INCH POUND

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3 November 1993
SUPERSEDING
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1 August 1977
(See 6.14)

MILITARY SPECIFICATION

GENERATOR SETS, GAS TURBINE, DIRECT AND ALTERNATING CURRENT NAVAL SHIPBOARD USE

This specification is approved for use by the Naval Sea Systems Command, Department of the Navy, and is available for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 Scope. This specification covers gas turbine generator sets rated up to 1,000 kilowatts (kW) direct current (dc) and up to 3,500 kW alternating current (ac) for shipboard use.

1.2 Classification. The gas turbine generator sets shall be of the following types and classes as specified (see 6.2):

Type I - dc
Type II - ac
  Class A - Ship service application
  Class B - Emergency application

2. APPLICABLE DOCUMENTS

2.1 Government documents.

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

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Commander, Naval Sea Systems Command, SEA 03R42, 2531 Jefferson Davis Hwy., Arlington, VA 22242-5160 by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

AMSC N/A FSC 6115

SPECIFICATIONS

FEDERAL

UU-P-268	-	Paper, Kraft, Wrapping.
PPP-C-850	-	Cushioning Material, Polystrene Expanded, Resilient (For Packaging Uses).
PPP-C-1120	-	Cushioning Material, Uncompressed Bound Fiber for Packaging.
PPP-F-320	-	Fiberboard: Corrugated and Solid, Sheet Stock (Container Grade) and Cut Shapes.

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MIL-C-104	-	Crates, Wood: Lumber and Plywood Sheathed, Nailed and Bolted.
MIL-P-116	-	Preservation, Methods of.
MIL-S-901	-	Shock Tests, H.I. (High-Impact) Shipboard Machinery, Equipment, and Systems, Requirements for.
MIL-A-907	-	Antiseize Thread Compound, High Temperature.
MIL-E-917	-	Electric Power Equipment, Basic Requirements (Naval Shipboard Use).
MIL-S-1222	-	Studs, Bolts, Hex Cap Screws, Socket Head Cap Screws and Nuts.
MIL-E-2036	-	Enclosures for Electric and Electronic Equipment.
MIL-L-2104	-	Lubricating Oil, Internal Combustion Engine, Combat/Tactical Service.
MIL-R-2729	-	Regulator-Exciter Systems, Voltage, A.C. Generator, Naval Shipboard Use.
MIL-G-3111	-	Generators, Electric, Direct-Current (Naval Shipboard Use).
MIL-G-3124	-	Generator, Alternating Current, 60-Hertz (Naval Shipboard Use).
MIL-C-5015	-	Connectors, Electrical, Circular Threaded, AN Type, General Specification for.
MIL-C-5541	-	Chemical Conversion Coatings on Aluminum and Aluminum Alloys.
MIL-E-5607	-	Engine, Gas Turbine, Preparation for Storage and Shipment of, Process for.
MIL-T-5624	-	Turbine Fuel, Aviation, Grades JP-4, JP-5 and JP-5/JP-8 ST.
MIL-R-6130	-	Rubber, Cellular, Chemically Blown.
MIL-A-8625	-	Anodic Coatings, for Aluminum and Aluminum Alloys.
MIL-L-9000	-	Lubricating Oil, Shipboard Internal Combustion Engine, High Output Diesel.
MIL-P-15024	-	Plates, Tags and Bands for Identification of Equipment.
MIL-P-15024/5	-	Plates, Identification.
DOD-B-15072	-	Batteries, Storage, Lead-Acid, Portable; General Specification for (Metric).
MIL-T-15108	-	Transformers, Power, Step-Down, Single Phase, 60 Hertz, 1 Kilovoltampere Approximate Minimum Rating, Dry Type, Naval Shipboard.

MIL-T-15377 - Temperature Monitor Equipment Naval Shipboard.
MIL-C-15730 - Coolers, Fluid, Naval Shipboard: Lubricating Oil, Hydraulic Oil and Fresh Water.
MIL-C-16173 - Corrosion Preventive Compound, Solvent Cutback, Cold Application.
MIL-E-16298 - Electric Machines Having Rotating Parts, Accessories and Associated Support Items; Packaging of.
MIL-F-16884 - Fuel, Naval Distillate.
MIL-T-17286 - Turbines and Gears, Shipboard Propulsion and Auxiliary Steam; Packaging of.
MIL-L-17331 - Lubricating Oil, Steam Turbine and Gear, Moderate Service.
MIL-E-17341 - Engines, Gas Turbine, Propulsion and Auxiliary Naval Shipboard.
MIL-E-17555 - Electronic and Electrical Equipment Accessories, and Provisioned Items (Repair Parts); Packaging of.
MIL-H-17672 - Hydraulic Fluid, Petroleum Inhibited.
MS17828 - Nut, Self-Locking, Hexagon, Regular-Height, (Nonmetallic Insert) 250°F, Nickel-Copper Alloy.
MS17829 - Nut, Self-Locking, Hexagon, Regular Height, 250°F, (Non-Metallic Insert) Non-Corrosion-Resistant Steel.
MIL-C-18087 - Clutches for Propulsion Units and Auxiliary Machinery, Naval Shipboard.
MIL-L-19140 - Lumber and Plywood, Fire-Retardant Treated.
MIL-C-19836 - Coolers, Fluid, Industrial, Air, Motor and Generator, Naval Shipboard.
MIL-R-20092 - Rubber or Plastic Sheets and Assembled and Molded Shapes, Synthetic, Foam or Sponge, Open Cell.
MIL-G-21410 - Governing Systems, Speed and Load-Sensing, Naval Shipboard Use.
MIL-L-23699 - Lubricating Oil, Aircraft Turbine Engine, Synthetic Base, NATO Code Number 0-156.
MIL-T-24388 - Thermocouple and Resistance Temperature Detector Assemblies, General Specification for (Naval Shipboard).
MIL-C-24643 - Cable and Cord, Electrical, Low Smoke, for Shipboard Use, General Specification for

STANDARDS

FEDERAL

FED-STD-H28 - Screw-Thread Standards for Federal Services.

MILITARY

MIL-STD-129 - Marking for Shipment and Storage.
MIL-STD-167-1 - Mechanical Vibrations of Shipboard Equipment (Type I - Environmental and Type II - Internally Excited).

MIL-STD-178	-	Definitions Applicable to Speed-Governing of Electric Generator Sets.
MIL-STD-278	-	Welding and Casting Standard.
MIL-STD-471	-	Maintainability Verification/Demonstration/ Evaluation.
MIL-STD-721	-	Definitions of Terms for Reliability and Maintainability.
MIL-STD-740-1	-	Airborne Sound Measurements and Acceptance Criteria of Shipboard Equipment.
MIL-STD-740-2	-	Structureborne Vibratory Acceleration Measurements and Acceptance Criteria of Shipboard Equipment.
MIL-STD-756	-	Reliability Modeling and Prediction.
MIL-STD-777	-	Schedule of Piping, Valves, Fittings, and Associated Piping Components for Naval Surface Ships.
MIL-STD-1186	-	Cushioning, Anchoring, Bracing, Blocking and Waterproofing; with Appropriate Test Methods.

HANDBOOK

MILITARY

MIL-HDBK-472	-	Maintainability Prediction.

(Unless otherwise indicated, copies of federal and military specifications, standards, and handbooks are available from the Standardization Documents Order Desk, BLDG. 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.)

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

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

B 26	-	Standard Specification for Aluminum-Alloy Sand Castings
D 2519	-	Standard Test Method for Bond Strength of Electrical Insulating Varnishes by the Helical Coil Test.
D 3951	-	Standard Practice for Commercial Packaging.
E 208	-	Standard Test Method for Conducting Drop-Weight Test to Determine Nil-Ductility Transition Temperature of Ferritic Steels.

(Application for copies should be addressed to the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.)

AMERICAN GEAR MANUFACTURERS ASSOCIATION, INC. (AGMA)

2000	-	Gear Classification and Inspection Handbook Tolerances and Measuring Methods for Unassembled Spur and Helical Gears (Including Metric Equivalents). (DoD adopted)
6010	-	Standard for Spur, Helical, Herringbone, and Bevel Enclosed Drives.
		Catalog of Technical Publications.

(Application for copies should be addressed to the American Gear Manufacturers Association, Inc., 1500 King Street, Suite 201, Alexandria, VA 22314.)

(Non-Government standards and other publications are normally available from the organizations that prepare or distribute the documents. These documents also may be available in or through libraries or other informational services.)

2.3 Order of precedence. In the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. REQUIREMENTS

3.1 First article. When specified (see 6.2), a sample shall be subjected to first article inspection (see 6.7) in accordance with 4.4.

3.2 Material. Material used shall be compatible with the operating life requirement, and the reliability and maintainability requirements. Metals used in the construction of the gas turbine engine, except those metals which are in constant contact with lubricating oil, shall be of a corrosion-resistant type or shall be treated to resist corrosion. In order to prevent deterioration due to corrosion, all bolts, nuts, studs, pins, springs, screws, fastenings, fittings, and fuel system component parts (internal and external) shall be of a corrosion-resisting material, or of a material treated in a manner that will prevent deterioration and render it resistant to corrosion. Materials subjected to operating and shock stresses shall have an elongation of not less than 3 percent. Materials used in turbine and compressor rotating assemblies shall have a minimum elongation of 6 percent throughout the temperature operating range of the material involved. Magnesium and its alloys shall not be used.

3.2.1 Recovered materials. Unless otherwise specified herein, all equipment, material, and articles incorporated in the products covered by this specification shall be new and may be fabricated using materials produced from recovered materials to the maximum extent practicable without jeopardizing the intended use. The term "recovered materials" means materials which have been collected or recovered from solid waste and reprocessed to become a source of raw materials, as opposed to virgin raw materials. None of the above shall be interpreted to mean that the use of used or rebuilt products is allowed under this specification unless otherwise specifically specified.

3.3 Design and construction. The requirements specified herein shall be considered as minimum standards (see 6.3).

3.3.1 Objectives. The design shall include the following in its objectives:

(a) Maximum reliability and maintainability (see 6.11.2).
(b) Maximum ease of operation.
(c) Best possible access for maintenance.
(d) Light in weight and compact meeting constraints of 3.3.13.

3.3.2 Maintenance. Design and construction shall provide that maintenance in service will not require precision workmanship or critical adjustments.

3.3.3 Reliability and maintainability. The contractor shall employ in the process of design and manufacture such methods as are necessary to ensure achievement of levels of reliability and maintainability of the complete generator set no less than those specified in 3.3.3.2 and 3.3.3.3 (see 6.3 and 6.9).

3.3.3.1 Operating life. Generator set shall have an operating life not less than 100,000 hours for class A generator sets and 25,000 hours for class B generator sets, over a period no less than 30 years. This life shall be predicted on the following:

	Class A generator sets	Class B generator sets
Hours at rated load	10,000	8,000
Hours at 60 percent load	65,000	15,000
Hours at 40 percent load	25,000	2,000

The generator set shall be designed for no less than 12,500 starts for class A generator sets and 30,000 starts for class B generator sets during operating life, and for satisfactory operation for 12,000 hours for class A and 3,000 hours for class B generator sets between overhaul periods.

3.3.3.2 Reliability prediction. The reliability prediction for the generator set shall be based on the failure rate of parts and the information specified in 3.3.3.1 . The design and application of these parts shall be such that the inherent mean-time-between-failure (MTBF) is not less than 3000 hours for class A and 1,000 hours for class B generator sets. The MTBF shall be predicted using the design prediction procedure of MIL-STD-756 and using the failure rate sources specified therein. For parts where no failure rate is available, a failure rate shall be estimated and the basis for the estimate shall be calculated. The derating factors used for each part and the stress levels at which each part is operating shall be calculated. The stress levels shall be those determined by test, insofar as practicable. In those instances where test data are not available, design data shall be used. A failure is defined as occurring when either equipment becomes inoperative or its performance degrades to the point where the requirements of this specification cannot be met without repair or unscheduled adjustment or replacement (see 6.3).

3.3.3.3 Maintainability. The maintainability of the complete generator set shall be predicted in accordance with procedure IV of MIL-HDBK-472. The failure

rates used shall be those which have been determined in the reliability predictions. The maintainability prediction shall take into consideration all design changes made during the engineering design phase (see 6.3). Mean-time-to-repair (MTTR) as defined in MIL-STD-721 shall be not greater than 8 hours assuming that repair parts and tools are available on board the ship.

3.3.3.4 Design reviews. The contractor shall establish and conduct design reviews (see 6.3). Participants shall include personnel from design, reliability, maintainability, and other pertinent areas of the contractor's organization.

3.3.4 Safety analyses. Safety analyses shall be performed by the contractor to identify hazardous conditions for the purpose of their elimination or control. Analyses shall consist of an examination of the equipment, subsystems, components, and their interrelationship, including logistic support, training, maintenance, and operational environments (see 6.3).

3.3.5 Standardization. Generator sets, other than those used for special applications, shall have power output ratings (300 kW and above) as specified in table I. The ratings for type II generator sets are based on 80 percent lagging power factor (pf).

TABLE I. Output ratings.

kW ratings	
Type I generator sets	Type II generator sets
300 500 750 1000	300 500 750 1000 1500 2000 2500 3000 3500
Voltage ratings	
Type I generator sets	Type II generator sets
120/240 volts (3-wire)	450 volts (3-phase, 3-wire)

3.3.6 Design for maintenance.

3.3.6.1 Accessibility. Accessibility shall be provided for parts which require maintenance or replacement in service without the need for disconnection or removal of another part or assembly other than an access panel or cover. Each access panel and cover shall be openable and closeable or reusable and replaceable (as applicable), starting from the secured position and returning to the secured position, in not greater than 0.05 hour. Time required for examination, maintenance, or replacement of the part is not included. The envelope of the minimum

required space around the generator set and its parts for ease of maintenance shall be as shown on the outline installation drawing.

3.3.6.1.1 Inspection plate. When specified (see 6.2), the generator shall be equipped with a transparent polycarbonate end plate to facilitate winding inspection.

3.3.6.1.2 Indicating and monitoring devices. All indicating and monitoring devices mounted on the generator set shall be visible without the removal of access covers or plates.

3.3.6.2 Interchangeability. In no case shall parts be physically interchangeable or reversible unless such parts are also interchangeable or reversible with regard to function, performance and strength.

3.3.7 Generator set mounting. Except for the switchboard mounted accessories and other accessories which are specified as being detached (see 6.2), the following mounting requirements shall apply. Each complete generator set shall be assembled on a welded steel bedplate, and shall form a rigid self-supporting structural unit for maintaining alinement of units in service during shock tests and for handling during shipment and installation onboard ship without further stiffening or bracing. Unless otherwise specified (see 6.2), the generator set shall have a three point support whereby the generator set bedplate is supported by the ship's foundation at three points.

