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PERFORMANCE SPECIFICATION

GENERATOR SYSTEM, ELECTRIC POWER, 400 HERTZ, ALTERNATING CURRENT, AIRCRAFT; GENERAL SPECIFICATION FOR

Comments, suggestions, or questions on this document should be addressed to the Naval Air Systems Command (Commander, Naval Air Warfare Center Aircraft Division, Code 4L8000B120-3, Highway 547, Lakehurst, NJ 08733-5100) or emailed to michael.sikora@navy.mil. Since contact information can change, you may want to verify the currency of this address information using the ASSIST Online database at https://assist.daps.dla.mil.

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

1. SCOPE

1.1 Scope. This specification establishes the general requirements for three phase, four wire, wye-connected, 400 Hertz, alternating current (AC), constant input speed, electric power generator systems for use on aircraft.

1.2 Classification.

1.2.1 Generator class. Generator systems are classified as follows (see 6.1):

Class N – Generator systems designed to operate within a narrow speed range (393 to 407 Hertz). Typical drive mechanisms with narrow speed range include hydro-mechanical constant speed drives and Auxiliary Power Units (APUs) with precision speed control.

Class W – Generator systems designed to operate within a wide speed range (380 to 420 Hertz). Typical drive mechanisms with wide speed range include propeller gearboxes, helicopter rotor transmissions, hydraulic motors, ram air turbines, and APUs with electromechanical speed control.

1.2.2 Part or identifying number (PIN). Each component PIN will consist of the letter "M"; the general specification number; a slash followed by the specification sheet number; and an assigned dash number (example: M21480/3-01).

2. APPLICABLE DOCUMENTS

2.1 General. The documents listed in this section are specified in sections 3 or 4 of this specification. This section does not include documents cited in other sections of this specification or recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirements of documents cited in sections 3 or 4 of this specification, whether or not they are listed.

2.2 Government documents.

2.2.1 Specifications and standards. The following specifications and standards form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract (see 6.2).

FEDERAL STANDARD

FED-STD-595/17875 Miscellaneous, Gloss

DEPARTMENT OF DEFENSE SPECIFICATIONS

MIL-PRF-7808	Lubricating Oil, Aircraft Turbine Engine, Synthetic Base.
MIL-PRF-23699	Lubricating Oil, Aircraft Turbine Engine, Synthetic Base, NATO Code Number 0-156.
DOD-PRF-85734	Lubricating Oil, Helicopter Transmission System, Synthetic Base.

(See ASSIST database for list of specification sheets.)

DEPARTMENT OF DEFENSE STANDARDS

MIL-STD-130	Identification Marking of U.S. Military Property.
MIL-STD-202	Electronic and Electrical Component Parts.
MIL-STD-461	Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment.
MIL-STD-704	Aircraft Electric Power Characteristics.
MIL-STD-810	Environmental Engineering Considerations and Laboratory Tests.
MIL-STD-889	Dissimilar Metals.

(Copies of these documents are available online at https://assist.daps.dla.mil/quicksearch/ or from the Standardization Document Order Desk, 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111-5094.)

2.3 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of documents are those cited in the solicitation or contract.

AEROSPACE INDUSTRIES ASSOCIATION (AIA)

NASM 90415	Nut, Self-Locking, Steel, 160 KSI, 450 °F, 12-Point, Captive Washer (DOD Adopted)

(Copies of these documents are available from www.aia-aerospace.org or Aerospace Industries Association of America, 1000 Wilson Blvd., Suite 1700, Arlington, VA 22209-3901.)

SAE INTERNATIONAL

SAE-AMS2175	Casting, Classification and Inspection of. (DoD Adopted)
SAE-AS8879	Screw Threads, UNJ Profile, Inch, Controlled Radius Root with Increased Minor Diameter. (DoD Adopted)
SAE-AS14169	Circular Spline and Adapter Details, Engine Driven Accessories.

(Copies of these documents are available from www.sae.org or SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001.)

2.4 Order of precedence. Unless otherwise noted herein or in the contract, in the event of a conflict between the text of this document and the references cited herein (except for related specification sheets), 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 Specification sheets. The individual item requirements shall be as specified herein and in accordance with the applicable specification sheet. In the event of any conflict between the requirements of this specification and the specification sheet, the latter shall govern.

3.2 Qualification. Generator systems furnished under this specification shall be products that are authorized by the qualifying activity for listing on the applicable qualified products list before contract award (see 4.2 and 6.3).

3.3 Materials.

3.3.1 Selection of materials, parts, and processes. Materials shall be used which enable the generator system components to meet all of the operational and environmental performance requirements of this specification and the applicable specification sheet (see 6.5.1 and 6.5.2). Classification and inspection of castings shall be in accordance with SAE-AMS2175. Gearbox-mounted components shall be class 1 or class 2, and all castings shall be classified as grade C or higher in accordance with SAE-AMS2175.

3.3.2 Moisture resistance. Non-metal materials, including plastics, ceramics, fabrics, and protective finishes, shall be moisture resistant. Non-metal materials and parts may be treated to conform to this requirement. Electrical connectors shall be environment resistant as required to withstand the environmental tests herein (4.5.20 through 4.5.28).

3.3.3 Corrosion resistance. All metals used in the generator system components construction shall be processed and protected to resist corrosion (see 6.5.1.2). Protective coatings and finishes shall provide abrasion resistance as required to withstand the environmental tests specified herein. Magnesium alloy materials shall not be used in air cooled generators. Dissimilar metals shall not contact each other unless protected against electrolytic corrosion in accordance with MIL-STD-889. Corrosion protection applied to dissimilar metals, such as metal plating and coatings, shall withstand the environmental tests specified herein.

3.3.4 Contamination by fluids. With the generator external surface temperature between -40 °C and 150 °C, the generator package shall show no deterioration due to wetting from aviation fluids, including fuel (JP-5/JP-8), fire extinguishing compounds, de-ice fluids, aircraft washing fluids, hydraulic fluids, and lubricating oils (see 4.5.27 and 6.5.6).

3.3.5 Toxicity and fire resistance. Materials used shall be flame resistant, shall not support combustion, and shall be non-toxic when exposed to flame in accordance with 4.5.33.

3.4 Design and construction. Components shall be constructed with parts and materials designed to provide the specified performance, reliability, and service life under all environmental and operating conditions specified herein. Electronic parts shall be de-rated to enable components to provide the specified performance, reliability, and service life (see 6.5.3). Static discharge control shall be provided for protection of electronic devices during assembly and handling (see 6.5.2.4).

3.4.1 Electrical insulation and dielectric. Components shall withstand the high voltage tests of 4.5.5 without discharge (surface or air) or electric insulation breakdown. Inspection shall be in accordance with 4.5.5.1 for qualification and 4.5.5.2 for production lot conformance. Component exposure to the electrical performance, endurance, and environmental tests required by 4.5 of this specification shall not cause insulation breakdown or degradation.

3.4.2 Environmental performance. The generator package and all remote generator system components shall conform to the requirements of this specification when subjected to environmental conditions, as specified by the tests herein.

3.4.2.1 Temperature-altitude. The generator package and remote components shall withstand the temperature-altitude conditions of the aircraft operating environment, as simulated by the tests of 4.5.3, 4.5.14, and 4.5.28.

3.4.2.1.1 Blast air cooled and integral fan cooled components. Components that are blast air cooled, or self-cooled by integral fan, shall meet the requirements of this specification when subjected to the following conditions: (1) component compartment ambient conditions are within the temperature-altitude limits on figure 1; (2) component cooling air temperature is within the limits on figure 2; (3) cooling air flow and pressure are within specified limits of 3.4.9.6.1.b; and (4) electrical load and shaft speed are within specified limits of 3.4.8, 3.4.9.1, and 3.5.3. Operation with cooling air inlet temperatures above 85 °C shall be as specified in 3.4.9.6.1. Unless otherwise required by the specification sheet, the altitude limit for continuous operation is 35,000 feet.

3.4.2.1.2 Liquid-cooled and self-cooled components. Components that are liquid cooled, or self-cooled by convection, shall meet the requirements of this specification when subjected to the following conditions: (1) component compartment ambient conditions are within the temperature-altitude limits on figure 1; (2) liquid coolant supplied to components is within the limits of 3.4.9.6.2; and (3) electrical load and shaft speed are within specified limits of 3.4.8, 3.4.9.1, and 3.5.3. Unless otherwise required by the specification sheet, the altitude limit for continuous operation is 50,000 feet.

3.4.2.2 Humidity. System components shall withstand the humidity effects of operation and storage, in tropical and maritime environments, as simulated by the test of 4.5.25.

3.4.2.3 Salt-spray. System components shall withstand the effects of operation and storage, in maritime salt-spray and salt-fog environments when subjected to the test of 4.5.20. Air cooled components shall withstand the effects of oil-saltwater ingestion from aircraft operation in a maritime salt-spray environment. Components exposed to oil-saltwater ingestion include: (1) blast-cooled generators; (2) self-cooled generators with integral fans; and (3) blast-cooled heat exchangers used with liquid-cooled generators.

3.4.2.4 Fungus. System components shall be constructed of non-nutrient materials that do not support the growth of fungus in aircraft operating environments (see 4.5.21).

3.4.2.5 Sand and dust. System components shall withstand the effects of sand and dust particles from world-wide operation including desert and mountainous terrain, as simulated by the sand and dust test of 4.5.22.

3.4.2.6 Mechanical shock (functional and crash safety). System components shall withstand the effects of mechanical shock from handling, transport, and aircraft operations, as simulated by the tests of 4.5.24 and the functional shock spectrum on figure 3. Components shall remain in place and not create a safety hazard during a crash landing, as simulated by the crash shock spectrum on figure 3.

3.4.2.7 Vibration.

3.4.2.7.1 Engine vibration (category 1). Components exposed to vibration from engines and engine-driven gearboxes shall withstand the vibration spectrum on figure 4, when tested in accordance with 4.5.23.2.1. Acceleration spectral density (g^2/Hz) and vibration frequency (Hz) values for the narrow band random spikes on figure 4 shall be as required by the specification sheet (see 6.6.3.2).

3.4.2.7.2 Aircraft platform vibration. Non-engine mounted components shall withstand the vibration environment of the applicable aircraft platform as specified herein (see 6.6.3.2).

a. Category 2 - Components mounted in jet aircraft shall withstand exposure to the vibration spectrum on figure 5, when tested in accordance with 4.5.23.2.2.a.

b. Category 3 - Components mounted in propeller aircraft shall withstand exposure to the vibration spectrum on figure 6, when tested in accordance with 4.5.23.2.2.b. Acceleration spectral density (g^2/Hz) and vibration frequency (Hz) values for the narrow band spikes on figure 6 shall be as required by the specification sheet.

c. Category 4 - Components mounted in helicopter rotary wing aircraft shall withstand exposure to the vibration spectrum on figure 7A, when tested in accordance with 4.5.23.2.2.c. Peak sine amplitude (g) and frequency (Hz) values for the sinusoidal spikes on figure 7A shall be as required by the specification sheet.

3.4.2.8 Acceleration forces. System components shall withstand the inertial loads induced by aircraft operation (acceleration, deceleration, and maneuvers) and provide specified performance when subjected to the acceleration test of 4.5.35. Liquid-cooled generators shall maintain specified performance (see 3.4.9.6.2) when exposed to aircraft operation inertial loads.

3.4.2.9 Water intrusion and immersion. Unless otherwise required by the specification sheet, operation during water immersion is not required. Generator system component design shall include waterproof protection from exposure to rainwater intrusion, as required by the specification sheet. Air inlet water ingestion requirements are specified in 3.4.2.3.

3.4.2.10 Chemical, biological, and radiological (CBR). When required by the specification sheet, components shall withstand exposure to CBR and de-contamination agents.

3.4.2.11 Lightning, electromagnetic pulse, and directed energy weapons. When required by the specification sheet, components shall withstand nuclear electromagnetic pulse effects, directed energy weapon effects, and the indirect effects of lightning.

3.4.3 Operating position. Unless otherwise required by the specification sheet, the generator shall withstand operation at all of the positions and time durations on figure 8. All generator system components mounted remote to the generator package shall be capable of operating in any position.

3.4.4 Explosive atmosphere. The generator package and connections shall not ignite any surrounding explosive mixture when tested in accordance with 4.5.32. Seals and coatings providing ignition hazard protection shall be undamaged by the tests in 4.5.

3.4.5 Configuration. Component weights, dimensions, and center of gravity, including tolerances, shall be in accordance with the specification sheet. Limits for generator package overhung moment shall be in accordance with the specification sheet. Provisions for electrical interconnections between generator system components shall be in accordance with the requirements of the specification sheet.

3.4.6 Consolidation of generator system components. Except for feeder fault protection current transformers and generator control switch which must be remotely located, all other protection, regulation, and control components shall be consolidated in the generator control unit (GCU). Unless otherwise indicated by the specification sheet, the generator control unit shall be consolidated into the generator package (see 6.8.9).

3.4.7 System control (see 4.5.16).

3.4.7.1 Manual system control. Manual system control of the AC power source shall be provided by a two-position switch, or three-position switch, as required by the specification sheet (see 6.8.2 for definitions of switch types I, II, and III). GCU control circuitry in conjunction with switch operation shall function as specified herein. In the event of a protective function trip, the system shall open the Generator Line Contactor (GLC) and remain tripped until manual reset occurs. Manual reset shall occur when the control switch is held momentarily in the OFF-RESET position and returned to the ON position. After manual reset the system shall automatically reconnect the AC power source to the load bus within one second under the following conditions: (1) all three phase voltages are within the range of 112.5 to 118.5 volts; and (2) frequency is within prescribed limits for normal operation, as defined in 3.5.7.4.

