously for a period of 1 minute. All semiconductors shall be shorted out before applying the voltage.

A.c (r.m.s.) input or output voltage	Test voltage (r.m.s.)
60 and under	600
61 to 90	900
91 to 600	1000 plus twice rated
Over 600	2000 plus 2-1/2 times rated

4.5.19.3 Measurement of test voltage. The measurement of the voltage used in dielectric tests shall be made by the voltmeter method whereby the meter derives its voltage from the high-voltage circuit either directly or by means of a voltmeter coil placed in the testing transformer, or through an auxiliary ratio transformer.

4.5.19.4 Points of application. The test voltage shall be successively applied between each electric circuit and all other electrical circuits and grounded metal parts not electrically connected to it.

4.5.20 Weight and size.

4.5.20.1 Weight. The weight of the equipment and the weight of the onboard repair parts shall be taken and recorded separately. The weight of the equipment shall not exceed the value shown on the applicable approved drawings or the maximum value specified in table I, whichever is least. The weight of the onboard repair parts shall be recorded on a "per set" basis. This weight shall not exceed the value shown on the applicable approved drawings by more than 2 percent.

4.5.20.2 Size. The overall dimensions of each equipment shall be taken and recorded. The dimensions shall not exceed the requirements specified in table I.

4.5.21 Maintainability. Equipment malfunction shall be simulated in accordance with MIL-STD-471. Troubleshooting and repair procedures shall be performed in accordance with the applicable technical manual (see 3.6). Equipment repair shall be demonstrated in a manner consistent with MIL-STD-471. The $MTTR_G$ specified in 3.7 shall be confirmed.

4.5.22 Reliability. Equipment MTBF shall be predicted and reported in accordance with the Reliability and Maintainability Plan required by 3.8. MTBF prediction shall be subject to approval by NAVSEC.

4.6 Inspection of preparation for delivery. The packaging, packing, and marking shall be inspected for conformance with section 5 of this document.

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 Line voltage regulators.

5.1.1.1 Preservation and packaging. Preservation and packaging 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 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.

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. Where special requirements not covered by 5.1 are required, the 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 domestic shipment and storage or overseas shipment, which may be required when procurement is made (see 6.1).

5.2.1.1 Preservation, packaging, packing and marking.

5.2.1.1.1 Equipment and repair parts, shall be preserved and packaged Level A or C; packed Level A or B and marked in accordance with MIL-E-17555.

5.2.1.1.2 Manuals shall be prepared for shipment in accordance with MIL-M-15071.

5.2.1.1.3 Drawings shall be prepared for shipment in accordance with MIL-D-1000.)

6. NOTES

6.1 Ordering data. Procurement documents should specify the following:

(a) Title, number and date of this specification.
(b) Input and output rated voltage (see table II).
(c) Ampere rating.
(d) Drawings, quantity of (see 3.5.3).
(e) Technical manuals, quantity of (see 3.6).
(f) Levels of preservation, packaging, packing and marking (see 5.1 and 5.2).

6.2 With respect to products requiring qualification, awards will be made only for products which are at the time set for opening of bids qualified for inclusion in applicable Qualified Products List QPL 23099 whether or not such products have actually been so listed by that date. The attention of the suppliers is called to this requirement, and manufacturers are urged to arrange to have the products that they propose to offer to the Federal Government tested for qualification in order that they may be eligible to be awarded contracts or orders for the products covered by this specification. The activity responsible for the Qualified Products List is the Naval Ship Engineering Center, Prince George's Center, Center Building, Hyattsville, Maryland 20782, and information pertaining to qualification of products may be obtained from that activity. Application for Qualification tests shall be made in accordance with "Provisions Governing Qualification SD-6" (see 6.2.1).

6.2.1 Copies of "Provisions Governing Qualification SD-6" may be obtained upon application to Commanding Officer, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, Pennsylvania 19120.

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

6.4.1 Line voltage regulator. A line voltage regulator is a completely static device with regulation accomplished by means which may include arrangement of transformers, reactors, resistors, capacitors, silicon rectifiers, silicon controlled rectifiers and silicon transistors. Reference to "equipment" shall be considered as applying to line voltage regulators covered in this specification.