3.3.7.1 General.

3.3.7.1.1 Nil-ductility properties. Where carbon steel with less than 1 percent of any one alloy is used in the generator set bedplate or subbase and in unit mounting feet or mounting brackets, bearing caps, bearing pedestals and frames, nil-ductility transition temperatures shall be not greater than plus 10 degrees Fahrenheit (°F) as determined by the method described in ASTM E 208. This requirement does not apply to plate thickness less than 5/8 inch or greater than 4 inches. Subject to review by the command or agency concerned, the use of impact tests shall be substituted where there is sufficient statistical data to show correlation between nil-ductility properties and impact values.

3.3.7.1.2 Bedplate bolting. Generator set bedplate bolt holes provided for securing the generator set and mounting holes provided for securing detached units to the ship's foundation shall be used with nonfitted bolts conforming to types I or II of MIL-S-1222 and self-locking nuts conforming to MS17828 or MS17829. Bolts of higher grade are permitted when their use is accepted by the contracting activity. Maximum clearance between bolt-holes and bolts shall be not greater than the following:

Nominal bolt diameter	Maximum diameter of hole
3/4 inch or less	Nominal bolt diameter plus 1/32 inch
Greater than 3/4 inch	Nominal bolt diameter plus 1/16 inch

3.3.7.1.3 Attachment. Units that are rigidly supported shall not be attached to two structures which can deflect relative to each other under shock.

3.3.7.1.4 Resilient mounts. Unless resilient mounts are specified (see 6.2), shock mountings to minimize shock forces imparted to equipment shall not be used.

3.3.8 Minimum radius of cable bend. Sufficient clearance between units on the generator set and inside the enclosures of electrical accessories or electrical units furnished with the generator set shall be provided to permit ship's cabling to be connected. The location of connections and clearances shall be so that cables shall be installed with the minimum radius of bend as specified in table II.

TABLE II. Cable bend radii.

Current rating amperes of circuit involved	Cable overall maximum diameter (inches)	Minimum allowable radiu for cable bend (inches)
Over 360	2.203	13.5
291 to 360	1.957	13.0
215 to 290	1.669	11.0
135 to 214	1.515	9.5
100 to 134	1.134	7.5
75 to 99	0.969	6.5
45 to 74	0.812	5.5
15 to 44	0.575	4.5
Less than 15	0.411	3.0

3.3.9 Wiring connections. Main generator power terminals shall be located as specified (see 6.2) and shall be installed within a dripproof protected type enclosure in accordance with MIL-E-2036. The enclosure shall be provided with cable entrance plates. Wiring required between units on the generator set bedplate shall be permanently installed at the factory. Except for main generator power terminals, all electrical items installed on units attached to the generator set bedplate, which require connections to ship's wiring, shall be wired to terminal boards suitably enclosed, dripproof protected and conveniently located. Separate connection boxes or separate enclosed compartments within a common connection box shall be provided for each of the auxiliary services requiring connection to the ship's electrical wiring such as space-heaters, temperature detectors, contact making devices, governors, tachometers, lube oil pump, and so forth.

3.3.10 Lifting means. Eye-bolts, lugs, or holes shall be provided to permit lifting the completely assembled generator set and attached accessories as a complete package. Eye-bolts or other means for lifting the individual units shall not be depended upon for lifting the assembled generator set.

3.3.11 Short circuit.

3.3.11.1 Type I. Type I generator sets shall withstand, without damage to the unit, a short circuit for 30 seconds. The sustained value of current during a short circuit shall be not less than 3.2 times rated.

3.3.11.2 Type II. Type II generator sets shall conform to the short circuit requirements of MIL-G-3124.

3.3.12 Shock. Grade A, hull-mounted, class I, heavy-weight, type A requirements of MIL-S-901 shall apply where equipment is not required to be resiliently mounted. Where resilient mounting of equipment is required, the grade A, hull-mounted, class II or III, heavy weight, type A requirements of MIL-S-901 shall apply). The basis of shock design and acceptance shall be as specified hereinafter. The generator set shall be designed so that it can meet the performance requirements of this specification when subjected to the magnitude of shock specified for static and dynamic design methods or that encountered during shock tests, as applicable.

3.3.12.1 Shock test methods. Where equipment is tested, by reason of weight and size not exceeding the available facilities, such equipment shall be subjected to the shock tests specified in 4.6.19. The intent of this specification is to use shock testing to the maximum extent possible and use static and dynamic analysis only where testing is impractical. Accordingly, where the generator set exceeds the size and weight limitations of shock testing facilities, the generator set manufacturer shall propose removing one or more units from the generator set and test these units and the remaining portion of the set on an individual basis.

3.3.12.1.1 Static design method. Shock design of equipment not able to be tested as specified in 3.3.12 shall be based on the following minimum static shock factor values which apply at the bottom of mounting pads, rails, or feet, and so forth of the generator set package and detached accessories:

	Static shock factor		
Application	Vertical	Athwartship	Fore and aft
Generator set	75	45	20

3.3.12.1.1.1 Use of static shock factor values. Equipment shall withstand shock loads due to steady acceleration at the static shock factor values applied separately in each direction (plus or minus). Each mass element of the unit shall have an inertia load applied equal to (dm times G times g).

Where: dm = distributed mass.
G = static shock factor value tabulated herein.
g = acceleration of gravity.

The resulting stresses and deflections, when added to the maximum normal operating values, shall be not greater than allowable stresses or deflections.

3.3.12.1.1.2 Allowable stresses. The combination of shock and operating stresses shall be not greater than the 0.2 percent offset yield strength at operation temperature. The unit loading for combined shock and operating loads on babbitted bearings shall be limited to 22,000 pounds per square inch (lb/in^2). The criteria for failure when plastic set is permissible is the effective yield strength of the material, in tension and shear, which is represented by "δ" and "γ" respectively, defined as follows:

$$\delta = \delta y + F(\delta u - \delta y); \gamma = 0.6\delta$$

Where: δy is the 0.2 percent offset yield, elastic limit or other normal definition of material yield strength. δu is the normal definition of material failure strength. F is a factor which takes into account the efficiency with which the material in the member is utilized and is dependent on the kind of loading and cross section of the member. The value of F is equal to the load required to completely yield the member divided by that load required to just initiate yielding minus 1. F equals zero for members in tension and where material has less than 10 percent elongation before fracture in a tension test. F equals 0.5 for a rectangular section in pure bending.

3.3.12.1.2 Dynamic design method. When specified (see 6.2), the manufacturer shall conduct a concurrent dynamic analysis. Items found deficient by this analysis shall be identified and corrective action proposed by the manufacturer. Design changes will be incorporated at the option of the Government. The incorporation of these design changes in equipment is not the responsibility of the manufacturer.

3.3.12.2 Exceptions. The basis for shock design specified in 3.3.12 through 3.3.12..1.2 applies except in the following cases:

(a) When the equipment proposed is of identical design to one which has been previously shock tested and finally accepted by the Navy, such design will be acceptable provided it meets all other requirements of the application.

(b) When the equipment proposed is of identical design to one which has been previously statically or dynamically analyzed and such analysis has been finally accepted by the Navy, such design will be acceptable provided:

(1) The mathematical model applies without change. For example, the equipment is a repeat acquisition for which the ships foundation and other equipment affecting the model are dynamically the same.

(2) The equipment meets all other requirements of the application.

(c) When the equipment proposed is similar, but not identical, to a design previously shock tested or statically or dynamically analyzed and accepted by the Navy, such design shall be acceptable provided that the manufacturer submits a request for extension of acceptance including calculated shock factor capabilities demonstrating the adequacy of the similar design. If NAVSEA concurs that the similar design will provide equal or better shock capabilities in the intended application, extension of acceptance will be given. Request for extension based on unit designs previously extended will not be considered.

(d) Previously granted exceptions to shock test which are based on static or dynamic analysis and which were granted on the basis of equipment size and weight being in excess of the capacity of former

shock test machines are not applicable if the equipment is now within the capacity of existing shock test machines.

3.3.13 Weight and size. The overall weight and size of the complete generator unit (with attached accessories) shall be as specified (see 6.2 and 6.3).

3.3.14 Ambient temperatures. Generator set, complete with all attached accessories, shall meet the performance requirements of this specification at any compartment ambient temperature between 20 to 122°F. Gas turbine shall meet generator full power requirements based on 100°F ambient air into the engine inlet with an inlet pressure loss of 6 inches water and an exhaust pressure loss of 12 inches water.

3.3.15 Inclined operation. Generator set shall meet the performance requirements of this specification, shall maintain satisfactory lubrication, and shall experience no loss of liquids (including lube oil) under the following conditions:

(a) When the generator set is permanently inclined from the normal horizontal position as much as 5 degrees on either end and 15 degrees to either side.
(b) When the generator set is momentarily inclined from the normal horizontal position as much as 10 degrees on either end and 45 degrees on either side.

The momentary inclination cycle shall be as specified (see 6.2).

3.3.16 Vibration resistance (environmental vibration).

3.3.16.1 Vibration requirements. The complete generator set with attached accessories and all detached accessories shall be designed to withstand the following spectrum of environmental vibration without experiencing excess vibration which can prevent the equipment from performing its normal function or lead to damage or malfunctioning of the units.

Amplitude of vibration	
Frequency range hertz (Hz)	Amplitude (± mils)
5 to 15	30
16 to 25	20
26 to 33	10
34 to 40	5
41 to 50	3

3.3.16.2 Vibration testing. Vibration tests are not required on the completely assembled generator set. Vibration tests shall be conducted on individual equipments as required by the individual equipment specification or on individual equipments in accordance with MIL-STD-167-1.

3.3.16.3 Vibration test waiver. When the individual equipment proposed is of identical design to one which has been previously vibration tested and finally

accepted by the Navy, such design shall be acceptable provided it meets all other requirements of the specification.

3.3.17 Vibration (internally excited). Unless otherwise specified (see 6.2), the generator set shall meet the vibration requirements in accordance with MIL-STD-167-1 for the prime mover.

3.3.18 Welding and allied processes. Welding and allied processes shall be in accordance with MIL-STD-278. Where MIL-STD-278 requires review of specific aspects of welding and allied processes, the reviewing activity shall be NAVSEA.

3.3.19 Airborne and structureborne noise.

3.3.19.1 Airborne noise. Unless otherwise specified (see 6.2), the sound pressure level of the generator set at rated load, including all attached and detached accessories shall be not greater than the following levels when tested as specified in 4.6.20.1.

Octave band center frequency, Hz	Sound pressure level, decibels (db) micropascal 20 (μPa) reference
31.5	91
63	88
125	85
250	82
500	79
1000	76
2000	73
4000	70
8000	67

3.3.19.2 Structureborne noise. The structureborne noise levels at any measurement location and in any direction shall be not greater than the levels specified in 6.2 when tested as specified in 4.6.20.2. The structureborne noise levels of the generator set with all attached accessories, and the levels of detached accessories shall be measured at rated load. Details on whether generator sets and detached units must be resiliently mounted and the type of resilient mount to be used shall be specified (see 6.2). Design requirements for resilient mounts and structureborne noise are specified in 3.3.19.2.1 and 3.3.19.2.2.

3.3.19.2.1 Resilient mounts. Where resilient mounts are used, all mounts shall be of the same type and shall have equal loading. Flanges for mounts shall be installed so that the vertical distance between the horizontal center lines of mounts and the center-of-gravity of equipment is a minimum. Mount deflection under starting, operating and securing conditions of equipment, and under shock conditions shall be considered when determining clearances around the equipment and clearances between the mounts and surrounding structure on the equipment.

3.3.19.2.2 Design consideration for noise limitation. The following factors shall be considered by the manufacturer in the design of the generator set, as

located so as to measure the temperature of

necessary, to meet airborne and structureborne noise limitations of 3.3.19.1 and 3.3.19.2.

(a) Precision machining of rolling, rubbing, and fitted parts.
(b) Maximum effort shall be made in the production phase to minimize the amount of corrections required during the final balancing phase of the generator set.
(c) Provision shall be made for inplace balancing of rotating parts of the generator and access plates shall be provided for this inplace balancing.
(d) Sharp cutoffs and turbulence shall be avoided in air cooling system. Ventilation ducts and housings shall be damped, as necessary to prevent flow excited vibration.
(e) Most favorable combination of the following generator design features:

(1) Number of slots per pole pitch.
(2) Number of slots magnetically under one pole.
(3) Slot frequency as a function of the natural frequency of the magnetic frame.
(4) Skewing of stator slots.
(5) Skewing of pole tips and fairing of pole tip edges.

(f) Spring mounting of generator stator punchings.
(g) Close tolerance of generator air gap.
(h) Direct drive governor.
(i) Enclosures.
(j) Reduction gear cladding.
(k) Any other features specified (see 6.2).

3.3.20 Threaded parts. Threaded parts shall conform to FED-STD-H28.

3.3.21 Grounding of circuits during starting. Grounding of turbine control and start circuits is not permitted during starting of the generator sets (see 3.7.1).

3.3.22 Piping for oil and other fluids. Piping between units of the generator set shall be provided and installed by the generator set manufacturer and shall be in accordance with MIL-STD-777 except that copper or copper alloys shall not be used for piping for fuel. Piping for turbine fuel shall be stainless steel with compatible fittings. Tapered pipe threads shall not be used except where unavoidable, in which case they shall be secured by seal welding. Liquid piping and sump vents shall not be located where drops or sprays from leaks, condensation, splashing, or fumes could cause damage to electrical equipment. Where this is impractical, adequate shielding shall be provided.

3.3.23 Fire hazard. To minimize potential fire hazard, the following construction considerations shall be incorporated in locating piping and units:

(a) Oil shall not leak or spray on lagging or on hot surfaces which exceed 400°F.

(b) Locate lubricating oil strainers and filters remote from hot surfaces.
(c) Locate sump vents so that oil laden fumes cannot be drawn into the generator windings or other electrical equipment.

3.3.24 Resistance temperature sensing elements (RTE's). In addition to thermometers required by the generator specifications, RTE's shall be furnished in accordance with 3.3.24.1 through 3.3.24.4.10.

3.3.24.1 General requirements for RTE's. RTE's shall be provided on generator journal bearings, generator stator windings and for detecting the temperature of generator cooling air where totally enclosed water air-cooled generators, are specified and shall be suitable for use with monitors conforming to the requirements of MIL-T-15377.

3.3.24.2 Generator air temperature. Generator air temperature RTE's shall be located so as to measure the temperature of air to and from the generator air cooler. Air temperature RTE's shall be removable without the removal of the complete air cooler cover.

3.3.24.3 For generator stator winding on type II generator sets. Not less than two embedded RTE's per phase shall be provided in the stator winding, with the first placed as near as possible to the estimated hot spot of the winding, and the remainder spaced at equal intervals of 60 degrees.

3.3.24.4 Journal and thrust bearings. RTE's for journal and thrust bearings shall be as specified in 3.3.24.4.1 through 3.3.24.4.8. RTE's shall be in accordance with MIL-T-24388/8, with element wiring protruding from bottom or end at bottom (see figures 1 through 4 for guidance).