3.4.7.2 Automatic reset (engine shutdown/underspeed). Automatic reset shall occur when generator input speed drops below the minimum speed required to maintain integral control power (see 6.8.11). After automatic reset the system shall reconnect the AC power source to the load bus within one second under the following conditions: (1) generator control switch is in the ON position; (2) all three phase voltages build-up and remain within the range of 112.5 to 118.5 volts, and (3) frequency is within prescribed limits for normal operation, as defined in 3.5.7.4.

3.4.8 System capacity (power source rating). The system AC power source rating as required by the specification sheet shall be based on 115/200 volts, 400 Hz, three-phase, four-wire electric power. The direct current (DC) power source shall conform to the requirements of 3.4.8.4.2. The AC and DC power sources shall deliver rated capacity within the generator speed range (class N or class W), as required by the specification sheet. All ratings specified herein shall be available at the Point of Regulation (POR) as defined in 6.8.16 with a feeder voltage drop of 0 to 5 volts from the AC output terminals to the POR. Generator systems with a slash rating shall meet the applicable requirements for overload capacity as specified herein (see 6.8.17). Air cooled generators with a self-cooled rating and a blast-cooled rating shall provide the output capacity specified for each operating mode as required by the specification sheet (see 3.4.9.6.1).

3.4.8.1 Continuous capacity (AC power). The generator system AC power source shall be capable of continuously delivering power from no load to full load with balanced load and normal phase load unbalance of 3.5.3.a. For existing systems defined with a slash rating, the full load capacity for continuous output shall be based on the higher rating (see 6.8.17). Rated power factor is 0.75 lagging to unity from no load to 100 percent rated load.

3.4.8.2 Overload capacity (AC power). Overload capacity of the AC power source shall conform to the requirements herein and as required by the specification sheet. For new system design (class N or class W), the AC power source shall be capable of delivering 125 percent of the full rated capacity for five minutes and 150 percent of full rated capacity for five seconds, as defined herein. For existing class W systems defined with a slash rating, the five-minute overload capacity shall be 150 percent of the lower rating and the five-second overload capacity shall be 200 percent of the lower rating (see 6.8.17). The AC power source shall be capable of delivering the specified overloads with balanced load and normal phase load unbalance as specified in 3.5.3.a. Rated power factor is 0.75 lagging to unity for overloads up to the five-second overload capacity.

3.4.8.2.1 Motor starting (AC power). The generator AC power source shall be capable of supplying current for five seconds to a motor start load with locked-rotor. The motor start load shall be 60 percent of the AC power source rated capacity with 0.4 lagging power factor. The generator shall also be capable of supplying motor start current for five seconds during overload when the motor start load is applied with a prior generator load of up to 70 percent of rated capacity, at any rated power factor.

3.4.8.2.2 Emergency overload (AC power). If overload output for durations in excess of five minutes is required for aircraft emergency operation, then emergency requirements shall be in accordance with the specification sheet. Provision for generator system operation under emergency overload conditions requires procuring activity approval.

3.4.8.3 Short circuit capacity (AC power). For new system design, the minimum short circuit current capacity shall be 225 percent of full rated capacity. For existing generator systems defined with a slash rating, the minimum short circuit current capacity shall be 300 percent of the lower rating (see 6.8.17). The AC power source shall produce the minimum required short circuit current (225 or 300 percent, as applicable) for five seconds from the faulted phase during any single phase short circuit, and from all faulted phases either simultaneously or sequentially during a two phase, or three phase short circuit, including line-to-line or line-to-neutral faults. Unless otherwise required by the specification sheet, the new generator system designs shall include overcurrent protection (see 3.5.7.5).

3.4.8.4 Integral control power capacity. No source of power shall be required for generator excitation, control, and GCU DC output other than integral control power supplied by the generator package (see 6.8.11). Integral control power performance shall not be impaired by the application of specified AC overloads (3.4.8.2), AC short circuits (3.4.8.3), or DC overloads (3.4.8.4.2.a). Integral control power shall recover to full specified performance after application of DC short circuits (3.4.8.4.2.b) or PMG short circuits (see 6.8.11). The integral power shall provide the required capacity for simultaneous operation of the following loads: (1) excitation and regulation of the AC power source during all conditions specified in 3.4.8.4.1, including short circuit overload; (2) internal GCU power for protective functions and control circuitry; and (3) GCU DC output power supplied to external DC loads including the GLC control coil, bus transfer relay controls, and annunciation circuits (see 3.4.8.4.2).

3.4.8.4.1 Excitation and control of AC power. The GCU shall provide power for excitation and regulation of the main AC power source under the load and speed conditions specified in 4.5.3.1. Integral control power supplied to the GCU shall be conditioned as required for operation of the protective functions and generator system control. Generator system design shall preclude polarity reversal of the exciter field voltage

3.4.8.4.2 Rating of DC power source. The GCU power source supplying power to DC external loads shall be electrically independent of the AC excitation power. The DC power shall conform to the voltage limits of 3.5.1.2 over the generator speed range (see 6.8.7) under all specified load conditions (AC and DC), including application and removal of overloads (3.4.8.1, 3.4.8.2, 3.4.8.3, 3.4.8.4.2.a, and 3.4.8.4.2.b). The DC power source shall meet the requirements herein:

a. Continuous DC capacity – The DC power source shall be capable of delivering continuous DC current from no load to full rated DC load. The DC source's rated output current capacity for continuous operation shall be as required by the specification sheet. Unless otherwise approved by the procuring activity, the minimum DC capacity shall be not less than 2 amps.

b. Overload DC capacity - The DC power source shall be capable of delivering overloads up to 200 percent of rated current for five seconds.

c. Short circuit capacity – The DC power source shall be capable of delivering short circuit current of not less than 225 percent of rated DC current for five seconds. The DC output current shall be not greater than 300 percent of rated DC current for any DC short circuit fault.

3.4.9 System design (generator and control components).

3.4.9.1 Shaft speed. The generator package shall be capable of operating under any of the load conditions of 4.5.3 over the input shaft speed range as required by the specification sheet (see 6.8.7 for recommended ranges). During normal input speed transients, AC voltage shall conform to the limits of 3.5.1.1 and GCU DC voltage shall conform to the limits of 3.5.1.2. The limits for normal input speed transients shall correspond to the normal operation frequency transient limits of MIL-STD-704. The generator input nominal speed and speed range, shall be as required by the specification sheet. Shaft acceleration and deceleration limits, in rpm per second, shall be as required by the specification sheet.

3.4.9.1.1 Maximum speed for regulation. The generator system shall regulate phase voltages between 110 and 120 volts, with the generator input shaft driven at 120 percent of the nominal speed (see 4.4.9). Generator systems with overfrequency protection shall conform to the requirements of 3.5.7.4.

3.4.9.1.2 Overspeed. The generator shall withstand the following conditions simulating overspeeds from engine surge transients and drive system malfunction. For generators without overfrequency protection, voltage regulation and load limits for overspeed operation shall be as required by the specification sheet.

a. Engine surge overspeed - The generator package shall operate without failure for a duration of not less than 60 seconds when subjected to overspeeds between 120 and 130 percent of nominal shaft speed (see 4.4.9). Subsequent electrical performance of the system shall not be impaired by overspeed operation.

b. Maximum overspeed - The generator package shall contain all damage, if failure occurs during operation at overspeeds greater than 130 percent of nominal shaft speed (see 4.4.9).

3.4.9.2 Mounting and driving provisions. The generator shall be attached and secured to the drive pad with a V-band clamp or other acceptable means in accordance with the specification sheet. If a V-band clamp is used, it shall be designed so that it can be installed or removed by tightening or loosening one self-locking integrally retained fastener. Generator drive pad interface features and dimensions shall as required by the specification sheet. Provisions for positive alignment during generator package installation shall be as required by the specification sheet. The generator housing shall not rotate when mounted on the drive pad. An anti-rotation pin on the drive pad interface is one acceptable means of preventing rotation.

3.4.9.2.1 Shaft spline. The generator drive shaft spline shall include an adapter or other means of protection to reduce wear on the generator drive spline and the mating engine gearbox drive spline (drive pad). Generators using a circular drive spline and non-metallic adapter design shall conform to SAE-AS14169. Drive shaft misalignment tolerances for oil-lubricated drive splines shall be in accordance with the specification sheet.

3.4.9.2.2 Shear section. The generator drive shaft shall include a shear section to limit the torque transmitted from the generator to the drive pad. Shaft shear shall occur when applied torque is within the torque shear range required by the specification sheet. When the shaft shear section breaks, all rotating parts of the generator shall be disconnected from the drive pad (except the shaft end drive spline may be retained in the drive pad).

3.4.9.2.3 Maximum torque. The generator's mechanical demand from the drive source under any overload or fault condition (see 3.4.8.2 and 3.4.8.3) shall not exceed the maximum torque limit required by the specification sheet. The maximum torque occurring during overload or short circuit faults shall not cause drive system failure (the drive shaft shall not shear and non-metallic spline adapters shall not fail).

3.4.9.2.4 Flexible drive. Generators equipped with a flexible drive coupling between the drive spline and rotor shall conform to the requirements of the specification sheet. Amplitude limits for driveshaft torsional vibration shall conform to the requirements of the specification sheet.

3.4.9.3 Electric connections. Electric connections shall conform to the following:

a. Where terminals are used for electrical connection to generator system components they shall be of the stud-type and shall be designed so that the current is conducted by means of surface-to-surface contact and not through the stud threads. All studs shall be corrosion resistant steel, C-34 to C-42 Rockwell hardness. Stud diameter shall be not less than 3/16 inch and stud length shall accommodate installation of two terminal lugs with the nut. Stud nuts shall be steel capable of withstanding operational temperatures of 230 °C and the design shall be self-locking with captive washer in accordance with NASM 90415, or equivalent approved by the qualifying activity. There shall be no dielectric material in the compression buildup of a terminal. All terminal blocks shall be provided with nonflammable, non-conductive protective covers.

b. Terminal designations shall be permanently marked on the terminal block or adjacent structure of the generator package. Markings for the three-phase sequence of the generator shall be T_1-T_2-T_3. The neutral terminals for these three phases shall be T_4-T_5-T_6. For generators using a single neutral terminal, the terminal shall be marked as G. As an alternative, the three phases and single neutral may be marked as A-B-C-N.

c. Plug-in connectors and receptacles shall withstand all of the environmental effects and operating conditions as specified herein. The generator system shall be so designed that upon removal of the GCU connector plug, the associated generator and GCU shall be de-energized. The generator system is not required to de-energize upon removal of a connector from a feeder fault protection current transformer (see 6.8.4).

d. The AC and DC power outputs shall not be grounded internally. Output current shall return through the designated output terminals and not through the case. Component structure shall not be used as a current path except for radio noise shielding.

e. All external electrically conductive surfaces that are not part of electrical circuits shall be bonded to case with a bonding level not greater than 2.5 milliohms. Provision shall be made on the generator package for attaching a bonding strap to bonding pad with a maximum 2.5 milliohms from bonding strap to case. Electrical connectors on remote components shall provide a separate pin connected to case ground. The bonding path shall remain intact while carrying the fault current from a line-to-case short.

3.4.9.4 Direction of rotation. The direction of rotation, when viewing the generator drive end shall be as required by the specification sheet. A permanent marking on the generator shall indicate direction of rotation and shall be visible when the generator is mounted.

3.4.9.5 Efficiency (heat rejection). Generator system efficiency shall be as required by the specification sheet (see 6.8.5). Under the test conditions of 4.5.9, generator system efficiency at nominal speed with full rated load (0.75 lagging power factor) shall be not less than 80 percent.

3.4.9.6 Cooling.

3.4.9.6.1 Air cooling (convection or forced air). Components cooled with forced air shall be designed to resist the internal accumulation of sand, dust, moisture, or liquid contaminants. Internal electrical connections and bearings in air-cooled generators shall be protected from moisture intrusion. Operation during loss of cooling (ingestion of engine exhaust, hot air re-circulation, or airflow reversal) shall conform to the requirements of 3.4.9.6.1.c.

a. Air inlet/outlet - When outside air is ducted to the generator inlet for cooling, provisions for air entrance and exit shall be provided by means integral with the generator design. Provisions for connection to the inlet duct shall be as required by the specification sheet.

b. Temperature-altitude rating – Under the temperature-altitude and load conditions of 3.4.2.1 and 4.5.28.1, generator system capacity shall conform to the nominal rated output requirements on figure 2 and de-rated output requirements of curves A and B on figure 2 (see 6.6.1). The rated airflow required for blast-cooled rated output (at sea level with a hot day temperature of 52 °C), shall be as required by the specification sheet.

c. Loss of cooling - Generators shall withstand operation at 50 percent rated load for five minutes during hot air ingestion at 125 °C. Generators shall withstand operation at full rated load for one minute with airflow interruption (or airflow reversal).

3.4.9.6.2 Liquid cooling. All heat dissipated by the generator package shall be removed by means of an external liquid cooling system. Generators using oil or other fluids for cooling and lubrication shall operate continuously with the fluids required by the specification sheet.