6.4.2 Magnetic amplifier. A magnetic amplifier is an item consisting of a saturable reactor and rectifier(s) which is used for amplification purposes. It may include resistors, capacitors or other parts or both. NOTE: For purpose of this specification all saturable reactors and saturable transformers with any directly associated resistors, capacitors, and similar items shall be considered to be magnetic amplifiers and the degree of amplification may be unity or greater.

6.4.3 Transistor. An active semiconductor device with three or more electrodes.

6.4.4 Metallic rectifier. A metallic rectifier is an electrical item whose working element(s) is (are) constructed of metallic substances which change a.c. to pulsating d.c. by the rectifying action occurring at the junction interface(s) between a metallic conductor and a semiconductor.

6.4.5 Dry type transformer. A dry type transformer is a transformer cooled by the natural circulation of air and not liquid-immersed.

6.4.6 Primary winding (transformer). The primary winding of a transformer is the winding on the input side.

6.4.7 Secondary winding (transformer). The secondary winding of a transformer is the winding on the output side.

6.4.8 Tap (transformer). A tap in a transformer is a connection brought out of a winding at some point between its extremities, usually to permit changing the transformer ratio.

6.4.9 Ratio of a transformer. The ratio of a transformer is the turn ratio of the primary winding to the secondary winding of the transformer.

6.4.10 Continuous duty. Continuous duty is a requirement of service that the equipment shall operate at any constant load in the range of no-load to full load for an indefinitely long time.

6.4.11 Steady-state voltage regulation band. The steady-state voltage regulation band is the maximum R.M.S. voltage variation expressed in percent of rated R.M.S. equipment voltage under steady-state load conditions. This includes variations caused by load changes, voltage changes, frequency changes, and environment (such as temperature, inclination, meter error, and others), but does not include transient load changes or amplitude modulation effects.

6.4.12 Voltage unbalance. The voltage unbalance between phases is the difference between the highest and lowest R.M.S. phase voltage expressed in percent of the rated equipment R.M.S. voltage rating.

6.4.13 Transient voltage. A transient voltage is the rapidly changing condition of the voltage which goes beyond the steady-state voltage limits and returns to the steady-state voltage band within a specified time period (recovery time). Maximum permissible transient voltage variation is expressed in percent of rated voltage.

6.4.14 Transient voltage limit. The transient voltage limit is the maximum of permissible variation expressed in percent of the rated equipment voltage.

6.4.15 Transient voltage recovery time.

6.4.15.1 Input voltage transient recovery time. The input transient voltage recovery time is the time elapsed from initiation of the disturbance to the point at which the input voltage recovers to and remains thereafter within the steady-state voltage band.

6.4.15.2 Output voltage transient recovery time. The output voltage transient recovery time is the time elapsed between the recovery of the input voltage to the specified steady-state band and the return of the output voltage to the steady-state output voltage regulation band where output voltage thereafter remains.

6.4.16 Modulation amplitude. Modulation amplitude is a periodic sine wave voltage variation about rated equipment voltage expressed as follows:

$$\text{Modulation } \% = \frac{E \text{ max} - E \text{ min}}{E \text{ max} + E \text{ min}} \times 100 \text{ (peak or RMS)}$$

6.4.17 Harmonic. A harmonic is a multiple of any particular frequency. Specifically, the "second harmonic" of a fundamental frequency is equal to twice that fundamental frequency.

6.4.17.1 Harmonic content. The harmonic content of a voltage wave is the ratio, expressed as a percent of the effective value, of the residue after the elimination of the fundamental, to the effective value of the equipment r.m.s. voltage rating.

6.4.18 Steady-state frequency. The steady-state frequency limits covers the maximum frequency variations expressed in percent of rated system frequency under steady-state load conditions. This includes variations caused by load changes, environment (such as temperature, inclination, meter error and so forth), but does not include transient changes.

6.4.19 Transient frequency. A transient frequency is the changing condition of the frequency which goes beyond the steady-state limits and returns to the steady state frequency limits within a specified time period. Maximum permissible transient frequency variation is expressed in percent of rated frequency rating.

6.4.20 Transient frequency recovery time. Recovery time is the time elapsed from initiation of a disturbance to the point at which frequency returns to, and remains within, the steady-state frequency band.

6.4.21 Load unbalance. Load unbalance is the difference between the KVA load on any two phases expressed in percent of the single phase rating.

6.4.22 Phase rotation. The forward phase rotation, when facing a drawing, shall be AB, BC and CA from top to bottom and AB, BC and CA from left to right.