3.3.24.4.1 Journal bearings. Journal bearings on the generator shall be fitted with RTE's at the full power load line. There shall be one RTE in each journal bearing located in the middle third of the axial length of the bearing.

3.3.24.4.2 RTE installations. The RTE's shall be installed as shown on figure 1 in a radial hole in the bearing shell, with the sensing tip 1/16 inch below the bearing surface and with the bottom of the RTE casing bottoming on the shoulder in hole as shown.

3.3.24.4.3 Fusion bonding. RTE shall be fusion bonded to the surrounding bearing babbitt and the bearing surface shall be restored to design dimensions.

3.3.24.4.4 RTE lead wire connection. The wires attached to the RTE shall be brought out through a radially drilled 0.187 inch maximum diameter hole and channeled into a groove (approximately 1/8 by 3/16 inch) connecting the radial hole with a connection block (see figure 2) recessed in bearing edge or end at, or close to, the bearing part line. An air hardening epoxy-resin shall be applied in the groove to protect the wiring. All wires shall be soldered to the connection block (see figure 4).

3.3.24.4.5 Connection block wiring. Wiring between the bearing connection block and the casing (or bearing pedestal) wall is required to complete the

circuit. Wiring shall be recessed in epoxy-resin-filled grooves, in the holes, or in armored sheath to protect it against damage. Wiring shall be easily disconnected (mechanically or by melting soft solder) from the bearing connection block and shall penetrate the casing wall through a type "AN" connector in accordance with MIL-C-5015 (see figure 2). Location of "AN" connectors shall be such as to minimize the possibility of damage to connector and cables attached thereto. Penetration points shall be oiltight if the internal surfaces of these points are subject to being submerged or splashed with oil.

3.3.24.4.6 Pivoted shoe bearings. Procedures in 3.3.24.4 through 3.3.24.45 for journal bearings shall generally apply for installing RTE's in pivoted shoe bearings, except that the RTE shall be installed on the trailing edge of one lower shoe and the bearing connection block shall be recessed in the edge or end of the shoe on the pivot line.

3.3.24.4.7 Thrust bearings. When installing RTE's in thrust bearing shoes, the shoes on the housing joint shall be fitted with RTE's to facilitate disassembly when shoes are removed for examination and replacement. The RTE in each shoe shall be installed on the trailing edge of the shoe and the outer diameter, and the bearing connection block shall be recessed in the edge of the shoe on the pivot line. Figure 3 shows an acceptable arrangement.

3.3.24.4.8 Caution plate. A caution plate shall be permanently affixed to the external top of the bearing cap warning that the RTE wires to bearings shall be disconnected before rolling out the bearing. Such warning plate shall also be installed on the generator where disassembly of the generator could result in damage to the RTE arrangement installed in the generator stator and cooling air sections.

3.3.24.4.9 Terminal box. Wiring from RTE's shall be brought out to a connection box or boxes as specified in 3.3.9. External wiring from RTE's to the terminal box shall be firmly supported and protected by use of rigid or flexible conduit.

3.3.24.4.10 Temperature monitors. Unless otherwise specified (see 6.2), temperature monitors in accordance with MIL-T-15377 shall be furnished by the activity installing the generator set.

3.3.25 Torsional vibration.

3.3.25.1 Operating speed range. The operating speed range is from 95 percent to 105 percent of rated speed.

3.3.25.2 Basis of acceptability.

3.3.25.2.1 Limits. The combined rotor system shall have no torsional natural frequencies coincident with operating speed range frequencies or any multiple of operating range frequencies. No torsional natural frequency shall be within plus or minus 10 percent of first two multiples of operating range frequencies. If this margin cannot be maintained, a torsional short circuit analysis is required to determine peak vibratory torques and stresses to verify the adequacy of all components. The system shall have no steady state torsional

vibratory stresses or deflections in the operating range sufficient to adversely affect the life of the unit or its synchronization with other units.

3.3.25.2.2 Stresses. Maximum steady state torsional shaft stresses shall be not greater than 10 percent of the ultimate tensile strength. Peak vibratory torsional stresses under short circuit conditions shall be not greater than 45 percent of the material ultimate tensile strength.

3.3.25.2.3 Short circuit requirement. With voltage regulators automatically controlling generator excitation and the generator load at any value from 0 to rated load, the complete type II generator set shall withstand, without damage to any unit, a single phase or three-phase, fully asymmetrical short circuit at the switchboard (assuming 25 feet of interconnecting LSTSGA cable in accordance with MIL-C-24643 from each generator power terminal to switchboard), with the quantity and size of cables installed as specified. Type I generator sets shall also withstand, without damage, a short circuit of the switchboard (assuming 25 feet of interconnecting cable from each generator power terminal to switchboard), with the quantity, type, and size of cables as specified (see 6.2 and 6.3).

3.3.25.2.4 Torsional analysis. The first through fifth torsional critical frequencies for the generator set shall be determined by test or calculation. If any of these are within 10 percent of operating frequency or twice operating frequency, a transient torsional analysis indicating compliance with 3.3.25.2.2 shall require contracting activity approval prior to construction of the unit. Approval of such a mathematical analysis does not release the contractor from the responsibility for the accuracy of the method, assumptions made, or results.

3.3.26 Starting. Starting of the generator set shall be accomplished either by an electric, hydraulic, combustion system or a compressed air starting system as specified (see 6.2).

The generator shall start and produce rated voltage and frequency at the generator terminals and supply rated load within 60 seconds after the starting system has been energized.

3.3.27 Load and overload. Generator set shall deliver rated kW load at rated power factor continuously under standard operating conditions in accordance with MIL-E-17341 without part failure or deterioration of the generator set life. Type II generator sets shall deliver 150 percent of rated current for 2 minutes at 0.5 pf.

3.3.28 Governing systems.

3.3.28.1 Type I generator sets. Governors for type I generator sets shall be of the hydraulic relay, centrifugally controlled type or the electric speed and load sensing type as specified (see 6.2). For parallel operation requirements, see 3.10.

3.3.28.2 Type II generator sets. Governors for type II generator sets shall be the electric speed and load sensing type in accordance with MIL-G-21410.

3.3.28.3 Governor speed changing.

3.3.28.3.1 Hydraulic relay, centrifugally controlled governors. Where the hydraulic relay, centrifugally controlled type governor is furnished, it shall include an electric motor drive to allow control of generator set speed from remote locations.

3.3.28.3.2 Electric speed and load sensing governor. Where an electric speed and load sensing governor is furnished speed setting shall be accomplished in accordance with MIL-G-21410 (see 6.2).

3.3.28.3.3 Electric motors. Electric motors specified in 3.3.28.3.1 shall be of the varying speed type with reversible rotation and shall be of the following classification:

(a) Rating volts - 115 ac, 60 Hz.
(b) Revolutions per minute (r/min) horsepower (hp) and maximum torque - As required by the speed changing device.
(c) Duty, intermittent - 1/2 hour.
(d) Enclosure - Totally enclosed.
(e) Phases - Single phase without commutator.
(f) Bearings - Ball or sleeve.
(g) Ambient temperature - 40 to 122°F.
(h) Mounting - Horizontal.

3.3.29 Load-speed characteristics.

3.3.29.1 Speed characteristics. The definition of speed characteristics as defined in MIL-STD-178 are applicable and requirements shall be as specified in 3.3.29.2 through 3.3.29.3.

3.3.29.2 Electric speed and load sensing governor. Where the governing system is of the electric speed and load sensing type, the performance requirements of type GT in MIL-G-21410 shall apply.

3.3.29.3 Centrifugally-controlled governor. Where the governing system is of the hydraulic relay, centrifugally controlled type, performance shall be as specified in 3.3.29.3.1 and 3.3.29.3.2.

3.3.29.3.1 Governor speed. The mean governed speed shall be adjustable within 5.0 percent above and 5.0 percent below the rated speed from no-load to maximum continuous rated-load.

3.3.29.3.2 Speed regulation. Under the conditions of test specified in 4.6.5, the speed regulation shall conform to the following requirements:

(a) Load-speed characteristics. Load-speed curves from no-load to 100 percent continuous rated-load shall fall between parallel straight lines having the no-load to continuous rated-load speed droop shown in column 1 of table III and the load spread shown in column 2 of table III. The maximum and minimum values of speed droop from no-load to rated-load shall be as specified in column 3 of table III.

(b) Speed fluctuation. At any load from 0 to 100 percent continuous rated-load for sets having no overload capacity, the speed fluctuation for any constant load shall be not greater than the values shown in column 4 of table III.

TABLE III. Load-speed characteristics.

Rated continuous kW load of generator set	Column 1	Column 2	Column 3	Column 4	Column 5
	Droop of lines for limits of load-speed curves (percent)	Load spread of lines for load speed curves (percent)	Range of overall speed droop (0 to 100 percent load) as determined from columns 1 and 2 (percent)	Maximum value of periodic speed fluctuation (percent)	Maximum speed deviation following sudden load change (percent)
Up to 249 kW	3.1	30	2.2 to 4.0	0.15	3.0
250 kW and over	3.3	20	2.7 to 4.0	0.15	3.0

(c) Sudden load change. The inertia of the generator set, the characteristics of the turbine and reduction gear and the response of the governor shall be such that upon sudden application of 80 percent continuous rated-load in one step and sudden removal of 70 percent continuous rated-load in one step from the 80 percent load originally applied, the maximum speed deviation from initial speed shall be not greater than the values shown in column 5 of table III. In addition, the speed shall return to, and remain within, 1.0 percent of the final steady state speed in not greater than 2.0 seconds following the load application or removal.

3.3.30 Shaft end and couplings.

3.3.30.1 Shaft end. Single-bearing generators larger than 60 kW shall be provided with a forged-on half-coupling to suit the prime mover reduction gear output shaft flange. Generators rated 60 kW and below shall be provided with a shaft extension having a keyway and a shrunk-on coupling. All two-bearing generators shall be provided with a keyed shaft extension for a shrunk-on coupling.

3.3.30.2 Couplings. Flexible couplings allowing angular misalignment between units shall be used. Geared (dental) or diaphragm type couplings are acceptable. Lubrication oil, if required, shall be the same as required by the engine, gear, or generator. Couplings shall be balanced in accordance with MIL-C-18087 and shall withstand the torque resulting from generator short circuit conditions. Coupling torque ratings shall be not greater than the capability of

the shaft ends they couple. The coupling shall be provided with a coupling guard to protect personnel from external rotating parts.

3.3.31 Use of aluminum. Use of aluminum or aluminum alloys (except those designed to carry current) shall conform to 3.3.31.1 through 3.3.31.3.

3.3.31.1 Surface treatment. Unpainted surfaces of aluminum or aluminum alloys shall be treated to conform to the requirements of MIL-A-8625. Surfaces to be painted shall be treated to conform to the requirements of MIL-C-5541.

3.3.31.2 Galvanic corrosion protection. When dissimilar metals (galvanically incompatible) are used in intimate contact in the presence of a conducting solution, protection against galvanic corrosion shall be applied. Aluminum members of dissimilar metal couples shall have their faying surfaces anodized.

3.3.31.3 Assembly of aluminum parts. Where threaded surfaces or faying surfaces shall require disassembly in service, an antiseize compound conforming to MIL-A-907 shall be used. For the assembly of aluminum alloy parts, through-bolting is preferred using zinc plated steel bolts and nuts; this applies with particular emphasis to comparatively highly stressed assemblies or those subject to vibrating loads. Where the use of tap bolts or machine screws is necessary, these shall be threaded into steel inserts in the aluminum or aluminum alloy. The steel inserts shall be secured in such a manner as to prevent their turning or backing out. No alloys of copper, such as brass or bronze, will be acceptable for use in threaded contact with aluminum alloys.

3.3.32 Generator frames. Frame shall have feet of a size large enough to accommodate holding-down bolts, dowel pins, and jackscrews where used, to ensure attachment to the subbase. Generator set shall be so constructed that the frame of the generator shall not extend below the lower face of the subbase. Generator (water-air-cooled type) frame shall be so constructed or fitted with baffles so that condensation will not drop on the generator windings. The condensation shall be drained to the outside of enclosures.

3.3.33 Bearings. Either sliding surface or ball bearings shall be furnished on generators 40 kW and smaller having a flexible coupling between the prime mover and generator. Sliding surface bearings shall be furnished on generators over 40 kW having a flexible coupling between the prime mover and generator, and on all sizes having a rigid coupling between the prime mover and generator. Bearings for generators over 40 kW shall be forced fed lubricated from either the engine, the reduction gear, or from a separate lubricating system. Sight flow fittings and thermometers shall be provided at the bearing oil discharge. The lubrication system shall prevent oil, oil laden mist, or grease from leaking or migrating from the oil seal, bearing housing, or split lines under the inclined operation conditions in accordance with MIL-E-917.

3.3.34 Generator lubrication. Lube oil shall be compatible with the insulation used on the generator windings. Where synthetic oil is used, the oil shall be tested in accordance with ASTM D 2519 to prove compatibility with the varnish insulation of the generator windings. A separate lube oil system shall be used for the generator where synthetic oil has to be used for the turbine engine and the oil cannot be proven to be compatible with the insulation of the generator windings.

3.4 Gas turbine engine. Gas turbine engine shall be a single shaft engine conforming to types A and B of MIL-E-17341, except as otherwise specified herein.

3.5 Reduction gears. Reduction gear unit shall be in accordance with the applicable standards listed in the latest issue of the AGMA Catalog of Technical Publications except as otherwise specified herein. Reduction gear of a design previously used in similar applications by the command or agency concerned shall be used. However, any changes from a previously used design shall require review by the command or agency concerned. Gears shall be double or single helical, case hardened by nitriding or carburizing. The reduction gear unit shall have a quality level of 12 or better as defined in AGMA 2000.

3.5.1 Planetary gears. The use of planetary gears shall be considered, however, the use of these gears shall require contracting activity approval.

3.5.2 Gear loading. The following shall be used for determining gear loading:

With B hn	Compressive stress	Bending stress
159-202	60,000	20,000
207-248	65,000	22,000
255-302	75,000	27,000
311-352	85,000	30,000
470-545	140,000	32,000
601-660	175,000	35,000

The command or agency concerned will give consideration to loading and materials as proposed. Maximum loading for bevel gears shall be in accordance with the Gleason practice, or equivalent. For bending stress calculations, a stress concentration factor in accordance with AGMA 6010 shall be used.

3.5.3 Gear surface finish. Surface finish roughness on tooth meshing areas shall be not greater than 32 microinches root mean square (rms).

3.5.4 Gear case and cover. Gear case and cover shall be constructed of heat treated aluminum alloy in accordance with ASTM B 26. Inserts shall be provided for all bearing bores and each gear case shall be provided with an adequate vapor vent.

3.5.5 Gear lubrication. Gears shall be suitable for lubrication with oil in accordance with MIL-L-23699, MIL-L-9000, MIL-L-2104, MIL-H-17672, or MIL-L-17331 symbol 2190 TEP. Where cross-contamination of oil systems is possible, the gear shall use MIL-L-23699 oil.