Oil-cooled generators shall be capable of operating with MIL-PRF-7808, MIL-PRF-23699, and DOD-PRF-85734 type oils.

a. Coolant pressure, flow, and temperature - The pressure, flow, and temperature characteristics of the coolant at the inlet and outlet of the generator package shall conform to the requirements of the specification sheet. If generator integral overpressure bypass protection is required, bypass operation shall be as specified by the specification sheet. The generator package maximum coolant inlet temperatures for both continuous operation and five-minute operation shall be as required by the specification sheet. The minimum coolant temperature for start-up and operation of any liquid cooled component shall be -40 °C.

b. Leakage - Unless otherwise required by specification sheet, coolant leakage from each rotating seal of the generator package shall be not greater than 2 cubic centimeters per hour during operation. Coolant leakage limits for non-operating conditions shall be as required by the specification sheet. Any seal leakage shall be directed into a drain and provision made for connection to the aircraft overboard drainage system.

c. Loss of cooling/lubrication - Liquid-cooled generators shall withstand operation at full load when the supply of coolant is interrupted for intervals of up to one minute in duration. In the event of cooling supply failure, the generator system shall operate for the period required by the specification sheet. If failure occurs due to loss of cooling (run dry) operation, the generator package shall contain all damage. Generator rupture, ignition, or breakup shall not occur and the shaft may shear.

d. Coolant contamination - Generator package requirements for filtering and coolant return contamination limits (outlet port debris emissions) shall be as required by the specification sheet.

e. Fluid level indication - All generator packages with an integral fluid pumping system shall have a warning device on the unit to provide an indication of internal fluid level. Requirements for fluid servicing shall be as required by the specification sheet.

3.4.9.7 Generator service life. The generator package service life shall be not less than 4,000 hours between overhauls, when subjected to the environmental conditions and electrical loads specified herein (see 4.5.3 and 4.5.28). The service life of grease lubricated bearings and bearing seals shall be not less than 4,000 hours. The service life of oil lubricated parts (drive splines, bearings, and seals) shall be not less than 5,000 hours. The cumulative service life of the generator package (rotor/stator and housing) shall be not less than 10,000 hours, when operated under any of the conditions specified herein.

3.4.10 Control component service life. The generator control unit shall have a service life of not less than 5,000 hours between overhaul or repair, when subjected to the environmental conditions and electrical loads specified herein (see 4.5.3 and 4.5.28). The service life of current transformers shall be not less than 15,000 hours.

3.4.11 Color. System components shall be finished in a glossy white color conforming to FED-STD-595, color number 17875. As an alternative, components may be finished in a chemical film resulting in an aluminum or stainless steel color. Finishes shall be undamaged after system components are subjected to the environmental tests specified herein.

3.4.12 Markings. Equipment, assemblies, and parts shall be marked with identification in accordance with MIL-STD-130 or equivalent (see 6.5.5). Safety warnings and identification of electrostatic discharge sensitive components shall be in accordance with MIL-STD-130, or equivalent. The generator package and each system control component shall include a nameplate with the location as indicated by the specification sheet. Nameplates shall include the following information: (1) item nomenclature, including rated capacity and nominal speed; (2) voltage and frequency; (3) manufacturer's identification; (4) part number and serial number; (5) CAGE code number; (6) national stock number; (7) contract number; and (8) unique item identifier as specified in MIL-STD-130. Markings shall remain legible after exposure to the required environmental testing.

3.4.13 Adjustments. All mechanical and electrical adjustments, such as rotor balance, voltage regulation settings, protection trip and reset settings shall be made at the time of manufacture or depot repair overhaul. Device setting adjustments shall be locked and sealed (see 3.7). No adjustment shall be required during aircraft installation or between overhauls.

3.5 Electrical performance. All electrical characteristics specified herein for the AC and DC power sources are as measured at the POR (see 6.8.16).

3.5.1 Voltage limits for normal operation. The generator system AC and DC output shall remain within the voltage limits of 3.5.1, 3.5.2, 3.5.4, and 3.5.5 under the following conditions for normal operation: (1) generator input speed remains within normal transient and steady state limits as required by 3.4.9.1; (2) three phase AC loads applied in accordance with 3.4.8.1, 3.4.8.2, and 3.5.3.a; (3) DC load applied in accordance with 3.4.8.4.2; and (4) component environment and cooling is within specified limits of 3.4.2.1 and 3.4.9.6.

3.5.1.1 Voltage limits for AC power source. Under normal operation (see 3.5.1 and 6.8), the line-to-neutral AC phase voltages shall conform to the transient and steady state phase voltage limits on figure 9 for class N and figure 10 for class W.

3.5.1.2 Voltage limits for DC power source (see 3.4.8.4.2). Under normal operation (see 3.5.1 and 6.8), the GCU DC output shall conform to the requirements herein. For class N, transient DC voltage shall remain within curve A limits on figure 11 and steady state voltage shall be between 26 and 29 volts. For class W, transient DC voltage shall remain within the curve B limits on figure 11 and steady state voltage shall be between 24 and 29 volts. The ripple voltage amplitude, DC distortion spectrum, and distortion factor shall be as specified in 3.5.5.

3.5.2 Voltage modulation (AC power source). The modulation amplitude of each line-to-neutral phase voltage shall remain within the limits on figure 12, under steady state load conditions during constant speed operation (see 6.8.1 and 6.8.18). Under any steady state load condition of 3.4.8.1 or 3.4.8.2, the voltage modulation amplitude of each phase shall not exceed the amplitude modulation limit of 1.25 volts peak, as shown on figure 12. The 1.25 volts peak modulation limit is equivalent to an amplitude modulation of 0.9 volt root-mean-square (RMS) for an AC waveform with nominal crest factor of 1.41 (see 6.8.3).

3.5.3 Voltage unbalance and phase displacement. For existing systems defined with a slash rating, the percentage of phase load unbalance, as defined in 6.8.13, shall be based on the higher rating (see 6.8.17). For generator input speeds within the specified range for rated output (see 6.8.7), the AC phase voltage unbalance and displacement shall conform to the following requirements:

a. The AC power source shall conform to the requirements herein with phase load unbalance of up to 15 percent. For phase load unbalances of 15 percent (or less), the phase angle and phase voltage shall be within the following limits: (1) displacement between phases shall be within the phase angle limits of 118° to 122°, excluding harmonics; (2) voltage unbalance between phases shall not exceed 3 volts; and (3) all three phase voltages shall remain within the limits on figure 9 for class N and figure 10 for class W.

b. For phase load unbalances of 30 percent, the phase angle and phase voltage shall be within the following limits: (1) The displacement between phases shall be within 116° to 124°, excluding harmonics; (2) voltage unbalance between phases shall be less than 6 volts; and (3) all three phase voltages shall remain within the no trip limits of area A as depicted on figure 13 for class N and figure 14 for class W.

c. If phase load unbalance is greater than 35 percent and voltage unbalance exceeds the limits of 3.5.3.b, the generator protection shall disconnect AC power from the load bus and de-energize the AC power source before any phase voltage exceeds protective function limits (see 3.5.7.2 and 3.5.7.3).

3.5.4 Voltage waveform (AC power source). The AC phase voltages shall conform to the following requirements for crest factor and waveform distortion (see 6.8.3 and 6.8.19).

a. The crest factor of each phase voltage waveform shall be 1.41 ±0.07, under the continuous load conditions of 3.4.8.1. The crest factor shall be 1.41 ±0.10 under the overload conditions of 3.4.8.2.

b. The total harmonic distortion content of each phase voltage shall be not greater than 3 percent and no single harmonic shall exceed 1.5 percent of the fundamental, under any of the steady state load conditions specified in 3.4.8.1 and 3.4.8.2. The distortion factor for the phase voltage waveform shall be not greater than 0.05 under continuous load and not greater than 0.08 under overload conditions. The AC power source distortion components shall conform to the distortion spectrum limits on figure 15. The DC content of the AC output voltage shall be not greater than ± 0.10 volt under the unbalanced load conditions of 3.5.3.a.

3.5.5 Voltage ripple and distortion (DC power source). The peak-to-mean ripple amplitude of the GCU DC output voltage shall not exceed 1.5 volts under steady state conditions with any DC load up to the rated capacity of the DC output (see 3.4.8.4.2). The DC distortion factor shall not exceed 0.035 and the DC power source shall conform to the distortion spectrum limits on figure 16.

3.5.6 Simultaneous load and speed transients. Unless otherwise required by the specification sheet, testing of simultaneous load and speed transients is not required.

3.5.7 Protective functions (abnormal power and fault conditions). Protective function performance shall not be impaired by input speed variations or loads applied to the AC or DC power sources, including overloads of 3.4.8.2 and short circuit faults of 3.4.8.3. Internal power supply circuits and external circuitry shall be designed such that no single fault or failure shall result in generator system operation outside the protective limits specified herein.

3.5.7.1 False trips. No tripping of the system shall be caused by load switching, input speed acceleration or deceleration, or fault clearing by other protective devices within the aircraft electrical system. The system shall not trip during generator build-up, unless a fault condition exists within the generator system.

3.5.7.2 Overvoltage protection. If an overvoltage condition occurs, the protective function shall open the GLC and de-energize the generator before the POR voltage of any phase exceeds the overvoltage limits on figure 13 for class N and figure 14 for class W. Power shall be reconnected to the load bus as required by 3.4.7.1 (after manual reset), or 3.4.7.2 (after automatic reset).

3.5.7.3 Undervoltage protection. If an undervoltage condition occurs and the fault is not cleared, the protective function shall open the GLC and de-energize the generator before the POR voltage of any phase exceeds the undervoltage limits on figure 13 for class N and figure 14 for class W. Power shall be reconnected to the load bus as required by 3.4.7.1 (after manual reset) or 3.4.7.2 (after automatic reset).

3.5.7.4 Frequency protection. Frequency protection shall be as specified herein, with exceptions as follows: (1) underfrequency protection may be disabled in flight on rotary wing aircraft; and (2) generator system overfrequency protection is not mandatory when redundant protection is provided by speed control limits in the drive system.

a. Class N - The GLC shall be opened before the underfrequency limits on figure 17 are exceeded. After underfrequency dropout occurs, the protection shall function as follows: (1) connection of AC power to the load bus is permitted, but not required, when frequency is between 390 and 392 Hertz; and (2) AC power shall be automatically reconnected to the load bus within one second after frequency recovers within the limits of 392 to 408 Hertz. The GLC shall be opened and the AC power source de-energized before the overfrequency limits on figure 17 are exceeded. After trip and reset, the protection shall function as follows: (1) connection of AC power to the load bus is permitted, but not required, when frequency is between 408 to 410 Hertz; and (2) AC power shall be automatically connected to the load bus within one second after frequency recovers within the limits of 392 to 408 Hertz.

b. Class W - The GLC shall be opened before the underfrequency limits on figure 18 are exceeded. After underfrequency dropout occurs, the protection shall function as follows: (1) connection of AC power to the load bus is permitted, but not required, when frequency is between 379 and 385 Hertz; and (2) AC power shall be automatically reconnected to the load bus within one second after frequency recovers within the limits of 385 to 415 Hertz. The GLC shall be opened and the AC power source de-energized before the overfrequency limits on figure 18 are exceeded. After trip and reset, the protection shall function as follows: (1) connection of AC power to the load bus is permitted, but not required, when frequency is between 415 and 421 Hertz; and (2) AC power shall be automatically connected to the load bus within one second after frequency recovers within the limits of 385 to 415 Hertz.

3.5.7.5 Overcurrent protection (short circuit AC current limit). Unless otherwise required by the specification sheet, new generator system designs with overcurrent protection shall limit AC output current between 250 and 350 percent of rated capacity during short circuit fault conditions.

3.5.7.6 Feeder fault. The generator system protective functions shall detect power feeder fault currents between the generator AC output terminals and the three phase AC power connection to the GLC. No fault, other than a feeder fault, shall cause the feeder fault protective circuits to function. The protective function shall disconnect the system from the load bus and de-energize the generator when the RMS feeder fault current on any phase, or multiple phases, exceeds the limits specified herein. After manual reset (see 3.4.7.1), or automatic reset (see 3.4.7.2), power shall be reconnected to the load bus, unless the feeder fault condition is re-energized by the AC power source.

a. Generator rated capacity of less than 30 kVA - The AC power source and generator line contactor shall both be de-energized within a period of 25 to 75 milliseconds when the feeder fault current exceeds 15 amperes RMS. The protection may trip for feeder fault currents between 10 and 15 amperes RMS.

b. Generator capacity in the range of 30 to 80 kVA - The AC power source and generator line contactor shall both be de-energized within a period of 25 to 75 milliseconds when the feeder fault current exceeds 25 amperes RMS. The protection may trip for feeder fault currents between 15 and 25 amperes RMS.

c. Generator capacity greater than 80 kVA - The AC power source and generator line contactor shall both be de-energized within a period of 25 to 75 milliseconds when the feeder fault current exceeds 35 amperes RMS. The protection may trip for feeder fault currents between 15 and 35 amperes RMS.

3.5.7.7 Anti-cycling. The generator system shall provide a means to prevent on/off cycling when a fault exists and a protective function trip occurs. After a protective function trip for abnormal voltage of feeder fault occurs, the system shall reset when the control switch is placed momentarily in the RESET (or OFF-RESET) position and returned to the ON position. If the cause of the trip still remains when the control switch is placed in the ON position, then the system shall trip again and remain tripped until manual reset is repeated.

3.5.7.8 Bus fault isolation. If a system protective function is activated by other than undervoltage (see 3.5.7.3), the AC power source shall be de-energized, the GLC opened, and the load bus transferred without any delay. When bus fault isolation protection is provided by the generator system, only the undervoltage protection circuits shall inhibit the transfer of a faulted bus from its power source to an alternate power source. Activation of the bus transfer inhibit logic shall be as required by the specification sheet.

3.5.7.9 Waveform protection (extraneous AC distortion and DC content). Extraneous non-linear loads may cause generator system AC voltage to exceed waveform distortion limits (see 3.5.4). Unless otherwise required by the specification sheet, extraneous distortion protection is not required for the generator system.

3.5.7.10 Arc fault power feeder protection. As required by the specification sheet.

3.5.8 Electromagnetic compatibility. The generator system shall conform to the requirements of MIL-STD-461 when tested to the requirements as specified in 4.5.12. The generator system shall not interfere with the performance of the other equipment as a result of radiated or conducted electromagnetic interference. In addition, the generator system performance shall not be degraded as a result of electromagnetic interference susceptibility as a result of electromagnetic interference from other aircraft equipment.