6.4.23 Deviation factor. The deviation factor of the voltage wave is the ratio of the maximum difference between corresponding ordinates of the voltage wave and of the equivalent sine wave to 1.414 times the rated voltage when the waves are superimposed to make the maximum difference as small as possible. This does not apply to ordinates within 10 electrical degrees on either side of zero voltage.

$$\text{Deviation factor } \% = \frac{\text{Max. deviation } (100)}{\sqrt{2} \text{ nominal voltage}}$$

6.4.24 Output voltage build-up time. Output voltage build-up time is the time required for the load voltage to reach and remain within a specified band about rated load voltage, after the application of input power by a switch and the return of the input voltage to the steady-state input voltage band.

6.4.25 KVA efficiency. KVA efficiency is defined as the ratio of KVA output to KVA input.

6.4.26 KW efficiency. KW efficiency represents the ratio of KW output, measured at any output load and load power factor specified in table II, to KW input.

6.4.27 Rated voltage. The term "rated voltage" appearing in this specification shall be understood to refer to identification plate RMS voltage, expressed as input volts (a.c.) and output volts (a.c.), such as 115 volts R.M.S.

6.4.28 Output voltage. Output voltage refers to the voltage at the point of regulation, which under modes (b) and (c) of 3.3.2, is the voltage at the load terminals as opposed to the regulator terminal voltage.

6.5 Rating system. The following tabulation shows the previous KVA ratings per MIL-R-23098(SHIPS) dated 11 December 1961 and Amendment-2 of 30 September 1966 as compared to the present line current rating system:

Output line current (maximum container amperes)	Voltage RMS volts	KVA per phase (balance delta circuit)
75	115	5
150	115	10
225	115	15 1/
20	440	5
40	440	10

1/ 26 KVA per phase rating when used in a four-wire wye corrected circuit.

6.6 Management control system documents. The following management control system documents should be included on DD form 1660:

(a) MIL-STD-470 (see 3.7 and 3.8)
(b) MIL-STD-471 (see 3.7)
(c) MIL-STD-785 (see 3.8)
(d) MIL-I-45208 (see 4.1.1)

6.7 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 6110-N082Sh)

A. Supplementing NAVSHIPS drawing:

Equipment	NAVSHIPS Dwg. No.	Rev.	Mfr's Drawing No.

B. Applicable specification _____ of _____ and Amend. of _____

C. Navy contract or shipbuilders order no. _____ Item _____ Date _____

D. Mfr. _____ Mfr's Order No. _____

E. Mfr's identification and rating:

Descriptive title _____ Type: _____ Freq: _____

Input: Voltage _____ Output: Voltage _____ Current _____

F. Application _____

G. No. of ships involved

H. Ships identification numbers.

I. No. of units: Per ship _____, Per contract _____, For stock _____

J. No. of sets onboard repair parts; Per ship _____, Per contract _____

For stock _____

Note: See sheet 2 for listing of 1 set onboard repair parts.

K. Wt. of onboard repair parts (unboxed): Per set _____, Per contract _____

L. Reference drawings

Title	NAVSHIPS Dwg. No.	Mfr's Dwg. No.	Certification data

M. Notes:

N.

(Other listings as desired for Mfrs. information)

O.

Date: Drawn by: Approved Date By _____ _____ By _____ _____ Approval reference ltr. _____ _____ _____	CERTIFICATION DATA FOR	MFR.	
	(Equipment title)	Mfr. Dwg. No.	
		NAVY DEPT. NAVSHIPS DWG. NO.	REV
	Wt. Calc. _____ Actual _____	Cont'd. on Sht. 2, Sht. No. 1	

Figure 1 - Certification drawing (sheet 1 of 2)

List of onboard repair parts and tools

Item No.	No. per set	No. per equipment	Name of part or tool	Identification data		Federal stock No.
				Contractor	Manufacturer	

Date: Drawn by: Approved By_____ Date _____ By_____ _____ Approval reference ltr.	CERTIFICATION DATA FOR	MFR.	
	(Equipment title)	Mfr. Dwg. No.	
		NAVY DEPT. NAVSHIPS DWG. NO.	REV
	Wt. Calc._____Actual____	Cont'd. on Sht.___, Sht. No. 2	

Figure 1 - Certification drawing (sheet 2 of 2)