3.6 Air coolers. Generator air coolers shall conform to the requirements for class 2 of MIL-C-19836 and shall be designed for 180 lb/in^2 water pressure.

3.7 Electrical equipment.

3.7.1 Grounding. Electrical circuits shall be ungrounded.

3.7.2 Type I, dc generators. Type I generators shall conform to the requirements of MIL-G-3111 and shall be of the following classification:

(a) Service application - Ship's service.
(b) kW rating - As specified (see 6.2).
(c) Voltage - Voltage, two or three wire, as specified (see 6.2).
(d) R/min - As specified (see 6.2).
(e) Enclosure - Below 500 kW, dripproof-protected.
500 kW and larger, totally-enclosed, water-air-cooled.
(f) Ambient temperature 20 to 122°F.
(g) Bearings - Sleeve, ball, or roller type, as specified (see 6.2).
(h) Insulation - Class B or F, as specified (see 6.2).

3.7.2.1 Balance coils. Balance coils for three wire type I generator sets shall be furnished. These coils shall conform to MIL-T-15108 and shall be of the following classification:

(a) Enclosure - Dripproof-protected.
(b) Rating - As required by the type I generator.
(c) Duty - Continuous (see 6.11.1).
(d) Ambient temperature 20 to 122°F.
(e) Mounting - As specified (see 6.2).

3.7.3 Type II, ac generators. Type II generators shall conform to the requirements of MIL-G-3124 and shall be of the following classification:

(a) Service application - Ship's service, emergency service, combination of ship's service and emergency, or special application, as specified (see 6.2).
(b) Type - Rotating field (salient pole or round rotor) as specified (see 6.2).
(c) kW rating - As specified (see 6.2).
(d) Voltage - As specified (see 6.2).
(e) Phases - 3.
(f) Frequency - 60 Hz or special, as specified (see 6.2).
(g) R/min - As specified (see 6.2).
(h) Enclosure - Below 500 kW, dripproof-protected.
500 kW and larger, totally-enclosed, water-air-cooled.
(i) Bearings - Sleeve, ball, or roller type as specified (see 6.2).
(j) Ambient temperature 20 to 122°F.
(k) Insulation - Class B, F, H, or N, as specified (see 6.2).

3.7.4 Excitation and voltage regulation equipment.

3.7.4.1 Type I generator sets. Where type I generator sets are specified, the requirements specified in 3.7.4.1.1 and 3.7.4.1.2 shall apply.

3.7.4.1.1 Excitation. The type I generator shall be of the self-excited type. Voltage regulators shall not be furnished.

3.7.4.1.2 Generator field rheostats. Generator field rheostats shall be furnished and shall have the following characteristics:

(a) Enclosure - Dripproof-protected.
(b) Rating - As required for the generator.
(c) Duty - Continuous.
(d) Mounting - Switchboard.
(e) Ambient temperature 20 to 122°F.
(f) Control - The rheostat shall have sufficient resistance to reduce the open circuit generator voltage to 50 percent of rated value at rated speed. In addition, with the generator operating at rated speed, the rheostat shall adjust the generator voltage in steps of not greater than 0.5 percent of rated voltage between the limits of 96 to 105 percent of rated voltage and in steps of not greater than 1.0 percent of rated voltage between the limits of 90 to 96 percent of rated voltage at any generator load between zero and rated value.

3.7.4.2 Type II generator sets. Where type II generator sets are specified, the voltage regulation system shall conform to the requirements of MIL-R-2729 and shall perform parallel operation.

3.8 Voltage buildup for type II generator sets. Voltage buildup shall be in accordance with the requirements of MIL-G-3124. Voltage shall buildup to rated value within 60 seconds after starting (see 3.3.26) when tested as specified in 4.6.14.

3.9 Generator set voltage regulation.

3.9.1 Type I generator sets. For type I generator sets, the following voltage regulation shall apply:

(a) With the generator field rheostat, generator load, and turbine speed adjusted so that the generator is operating at rated voltage, current, and r/min, the rise in voltage shall be not greater than 8.0 percent when the load is gradually reduced from rated-load to no-load in 20 percent steps.
(b) With the generator field rheostat, generator load, and turbine speed adjusted so that the generator is operating at rated voltage, no-load, and a speed corresponding to the no-load speed noted in (a) the drop in voltage shall be not greater than 12.5 percent when rated-load is applied in 20 percent steps up to rated output.
(c) At any point on the voltage-load curve with the generator field rheostat adjusted as specified in (a) and (b), there shall be no rise in voltage with increase in load or any drop in voltage with decrease in load.

3.9.2 Type II generator sets. For type II generator sets, the requirements of MIL-R-2729 shall apply.

3.10 Generator set parallel operation. When parallel operation is specified (see 6.2), generator sets shall comply with the requirements of 3.10.1 through 3.10.2.

3.10.1 Type I generators sets. For type I generator sets the parallel operation shall be as follows:

(g) Bolts, nuts and other similar devices are tight and adequate provision has

(a) Generator sets shall operate in parallel without equalizers so that at any load under the conditions of test specified in 4.6.12, the current load on any generator expressed as a percentage of its rated-load current shall not differ from the total system current load expressed as a percentage of the total rated-load currents of all connected generators, by greater than 7.5 percent for generators of the same type, design and kW ratings or 15.0 percent for generators of different designs, types, and kW ratings. For example, if four 120/240 volt, type I generator sets (A, B, C, and D) rated 60, 100, 100 and 100 kW respectively are operating in parallel and at one point are delivering 165, 194, 195, and 196 amperes, respectively, with no current flowing in the neutral lead, generator A would not be meeting specification requirements. The generator sets would be meeting specification requirements at a certain point, however, if they were delivering 160, 196, 197, and 197 amperes, respectively, with no current flowing in the neutral lead.

(b) Where there are load currents in neutral leads of three wire generators operating in parallel, the larger of two main line currents in each generator set shall be used to determine if parallel operation requirements have been met.

3.10.2 Type II generator sets. Where type II generator sets are specified the load division requirements of MIL-G-21410 shall apply.

3.11 Damper bars. Damper bars shall be furnished on type II generators and shall be interconnected between poles.

3.12 Identification plate. An identification plate shall be furnished with each generator set and shall be installed on the bedplate in a location where it can be easily read without danger to personnel. The identification plate shall be in accordance with MIL-P-15024 and MIL-P-15024/5.

3.12.1 Classified markings. Identification plates shall not contain any classified (Security) markings. For the markings which are indicated as classified by contract security provisions specified in the contract, the items shall be stamped with an asterisk only and the following added at the bottom of the plate:

"* Classified data - See technical manual."

3.13 Repair parts and special tools. Repair parts and special tools shall be furnished in accordance with the requirements specified (see 6.2). Onboard repair parts shall be based on the number of identical generator sets installed per ship, as specified (see 6.2), and the following:

(a) A set of special tools which are required for disassembly, repair, adjustment, and reassembly, shall be furnished on a per ship basis. Special tools are defined as those tools not listed in the Federal Supply Catalog (copies of this catalog shall be consulted in the office of Defense Contract Administration Services Management Area (DCASMA).

(b) The specific repair parts and quantity of each part shall be furnished as specified in the individual equipment military specification.
(c) Where special tools are required for installation and alinement of the generator set, one set of such tools shall be shipped with the first generator set scheduled for installation on each ship.

3.14 Electromagnetic Interference (EMI) control. The generator set shall be designed to meet EMI control requirements in accordance with part 5 or part 6, as applicable, of MIL-STD-461.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order, the contractor is responsible for the performance of all inspection requirements (examinations and tests) as specified herein. Except as otherwise specified in the contract or purchase order, the contractor 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 this specification where such inspections are deemed necessary to ensure supplies and services conform to prescribed requirements.

4.1.1 Responsibility for compliance. All items shall meet all requirements of sections 3 and 5. The inspection set forth in this specification shall become a part of the contractor's overall inspection system or quality program. The absence of any inspection requirements in the specification shall not relieve the contractor of the responsibility of ensuring that all products or supplies submitted to the Government for acceptance comply with all requirements of the contract. Sampling inspection, as part of the manufacturing operations, is an acceptable practice to ascertain conformance to requirements, however, this does not authorize submission of known defective material, either indicated or actual, nor does it commit the Government to accept defective material.

4.2 Classification of inspections. The inspection requirements specified herein are classified as follows:

(a) First article inspection (see 4.4).
(b) Quality conformance inspection (see 4.5).

4.3 Conditions of test.

4.3.1 Fuel and lubricating oil. Fuel used during the tests shall be in accordance with MIL-F-16884. However, during tests required by 4.6.15 through 4.6.15.2 both diesel and JP-5 fuels, conforming to MIL-F-16884 and MIL-T-5624 respectively, shall be used during equal portions of the test without making adjustments or changes to the unit. Lubricating oil shall conform to MIL-L-23699 for the engine system and MIL-L-17331 for the generator system. Lubricating oil for the gear shall conform to either MIL-L-23659 or MIL-L-17331, whichever is used in actual operation.

4.3.2 Cooling water temperature. The temperature of the water to the sea water pumps shall be maintained at 85°F.

4.3.3 Capacities. The capacities of pressure lubricating oil, scavenging oil, and sea water pumps shall be determined at speeds within their installed operating range.

4.3.4 Starting batteries. Electric starting tests shall incorporate use of the required number of type BB-257/U batteries conforming to DOD-B-15072.

4.3.5 Unit tests. Units shall be tested in accordance with individual equipment specifications. It is preferred that these tests be conducted at the place of manufacture prior to final assembly of the generator set. However, if it is more practical to conduct all or part of the required unit tests after final assembly of the generator set, such method of conducting unit tests is acceptable provided all necessary loading and instrumentation facilities are available and tests are conducted in strict compliance with the applicable specifications.

4.4 First article inspection. The first generator set of a design, type, and size offered for delivery shall be subjected to the inspections and tests specified in table IV (see 6.3). Thereafter, one identical generator set of each design, type, and size shall be subjected to first article inspection every 2 years during which such generator sets are offered for delivery except that shock and inclined operation inspections are not required. First article inspection shall be conducted after any change in design which affects the performance characteristics. If group A and group B inspection data reveal variations beyond the manufacturer's established design tolerances as shown on drawings and design data sheets, the DCASMA shall require that any or all of the first article inspection be made on a particular generator set to demonstrate that it conforms to this specification. Where the manufacturer has conducted first article inspection within a 2-year period prior to receipt of a request for bid, the bid proposal shall contain a statement to indicate whether the manufacturer intends to conduct first article inspection. If such statement is included with bids, a copy of the latest first article inspection results with adequate abstract shall be included with bid data to verify conformance with the first article inspection herein (see 6.3).

TABLE IV. First article inspection.

Inspection	Requirement	Test method
Visual and mechanical	See note 1	4.6.1
Generator air gap	----	4.6.2
Forty-five minute preliminary run	----	4.6.3
Four-hour condinuous test at full load	----	4.6.4
Mechanical balance	3.3.17	4.6.5
Governor	3.3.28, 3.3.29	4.6.6
Voltage regulation	3.9	4.6.7
Commutation	----	4.6.8
Rheostat	3.7.4.1.2	4.6.9

see note on next page.

TABLE IV. First article inspection - Cont'd.

Inspection	Requirement	Test method
Effectiveness of enclosure	----	4.6.10
Lubrication	3.3.15	4.6.11
Parallel operation	3.10	4.6.12
Performance	3.3.27	4.6.13
Starting	3.3.26	4.6.15
Inclined operation	3.3.15	4.6.16
Weight	3.3.13	4.6.17
Voltage build-up	3.8	4.6.14
Safety	3.3.4	4.6.18
Shock	3.3.12	4.6.19
Noise	3.3.19	4.6.20
Maintainability demonstration	3.3.3	4.6.21
EMI control	3.14	4.6.22

NOTE 1: The test method in 4.6.1 shall verify conformance to all of the visual and mechanical requirements contained in this specification and applicable documents. Visual and mechanical inspection shall determine conformance to specified design and workmanship.

4.5 Quality conformance inspection. Quality conformance inspection shall consist of the group A and group B tests as specified in table V (see 6.3).

4.5.1 Inspection. Generator set shall be subjected to the inspection shown in table V, as applicable. Inspection shall be conducted with the generator set operating as a complete unit with all attached and detached accessories. When conducting group A inspection the same detached accessories shall be used to inspect each generator set provided each detached accessory supplied under the contract or order is examined and tested in accordance with the individual equipment specification covering the particular accessory. For example, where static type excitation systems are furnished (type III of MIL-R-2729) as detached accessories, only two of these excitation systems would be required for generator set parallel operation tests and these two systems shall be used to conduct tests on remaining generator sets being furnished provided all other excitation systems have been subjected to the tests required by MIL-R-2729.

4.5.2 Sampling for group A tests. As a minimum, each completed generator set offered for delivery shall be subjected to the group A tests as specified in table V. If one or more defects are found in any generator set, the unit shall be rejected and require that corrective action be implemented by the contractor. The contractor shall maintain for a period of three years after contract completion all records of inspections, tests, and any resulting rejections.

4.5.3 Sampling for group B tests. As a minimum, the contractor shall randomly select a sample quantity from each lot of completed generator sets in accordance with table VI and subject them to the group B tests as specified in

table V. If one or more defects are found in any sample, the entire lot represented by the sample shall be rejected and require that corrective action be implemented by the contractor. If a lot is rejected, the contractor has the option of screening 100% of the lot for the defective characteristic(s) or providing a new lot which shall be subjected to the group A and B tests as specified herein. The contractor shall maintain for a period of three years after contract completion all records of inspections, tests, and any resulting rejections.

TABLE V. Quality conformance inspection.

Inspection	Group A tests	Group B tests	Requirement	Test method
Visual and mechanical	X	X	see note 1	4.6.1
Generator air gap	X	X	----	4.6.2
Forty-five minute preliminary run	X	X	----	4.6.3
Four-hour continuous test at full load	X	X	----	4.6.4
Mechanical balance	X	X	----	4.6.5
Governor	X	X	3.3.17	4.6.6
Voltage regulation	X	X	3.3.28	4.6.7
Commutator	X	X	----	4.6.8
Rheostat	----	X	3.7.4.1.2	4.6.9
Lubrication	X	X	3.3.15	4.6.11
Starting	X	X	3.3.26	4.6.15
Safety	X	X	3.3.4	4.6.18

NOTE 1: The test method in 4.6.1 shall verify conformance to all of the visual and mechanical requirements contained in this specification and applicable documents. Visual and mechanical inspection shall determine conformance to specified design and workmanship.

TABLE VI. Sampling for group B tests.