3.5.9 Paralleling. Unless otherwise required by the specification sheet, provision for AC power source paralleling of generator channels is not required.

3.5.10 Generator output characteristics. Generator complex impedance, transient/sub-transient reactance, and saturation curve characteristics shall be as required by the specification sheet.

3.6 Interchangeability. All parts having the same part or identifying number (PIN) shall be directly and completely interchangeable with respect to installation and performance.

3.7 Mechanical connections, fasteners, inserts, and retaining hardware. Screw threads shall be unified inch standard series UN, UNR, and UNJ (see 6.5.1.3). UNJ screw threads shall conform to the requirements of SAE-AS8879. All internal and external threaded parts shall be positively locked (self-locking nuts, safety wiring, or acceptable alternative methods used to prevent loosening of threaded parts). Staking shall not be used. Internal devices with mechanical adjustment provisions shall be locked and sealed during production.

3.8 Seals, coatings, and sealant compounds. Internal seals (including O-rings, gaskets, and grommets), sealants, potting compounds and circuit board conformal coatings shall have a service life of not less than 5000 hours between component overhaul or repair.

3.9 Endurance (durability). The system shall conform to the requirements herein when subjected to the endurance tests as specified in 4.5.28.

3.10 Reliability. System reliability of the generator, GCU, and CT assemblies shall be not less than 5,000 mean flight hours between failures. The reliability of the GCU protective function circuitry shall be not less than 10,000 mean flight hours between failures.

3.11 Maintainability. The generator system maintainability requirements shall be as required by the specification sheet.

3.12 Workmanship. Components shall be free from irregularities or defects that could degrade performance or durability.

4. VERIFICATION

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

a. Qualification inspection (see 4.2 and 6.3).

b. Conformance inspection (see 4.3).

4.2 Qualification inspection.

4.2.1 Qualification sample submittal. The qualifying activity will acquire generator systems for qualification or unsolicited samples may be submitted to the qualifying activity by manufacturers seeking qualification (see 6.2 and 6.3). The typical qualification requires three or four samples of each component (qualification with less than three samples requires qualifying activity approval). The test schedule matrix in table I is based on four test samples for component qualification.

4.2.2 Qualification inspections and tests. Qualification inspection shall consist of the examinations and tests required by this specification and the applicable specification sheet. The manufacturer or an independent laboratory may conduct qualification testing with approval from the Government qualifying activity.

a. Laboratory qualification test - The examinations and tests listed in table I shall be conducted on the generator system components submitted for qualification. In addition, the qualifying activity shall have the following options: (1) the qualification test matrix listed in table I is subject to alteration such that any test may be conducted on any sample submitted for qualification; (2) inspections may be conducted to verify conformance to any of the requirements that were qualified by similarity; and (3) additional tests/repeated tests may be conducted to determine specification compliance when the measured performance is at specification limits and evidence of compliance/non-compliance is inconclusive due to instrumentation accuracy/measurement tolerance.

b. Aircraft demonstration (ground and flight) – Prior to flight, the generator system will be subjected to an aircraft ground demonstration for system electromagnetic compatibility. Generator system conformance to specification requirements shall be demonstrated throughout all aircraft operations and the cumulative operating flight time for the generator system shall be not less than 50 hours.

4.2.3 Qualification retention. Inspection requirements for qualification retention samples shall consist of the examinations and tests listed in table I in accordance with the specification and applicable specification sheet. Samples shall be randomly selected from a production run and submitted to the qualifying activity. Products may be removed from the Qualified Products List if: (1) the manufacturer has not provided the requested certification; (2) the manufacturer has requested that the product be removed from the list; or (3) the qualifying activity has removed the product pending the results of re-qualification testing.

a. The qualifying activity will conduct an evaluation to determine if re-qualification test is necessary when any of the following conditions occur: (1) change in manufacturer's product design, materials, or processes; (2) change in performance levels or functional requirements due to specification revision; (3) production facility relocation; or (4) company sale or transfer to new ownership.

b. Components demonstrating satisfactory performance to tests conducted for qualification retention will be approved in writing by the qualifying activity for retention on the applicable qualified products list.

4.2.4 Rejection, resubmittal, and retest. Requirements for resubmittal or retest of repaired or reworked test samples will be covered in the contract or purchase order.

4.3 Conformance inspection. Conduct conformance inspection tests in accordance with table I and the specification sheet. The qualifying activity may conduct conformance inspection on any production components. Unless otherwise directed by the Government contracting officer, delivery of production components should not be delayed pending: (1) results of any test inspection; or (2) correction of failures/defects disclosed during conformance inspection. Production lot samples will be selected at random by a Government inspector from production lots and forwarded to the qualifying activity under the contract provisions. Production samples forwarded to the qualifying activity will be subjected to conformance verification inspection in accordance with this specification. At the conclusion of test, the Government will forward a report of test results to the manufacturer.

4.4 Standard conditions. Unless otherwise specified by the individual tests of 4.5, the following standard inspection conditions shall apply:

a. Ambient temperature: 23° ±10°C (73° ±18°F)

b. Relative humidity: 50 ±30 percent

c. Atmospheric pressure: 25.5 to 30.5 inches of Mercury (650 to 775 mm of Mercury)

d. Coolant temperature: Coolant supply at the fluid inlet shall be maintained at 80 percent of the maximum continuous coolant temperature required by the specification sheet.

4.4.1 Tolerances for controlled test environment. Unless otherwise specified by the tests of 4.5, the limits for test condition tolerances shall be as follows:

a. Chamber temperature: ±2 °C of specified value (±3.6 °F)

b. Air flow: ±5 percent of specified value

c. Temperature of coolant (liquids and forced air): ±2 °C of specified value (±3.6 °F)

d. Pressure altitude: ±5 percent of specified value

e. Relative humidity: ±5 percent

4.4.2 Test sample. Tests are to be conducted on a complete generator channel with components interconnected as shown by the specification sheet. The conductor current-carrying capacity and length of the AC and DC power feeders shall be configured to simulate the aircraft installation (see 6.5.2.1). All other control leads shall be less than fifty feet in length and of a conductor size capable of carrying the required current. Unless otherwise required by the specification sheet, conductors shall not be smaller than size 22 gage. A generator control switch (see 3.4.7.1 and 3.4.7.2) shall be used for manual system control and shall remain in the ON position throughout each test unless reset or de-energizing of the AC power source is specifically required.

4.4.3 Loading of the AC power source. The AC power source shall deliver 100 percent rated AC output at the POR to a balanced three phase linear load (see 6.8.13), with the generator input shaft at nominal cruise speed. The AC power source shall be operated at rated load for a minimum of 5 minutes between successive overloads or short circuit fault applications.

4.4.4 Loading of the DC power source. The DC power source shall deliver 100 percent rated DC current output. The DC power source shall be operated at rated load for a minimum of 5 minutes between successive overloads or short circuit fault applications.

4.4.5 Voltage and frequency measurements. Measurement of generator system output voltage and frequency shall be made at the POR (see 6.8.16).

4.4.6 Power factor. Loads shall be at unity power factor.

4.4.7 Component mounting. Unless otherwise required by the specification sheet, the generator package shall be mounted in the 0° roll and 0° pitch position. If the 0° roll position is not specified, the generator package may be tested in any position of roll. If the 0° pitch position is not specified, the generator shall be mounted with the rotational axis in the horizontal position. Unless otherwise required by the specification sheet, control components shall be mounted in a horizontal position with base down.

4.4.8 Thermal.

4.4.8.1 Thermal isolation. Thermal insulation shall be placed between system components and any objects with which the components come in contact to reduce heat transfer during thermal tests. Insulation is not required at the mounting face or input shaft of the generator package.

4.4.8.2 Warm-up and temperature stabilization. Prior to each test the system shall be operated, delivering rated current at rated voltage, for sufficient time for the temperature of each system component to stabilize. The temperature of components shall be considered to have stabilized when the temperature at the monitoring points changes less than 2 °C during a period of 5 minutes.

4.4.9 Generator package input shaft speed. The generator package input shaft shall be driven at nominal speed. Unless otherwise required by the specification sheet, nominal speed shall correspond to the rated speed for AC power source frequency of 400 Hertz.

4.4.10 Environmental test methods. For the environmental tests specified herein, pre-test and post-test requirements shall be in accordance with the applicable test methods of MIL-STD-810. After each environmental test is conducted, components shall be subjected to the tests of 4.5.3.1.b and 4.5.3.1.d to verify that electrical performance meets specification requirements.

4.4.11 Electrical performance verification. Unless otherwise specified the protective functions test of 4.5.17 shall be conducted to verify that the generator system conformance can meet the requirements of 3.5.7 (see 4.5.20, 4.5.21, 4.5.22, 4.5.23, 4.5.24, 4.5.25. 4.5.26, 4.5.27, 4.5.32, and 4.5.35).

4.5 Methods of inspection.

4.5.1 Examination of product. Each generator system component and all parts submitted for inspection shall be examined by the Government inspector and the qualifying activity as deemed necessary to comply with the requirements herein. Component envelope, geometry, mounting interface, and weight shall be examined for conformance to specification sheet dimensions and tolerances, as required by 3.4.5 and 3.4.9.2 herein and the specification sheet. Visual examinations shall also be conducted to verify that workmanship and construction conform to the specification requirements of 3.4.11, 3.4.12, and 3.12.

4.5.2 Maximum speed for regulation. Generator system components shall not be warmed up prior to this test. Conduct maximum speed for regulation test to determine conformance to 3.4.9.1.1. The input shaft speed shall be accelerated to 120 percent of rated shaft speed (480 Hertz) with the generator electrically loaded and operated as required by the specification sheet. Measure AC voltage to determine conformance to the limits on figure 9 for class N and figure 10 for class W. Measure GCU DC voltage to determine conformance to the limits on figure 11. Generator systems with overfrequency protection shall conform to the requirements of 3.5.7.4.

4.5.3 Electrical performance. Under the following test conditions, shaft acceleration and deceleration rates shall be maintained between 40 and 100 percent of the maximum rate required by 3.4.9.1 as modified by the specification sheet. Coolant temperature, pressure drop (from inlet to outlet), and flow rate shall be measured during the tests herein to verify coolant parameters conform to 3.4.9.6 as modified by the specification sheet.

4.5.3.1 Electrical performance at standard temperature. Ambient temperature for all components shall be maintained at 23 ±10 °C and liquid cooling shall be maintained at the standard conditions as specified by 4.4. Conduct the following tests to determine electrical performance at standard temperature:

a. Under conditions wherein the control switch is placed in the ON position and the generator input shaft is accelerated from zero speed to nominal speed, measure generator excitation (voltage and current), AC output voltages, and GCU DC voltage to verify that the system control, voltage build-up, and voltage regulation conforms to the requirements of 3.4.7 and 3.5.1. Measure AC voltage and current when component temperatures have stabilized in accordance with 4.4.8.2.

b. Measure output voltage and current (generator AC and GCU DC) under each test condition in table II to determine conformance to the requirements of 3.4.8.1, 3.4.8.2, 3.5.1.1 and 3.5.1.2. Under each of the table II test conditions for continuous operating mode, apply the AC load suddenly and measure the transient response of the AC and DC voltages. After application of these AC loads, measure the steady state regulation of the AC and DC voltages. After component temperatures have stabilized within 4.4.8.2 criteria, remove the AC load suddenly and measure the transient response of the AC and DC voltages. Under the five-minute and five-second AC overload conditions in table II, apply AC overloads suddenly and measure the transient response and regulation of the AC and DC voltages. After the specified period (five minutes or five seconds), remove the AC overload suddenly and measure the transient response of the AC voltages and DC voltage. Under continuous load and five-minute overload conditions in table II, measure steady state AC voltage modulation and waveform (crest factor and distortion) to determine conformance to the requirements of 3.5.2 and 3.5.4. During steady-state conditions, measure DC voltage (ripple amplitude and distortion spectrum) to determine conformance to the requirements of 3.5.5.

c. Under the rated load, five-minute overload, and five-second overload conditions of 4.5.3.1(b), operate control switch functions to determine conformance of generator system response to the requirements of 3.4.7 and 3.5.1 as specified herein. Measure voltage and current (AC and DC) under the following test conditions: (1) measure generator voltage transient response during exciter field build-up and measure the time period from control switch ON to GLC closure; (2) measure voltage transient response to application of rated load as GLC closes; (3) switch to OFF position and measure AC voltage transient response to rated load removal, as GLC opens, and exciter field de-energizes. Repeat this test with load application and removal at the five-minute overload capacity and five-second overload capacity.

d. Under any of the load conditions of 4.5.3.1.b, conduct the protective function tests of 4.5.17 to determine conformance to the requirements of 3.5.7. Under AC output conditions of 10 and 100 percent rated load, apply feeder faults and measure protective function response (fault current trip level and trip time) to determine conformance to the requirements of 3.5.7.6.

e. Conduct normal unbalanced load tests of 3.5.3.a (steps 1 through 7 of table III) and measure AC phase voltages to determine conformance to the requirements of 3.5.1.1 during load application and removal at each required test condition.

f. With the generator at nominal speed and the AC power source at rated load, measure DC voltage to determine conformance to the requirements of 3.5.1.2: (1) steady state DC voltage regulation shall be measured at 10, 50, and 100 percent rated DC load; and (2) transient voltage response to DC load application and removal shall be conducted at 50 and 100 percent rated DC load. These tests shall be repeated at minimum speed and maximum speed for rated AC power output. At 50 and 100 percent rated DC load conditions, measure steady state DC voltage (ripple and distortion) to determine conformance to the requirements of 3.5.5.

4.5.3.2 Electrical performance at minimum temperature. Determine system performance under minimum temperature conditions as follows:

a. All system components shall be de-energized and cold soaked for 4 hours. Cold soaking shall be accomplished as follows: Components shall be soaked at an ambient temperature of -55 °C for 2 hours. After 2 hours at -55 °C, increase component ambient temperature to -40 °C for a period of not less than 2 hours before startup.

b. After the 4 hour cold soak, accelerate the generator input shaft from zero speed to rated speed and measure voltage (AC and DC) during generator build-up to determine conformance to the requirements of 3.4.7.2, 3.5.1.1, and 3.5.1.2. The initial temperature of the coolant entering liquid cooled generators shall be -40 °C. After startup, the temperature of the liquid coolant entering the generator shall be allowed to rise to 45 ± 10 °C and then shall be maintained at this temperature throughout the tests of 4.5.3.2. After startup, the ambient air temperature for components shall be maintained at -40 °C throughout the tests of 4.5.3.2.

c. With -40 °C ambient temperature and coolant maintained at 45 ±10 °C, repeat the tests of 4.5.3.1(b). Under each test condition in table II, measure AC voltage and current during steady state voltage regulation and voltage transient response (load application and removal) to determine conformance to the requirements of 3.5.1.1. Under steady state conditions, measure AC voltage modulation and voltage waveform (crest factor and distortion) to determine conformance to the requirements of 3.5.2 and 3.5.4. Under any of the load conditions of this test, conduct the protective function tests of 4.5.17 to determine conformance to the requirements of 3.5.7.

d. With the generator at rated speed and the AC power source at rated load, measure DC power (voltage and current) to determine conformance to the requirements of 3.5.1.2. Measure transient and steady state DC voltage as rated DC load is suddenly applied, maintained for 15 minutes, and then suddenly removed. Under steady state conditions, measure DC voltage (ripple and distortion) to determine conformance to the requirements of 3.5.5. Tests shall be repeated at minimum and maximum speeds for rated AC power output.

4.5.3.3 Electrical performance at maximum temperature. Determine system performance under maximum temperature conditions as follows:

a. All components shall be de-energized and hot soaked for 4 hours. Unless otherwise required by the specification sheet, hot soaking shall be accomplished as follows: Control components and air cooled generators shall be soaked at an ambient temperature of 85 °C. Liquid cooled generators shall be soaked at the maximum ambient temperature required by 3.4.2.1.2 as modified by the specification sheet. Throughout the tests of 4.5.3.3, the ambient air temperature shall be maintained at 85 °C (or the specified maximum temperature required by the specification sheet). The temperature of the coolant entering the generator shall be maintained at the maximum temperature for continuous operation at rated AC output, as required by the specification sheet (3.4.9.6.1 or 3.4.9.6.2, both as modified by specification sheet).

b. After the 4 hour hot soak, accelerate the generator input shaft from zero speed to rated speed and measure voltage (AC and DC) during generator build-up to determine conformance to the requirements of 3.4.7.2, 3.5.1.1, and 3.5.1.2.

c. Repeat the test of 4.5.3.1.b with component coolant and ambient air temperatures at the maximum temperature for continuous operation as required by 3.4.2.1.2 as modified by the specification sheet. Under each test condition in table II, measure AC voltage and current during steady state voltage regulation and voltage transient response (load application and removal) to determine conformance to the requirements of 3.5.1.1. Under steady state conditions, measure AC voltage modulation and voltage waveform (crest factor and distortion) to determine conformance to the requirements of 3.5.2 and 3.5.4. Under any of the load conditions of this test, conduct the protective function tests of 4.5.17 to determine conformance to the requirements of 3.5.7.

d. With the generator at rated speed and the AC power source at rated load, determine conformance of DC voltage to the requirements of 3.5.1.2. Measure transient and steady state DC voltage as rated DC load is suddenly applied, maintained for 15 minutes, and then suddenly removed. During steady state conditions, measure DC voltage (ripple and distortion) to determine conformance to the requirements of 3.5.5. Test shall be repeated at the minimum and maximum speeds for rated AC output.

e. Operate the generator system at rated speed while delivering rated power until temperature stability of 4.4.8.2 is achieved. Determine conformance to the short circuit requirements of 3.4.8.3 as single-phase, two-phase, and three-phase short circuits are applied at the AC power source POR with a minimum impedance load (less than 0.2 ohm) across the line-to-neutral and line-to-line terminals (see 4.5.10). For generators without overcurrent protection, the fault impedance may be increased to prevent damage to the generator (fault current per phase limited to 250 percent of rated capacity). Each short circuit shall be removed within five seconds after application. The AC power source may de-energize in 3.5 to 5.0 seconds if an undervoltage trip occurs (see 3.5.7.3).

f. Determine DC power source conformance to the short circuit requirements of 3.4.8.4.2. Short circuits shall be applied as a minimum resistance load (less than 2 ohms) across the POR terminals of the DC power source. Each short shall be applied for five seconds.

g. With the generator at nominal speed and the AC power source loaded at 70 percent of capacity (balanced three-phase load at 0.75 power factor), maintain component ambient temperature and coolant temperature at the maximum continuous values required by the specification sheet. With an initial AC load at 70 percent of rated capacity, suddenly apply an additional load simulating a motor start condition (three phase balanced load with phase current at 60 percent of rated capacity and 0.4 lagging power factor). Measure the AC transient voltages and current to determine conformance to curve B voltage limits on figure 9 for class N and figure 10 for class W. The motor start load shall be applied for five seconds.

h. Measure AC and DC voltages to determine conformance to the requirements of 3.5.1 and 3.5.2, under the maximum coolant temperature condition for five-minute operation, as required by 3.4.9.6 of the specification sheet (3.4.9.6.1 or 3.4.9.6.2, as applicable).

4.5.3.4 Electrical performance for conformance inspection. Conformance inspection (see 4.3) shall include the following tests conducted under standard conditions of 4.4 (see 3.4.9.1):

a. Conduct 4.5.3.1.a, except that AC power source tests are only required at the 10 percent and 100 percent rated load conditions. Shaft acceleration and deceleration rates shall be maintained within the limits of 40 to 100 percent of the maximum specified in 3.4.9.1 of this specification and the applicable specification sheet.

b. Conduct 4.5.3.1.b with the AC power source operating at each of the test conditions in table II, except that tests at 60 percent rated load are not required. Inspections for AC waveform distortion and crest factor are not required.

c. Conduct 4.5.3.1.f, except that DC power source tests are only required at the 100 percent rated DC load condition. Inspection for DC waveform distortion is not required.

4.5.4 Overspeed. Conduct the following overspeed tests to determine conformance to the requirements of 3.4.9.1.2:

a. With the generator at rated speed and load, measure AC and DC voltages and verify conformance to 3.4.9.1.2.a as the generator input shaft is accelerated to 130 percent of nominal speed and maintained for 60 seconds.

b. With the generator at rated speed and load, measure AC voltage and verify conformance to 3.4.9.1.2.b as the generator input shaft is accelerated to 135 percent of nominal speed and maintained for 30 seconds.

4.5.5 Dielectric strength. Measure leakage current under the high voltage potential test conditions of 4.5.5.1 to determine conformance to the requirements of 3.4.1. The frequency of the AC voltage shall be 60 Hertz with the AC voltage applied at the RMS value and duration as specified by 4.5.5.1 for dielectric test. Test voltage shall be applied between the generator windings and between each winding and frame. Control components shall be tested from each terminal to case. Wire wound electric components (such as transformers and solenoids) having leakage currents exceeding 5 milliamps shall be rejected. All other components having leakage currents exceeding 3 milliamps shall be rejected. The tolerance of all applied test voltages shall be ± 1 percent. If it is necessary to repeat a dielectric test, the voltage levels listed herein shall be reduced to 75 percent of the values shown in 4.5.5.1.

4.5.5.1 Qualification and conformance inspection. Apply test voltages as follows:

a. Circuits operated above 50 volts: Test voltage of twice the rated voltage plus 1,000 volts RMS for 60 seconds (1,250 volt test for 115 volt AC circuits and 1,500 volt test for 200 volt AC circuits).

b. Circuits operated at 50 volts or less: Test voltage of 500 volts RMS for 60 seconds. (Dielectric test voltages applied to electronic devices, noise filters, and capacitors shall not exceed 100 volts.)

4.5.5.2 Production lot inspection (manufacturer only). The following test voltages shall be used when generators are subjected to production lot inspection:

a. Circuits operated above 50 volts: Twice the rated voltage plus 1,200 volts RMS for one to two seconds.

b. Circuits operated at 50 volts or less: 600 volts RMS for one to two seconds.

4.5.6 Load and speed transients. Unless otherwise required by the specification sheet, testing of the combined effects of simultaneous load and speed transients is not required.

4.5.7 Voltage ripple and distortion (DC power source). In conjunction with the tests of 4.5.3, determine conformance to the requirements of 3.5.5.

4.5.8 Phase balance. Measure AC voltages, phase current, and phase angle displacement to determine conformance to the requirements of 3.5.3 as follows:

a. Normal operation load unbalance – In conjunction with tests of 4.5.3.1.e, determine conformance to 3.5.3.a. Conduct steps 1 through 4 of table III at nominal rated speed with loads at unity power factor and 0.75 lagging power factor. Repeat steps 1 through 4 at minimum rated speed and maximum rated speed. Conduct steps 5 through 7 of table III at nominal rated speed and unity power factor load. Air-cooled generators shall be operated in the self-cooled mode for steps 1 through 6 and blast-cooled mode for step 7, all of table III.

b. Emergency operation load unbalance – Conduct steps 8 through 10 of table III at nominal rated speed and unity power factor loads to determine conformance to 3.5.3.b. Air-cooled generators shall be operated in self-cooled mode.

c. Abnormal operation load unbalance – Conduct steps 11 through 15 of table III at nominal rated speed and unity power factor loads to determine conformance to 3.5.3.c. Air-cooled generators shall be operated in self-cooled mode.

4.5.9 Efficiency (heat rejection). With the generator operating at nominal speed, measure the generator system efficiency during continuous operation at 10, 60, 100, and 125 percent rated AC load conditions and verify conformance to the requirements of 3.4.9.5. Tests shall be repeated with the generator operating at the minimum speed and the maximum speed for rated AC power output. The generator efficiency measurement shall be accurate within 5 percent.

4.5.10 Short circuit capacity (AC and DC). In conjunction with the tests of 4.5.3 and 4.5.28, measure AC and DC power output (voltage and current) during short circuit fault applications to determine conformance to the requirements of 3.4.8.3 and 3.4.8.4.2. Each of the following short circuit faults shall be applied to the AC power source for 4 $\pm$ 1 seconds: (1) single-phase line-to-neutral short circuit; (2) two-phase line-to-neutral short circuit; (3) two-phase line-to-line short circuit; (4) three-phase line-to-neutral short circuit; and (5) three-phase line-to-line short circuit. Single-phase and two-phase short circuits shall be varied during the tests of 4.5.3.3.e and 4.5.28 so that a different phase (or phases) are loaded with each successive short circuit test. The generator shall be operated at no load for a minimum of 15 minutes between successive short circuit tests. For generator systems without current limit protection, short circuit AC overloads applied during testing may be limited to 250 percent of rated capacity to avoid damaging the generator.

4.5.11 Output AC voltage modulation. In conjunction with the steady state test conditions of 4.5.3, measure the modulation of AC phase voltage amplitude to determine conformance to the requirements of 3.5.2. Modulation shall be measured with shaft speed variation maintained within the range for constant speed operation (±0.2 percent rpm bandwidth).

4.5.12 Electromagnetic emissions and susceptibility. The generator system shall be in accordance with MIL-STD-461 specific requirements of CE102, CS101, CS114, CS115, CS116, RE102, and RS103 and executed as stated within MIL-STD-461. The power output feeders, including neutral, of the generator system shall comply with the CE102 requirement for power input leads, except that the emissions limit shall be relaxed by an additional 10dB. Generator systems intended for use on Army aircraft or Navy antisubmarine aircraft shall also be in accordance with these specific requirements of MIL-STD-461: CE101, RE101, and RS101. All tests shall be performed with the generator system operating at 10 percent and 100 percent of rated load conditions. Operation shall be at nominal speed. Coolant temperature for oil-cooled systems shall be within 20 °C of the maximum temperature for continuous operation. Tailoring of RE102 testing above 1 GHz shall be subject to qualifying activity approval. During electromagnetic susceptibility test, the AC and DC voltage regulation shall remain within the voltage limits of 3.5.1.1 and 3.5.1.2.

4.5.13 Voltage waveform distortion. In conjunction with the steady state test conditions of 4.5.3, measure AC voltage waveform distortion spectrum and crest factor to determine conformance to the requirements of 3.5.4.

4.5.14 Temperature-altitude. The temperature change rate shall be not greater than 1°C per second and pressure change rate shall be not greater than 0.5 inch of mercury per second when transitioning between temperature-altitude test conditions. Generator system components shall be de-energized during transition from one temperature-altitude condition to another. Measure component temperatures (cooling inlet, outlet and case) and generator output voltage during the temperature-altitude testing herein.

a. Air-cooled generator and control components – Determine conformance to the requirements of 3.4.2.1, 3.4.9.6.1, and 3.5.1. With the temperature (generator air inlet and ambient) and altitude at each condition specified herein, maintain generator operation at rated load and nominal speed for 30 minutes, or until generator temperature stabilization (see 4.4.8.2) is reached, whichever duration is greater. Generator system components shall be subjected to the above procedure with the following test conditions during self-cooled operation: (1) 52 °C at sea level; (2) 42 °C at 5,000 feet; (3) 32 °C at 10,000 feet; and (4) 12 °C at 20,000 feet. Control components shall be subjected to the following additional tests using the above procedure: (1) 71 °C at sea level; (2) 67 °C at 10,000 feet; and (3) 52 °C at 20,000 feet. Blast-cooled generator temperature-altitude testing shall be in accordance with the specification sheet.

b. Liquid-cooled generator system – Temperature-altitude testing for liquid-cooled generator systems shall be in accordance with the specification sheet.