Number of generator sets on contract or order	Minimum number to be tested
1 to 8	1
9 to 15	2
16 to 35	3
36 to 65	4
66 to 100	5
101 to 150	6

4.6 Inspection and test methods. Inspections shall be as specified in 4.6.1 through 4.6.21.

4.6.1 Visual and mechanical. Generator set shall be subjected to a thorough examination to ascertain that:

(a) Parts requiring servicing are conveniently accessible.
(b) Mounting of units, overall dimensions, location and size of pipe connections (particularly those to be completed by the activity installing the generator set), generator air gap and all clearances conform to drawing requirements.
(c) Bolting arrangements have adequate provision for installing and tightening bolts and nuts (particularly where units are shipped detached and are to be assembled by the activity installing the generator set).
(d) Bolts, nuts, and other similar devices are tight and adequate provision has been made to prevent these items from becoming loose in service.
(e) Lube oil system including sumps, coolers, strainers, filters, and bearing bracket reservoirs have been thoroughly cleaned of foreign material (dirt, metal chips, and so forth) and that surfaces exposed to oil have not been painted.
(f) All cable bends meet the minimum radius specifications required in table II.
(g) Wiring connections are as required in paragraph 3.3.9.
(h) Eye bolts, lugs, or holes provided to permit lifting of the assembled generator set and attached accessories are as specified.
(i) Threaded parts conform to requirements.
(j) Resistance temperature sensing elements (RTDEs) are as specified in 3.3.24.
(k) Shaft end and couplings are as specified in 3.3.30.
(l) Use of aluminum conforms to 3.3.31.
(m) Gas turbine engine is as specified in 3.4.
(n) Reduction gears are as specified in 3.5.
(o) Air coolers are as specified in 3.6.
(p) Electrical equipment is as specified in 3.7.
(q) Identification plates conform to the requirements of 3.12.

Generator repair parts shall be subjected to a thorough examination to ascertain that the materials, workmanship, and finish conform to the manufacturer's drawings. The principal object of this examination shall be to determine if the repair parts are exact duplicates of those used in the generator set. If the DCASMA has reason to doubt the ready interchangeability of the repair parts with the original parts, he shall require a demonstration of such interchangeability. However, waiving of a demonstration shall not relieve the contractor of the responsibility for providing interchangeable workable repair parts.

4.6.2 Air gap. The minimum air gap between the rotor and stator iron shall be carefully measured by means of suitable steel feelers or gages. The measurement shall be made at each end of the generator in not less than six places, approximately 60 mechanical degrees apart, with one of the measurements obtained at the bottom. Where it is physically impossible to measure the air gap at six places on each end, measurements shall be obtained in as many places as practicable. If necessary, the generator shall be partially disassembled providing the relative position between the stationery and rotating elements is not disturbed. All air gaps shall be within 10 percent of the air gap design indicated on the drawings. In the case of salient pole generators, the air gap shall be measured at the center of the poles. The number of readings obtained depends on the number of poles.

4.6.3 Forty-five minute preliminary run. Generator set shall be operated at full load for 45 minutes to bring it up to or near its operating temperature. During this period the general operation of the set shall be observed and any necessary adjustments shall be made.

4.6.4 Four-hour continuous test at full load. Immediately following the test specified in 4.6.3, the generator set shall be operated at full load for 4 hours. Generator operating parameters shall be checked at 15 minute intervals.

4.6.5 Mechanical balance. The mechanical balance of the complete generator set shall be measured in the vertical and horizontal planes on the reduction gear (if furnished), the gas turbine and the generator bearing caps, or the associated shafts adjacent to these caps. Under no-load conditions, the vibration shall be continuously monitored during a non-stop run wherein speed is slowly increased from 95 percent to 107 percent rated. Under rated load conditions, the vibration shall be monitored during a non-stop run wherein speed is slowly increased from 95 percent to 107 percent rated. The unit shall be run for not less than 30 minutes at the start of the load test in order to stabilize readings. In addition, during both the no-load run and the rated-load run, vibration readings shall be taken at 1 percent speed intervals between the range of 95 percent to 107 percent rated. These tests shall demonstrate conformance with 3.3.17.

4.6.6 Governor tests.

4.6.6.1 Electrohydraulic governors. Where the governor system is of the electric speed and load sensing type, tests shall be conducted as required in accordance with MIL-G-21410.

4.6.6.2 Hydraulic governors. On type I generator sets where the governor system is of the hydraulic relay, centrifugally controlled type, tests shall be conducted as follows:

(a) Load speed test:

(1) At no-load the generator set speed shall be adjusted to 102 percent of rated speed.
(2) The load shall be changed in 5.0 percent increments from no-load to 100 percent and back to no-load. The voltage shall be adjusted to rated value at each load point. The speed shall be determined for each load.

(b) Speed fluctuation. At 0, 25, 75, and 100 percent continuous rated load, the periodic speed fluctuation shall be observed using an oscillograph or other similar device.

(c) Sudden load change:

(1) The generator set shall be operated at rated speed, voltage and at 80 percent rated kW load. A 70 percent rated kW load shall be suddenly removed in one step.
(2) The generator set shall be operated at rated speed and voltage. An 80 percent rated kW resistance load shall be suddenly applied in one step.

(d) Reading of overspeed, underspeed, and recovery time shall be taken by means of an oscillograph or similar device. Sudden removal or application of load shall be accomplished by means of a circuit breaker installed between the load and the generator output terminals.

4.6.7 Voltage regulation tests.

4.6.7.1 Type I generators. On type I generators sets, the voltage regulation test shall be conducted to determine conformance with 3.9.1

4.6.7.2 Type II generators. Voltage regulation tests shall be performed in accordance with MIL-R-2729.

4.6.8 Commutation. During the voltage regulation tests on type I generator sets, the commutation shall be observed at each load point and when rated-load is applied or removed in one step. Commutation shall be in accordance with MIL-G-3111.

4.6.9 Rheostat tests. On type I generator sets rheostat tests shall be conducted with the generator fields hot and cold. Such tests shall demonstrate conformance with 3.7.4.1.2.

4.6.10 Effectiveness of enclosure. Enclosure tests shall be conducted as required by the applicable individual equipment specifications. Where these tests have been conducted by the equipment manufacturer, repeat tests need not be conducted on the generator set.

4.6.11 Lubrication. By careful observation and general examination of parts and by readings taken from temperature indicating devices, it shall be determined that lubrication is satisfactory and the oil does not leak past seals during the process of all tests including inclined operation tests. It shall be demonstrated that the limitations of bearing temperatures specified in the individual equipment specifications have not been exceeded. Bearing temperature limits do not apply during the mechanical balance test of 4.6.5. See 4.3.1 for type of lubricant required.

4.6.12 Parallel operation tests. Unless otherwise specified (see 6.2), parallel operation tests shall be required. This test shall be conducted on the generator set being subjected to first article inspection and a generator set of identical design. Where hydraulic relay, centrifugally controlled governors are furnished, the speed droop shall be not greater than the maximum specified in column 3 of table III.

4.6.12.1 Type I generator sets. With each generator set operating at rated voltage and at a speed corresponding to approximately 20 percent load, the gas turbine governors and rheostats shall be adjusted for equal percentage division of load equal to approximately 20 percent of the combined kW rating of the paralleled generators. No further adjustments of the governor or rheostats shall be made for the duration of the test. The load shall be varied from 20 to 100 percent of the combined kW ratings of the two paralleled generator sets in four approximately equal steps and back to 20 percent load in the same manner. The speed, line

current, kW load, field voltage, and field current of each generator set at each load point shall be determined.

4.6.12.2 Type II generator sets. Parallel operation tests shall be conducted in accordance with MIL-G-21410 and MIL-R-2729.

4.6.13 Performance test. The first generator set of a particular design, type, and size shall be operated for 80 hours (10 cycles) as specified in the following schedule:

Rated-load	3 hours
1/3 rated-load	1 hour
2/3 rated-load	3 hours
No-load	1/2 hour
110 percent load	1/2 hour

The repair or replacement of any part shall require rerun of the test. If adjustments are required or a forced outage occurs during this test, the complete test shall be rerun.

4.6.14 Voltage build-up (type II sets only). The generator set shall be subjected to six consecutive starting operations to demonstrate positive voltage build-up of generator terminal voltage. Time between consecutive starts shall be as determined by the contractor. Initial starting operation shall be conducted as follows:

(a) Set the voltage regulator control switch in automatic position.
(b) Set the automatic voltage adjusting rheostat to obtain rated no-load generator terminal voltage when operating at rated speed and leave in this position for the duration of this test.
(c) Start the prime mover and determine the time, in seconds, required for the generator to produce rated voltage at the generator terminals.
(d) Shut down the unit. Complete the remaining five starting cycles, in the same manner determining the time required for voltage to build up during each start. The time required to produce full voltage at the generator terminals during any starting cycle shall be as specified in 3.3.26.

4.6.15 Starting test.

4.6.15.1 First article and group B inspection only. The first unit of a design, type, and size offered for delivery, and units selected in accordance with the sampling plan contained in table VI, shall be started 100 times including the following:

(a) Five starts with the unit in an ambient temperature of 90 to 100°F.
(b) Ten successive starts without a false start. One false start shall be cause for rerunning the ten successive starts. These ten starts shall be made during other complete unit tests and the unit shall prove that it can restart in the following intervals after coasting to zero r/min from the rated load operating condition: 30 seconds, 5 minutes, and 15 minutes.

(c) Five starts with the unit at cold condition in ambient temperature of 40 to 50°F to prove the unit can start, produce rated voltage and frequency at the generator terminals and supply rated load within 60 seconds

4.6.15.2 Group A inspection only. Starting tests for group A inspection shall consist of six starts of the complete generator set. Where a combustion type starter for use as either a combustion starter or cold air starter is provided, this test shall consist of six tests by both methods. One false start shall be cause for rerunning the six starts.

4.6.16 Inclination test. Generator set shall be operated at the rated operating speed, with or without load, for not less than 30 minutes in each of the following four positions:

Position	Degrees
Shaft inclined, forward end down	5
Shaft inclined, forward end up	5
Shaft horizontal, base inclined to right	15
Shaft horizontal, base inclined to left	15

During the inclination test, the lubricating oil sump shall be filled to the maximum operating level. It shall be determined that mechanical balance is as good as it was in the horizontal position, that there is no pounding or grinding of bearings, that lubrication is satisfactory and there is no leakage of oil or water, particularly leakage of oil through the seals into the generator. Speed and speed fluctuations shall be observed in each of the positions by means of an oscillograph or similar device.

4.6.17 Weight and center-of-gravity. Generator set and all detached accessories shall be weighed dry. The operating weight of the generator set and any detached accessories, as applicable, shall be calculated using the dry weight and adding the weight of liquids which are used during normal operation of the generator set. The center-of-gravity for the generator set and all detached accessories greater than or equal to 100 pounds shall be determined for both the dry and operating condition.

4.6.18 Safety test. Safety devices incorporated in the complete generator set shall be tested not less than three times during actual operation of the generator set to demonstrate their effectiveness.

4.6.19 Shock tests. Generator sets shall be tested in accordance with the requirements for grade A, class I of MIL-S-901. Where resilient mounting of equipment is required, generator sets shock tests shall be conducted in accordance with the requirements for grade A, class II or III of MIL-S-901.

4.6.19.1 Intended function. The intended function of a shockproof generator set is to continuously deliver electrical power as specified in the performance requirements herein during and after being subjected to the shock of the magnitude in accordance with MIL-S-901. Further, a shockproof generator set, when subjected to shock, shall not suffer damage to the extent that it creates a possible hazardous situation such as fire or injury to personnel or such as to result

in likely failure of major units if the set is not immediately shut down for corrective action to prevent such failure.

4.6.19.2 Acceptance of generator set. Acceptance of generator set and accessory designs which have been subjected to shock tests shall be based on the ability of equipment to meet the requirements of 4.6.19.1, 4.6.19.9 and 4.6.19.10 without damage. Where damage is revealed, acceptance shall be based on NAVSEA approval of corrective action proposed by the contractor (see 6.10).

4.6.19.3 Method of test. Method of test shall be as follows:

(a) All required performance tests shall be satisfactorily completed prior to shock testing.
(b) The generator set package, for example, prime mover, reduction gear, generator, exciter (if attached), subbase, heat exchanger and all attached accessories and any other detached accessories needed to control and operate the set during shock tests shall be tested as a principal unit. Other detached accessories shall be tested along with the generator set package if the weight, size, and arrangement limitation of the test machine is not exceeded. Detached accessories not tested with the generator set package shall be individually tested using the applicable shock testing machine referenced in MIL-S-901 and in accordance with the individual equipment specification applicable to the accessory.

4.6.19.4 Mounting of equipment on floating shock test platform. Mounting of equipment on floating shock test platform shall be as follows:

(a) Generator set package shall be mounted on a foundation welded to the inner deck of the floating test platform. This foundation shall be designed to simulate a typical shipboard foundation characteristic as closely as possible.
(b) Deck mounted detached accessories, if tested with the generator set package, shall be mounted on a fixture designed to accommodate the accessory and welded to the inner deck.
(c) Bulkhead mounted detached accessories, if tested with the generator set package, shall be mounted on a fixture designed to accommodate the accessory and welded to the side of the floating shock test platform.
(d) The test shall be performed on a foundation having a natural frequency of greater than or equal to 60 Hz if the gas turbine generator set is to be hull mounted, or 30 Hz if the generator set is to be deck mounted.

4.6.19.5 Test procedure. Shock tests shall be conducted in accordance with MIL-S-901 and as specified in 4.6.19.5.1 through 4.6.19.5.2.

4.6.19.5.1 Generator set operating conditions. The generator set shall be operated at rated speed and voltage, no load, during blows 1, 2 (with bleed air), and 4.

4.6.19.5.2 Remote provisions. Provision shall be made by the shock testing facility for remote observation of lubricating oil pressure during periods when

the generator set is unattended. Provision shall also be made for remote emergency shutdown of the generator set.

4.6.19.6 Examination. As a minimum, the examination specified in 4.6.19.6.1 through 4.6.19.6.3 should be accomplished at the shock test facility.

4.6.19.6.1 Examination at the shock testing activity. Upon receipt of equipment at the shock facility, it shall be examined for any sign of damage during shipment. Any apparent damage shall be reported to the generator set manufacturer for appropriate corrective action. All disassembly and internal examination of generator sets shall be conducted under the guidance of the manufacturer's representative.

4.6.19.6.2 Examinations during shock. During shock tests, the following examination shall be accomplished before each blow or shot:

(a) Equipment shall be rotated by hand to check for signs of damage associated with moving parts, such as rubs, noise, and increased friction. If no sign of damage that would preclude safe operation of the equipment is revealed, and upon concurrence by the generator set manufacturer's representative, the generator set shall be started and operated at rated speed, no-load for a period of time necessary to determine that all components are functioning normally. The vibration levels of the generator set while operating shall be measured.

(b) Permanent shock induced misalinement or offset between accessible parts connected by or alined by bolts, keys, or other means shall be noted and measured at all locations where maintenance of correct alinement is of significant importance. To accomplish this, punch marks, scribed lines, or measurements (as appropriate for the accuracy required) shall be used to establish the relative location of such parts before tests. Any deviation from the pretest status shall be measured.