4.5.15 Operating position. Determine conformance to 3.4.3 as follows:

a. Unless otherwise specified by the specification sheet, the generator shall be operated at nominal speed and rated load in each of the positions listed in table IV for the specified duration. Measure AC and DC voltages throughout this test to verify conformance to the voltage limits of 3.5.1. Unless otherwise required by the specification sheet, the pitch angles listed in table IV are measured from the horizontal position (generator rotational axis as the 0° pitch position). Roll angles listed in table IV are measured from the 0° roll position. The 0° roll position shall be as required by the specification sheet (if the 0° position is not identified by the specification sheet, the qualifying activity will select a 0° roll position).

b. Control components shall first be tested with the component mounted in the base down position or the normal mounting position required by the specification sheet. At periodic intervals (not less than 15 minutes), control components shall be rotated 90 degrees clockwise to the 90°, 180°, and 270° positions about the lateral and longitudinal axes (a total of six conditions for this test). This positioning of control components shall not cause the generator system performance to exceed specified regulation limits of 3.5.1.

4.5.16 Switch operation (control and reset functions). In conjunction with the tests of 4.5.3 and 4.5.17, the generator system response to control switch operation shall be monitored to verify conformance to the requirements of 3.4.7 and 3.5.7.

4.5.17 Protective functions. Determine conformance of the generator to 3.5.7 using the conditions given in 4.5.3 and the following methods:

a. Overvoltage protection – Using an adjustable three phase AC power supply, gradually increase the three AC phase voltages connected to the GCU POR sensing. Measure the voltage and trip time at which overvoltage protective function trip occurs and determine conformance to the requirements of 3.5.7.2. After decreasing the three AC phase voltages to 118.0 volts, perform a manual reset and determine conformance to the requirements of 3.4.7.1. Three phase AC overvoltages of 135, 150, 165, and 180 volts shall each be suddenly applied and trip times measured to determine conformance to the trip curve limits on figure 13 for class N or figure 14 for class W. Repeat this test with single-phase AC overvoltage conditions of 135, 150, 165, and 180 volts.

b. Undervoltage protection - Using an adjustable three phase AC power supply, gradually decrease the three AC phase voltages signals to the GCU POR sensing. Measure the voltage and trip time at which undervoltage protective function trip occurs and determine conformance to the requirements of 3.5.7.3. After increasing the three AC phase voltages to 112.5 volts, perform a manual reset and determine conformance to the requirements of 3.4.7.1. Three phase AC undervoltages of 100, 95, 75, and 50 volts shall each be suddenly applied and trip times measured to determine conformance to the trip curve limits on figure 13 for class N or figure 14 for class W. Repeat the test with single-phase AC undervoltage conditions of 100, 95, 75, and 50 volts.

c. Underfrequency protection - Gradually decrease the AC frequency signal to the GCU sensing. Measure the frequency and trip time at which underfrequency protective function trip occurs and determine conformance to the requirements of 3.5.7.4. Gradually increase the AC frequency signal and measure the frequency at which automatic reset occurs and determine conformance to the requirements of 3.4.7.2. Underfrequency conditions of 375 and 360 Hertz shall each be suddenly applied and trip times measured to determine conformance to the trip curve limits on figure 17 for class N or figure 18 for class W.

d. Overfrequency protection - For systems with overfrequency protection, gradually increase the AC frequency signal to the GCU sensing. Measure the frequency and trip time at which overfrequency protective function trip occurs and determine conformance to the requirements of 3.5.7.4. Gradually decrease the AC frequency signal and measure the frequency at which manual reset occurs and determine conformance to the requirements of 3.4.7. Overfrequency conditions shall be applied as required by the specification sheet.

e. Feeder fault protection - The three phase AC power feeder configuration shall be modified to cause a differential between the three phase current output of the generator terminals and the current flowing through the three phases of the CT assembly at the power connection to the load bus. Measure feeder fault current and trip time as single phase and multiple phase feeder fault conditions are suddenly applied to determine conformance to the requirements of 3.5.7.6.

4.5.18 Electrical disconnect (safety interlock). The electrical connector plug to the GCU shall be disengaged while the generator is operating to determine conformance to the requirements of 3.4.9.3.b. Unless otherwise required by the specification sheet, disconnect tests on generator connector plugs and power terminal feeder connections are not required.

4.5.19 Maximum generator torque. The fault impedance producing maximum torque demand by the generator shall be applied for five seconds with transient and steady state torques measured. The maximum torque measured shall not exceed the limit required by 3.4.9.2.3 of the specification sheet.

4.5.20 Salt-fog environment and oil-saltwater ingestion.

4.5.20.1 Salt-fog. Generator system components and mounting hardware shall be subjected to the MIL-STD-810, method 509. Unless otherwise required by the specification sheet, the duration of salt-fog exposure shall be 48 hours (see 6.6.2).

4.5.20.2 Oil-saltwater ingestion. Air cooled generators and fan cooled heat exchangers shall be subjected to following oil-saltwater ingestion test:

a. In preparation for test, generators shall be immersed longitudinally in MIL-PRF-23699 oil up to the bearings and the generator shall be rotated approximately 60° every 15 minutes. After 16 hours of immersion the generator shall be drained for one hour.

b. During the four hour test cycle, MIL-PRF-23699 engine oil shall be injected into the component cooling air at the rate of 5 milliliters per hour (ml/hr). During the first two hours of the cycle, synthetic sea water (as defined by MIL-STD-810, method 509) shall be continuously injected into the cooling air at the rate of 500 ml/hr. For the next ten minutes, fresh water shall be continuously injected into the cooling air at the rate of 750 milliliters per minute. For the last one hour and 50 minutes of the cycle, no water is to be injected into the cooling air. The generator shall be operated for one hour at each of the following load conditions during the four hour cycle: (1) no load at minimum rated speed; (2) 75 percent load at rated speed; (3) 75 percent load at maximum rated speed; and (4) 75 percent load at minimum rated speed.

c. Components cooled by ducted blast air shall be subjected to 25 cycles of 4.5.20.2.b. Components self-cooled by integral fan shall be subjected to 25 cycles of 4.5.20.2.b. At the completion of the test, components shall be operated and inspected. The generator AC output shall conform to voltage limits of 3.5.1.1 and there shall be no evidence of: (1) material degradation such as corrosion or blistering of paint; (2) binding or clogging of moving parts; (3) degradation of bearing seals/lubricant; or (4) degradation of electrical insulation.

4.5.21 Fungus. Generator system component testing shall be conducted in accordance with MIL-STD-810, method 508. A certificate signed by an individual authorized to speak for the manufacturer may by submitted in lieu of fungus testing with the approval of the qualifying activity. The certificate shall state that the generator system components are constructed of non-nutrient materials and do not use any organic material.

4.5.22 Sand and dust. The dust test is only required for components which are fan cooled, or vented to the environment. Unless otherwise required by the specification sheet, the sand ingestion testing is not required (MIL-STD-810, method 510, procedure II). Air-cooled generators and vented control components shall be subjected to a blowing dust test in accordance with MIL-STD-810, method 510, procedure I as follows:

a. Dust composition shall be silica flour.

b. For step 3 of procedure I, the test item shall be operated at no load for six hours at 23 °C (dust concentration of 0.3 ±0.2 gram per cubic foot and air velocity of 1,750 ±250 feet per minute). The chamber temperature shall be increased to 63 °C during step 4. For step 7, the test item shall be operated at no load for six hours at 63 °C (same blowing dust conditions as step 3).

c. Conduct steps 8 through 11 and verify conformance to 3.4.2.5 requirements.

4.5.23 Vibration. Generator system components shall withstand the vibration environment induced by aircraft operations, as simulated by the vibration tests herein. Generator packages shall be subjected to category 1 vibration levels and durations in accordance with 4.5.23.2 and 4.5.23.2.1. Non-engine mounted generator system components, including generator control units and current transformers, shall be subjected to vibration levels and durations for category 2, 3, or 4, as applicable. Vibration test level tolerances shall be in accordance with method 514 criteria of MIL-STD-810 (see 6.6.3.2). At the conclusion of the test, the generator system components shall be operated and inspected. After vibration exposure, component electrical performance shall be within specified limits and all component parts, connections and mounting hardware shall exhibit no evidence of cracking, rupture, or operational degradation.

4.5.23.1 Test fixture inspection and preparation. A vibration fixture survey shall be performed in accordance with MIL-STD-810, method 514using a dynamically equivalent test specimen. If a test specimen is not available, the actual component shall be used for the fixture survey (see 6.6.3.2). A sine sweep shall be performed: (1) after the fixture survey; (2) prior to each test excitation in the x, y, or z-axis; and (3) after each test excitation in the x, y, or z-axis. Examine each sine sweep to verify that no changes have occurred during the vibration testing in each orthogonal axis.

4.5.23.2 Vibration exposure level and duration. Components shall be subjected to vibration tests at the functional and endurance levels as required by the applicable equipment category (see 4.5.23.2.2.a, 4.5.23.2.2.b, 4.5.23.2.2.c, and 6.6.3). The exposure duration shall be one hour at both the functional level and the endurance level in each of the three orthogonal axes. The component shall be exposed to 30 minutes of vibration at the functional level, followed by 60 minutes (1 hour) of endurance level vibration, and then the final 30 minutes of functional level vibration for a total exposure time of 2 hours per axis. Unless otherwise required by the specification sheet, the endurance level vibration shall be 3 dB higher than the functional level. The generator shaft shall be rotating and control components shall be energized during vibration excitation at both the functional level and endurance level.

4.5.23.2.1 Test procedure for engine and gearbox mounted components. Using the vibration test spectrum on figure 4, conduct testing at the functional and endurance levels as specified in 4.5.23.2. Unless otherwise required by the specification sheet, the W_0 functional level shall be 0.30 g^2/Hz from 15 Hz to 2000 Hz (with a test monitoring value of 7.72 g RMS). The specific frequencies of the narrow band spike amplitudes shall be as required by the specification sheet. Unless otherwise required by the specification sheet, the functional level amplitude for narrow band spikes shall be 1.0 g^2/Hz. Spike bandwidth shall be ± 5 percent of the spike frequency (f_X).

4.5.23.2.2 Test procedure for non-engine mounted components.

a. Jet aircraft (category 2) – Using the vibration test spectrum on figure 5, conduct testing at the functional and endurance levels as specified in 4.5.23.2. Unless otherwise required by the specification sheet, the flat spectrum of the W_0 functional level shall be 0.20 g^2/Hz from 300 Hz to 1000 Hz (see table V).

b. Propeller aircraft (category 3) - Using the vibration test spectrum on figure 6, conduct testing at the functional and endurance levels as specified in 4.5.23.2. Unless otherwise required by the specification sheet, the L_0 magnitude of the first spike shall be 0.30 g^2/Hz. The magnitudes of the narrow band spike harmonics (L_1 - L_3) descend at a rate of 6 dB per octave. The spike amplitude frequencies (f_0 - f_3) shall be as required by the specification sheet. Spike bandwidth shall be ± 5 percent of each spike frequency (f_0 - f_3).

c. Helicopter rotary wing aircraft (category 4) - Using the vibration test spectrum on figure 7A, conduct testing at the functional and endurance levels as specified in 4.5.23.2. Unless otherwise required by the specification sheet, the flat spectrum of the W_0 functional level shall be 0.020 g^2/Hz and the upper frequency limit (f_{max}) of the spectrum shall be 2000 Hz. The peak sinusoid frequencies (f_X) and peak magnitudes (A_X) superimposed on the functional level spectrum shall be as required by the specification sheet (see table VI).

4.5.24 Shock. Generator system components shall be subjected to functional shock and crash hazard shock tests specified herein using the Shock Response Spectra (SRS) on figure 3. Prior to shock testing, calibration shocks shall be applied in accordance with MIL-STD-810, method 516. The following MIL-STD-810 tests shall be conducted in accordance with procedure I of method 516 for functional shock and procedure V of method 516 for crash hazard shock (see 6.6.4):

a. Functional shock - Unless otherwise required by the specification sheet, components shall be subjected to shock tests using the functional level spectrum on figure 3. Components shall be subjected to three shocks in each of the three orthogonal axes for a total of nine shocks at the functional level. A post-test functional check shall be performed after each axis functional test is completed. At the conclusion of the test, the component performance shall be within the specified limits of 3.5.1 and 3.5.7. There shall be no evidence of cracking, or rupture of any component part, connection, or mounting assembly.

b. Crash hazard shock - Unless otherwise required by the specification sheet, components shall be subjected to shock tests using the crash hazard level spectrum on figure 3. Components shall be subjected to two shocks in each of the three orthogonal axes for a total of six shocks at the crash hazard level. The components need not be operable after the crash safety test.

4.5.25 Humidity. Generator system components and mounting hardware shall be subjected to the humidity test in accordance with MIL-STD-810, method 507. Components shall be subjected to a 24-hour conditioning period, followed by seven cycles of the 48-hour aggravated temperature-humidity cycle. Control components shall be energized during the last 15 minutes of each 48-hour cycle. At the end of each cycle, determine generator system conformance to 3.5.1 at rated load under standard conditions (see 4.4). The inlet oil temperature for liquid cooled components shall be adjusted to the maximum temperature specified for rated AC output and the unit shall be operated for 30 minutes at full load. The generator control switch shall be cycled three times during this 30-minute period. At the conclusion of humidity test, the components shall be inspected and operated. There shall be no evidence of: (1) material degradation, such as blistering, swelling, physical distortion, or corrosion; (2) degradation of electrical insulation; or (3) degradation of mechanical/motive functions.

4.5.26 Rain intrusion. If testing is required, components shall be subjected to water intrusion testing in accordance with MIL-STD-810, method 506 and the specification sheet.