(c) Accessible bolts and dowels shall be checked for any sign of looseness. The location and function of each loosened bolt and dowel and the number or fraction of turns required to tighten the bolts shall be measured. Where excessive yielding of bolts is experienced, the bolts shall be replaced by higher strength types before proceeding to the next blow or shot. Bolts shall be tightened or secured before proceeding to the next blow or shot.

(d) A thorough visual examination of all accessible items shall be accomplished. Examination covers and generator upper-half end shields, as applicable, shall be removed to examine internals. For any evidence of distortion, impact, rubbing, leaks, excessive wear, weld cracking, or unwarrented relative motion.

(e) Turbine, gear, and generator thrust bearing axial clearance, as applicable, shall be measured. Where this measurement indicates that the clearance has changed, the turbine nozzle clearance (minimum) and the total rotor axial clearance (rotor float) with thrust bearing shoes removed shall be measured. (Note: The angular position of the shaft for repeat measurements taken during the shock test shall be the same as the pretest position. Measurement accuracy shall be within plus or minus 0.002 inch.)

(f) Generator and exciter (if rotating exciter is used) air gap measurements shall be taken. The angular position of rotating elements for repeat measurements taken during the shock test shall be the same as the pretest position. Measurement accuracy shall be within plus or minus 0.005 inch.

(g) Turbine tripping devices and actuating means shall be activated before each blow or shot. After each shot, it shall be verified that shock induced tripout did not occur and that all tripping devices operate properly.

(h) For type I generators measurements shall be taken to determine whether the magnitude of generator brush bounce during each shot will cause opening and closing of the generator field circuit.

(i) Where failures are experienced during a shot, particularly minor failures which can be conveniently corrected at the test site, corrective action shall be taken and proven on the next shot. For example, where equipment experiences a failure during shot 4, corrective action shall be taken and proven during shot 5. Where equipment experiences a failure during shot 5, corrective action shall be taken and proven by an additional shot which shall be a repeat of shot 5.

4.6.19.6.3 Examination Pre- and Post-shock. Before and after the series of shots, the following examination shall be made.

(a) Angular alignment between reduction gear and pinion teeth shall be determined. Blue transfer methods are preferred, but tooth spacing measurements shall be employed for this purpose.

(b) Runout of principal rotating parts, and facial and peripheral alignment between principal rotating parts, shall be determined.

(c) Watersides of all coolers associated with the generator set package shall be hydrostatically tested to the levels specified on manufacturer's drawings.

(d) Insulation resistance measurements shall be taken and dielectric strength tests shall be conducted on all electrical equipment tested with the generator set package. These tests shall be conducted as required by the individual electrical equipment specifications.

Additional examination shall be conducted as deemed necessary by the generator set manufacturer.

4.6.19.7 General requirements. General requirements shall be as follows:

(a) The shock facility shall prepare for and conduct tests based on the requirements specified herein (see 6.3). Where the detailed requirements presented herein are not applicable to the item of equipment being tested, the tests shall be performed in accordance with the requirements of MIL-S-901 and the applicable individual specification. Modification of shock test procedures contained herein, whether recommended by the generator set manufacturer or the test facility, shall also require NAVSEA approval. Where resilient mounted equipment is shock tested and mounts are of the Navy Standard type, such mounts will be supplied by NAVSEA for

tests and retained by the shock test activity. Where mounts are not of the Navy Standard type, such mounts shall be furnished by the generator set manufacturer.

(b) The generator set manufacturer shall furnish technical assistance to the shock testing activity in the formulation of examination and test procedures, operation and installation of the generator set, inspections to be required at the test site and shock test instrumentation.

(c) The activity procuring the generator set and NAVSEA shall be notified not less than 30 days in advance of scheduled shock tests so that arrangements can be made to witness the tests if desired. Such a notice shall be accompanied by a copy of the completed equipment data sheet (see the sample on figure 5).

4.6.19.8 Shock test instrumentation. Standard instrumentation for heavy weight equipment shock tests shall consist of one or more velocity transducers mounted on the floating shock platform deck. The generator set manufacturer shall determine the number and location of transducers to be used for this purpose. Generator set manufacturers desiring that additional instrumentation be used should contact the test facility as far in advance of tests as possible. Although the use (or extent of use) of additional instrumentation is subject to shock facility limitations, such facilities can generally furnish transducers with appropriate readout devices for remote measurement of velocity, acceleration, vibration, strain, voltage, r/min, and pressure. High speed motion picture cameras are usually available.

4.6.19.9 Post-shock examination and operation. After completion of shock tests and taking of readings as required herein, the generator set package and any detached accessories tested along with the package shall be returned to the generator set manufacturer's plant for tests, complete teardown, and examination as specified in the following:

(a) Equipment shall be given a visual examination to ensure that no damage has occurred during shipment.

(b) Equipment shall be given a post-shock operating test as follows:

(1) The examination covers of all units shall be removed, units examined and any other examination such as alignment shall be accomplished, as necessary, to determine the operativeness of the generator set.

(2) If such examination reveals no damage which would prohibit full power operation, the generator set with detached units shall be installed on a test stand and continuously operated at rated-load and at rated speed for 4 hours. Readings as required by 4.6.4 shall be taken.

4.6.19.10 Visual examination and dimensional checks. In general, upon completion of the post-shock test required by 4.6.19.9, the generator units shall be disassembled part by part and examined for breakage, deformation and misalinement. Areas highly stressed during shock response and areas suspected of yielding shall be dye-penetrant checked for cracks. Critical tolerance areas shall be checked for proper operating clearances. Dimensions shall be specified on the working drawings. The minimum detail examination shall be as follows:

(a) Check looseness of turbine thrust collar.
(b) Check concentricity of bearing housing bores to gland bores and the following:

(1) Check for signs of joint slippage.
(2) Check dowels for deformation.

(c) Check overspeed trip, body, and parts for damaged items.
(d) Remove gear cover. Record indications of rub, cracks, and any internal damage.
(e) Disassemble pinion and examine spigot fit and fitted bolts for damage.
(f) Check pinion and gear backlash. Also check teeth for damage.
(g) Place pinion and gear in lathe and check the following:

(1) Runouts in not less than three locations.
(2) Measure journal out-of-roundness.
(3) Measure journal diameters.

(h) Place pinion in balancing machine and check unbalance.
(i) Place gear and generator rotor in balancing machine and record unbalance. If gear and generator rotor originally balanced as separate items, they shall be placed in balancing machine as separate items in lieu of one assembly.
(j) Remove governor and check internal parts for damage.
(k) Remove oil pump or pumps and check internal parts for damage. Check oil pump drive shafts for runout.
(l) Check generator end bells and rotating exciter end bells (if rotating exciter used) for joint slippage. Check any dowels for deformation.
(m) Check generator brush rigging assembly (for dc sets) (including terminal leads, brushes, and brushholders) for damage and slippage.
(n) Check generator and rotating exciter (if used) air gaps.
(o) Remove generator and rotating exciter (if used) rotating assemblies and accomplish the following checks:

(1) Runouts at several locations.
(2) Journal out-of-roundness.
(3) Journal diameters.
(4) Blower arrangement.
(5) Damage to and movement of windings, poles, and coil braces.

(p) Check generator, rotating exciter (if used) and bearings pedestal (if applicable) foot welds for damage and check bolts which attach these items to the bedplate for distortion and elongation.
(q) Remove cover of generator and examine excitation system rectifier arrangement for damage (if this arrangement is mounted in the generator).
(r) Check generator air cooler (if used) for damage and movement. Also examine cooler holddown bolts for distortion and elongation. Subject the cooler to a hydrotest and examine for leaks.
(s) Check all supporting structures for deformation and for damage to welds.

(t) Conduct dielectric tests on the generator and rotating exciter (if used).
(u) Detached accessories which are shock tested along with the generator set shall be subjected to an examination to determine the extent of damage, if any. Where electrical items are involved, they shall be subjected to a dielectric test after completion of the examination. Such test shall be conducted as required by the individual equipment specification covering the item.
(v) Welds shall be examined and those suspected of deformation shall be checked using any applicable nondestructive test.

4.6.20 Airborne and structureborne noise tests.

4.6.20.1 Airborne noise. Airborne noise tests shall be conducted to determine conformance to 3.3.19.1. The measurements shall be performed on the completely assembled generator set in accordance with MIL-STD-740-1 and as follows (see 6.3):

(a) Under no-load and rated-load conditions.
(b) Tests shall be conducted at the manufacturer's plant when the ambient noise is at a minimum.
(c) With the generator set mounted on resilient mounts.

4.6.20.2 Structureborne noise. Structureborne noise tests shall be conducted to determine conformance to 3.3.19.2. The measurements shall be performed on a completely assembled generator set in accordance with MIL-STD-740-2 (see 6.3). Structureborne noise levels shall be measured in the vertical direction and in two other mutually perpendicular directions on each "foot" or attachment point of the turbine-generator unit and the detached accessories. Structureborne noise measurements shall also be taken at the following three locations to aid in future maintenance and diagnosis:

(a) On each end of the unit, near its axis, in a radial direction.
(b) On one end of the unit, near its axis, in an axial direction.

4.6.21 Maintainability demonstration test. A maintainability demonstration test shall be conducted to verify achievement of the quantitative value of predicted maintainability specified in 3.3.3.3. The demonstration shall be conducted in accordance with MIL-STD-471 except as modified herein (see 6.3).

4.6.22 EMI testing. The generator set shall meet the EMI control requirements specified in MIL-STD-461, part 5 or part 6, as applicable, when tested in accordance with the procedures contained in MIL-STD-462 (see 6.3).

4.7 Combining tests. Two or more of the tests specified herein shall be combined in the same run or series of runs provided objectives of each test are achieved as definitely as though separate runs were made.

4.8 Post trial examination and replacement of parts. Upon completion of first article inspection, the first generator unit shall be subjected to a post trial examination. Gear train covers shall be removed and the condition of gears, bearings, and bushings shall be determined. The post trial examination shall be extended to duplicate units (in part or as a whole) as necessary. After comple-

tion of the post trial examination on the first unit, all applicable parts (particularly parts designed for short life) shall be replaced so that the turbine generator unit complete with all accessories will be shipped in first class operating condition and shall meet the life and engine overhaul interval requirements specified herein. After replacement of the above parts, the combined unit shall be subjected to the group A tests specified in 4.5.2.

4.9 Inspection of packaging. Sample packages and packs, and the inspection of the preservation, packing and marking for shipment and storage shall be in accordance with the requirements of section 5 and the documents specified therein.

5. PACKAGING

(The packaging requirements specified herein apply only for direct Government acquisition. For the extent of applicability of the packaging requirements of referenced documents listed in section 2, see 6.6.)

5.1 General requirements. Packaging shall be as specified in 5.1.1 through 5.9.2 (see 6.3).

5.1.1 Disassembly.

5.1.1.1 Disassembly for cleaning and preservation. Equipment disassembly shall be the minimum necessary to make accessible for cleaning and preservation of all machined or critical internal surfaces.

5.1.1.2 Disassembly for shipment. Removal of secondary assemblies, accessories, or projecting parts which will facilitate equipment protection from damage, pilferage, and loss, or reduction of cube is permitted where such removal will not affect permanent settings or alignments and where the removed parts can be readily reassembled at the installation site without the need for special tools or gages. Removed hardware (bolts, nuts, pins, screws, washers, and others) shall be reinstalled in mating parts and secured to prevent their loss. Detached components shall be packed and included within the same container as the basic unit except where the minimum tare weight and cube are adversely affected, they shall be packed separately.

5.1.2 Matchmarking. Removed parts of the equipment shall be matchmarked to facilitate reassembly. Removed parts shall be tagged with cloth shipping tags. Tags shall also be attached to each mating part. The tags and printing thereon shall be resistant to water, oil, and fading.

5.1.3 Navy fire-retardant requirements.

(a) Treated lumber and plywood. Unless otherwise specified (see 6.2), all lumber and plywood including laminated veneer material used in shipping containers and pallet construction, members, blocking, bracing, and reinforcing shall be fire-retardant treated material conforming to MIL-L-19140 as follows:

Levels A and B - Type II - weather resistant.
Category 1 - general use.

Level C - Type I - non-weather resistant.
Category 1 - general use.

(b) Fiberboard. Fiberboard used in the construction of class-domestic, non-weather resistant fiberboard, cleated fiberboard boxes including interior packaging forms shall meet the flame spread index and the specific optic density, requirements of PPP-F-320 and amendments thereto.

5.2 Preservation. Preservation shall be level A or C, as specified (see 6.2).

5.2.1 Turbine generator set.

5.2.1.1 Level A. Preservation level A, shall be as follows:

(a) The gas turbine engine shall be cleaned and preserved in accordance with MIL-E-5607. Upon completion of preservation of the lubricating and fuel systems, the throw-away elements shall be replaced with new elements.
(b) Generators and other electrical units shall be preserved in accordance with the level A requirements of MIL-E-16298 or MIL-E-17555, as applicable. When the size and mounting arrangement of the generator does not permit enclosure of the generator within a waterproof barrier, the alternate method of packing specified in MIL-E-16298 shall be applied.
(c) Reduction gear, accessory gears and couplings shall be cleaned and preserved in accordance with MIL-T-17286.
(d) Coolers shall be cleaned and preserved in accordance with MIL-C-15730. All external unpainted ferrous surfaces shall be coated with a preservative conforming to type P-1 or type P-19 of MIL-P-116.
(e) Water pumps shall be cleaned and preserved as follows:

(1) Pumps shall be cleaned in accordance with process C-1 of MIL-P-116. Internal surfaces coming into contact with water shall be flushed or fog sprayed with a preservative conforming to type P-3 of MIL-P-116, or when chemical boil-out cannot be used for preservative removal or where removal by hot water or steam is desired, grade 5 of MIL-C-16173 shall be used. External unpainted ferrous surfaces shall be coated with a preservative conforming to type P-1 or type P-19 of MIL-P-116.

(f) Instrumentation such as gauges and thermometers shall be preserved in accordance with the level A requirements of the applicable individual equipment specification.

5.2.1.2 Commercial. Preservation of turbine generator sets shall be in accordance with ASTM D 3951.

5.2.1.2.1 Space heater connections. Accessible electrical connections shall be provided such that the generator space heaters can be readily energized during shipment and/or storage.

5.3 Packing. Packing shall be level A, B, or commercial, as specified (see 6.2).

5.3.1 Levels A and B.

5.3.1.1 Generator sets - assembled. Each assembled generator set weighing 30,000 pounds or less, preserved as specified (see 5.2), shall be packed for shipment in a crate conforming to MIL-C-104 and the appendix thereto. The class, type, and style selection shall be at the option of the contractor. Anchoring, blocking, and bracing of the crate contents shall be in accordance with MIL-STD-1186 and the appendix to MIL-C-104. Instrumentation and accessories such as gauges and thermometers shall be removed from the generator set, preserved as specified in 5.2, and packed in a container in accordance with the level A or B requirements of MIL-T-17286 as specified. Accessories and units furnished as detached items, preserved as specified (see 5.2), shall be packed in accordance with the level A or B requirements as specified of the applicable individual equipment specification.