4.5.27 Contamination by fluids. Determine conformance to the requirements of 3.3.4 by test or by similarity (see 6.2.c). Contamination by fluids testing shall be conducted in accordance with MIL-STD-810, method 504 (see 6.5.6).

4.5.28 Endurance. Conduct the endurance test of 4.5.28.a and 4.5.28.b to determine conformance to the requirements of 3.4.2, 3.4.8, and 3.9. Air cooled and liquid cooled generator systems shall be subjected to the tests of 4.5.28.1 and 4.5.28.2, respectively. Tailoring of endurance test schedule requirements is subject to qualifying activity approval. The endurance test shall include application of the following overloads and short circuit conditions (see table VII):

a. Overloads of 3.4.8.2 shall be imposed randomly throughout the test, with 10 applications of five-minute AC overload and 10 applications of five-second AC overload. During one of the five-second AC overloads, a five-second DC overload (3.4.8.4.2.b) shall be applied to the DC power source simultaneously with the AC overload. The five-second and five-minute overloads shall be applied at 0.75 power factor.

b. Five-second faults shall be imposed on the AC and DC power sources during the test. Line-to-neutral short circuits (single-phase and three-phase) and line-to-line short circuits (two-phase) shall each be applied to the AC power source as specified in 4.5.3.3.e and 4.5.10. For generators without overcurrent protection, the fault impedance may be increased to prevent damage to the generator (fault current per phase limited to 250 percent of rated capacity). Short circuit faults shall also be applied to the DC power source, except that AC and DC fault overloads shall not be imposed simultaneously.

4.5.28.1 Air cooled components. Generator systems that are self-cooled on the ground and forced air cooled in flight shall be subjected to 35 cycles in the table VII test schedule. For generators used on aircraft with a ceiling altitude of 25,000 feet, change the values in table VII as follows: (1) altitude shall be 25K feet and airflow shall be 75 percent of rated capacity for steps 4, 11, and 19; and (2) air inlet temperature shall be -45 °C for Step 4, -25 °C for Step 11, and 0 °C for Step 19.

a. When transitioning from one test condition to another, the rate of temperature change shall not exceed 1 °C per second and the rate of altitude change shall not exceed 32 feet per second. During transition, the generator shall be operated at rated speed with the AC power source loaded at 10 percent of rated capacity and the DC power source loaded at 50 percent of rated capacity.

b. At the end of each cycle, reduce the input shaft speed to zero and shut down the generator system for a minimum of ten minutes. After every 5 cycles, the generator system shall be shut down until all components have stabilized temperatures at 23 ±10 °C.

c. Measure cooling airflow, air temperatures (inlet and outlet), and generator case temperature during the endurance test to determine conformance to 3.4.2.1.1 and 3.4.9.6.1.

4.5.28.2 Liquid cooled components. Component coolant shall be maintained at the specified flow rate with the coolant temperature required for each step in table VIII. The ambient temperature required for each step in table VIII shall be maintained around all control components. The ambient temperature need not be maintained around liquid cooled components, if thermal isolation of 4.4.8.1 is maintained during test. Liquid cooled generators and control components shall be operated for 25 cycles in the table VIII test schedule.

a. During each step of the test the generator input shaft shall be operated at the minimum input speed for rated AC power output the first 15 minutes, at nominal rated speed for 90 minutes, and at maximum input speed for rated AC power output for the last 15 minutes. At the end of each cycle, reduce the input shaft speed to zero and shut down the generator system for a minimum of ten minutes. After every 5 cycles, the generator system shall be shut down until all components have stabilized temperatures at 23 ± 10 °C.

b. Measure coolant pressure, pressure drop across the generator, and flow rate during endurance test to determine conformance to 3.4.2.1.2 and 3.4.9.6.2. Coolant leakage shall be observed throughout testing and conformance to 3.4.9.6.2.b shall be determined. Fluid from the generator outlet port (fluid return) and fluid drains shall be checked for debris from the generator to determine conformance to the fluid contamination requirements of 3.4.9.6.2d.

4.5.29 Loss of cooling. The following test shall be performed on one generator package after all other required tests have been completed:

a. Determine air-cooled generator conformance to the requirements of 3.4.9.6.1c. The AC power source shall be loaded at 50 percent rated capacity for self-cooled operation and the DC power source shall be loaded at full rated capacity for this test. Inlet air temperature shall be maintained at a temperature of 120 ±5 °C and the generator shall be operated in the self-cooled mode for a duration of 5 minutes.

b. Liquid cooled generators shall be subjected to coolant interruption and run dry tests in accordance with the specification sheet to determine conformance to the requirements of 3.4.9.6.2.c. The generator need not be operable at the conclusion of the run dry test.

4.5.30 Spline wear examination. At the conclusion of the other tests specified herein, inspect the generator drive shaft spline for visible damage. Measure spline dimensions to determine conformance to dimensional tolerances, as specified in the specification sheet.

4.5.31 Input shaft shear. Secure the anti-drive end of the spare drive shaft assembly and measure the torque on the spline shaft drive-end as torsional force is gradually increased until the shaft shear section breaks. Verify that the torque required to break the shear section is within torque range required by 3.4.9.2.3.

4.5.32 Explosive atmosphere. Determine conformance to the requirements of 3.4.4. Unless otherwise required by the specification sheet, components shall be subjected to the explosive atmosphere test in accordance with MIL-STD-810, method 511.

4.5.33 Toxicity and fire resistance. Determine conformance of component materials to the requirements of 3.3.5 by test or by similarity (see 6.2c). If testing is required, components shall be subjected to a flammability test in accordance with MIL-STD-202, method 111.

4.5.34 Coolant contamination. Liquid cooled generators shall demonstrate conformance to the coolant contamination requirements of the specification sheet (see 3.4.9.6.2d).

4.5.35 Acceleration (inertia loads). Unless otherwise required by the specification sheet, acceleration testing to MIL-STD-810, method 513 is not required. Components may be subjected to acceleration inertia loads testing as part of the aircraft demonstration.

4.5.36 Reliability and maintainability. If required by the specification sheet, reliability development testing shall be conducted.

5. PACKAGING

5.1 Packaging. For acquisition purposes, the packaging requirements shall be as specified in the contract or order (see 6.2 and 6.7). When packaging of materiel is to be performed by DoD or in-house contractor personnel, these personnel need to contact the responsible packaging activity to ascertain packaging requirements. Packaging requirements are maintained by the Inventory Control Point's packaging activities within the Military Service or Defense Agency, or within the military service's system commands. Packaging data retrieval is available from the managing Military Department's or Defense Agency's automated packaging files, CD-ROM products, or by contacting the responsible packaging activity.

6. NOTES

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

6.1 Intended use. The generator systems qualified to this specification are intended for use on aircraft as a primary source of three-phase AC power (400 Hz nominal) and as a limited source of 28 volt DC power used to control the electrical power distribution. The military operating environment and electrical performance requirements of this specification exceed the requirements used for commercial aircraft generator systems.

6.2 Acquisition requirements. Acquisition documents should specify the following:

a. Title, number, and date of the specification and applicable specification sheet.

b. Packaging requirements (see 5.1 and 6.7).

c. Contract provisions for acquisition of manufacturer's data (see 4.2.1) may include:

(1) Schedules for component design, development, and delivery;
(2) System and component wiring diagrams, schematics, outline drawings;
(3) List of parts, list of materials, functional descriptions, operating instructions, installation instructions, and servicing requirements (see 3.3, 3.4.8, and 3.4.9);
(4) Temperature, altitude, and coolant flow rate criteria correlated with generator output capacity using rating chart format (see figure 19);
(5) Measured aircraft data for vibration and shock analyses (see 6.6.3 and 6.6.4);
(6) Design analyses of maximum generator fault torque, material fatigue life, and generator thermal modeling (see 3.4.9);
(7) Contractor analyses of sneak circuits, failure modes and effects, parts stress, parts failure rate modeling, and reliability prediction (see 3.10);
(8) Stress screening test procedures, acceptance test procedures, manufacturer's test data, and qualification by similarity data (see 4.5.21, 4.5.27, and 4.5.33);
(9) Quality assurance data, manufacturing process controls, quality inspection criteria, configuration management data, engineering change processes, and parts traceability (see 3.12).

d. Acquisition documents may include aircraft demonstration requirements for generator system reliability and maintainability.

6.3 Qualification. With respect to products requiring qualification, awards will be made only for products which are, at the time of award of contract, qualified for inclusion in Qualified Products List QPL-21480 whether or not such products have actually been so listed by that date. The attention of the contractors is called to these requirements, and manufacturers are urged to arrange to have the products that they propose to offer to the Federal Government tested for qualification in order that they may be eligible to be awarded contracts or orders for the products covered by this specification. Information pertaining to qualification of products may be obtained from the Naval Air Systems Command (AIR-4.4.5.2), 48298 Shaw Road, Patuxent River, MD 20670-1900 or matthew.haney@navy.mil. An online listing of products qualified to this specification may be found in the Qualified Products Database (QPD) at https://assist.daps.dla.mil.

6.3.1 Provisions governing qualification. Qualification will be conducted in accordance with the provisions and guidelines of SD-6. Copies of this document are available online at https://assist.daps.dla.mil/quicksearch/ or https://assist.daps.dla.mil or from the Standardization Document Order Desk, 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111-5094.

6.3.2 Qualification sample submittal. Qualification submissions should be submitted to the qualifying activity. The qualifying activity will acquire three (3) complete generator systems and one spare generator package input shaft to conduct qualification tests. Additional generator systems may be acquired for flight test evaluation. Each generator system will be acquired with installation hardware and a mating connector plug for each receptacle.

6.4 Cross reference. All products that were qualified to MIL-G-21480A are considered qualified to Class W of MIL-PRF-21480B.

6.5 Standard design practices. The following paragraphs contain design guidelines based on actual experience that should be considered by the manufacturer when a constant speed AC generator system is to be developed to meet the performance requirements of this specification.

6.5.1 Materials and structural design. Military standard parts are desired. Commercial industry parts, such as screws, bolts, nuts and washers, may be used provided that performance requirements are met under all specified operating conditions and environments.

6.5.1.1 Recycled, recovered, or environmentally preferable materials. The use of toxic chemicals, hazardous substances, and ozone depleting chemicals should be avoided in the preparation and production of equipment. Recycled, recovered, or environmentally preferable materials should be used to the maximum extent possible provided that the material meets or exceeds the operational and maintenance requirements, and promotes economically advantageous life cycle costs. Information regarding toxic chemicals, hazardous substances, and ozone depleting substances can be found at the Environmental Protection Agency Web site at http://www.epa.gov.

6.5.1.2 Corrosion. Corrosion resistance treatments for aluminum alloy materials are provided in MIL-A-8625. Corrosion protection methods for magnesium alloy materials are provided in SAE-AMS-M-3171.

6.5.1.3 Fasteners, inserts, and retaining hardware. Screws, fasteners, and inserts should be selected using industry standard NASM 1515 for guidance.

6.5.1.4 Bearing installation and lubrication. Steel sleeve bearing inserts are recommended when bearing support structure is made of non-ferrous material. The outer ring for each shaft bearing should be retained axially and should have a locking method to prevent rotation. Bearing inner rings should rotate with the drive shaft. The locking methods for the inner and outer bearing rings should allow for generator thermal expansion differentials. The grease type selected for bearing lubrication should withstand continuous operation at bearing temperatures from -40 °C to 205 °C.

6.5.2 Electrical and electronics design.

6.5.2.1 Wiring and distribution. External electrical wiring for power distribution, component interconnection and system control should conform to SAE-AS22759. Load contactor relays should conform to MIL-PRF-6106 standards. Power feeder sizes should be selected using SAE-AS50881 guidelines for conductor current-carrying capacity. Externally mounted connector receptacles should be environment resistant conforming to MIL-DTL-83723 (Series III), SAE-AS50151, or equivalent.

6.5.2.2 Electronics internal wiring and electric connections. Printed circuit board design criteria are provided in MIL-PRF-31032, MIL-HDBK-1547, MIL-HDBK-1861, and industry standards IPC-2221 and IPC-2222. Guidelines 1, 10, and 69 of MIL-HDBK-454 provide design guidance on internal wiring, connectors, and receptacles.

6.5.2.3 Electronics (semiconductors, resistors, capacitors, transformers, and relays). MIL-STD-750 and MIL-PRF-19500 provide guidance on the application and qualification of semiconductor devices. MIL-HDBK-199 provides guidance on resistor selection. Adjustable resistors conforming to MIL-PRF-39015 are preferred. MIL-HDBK-198 provides guidance on capacitor selection. Wet slug tantalum capacitors are not recommended for high reliability designs. MIL-STD-981 provides guidance on transformer and coil design. MIL-HDBK-454, guideline 57 provides guidance on relay selection.

6.5.2.4 Microelectronic devices. Microelectronic devices should be selected in accordance with MIL-HDBK-454, guideline 64. Microelectronic devices qualified to MIL-STD-883 are preferred. Static discharge control should be in accordance with MIL-STD-1686, or equivalent industry standards (such as EIA-625).

6.5.3 Parts de-rating. SD-18 electronics parts de-rating criteria and lessons learned concerning materials, processes, and reliability are available at the Web site (www.crane.navy.mil/sd18/default.htm).

6.5.4 Reliability. MIL-STD-790, MIL-HDBK-217, and MIL-HDBK-251 provide guidance on established reliability and reliability prediction. Slip rings and brush type electrical conductors should not be used in AC generator designs.

6.5.5 Identification markings. MIL-STD-130, MIL-STD-1285, and MIL-HDBK-1812 provide guidelines for identification marking of equipment and parts.