5.3.1.2 Generator sets - disassembled. The disassembled items and equipment shall be packed level A or B as specified in accordance with the requirements of the applicable individual equipment specification.

5.3.2 Commercial. Packing shall be in accordance with ASTM D 3951.

5.4 Marking.

5.4.1 Standard marking. In addition to any special marking required herein or by the contract or order (see 6.2), unit and intermediate packages and exterior shipping containers shall be marked in accordance with MIL-STD-129.

5.4.2 Special marking. Handling and structural markings as applicable shall be applied (see MIL-STD-129 and the appendix to MIL-C-104). In addition, shipping containers for equipment shall be stenciled as follows:

> "CAUTION - THIS EQUIPMENT MAY BE DAMAGED UNLESS UNPACKING INSTRUCTIONS ARE CAREFULLY FOLLOWED. UNPACKING INSTRUCTIONS ARE LOCATED (state where located)."

Where practical, this marking shall be applied adjacent to the identification marking on the side of the container.

5.5 Unpacking instructions. Unpacking instructions for equipment, assembled or disassembled generator sets, shall be provided in accordance with the requirements of MIL-E-16298.

5.6 Repair parts and special tools. Repair parts and special tools shall be preserved level A or commercial, packed level A, B, or commercial as specified (see 6.2) and marked in accordance with MIL-T-17286 or MIL-E-17555, as applicable. Repair parts shall be packed separately, and unless otherwise specified (see 6.2) shipped concurrently with the basic equipment.

5.7 Cushioning, dunnage, and wrapping materials.

5.7.1 Level A preservation level A and B packing. Use of all types of loose-fill materials for applications such as cushioning, filler, stuffing and dunnage for material destined for shipboard use is prohibited. Cushioning and wrapping materials selected, whenever available, shall exhibit improved performance characteristics for resistance to fire. Examples are:

UU-P-268	Paper, kraft wrapping	Type III, grade C or D
PPP-C-850	Polystyrene, expanded	Grade SE, type I or II only
PPP-C-1120	Bound fiber, uncompressed	Type III or IV, class C
MIL-R-6130	Cellular rubber	Grade A
MIL-R-20092	Cellular rubber	Class 1 or 4

5.7.2 Commercial preservation and packing. Unless otherwise specified in the contract or order use of all types of loose-fill materials for applications such as cushioning, filler, stuffing and dunnage for material destined for shipboard use is prohibited. When approved for use by the contract or order, unit packages and containers (interior and exterior) shall be marked or labeled as follows:

"CAUTION

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

6. NOTES

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

6.1 Intended use. The gas turbine generator sets are intended for use in Naval ship service and emergency applications.

6.2 Acquisition requirements. Acquisition documents must specify the following:

(a) Title, number, and date of this specification.
(b) Type of generator set required (see 1.2).
(c) Issue of DoDISS to be cited in the solicitation, and if required, the specific issue of individual documents referenced (see 2.1.1 and 2.2).
(d) When first article inspection is required (see 3.1).
(e) When transparent polycarbonate generator end plate is required (see 3.3.6.2).
(f) Accessories to be detached from generator set (see 3.3.7).
(g) Mounting principle to be employed if other than the principle of three point support (see 3.3.7).

(h) Whether generator sets are to be resiliently mounted, type of resilient mount, and design features not covered (see 3.3.7.1.4 and 3.3.19.2.2).
(i) Location of main generator power terminals (see 3.3.9).
(j) Whether shock design dynamic analysis is required (see 3.3.12.1.2).
(k) Weight and size (see 3.3.13).
(l) The momentary inclination cycles required (see 3.3.15).
(m) The magnitude of internally excited vibration where the specified magnitude does not apply (see 3.3.17).
(n) When temperature monitoring equipment is not to be furnished by the installing activity (see 3.3.24.4.10).
(o) Quantity, type, and size of cables to be installed between generator terminals and switchboard (see 3.3.25.2.3).
(p) Starting method (see 3.3.26).
(q) For governing systems:

(1) Type required (see 3.3.28.1), for type I generators.
(2) Where electric speed and load sensing governors are required, the method of remote speed setting required (see 3.3.28.3.2).

(r) Service application (see 3.7.2 and 3.7.3).
(s) Where type I, dc generators are required (see 3.7.2):

(1) kW rating.
(2) Voltage.
(3) R/min.
(4) Bearing type.
(5) Insulation.

(t) Mounting of balance coils for type I, 3-wire generator sets (see 3.7.2.1).
(u) Where type II, ac generators are required (see 3.7.3):

(1) Type.
(2) kW rating.
(3) Voltage.
(4) Frequency.
(5) R/min.
(6) Bearing type.
(7) Insulation.

(v) Whether parallel or nonparalled operation is required (see 3.10).
(w) Whether method A or B of MIL-E-16298 applies to repair parts and the number of generator sets to be installed per ship (see 3.13).
(x) Whether special airborne noise limitations are required and structureborne noise limitations (see 3.3.19.1 and 3.3.19.2).
(y) If parallel operation tests are not required (see 4.6.12).
(z) When Navy fire-retardant requirements do not apply (see 5.1.3).
(aa) Levels of preservation and packing required (see 5.2 and 5.3).
(bb) Special marking required (see 5.4.1).
(cc) Level of preservation and packing required for repair parts and special tools (see 5.6).

(dd) When repair parts are to be packed and shipped other than specified (see 5.6).

6.3 Consideration of data requirements. The following data requirements should be considered when this specification is applied on a contract. The applicable Data Item Descriptions (DID's) should be reviewed in conjunction with the specific acquisition to ensure that only essential data are requested/provided and that the DID's are tailored to reflect the requirements of the specific acquisition. To ensure correct contractual application of the data requirements, a Contract Data Requirements List (DD Form 1423) must be prepared to obtain the data, except where DoD FAR Supplement 27.475-1 exempts the requirement for a DD Form 1423.

Reference Paragraph	DID Number	DID Title	Suggested Tailoring
3.3	DI-DRPR-81000	Product drawings and and associated lists	----
3.3.3	DI-R-7079	Reliability program plan	----
3.3.3	DI-MNTY-80822	Maintainability program plan	----
3.3.3.2	DI-R-7085	Failure mode, effects and criticality analysis report	----
3.3.3.2	DI-R-7082	Reliability predictions report	----
3.3.3.3	DI-MNTY-80827	Report, maintainability prediction	----
3.3.3.4	DI-CMAN-81249	Conference agenda	----
3.3.4	DI-SAFT-80100	System safety program plan	----
4.4 and 4.5	DI-NDTI-80809	Test/inspection reports	----
4.6.19	DI-ENVR-80708	Shock test report	----
4.6.20.1	DI-HFAC-80272	Equipment airborne sound measurements test report	----
4.6.20.2	DI-HFAC-80274	Equipment structureborne vibration acceleration measurements test report	----
4.6.21	DI-MNTY-80831	Maintainability/testability demonstration test plan	----
	DI-MNTY-80832	Maintainability/testability test report	----
4.6.22	DI-EMCS-80200	EMI test report	----
5.1	DI-PACK-80120	Preservation and packing data	----
Appendix A	DI-GDRQ-80650	Design data and calculations	----

The above DID's were those cleared as of the date of this specification. The current issue of DoD 5010.12-L, Acquisition Management Systems and Data Requirements Control List (AMSDL), must be researched to ensure that only current, cleared DID's are cited on the DD Form 1423.

6.4 Technical manuals. The requirement for technical manuals should be considered when this specification is applied on a contract. If technical manuals are required, military specifications and standards that have been cleared and listed in DoD 5010.12-L, Acquisition Management Systems and Data Requirements Control List (AMSDL) must be listed on a separate Contract Data Requirements List (DD Form 1423), which is included as an exhibit to the contract. The technical manuals must be acquired under separate contract line item in the contract.

6.4.1 Format. The manual may be sectionalized as necessary to arrange the manual in major divisions, each covering one unit such as governor, reduction gear, turbine, compressor, combustor, lube system, generator, start system, control panel, and so forth. The following equipment, as applicable, should be covered in the manual:

(a) Gas turbine and any associated accessories (attached and detached).
(b) Reduction gears.
(c) Generator.
(d) Exciter.
(e) Balance coils (for 3-wire, dc sets).
(f) Voltage regulator.
(g) Field rheostat or manual control means (for dc sets).
(h) Temperature indicating and alarm equipment.
(i) Governor and governor motor.
(j) Special devices on equipment.
(k) Heat exchanger for generator.
(l) Turbine control and electrical system.
(m) Parts list.
(n) Starting equipments.

6.4.2 Drawings. The technical manual should contain reduced size copies of the installation (for dc sets) drawings and the gas turbine, generator, exciter, voltage regulator, governor, and rheostat drawings. The manual should also include a list of all drawings for the complete generator unit indicating the manufacturer's drawing numbers in parallel columns.

6.4.3 Test results. The results of combined unit tests (tests on the completely assembled turbine generator unit) should be included in the technical manual.

6.4.4 Preliminary manuals. Preliminary drafts of the technical manual should contain all the information which the generator set manufacturer proposes for the final manual except for photographs and results of tests. Preliminary manuals should be submitted for review.

6.5 Provisioning. Provisioning Technical Documentation (PTD), spare parts, and repair parts should be furnished as specified in the contract.

6.5.1 Spare parts. When ordering spare parts or repair parts for the equipment covered by this specification, the contract should state that such spare parts and repair parts should meet the same requirements and quality assurance provisions as the parts used in the manufacture of the equipment. Packaging for such parts should also be specified.

6.6 Sub-contracted material and parts. The packaging requirements of referenced documents listed in section 2 do not apply when material and parts are acquired by the contractor for incorporation into the equipment and lose their separate identity when the equipment is shipped.

6.7 First article. When first article inspection is required, the contracting officer should provide specific guidance to offerors whether the item(s) should be a preproduction sample, a first article sample, a first production item, a sample selected from the first production items, a standard production item from the contractor's current inventory (see 3.1), and the number of items to be tested as specified in 4.4. The contracting officer should also include specific instructions in acquisition documents regarding arrangements for examinations, approval of first article test results, and disposition of first articles. Invitations for bids should provide that the Government reserves the right to waive the requirement for samples for first article inspection to those bidders offering a product which has been previously acquired or tested by the Government, and that bidders offering such products, who wish to rely on such production or test, must furnish evidence with the bid that prior Government approval is presently appropriate for the pending contract. Bidders should not submit alternate bids unless specifically requested to do so in the solicitation.

6.8 Nonconformance. If a sample fails to pass group B inspection, the manufacturer should notify the contracting activity and the cognizant inspection activity of such failure, and take corrective action on the materials or processes, or both, as warranted, and on all units of products which can be corrected and which were manufactured with essentially the same materials and processes, and which are considered subject to the same failure. Acceptance and shipment of the product should be discontinued until corrective action acceptable to the contracting activity has been taken. After the corrective action has been taken, group B inspection should be repeated on additional sample units (all tests and examinations; or the test which the original sample failed, at the option of the contracting activity). Group A inspection may be reinstituted; however, final acceptance and shipment should be withheld until the group B inspection has shown that the corrective action was successful.

6.9 Accessibility. The contractor should include in the reliability and maintainability program the procedures to be used to ensure accessibility and adequate pull spaces for equipment maintenance after equipment installation.

6.10 Acceptance after corrective action. Where damage is revealed during shock tests or during the post-shock test inspection required by 4.6.19.9 and 4.6.19.10, acceptance will be based on NAVSEA approval of corrective action proposed by the contractor.

6.11 Line-connected devices. The design of many excitation systems causes a momentary overvoltage during generator startup. To avoid unnecessary stress, line-connected devices should be connected on the load side of the generator line breaker, where possible. Devices connected to the generator side of the line breaker should be able to withstand 150 percent of rated voltage for 2 seconds without damage.

6.12 Definitions. For the purpose of this specification, the definitions specified in 6.12.1 through 6.12.9 are applicable.

6.12.1 Continuous duty. Continuous duty is a service that demands equipment to operate in accordance with the performance requirements of this specification at all loads up to rated value for indefinite periods.

6.12.2 Reliability and maintainability. The definitions for reliability and maintainability of MIL-STD-721 shall apply for the purposes of this specification.

6.12.3 Unit. A unit is defined as an assembly or any combination of parts, subassemblies and assemblies mounted together, normally capable of independent operation in a variety of situations (for example, generator, turbine, reduction gears, pumps, electric motors).

6.12.4 Rated load. Rated load is the maximum load required to be supplied by the turbine generator set at rated frequency.

6.12.5 Rated frequency. Rated frequency is the nominal frequency at which the turbine generator set is required to operate at all loads.

6.12.6 Rated speed. Rated speed is the speed at which the turbine generator set is required to operate at all loads.

6.12.7 Rated voltage. Rated voltage is the voltage that the turbine generator set is required to supply at all loads.

6.12.8 Rated current. Rated current is the maximum current which can exist when rated load (kW and pf) is supplied at rated voltage.

6.12.9 Rated power factor. Rated power factor is the cosine of the angle between rated voltage and rated current, when rated load and current are supplied at rated voltage.

6.13 Subject term (key word) listing.

Battery, storage
Gears, propulsion
Regulator, voltage
Rheostat
Thermocouple

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

Preparing activity:
Navy - SH
(Project 6115-N609)

APPENDIX A

DESIGN DATA AND CALCULATIONS TECHNICAL CONTENT REQUIREMENTS

10. SCOPE

10.1 Scope. This appendix covers information that shall be included in the design data and calculations when specified in the contract or order. This appendix is mandatory only when data item description DI-GDRQ-80650 is cited on the DD Form 1423.

20. APPLICABLE DOCUMENTS

This section is not applicable to this appendix.

30. SHORT CIRCUIT TORQUE CALCULATIONS

30.1 Torsional analysis. The contractor shall prepare and submit a report to NAVSEA demonstrating that the entire generator set will withstand short circuit loading. The report shall include the manufacturer's statement that all factors have been considered in designing for short circuit loading and that all units will withstand this loading without damage. As a minimum the report shall contain the following data and shall be submitted with the generator set installation drawing for review:

(a) Description of the system relating information pertinent to analysis such as operating speeds, gear ratios and identification plate data.
(b) Labeled assembly drawing(s) showing arrangement of the elements, dimensions, and materials.
(c) Labeled line diagram of the mass elastic system with values of masses and stiffnesses, including basic assumptions.
(d) Natural frequencies of all important modes of vibration.
(e) Relative amplitude curves (mode shapes).
(f) Short circuit torque equation and values of constants.
(g) Peak short circuit torques, and shaft deflections.
(h) Stress calculations for maximum stress locations on each shaft including the location and stress concentration factor.

40. MAINTAINABILITY OF DESIGN

40.1 Maintainability demonstration test plan. A maintainability demonstration test plan shall be prepared by the contractor and submitted to the contracting activity for review. This plan shall be formulated so that it will apply to a basic design or designs and any known modifications thereto. Once this plan has been reviewed it shall be used on generator sets furnished under this specification except where a new basic design or modifications to the original basic designs have been incorporated in generator sets and are not covered by the original plan. In this case, the contractor shall submit a demonstration plan for the new basic design or the modification, as applicable to the contracting activity for review. The demonstration test plan shall include the following:

the contract or purchase ... test reports shall be as required in

(a) Replacement of air starter valve assembly.
(b) Replacement of the overspeed trip assembly.
(c) Replacement of the lube oil pump and drive assembly.
(d) Replacement of the fuel control assembly.
(e) Replacement of fuel nozzles.
(f) Replacement of all recording devices (thermometers, gauges, etc.) mounted on the generator set package. Also, check accessibility of these devices to verify that readings may be easily observed by operating personnel.
(g) Replacement of generator brushholders, springs, and brushes (for dc sets).
(h) Replacement of generator heaters, where furnished.
(i) Replacement of RTE's.
(j) Repair of governor.
(k) Repair of the voltage regulator.
(l) Repair of the static type exciter (for dc sets).

40.2 Simulation of faults or failures by introducing defective parts is required for the repair of governor, voltage regulator, and static-type exciter (for dc sets).

40.3 Trouble shooting, fault isolation, all functions required to correctly perform the repair action and verify the effectiveness of the repair shall be included in the MTTR.

40.4 The training and skill levels of manufacturer's personnel who perform the maintenance tasks of the demonstration test shall be commensurate with Navy personnel who will maintain the set.

40.5 The activity acquiring the generator set and NAVSEA shall be notified at least 30 days in advance of scheduled maintainability demonstration so that arrangements may be made to witness the test if desired. Such notice shall contain complete identification of the equipment involved.

50. RESILIENT MOUNTS

50.1 Performance calculations. Where resilient mounting is used, the following information shall be submitted to NAVSEA for review:

(a) Speeds of the equipment involved.
(b) Total weight of the mounted assembly in the operating condition. The weight shall include bedplate, service fluids, piping, filters, and all other attached accessories.
(c) Location of the center-of-gravity of the assembly in the operating condition in three planes.
(d) The moments of inertia and products of inertia of the assembly about three mutually perpendicular axis with the origin at the assembly center-of-gravity of the mounted unit and the orientation of the axis indicated with respect to the equipment.
(e) The six rigid body natural frequencies in Hz of the mounted assembly in the operating condition.
(f) The type of resilient mount used and any assumptions made in calculating the natural frequencies.

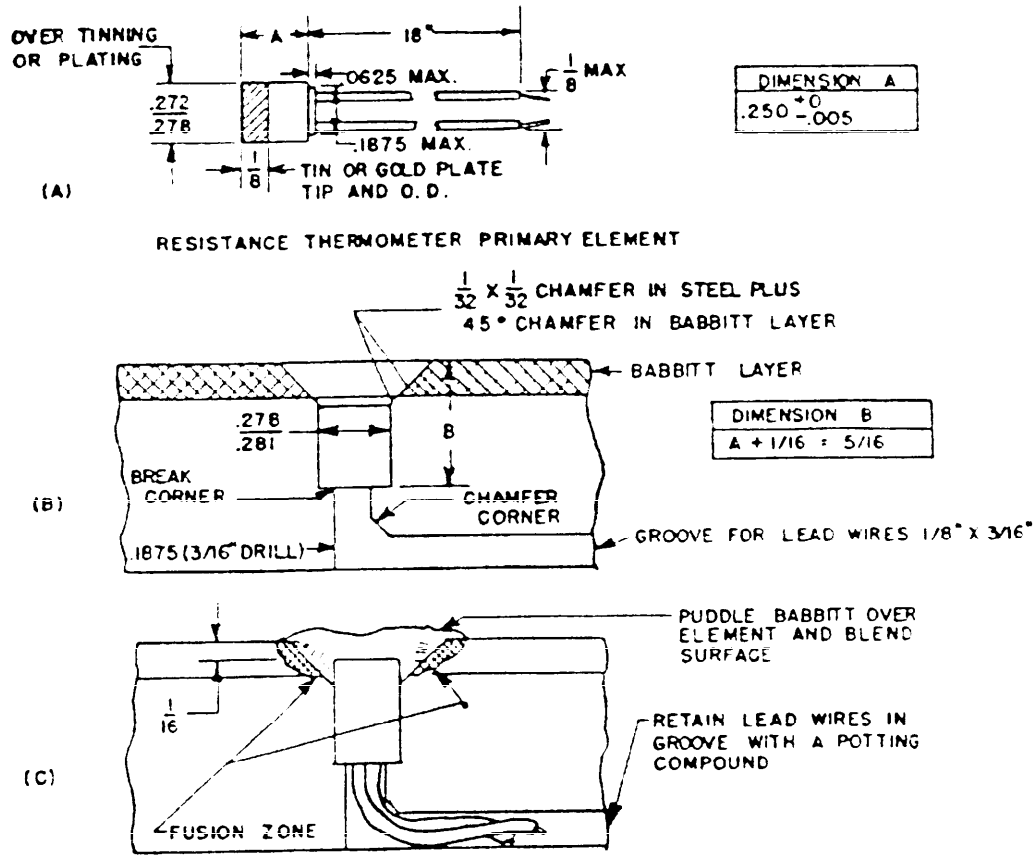

FIGURE 1. Typical RTE installation in a bearing.

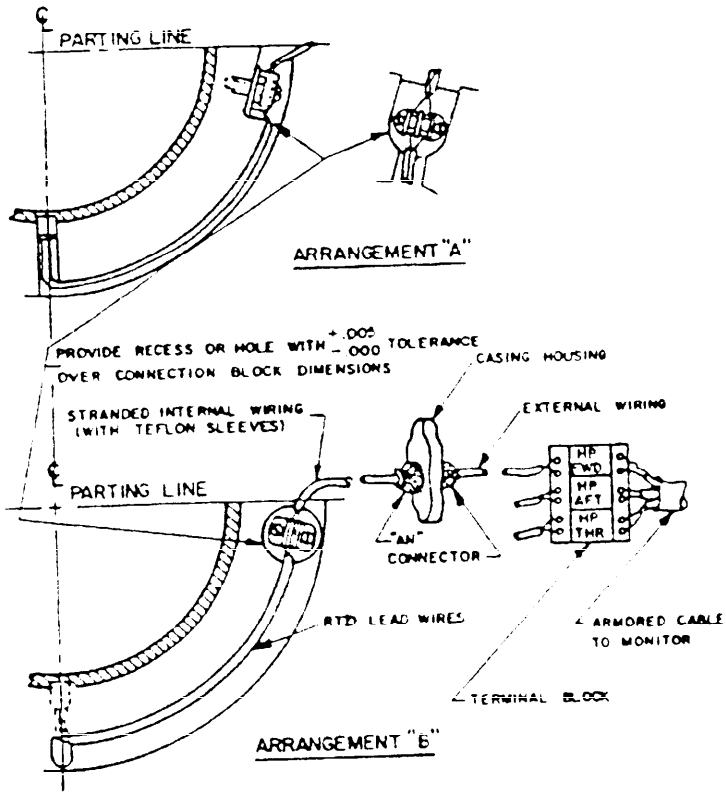

FIGURE 2. Suggested RTE installation arrangements in journal bearings.

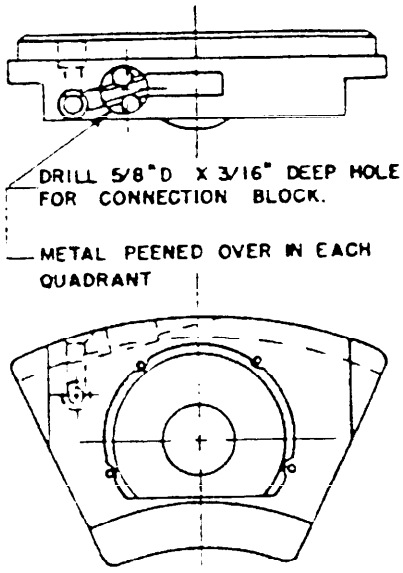

FIGURE 3. Suggested RTE installation in thrust bearing.

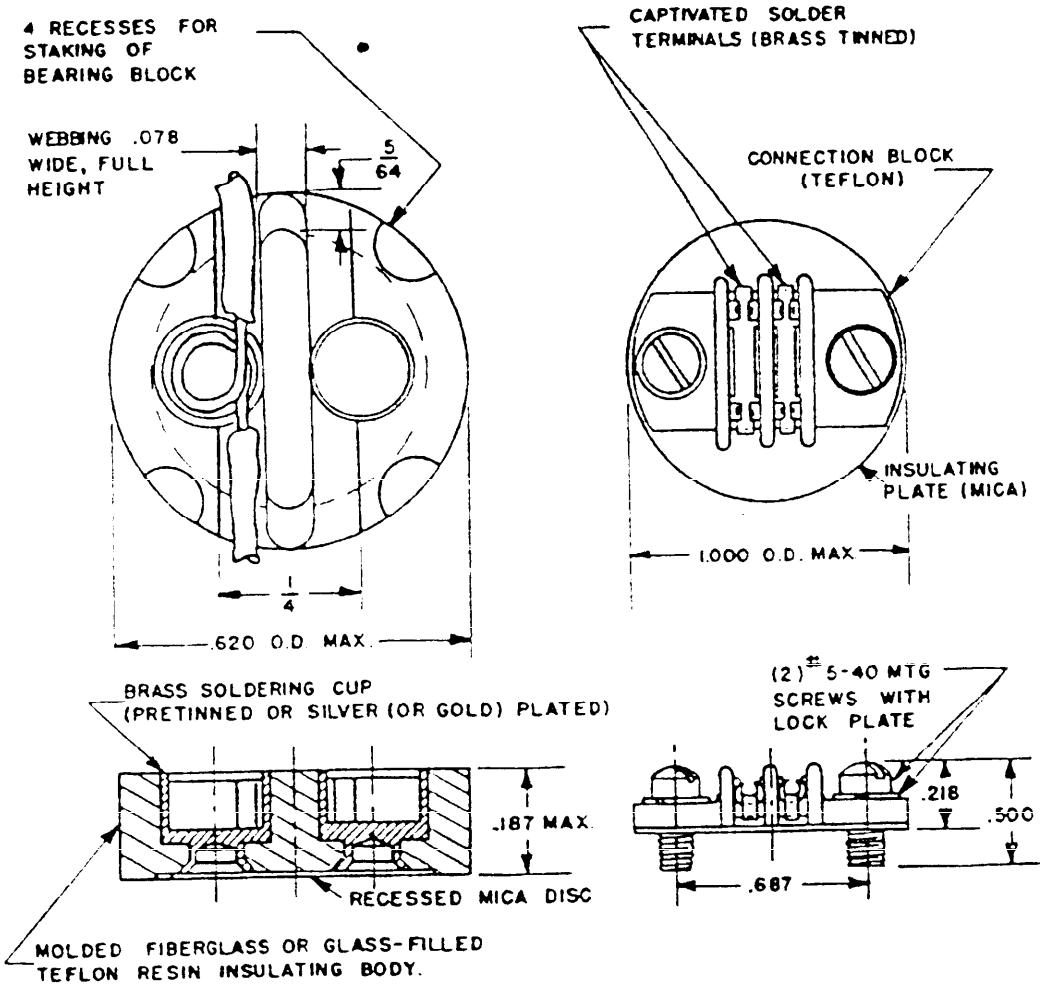

FIGURE 4. RTE connection blocks.

1. Equipment _____

2. Identification plate rating _____

3. Service _____

4. Manufacturer: Turbine _____
   Generator _____
   Gear _____

5. Place of manufacturer: Turbine _____
   Generator _____
   Gear _____

6. Model number: Turbine _____ Generator _____ Gear _____

7. Turbine generator set outline drawing: _____

8. Sectional assembly drawing: Turbine _____
   Generator _____
   Gear _____
   Subbase _____

9. Manual number: _____

10. Contract or purchase order number: _____

11. Weight:

	Dry	Wet
Turbine	_____	_____
Generator	_____	_____
Gear	_____	_____
Subbase	_____	_____
	Total	Total

12. Set overall size: Length _____ Width _____ Height _____

13. Height of center of gravity above bottom of the turbine _____

14. Applicable ships _____ Number per ship _____

15. Serial number of equipment to be tested: Turbine _____
    Generator _____
    Gear _____

16. List of detached accessories to be tested with generator set:
    (List accessory, assembly drawing number, and whether deck or bulkhead mounting)

17. Schedule date(s) delivery to shipbuilder: _____

18. Scheduled test date _____ Location _____

FIGURE 5. Equipment data sheet.

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

INSTRUCTIONS

1. The preparing activity must complete blocks 1, 2, 3, and 8. In block 1, both the document number and revision letter should be given.
2. The submitter of this form must complete blocks 4, 5, 6, and 7.
3. The preparing activity must provide a reply within 30 days from receipt of the form.

NOTE: This form may not be used to request copies of documents, nor to request waivers, or clarification of requirements on current contracts. Comments submitted on this form do not constitute or imply authorization to waive any portion of the referenced document(s) or to amend contractual requirements

I RECOMMEND A CHANGE:	1. DOCUMENT NUMBER	2. DOCUMENT DATE (YYMMDD)
	MIL-G-22077C(SH)	1993 NOVEMBER 3

3. DOCUMENT TITLE
GENERATOR SETS, GAS TURBINE, DIRECT AND ALTERNATING CURRENT, NAVAL SHIPBOARD USE

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

5. REASON FOR RECOMMENDATION

6. SUBMITTER

a. NAME (Last, First, Middle Initial)	b. ORGANIZATION	
c. ADDRESS (Include Zip Code)	d. TELEPHONE (Include Area Code) (1) Commercial (2) AUTOVON (If applicable)	7. DATE SUBMITTED (YYMMDD)

8. PREPARING ACTIVITY

a. NAME TECHNICAL POINT OF CONTACT (TPOC): K. GUPTA, SEA 03E21 NAVAL SEA SYSTEMS COMMAND	b. TELEPHONE (Include Area Code) (1) Commercial TPOC: 703-602-5473	(2) AUTOVON 8-332-5473
c. ADDRESS (Include Zip Code) SEA 03R42 2531 JEFFERSON DAVIS HWY. ARLINGTON, VA 22242-5160	IF YOU DO NOT RECEIVE A REPLY WITHIN 45 DAYS, CONTACT: Defense Quality and Standardization Office 5203 Leesburg Pike, Suite 1403, Falls Church, VA 22041-3466 Telephone (703) 756-2340 AUTOVON 289-2340	

DD Form 1426, OCT 89 *Previous editions are obsolete.* 198 290