6.5.6 Oil, fuel, and hydraulic fluids. Generator system qualification tests should be conducted with the same oil type as specified for the aircraft installation (MIL-PRF-23699, MIL-PRF-7808, and DOD-PRF-85734). The aviation fluid exposure test of 4.5.27 should include the oils listed herein and other fluids including MIL-PRF-5606, MIL-DTL-5624, MIL-PRF-8188, MIL-DTL-83133, and MIL-PRF-87257.

6.6 Environmental requirements tailoring.

6.6.1 Temperature altitude. Under extreme high temperature conditions (curves A and B on figure 2), air-cooled generator overload capacity for five-minute and five-second output may be reduced in proportion to the percent of continuous capacity de-rating (see 3.4.9.6.1).

6.6.2 Salt-fog (corrosion resistance). The MIL-STD-810 salt-fog test (method 509) is used to determine the corrosion resistance effectiveness of undamaged metal coatings and finishes. The salt-fog test is also used to determine the effect of salt deposits on physical operation and electrical characteristics (see 4.5.20.1).

6.6.3 Vibration. MIL-STD-810 tailoring guidelines of Method 514 recommend the use of measured aircraft vibration data for developing vibration test levels. Measured data for aircraft platform vibration may be available from the cognizant aircraft program office. Method 519 provides tailoring guidelines for developing gunfire vibration exposure levels. MIL-STD-810 also provides guidelines for endurance testing using life cycle environmental test profiles (see MIL-HDBK-781 for examples) and accelerated vibration levels.

6.6.3.1 Vibration test fixture. Where impedance mismatch between platform/material and laboratory vibration exciter/test item are significantly different, force control or acceleration limiting control strategies may be required to avoid unrealistically severe vibration response. If a dynamically equivalent test specimen is not available for the vibration fixture survey, then the actual component may be utilized provided the evaluation level does not exceed 20 percent of the actual RMS random specified value or 1 g (peak) when running sine vibration.

6.6.3.2 Vibration spectrum exposure level and duration (see 4.5.23.2).

a. Engine vibration (category 1) - Rotating components of engines and gearboxes are typical vibration sources. For components mounted on engines (and engine-driven gearboxes), the vibration spectrum shown on figure 4 consists of a flat broadband random background level with four narrow band spikes superimposed on the broadband level. The narrow band spikes are related to the fundamental and harmonic frequencies of the propulsion system rotating components.

b. Jet aircraft vibration (category 2) – For components mounted in jet aircraft, the vibration spectrum shown on figure 5 consists of a broadband random envelope from 15 Hz to 2000 Hz. The W_0 default value for functional level vibration (0.20 g^2/Hz) is listed in table V. The W_1 default value for endurance level vibration is 0.40 g^2/Hz (3dB above W_0).

c. Propeller aircraft vibration (category 3) – For components mounted in propeller aircraft, the vibration spectrum consists of a flat broadband random level of 0.01 g^2/Hz from 15 Hz to 2000 Hz, with four narrow band spikes superimposed on the broadband level. The four narrow band spikes are associated with the propeller blade passage frequency (f_0) and harmonics. Blade passage frequency is the propeller RPM multiplied by the number of prop blades. The 0.30 g^2/Hz narrow band spike magnitude (L_0) specified in 4.5.23.2.2b is for equipment mounted in the fuselage or wing. For components mounted in the engine compartment, the L_0 magnitude should be increased to 0.60 g^2/Hz, or greater.

d. Helicopter rotary wing vibration (category 4) - For components mounted near the helicopter rotors/drive train, the vibration spectrum consists of a broadband random envelope from 10 Hz to 2000 Hz, with superimposed sinusoidal peaks. The superimposed sinusoidal peaks result from the major rotating components, such as the main rotor and tail rotor. The frequencies and amplitudes of the peak sinusoids are specific to each type of rotary wing aircraft and component location (see figure 7B). The superimposed peak amplitudes and frequencies depend on the dominant vibration source (main rotor, drive train, and tail rotor). If multiple vibration sources are dominant for a component location, then additional peak sinusoids may be required. For components mounted outside the zone for dominant source vibration, the W_0 level may be decreased to 0.01 g^2/Hz and the upper frequency limit ($f_{\mathbf{max}}$) may be decreased to 500 Hz.

6.6.4 Shock. MIL-STD-810, method 516 provides criteria for developing SRS using measured platform data (see 4.5.24). When SRS test facilities are not available, functional shock and crash hazard shock tests may be conducted using the terminal peak saw-tooth pulse method.

6.7 Packaging. Preservation and packaging should be in accordance with level A or B of MIL-STD-2073-1, as specified by the contract.

6.8 Definitions. The definitions in MIL-STD-704, MIL-STD-810, and MIL-STD-461 will apply in addition to those definitions cited herein. Normal operation and abnormal operation characteristics for aircraft electrical systems are defined in MIL-STD-704, including definitions of transient and steady state conditions for voltage and frequency.

6.8.1 Constant speed operation. For measurement of steady-state characteristics, speed variation of the generator drive is maintained within an rpm bandwidth of ±0.2 percent of the average speed.

6.8.2 Control switch. Switch functions for configurations as follows:

a. Type I - Two-position switch (preferred for new design):

ON (center position) - In this switch position, the GLC is energized and AC power is connected to the main load bus when the electrical characteristics are within prescribed limits. The warning indicator is de-activated (de-energized), unless the generator is not providing power to the bus (GLC fails to close). Protective circuits are operative.

OFF-RESET (down position) - In this position, the AC power source is electrically de-energized and the GLC is open. Protective circuits are reset. The warning indicator is activated.

b. Type II - Three-position switch:

ON (center position) - In this switch position, the GLC is energized and AC power is connected to the bus when the electrical characteristics are within prescribed limits. The warning indicator is de-activated, unless the generator is not providing power to the bus. Protective circuits are operative.

OFF (down position) - In this position, the AC power source is electrically de-energized and the GLC is open. Protective circuits are reset. The warning indicator is activated.

RESET (momentary up position) - The GLC is opened and protective circuits are reset when the switch is held momentarily in this position. The switch returns to the ON position when released.

c. Type III - Three-position switch alternative (ON, OFF-RESET, and TEST positions) with TEST function as follows:

TEST (momentary position) - The AC power source is energized with the GLC open. Protective circuits are operative. The warning indicator is de-activated if the power characteristics are within the protective limits for normal operation, otherwise the warning indicator is activated.

6.8.3 Crest factor. The absolute value of the peak voltage to the RMS voltage for each half cycle of the AC voltage waveform.

6.8.4 Current transformer. Current sensing devices used to measure to AC phase current. Three phase current transformers located at the generator and the load bus used to measure phase current differential for sensing feeder fault current.

6.8.5 Efficiency. The ratio of generator electrical power output to the shaft power input.

6.8.6 Faults. Line-to-neutral or line-to-line electrical shorts occurring on single or multiple phases of the AC power feeders between the generator package terminals and the POR are generator feeder faults. Line-to-neutral or line-to-line shorts (single phase or multiple phase) between the POR (load bus) and aircraft electrical loads are distribution system faults.

6.8.7 Generator speed range. For Class W steady-state conditions, the typical speed range for rated output is ±5 percent of nominal speed (400 ±20 Hz). For class N steady-state, the typical range for rated output is ±2 percent of nominal speed (400 ±7 Hz). Under normal operation, the typical transient speed excursion is ±8 percent for class W (400 ±30 Hz) and ±6 percent for class N (400 ±25 Hz).

6.8.8 Generator system (channel). The generator system components and interconnected wiring required to generate, regulate, monitor, and deliver electric power to the POR when input shaft is mechanically driven. Multiple generator systems may be connected to the aircraft power distribution system.

6.8.9 Generator system component. Any generator system component removable from the aircraft as a unit, such as the generator package, generator control unit, and remote current transformer. The generator package comprises the generator plus any attached integral components.

6.8.10 Generator voltage rating. A voltage rating of 115/200 volts indicates an RMS line to neutral phase voltage of 115 volts RMS and line-to-line voltage of 200 volts RMS.

6.8.11 Integral control power. The typical generator design contains a Permanent Magnet Generator (PMG) consisting of a permanent magnet rotor and stator integrated with the main generator package. The PMG supplies integral control power to the GCU for excitation, regulation, and protection of the main AC power source and regulated DC power for control of external load contactors.

6.8.12 Phase current. The line-to-neutral currents of a three-phase wye-connected generator, measured in amperes RMS.

6.8.13 Phase load unbalance. The difference between the maximum AC phase current and minimum AC phase current (of the three phases), represented as a percentage of the single phase rated current capacity. Calculate percent load unbalance by subtracting the minimum phase current from the maximum phase current in amperes RMS, then divide the resulting value by the power source's rated single phase current capacity (amperes RMS) and multiply by 100. Phase load unbalance of 3 percent, or less, is defined as balanced load. Phase load unbalance of up to 15 percent may occur during normal aircraft operation.

6.8.14 Phase voltage. The line-to-neutral voltages of a three phase wye-connected generator. Steady state phase voltage is typically measured using the RMS value of the phase voltage averaged over a period of time. The phase voltage amplitude is measured as the peak instantaneous voltage of the phase voltage half-sine wave.

6.8.15 Phase voltage unbalance. The difference between the maximum and minimum AC phase voltage magnitudes of the three AC phase voltages (measured at the POR).

6.8.16 Point of regulation (POR). The point at which a power source regulates the channel voltage and where power characteristics are measured. For the AC power source, the POR is typically where the channel feeders are attached to the GLC for connection to the primary bus. The POR for DC power is typically the DC output terminals of the GCU.

6.8.17 Slash rating. Existing generator specification sheets may use a slash rating consisting of two numbers separated by a forward slash. The first number indicates the rating on which overload capacity is based (150 percent for five-minute rating and 200 percent for five-second rating). The second number is the full capacity for continuous operation (nominal rating). For example, a generator slash rating of 60/75 kVA indicates a continuous rating of 75 kVA, with overload ratings of 90 kVA for five minutes (150 percent) and 120 kVA for five seconds (200 percent). For air-cooled generators, the nominal rating should be the continuous self-cooled capacity during hot day operation at sea level, with air inlet temperature of 52 °C (125.6 °F).

6.8.18 Voltage modulation. The difference between the maximum and minimum AC phase voltage amplitude to occur in a one second interval under steady state conditions. Phase voltage amplitude of each half-sine wave may be measured in volts RMS or as the absolute value of the peak voltage.

6.8.19 Waveform distortion. The AC distortion factor is the ratio of the AC distortion to the RMS value of the fundamental component. The DC distortion factor is the ratio of the DC distortion to the average DC voltage.

6.9 Subject term (key word) listing.

Internal power control
Power source
Slash rating
Voltage

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

6.11 Specification sheet requirements. Specification sheets define the performance, design, interface, test, qualification, etc. requirements for a specific generator system and its components. The paragraphs and tables listed in table IX require information to be provided in the specification sheet and provide the minimum requirements to define the specific generator system. The following applies: Paragraphs with an X in the “As Required By” column will either have a default value given in this specification or must have a value or requirement given in the specification sheet. Paragraphs with an X in the “Unless Otherwise Specified” column will have the requirement or value given only in the specification sheet, if it is required.

TABLE I. Inspection schedules (qualification and conformance).

Inspection title (Examination and test)	Requirement paragraph	Test paragraph	Qualification sample				Conformance inspection
			1	2	3	4	
Examination of product	3.4.5 and 3.4.9.2	4.5.1	X	X	X	X	X
Dielectric strength	3.4.1	4.5.5	X	X			X
Maximum speed for regulation	3.4.9.1.1	4.5.2	X				
Electrical performance	3.4.8 and 3.5	4.5.3	X	X	X		X
Output AC voltage modulation	3.5.2	4.5.11	X		X		X
Phase balance	3.5.3	4.5.8	X	X	X		
Voltage waveform distortion	3.5.4	4.5.13	X	X	X		X
Voltage ripple and DC distortion (DC power source)	3.5.5	4.5.7	X	X	X		X
Switch operation (control and reset functions)	3.4.7	4.5.16	X	X	X	X	X
Protective functions	3.4.7 and 3.5.7	4.5.17	X	X	X	X	X
Electrical disconnect (safety interlock)	3.4.9.3.c	4.5.18		X			
Efficiency (heat rejection)	3.4.9.5	4.5.9		X			
Short circuit capacity (AC and DC)	3.4.8	4.5.10	X	X			
Electromagnetic emissions and susceptibility	3.5.8	4.5.12			X		* 1/
Temperature-altitude	3.4.2.1	4.5.14		X			* 1/
Operating position	3.4.3	4.5.15	X				
Max generator torque	3.4.9.2.3	4.5.19		X			
Salt-fog and oil-saltwater ingestion	3.4.2.3	4.5.20	X				* 1/
Fungus (if test required)	3.4.2.4	4.5.21	X				
Sand and dust	3.4.2.5	4.5.22	X				* 1/
Shock (functional)	3.4.2.6	4.5.24.a		X			* 1/
Humidity	3.4.2.2	4.5.25			X		* 1/
Vibration	3.4.2.7	4.5.23			X		* 1/
Rain intrusion (if required)	3.4.2.9	4.5.26			X		
Fluid effects (if required)	3.3.4	4.5.27			X		
Endurance (See 2/)	3.9	4.5.28	X	X			
Overspeed	3.4.9.1.2	4.5.4		X			
Loss of cooling	3.4.9.6	4.5.29		X			
Spline wear examination	3.4.9.2.1	4.5.30	X	X	X		X
Shaft shear (spare shaft)	3.4.9.2.2	4.5.31					
Explosive atmosphere	3.4.4	4.5.32			X		
Toxicity and fire resistance (if required)	3.3.5	4.5.33			X		
Fluid contamination (if required)	3.4.9.6.2	4.5.34	X	X			X

TABLE I. Inspection schedules (qualification and conformance) - Continued.

Inspection title (Examination and test)	Requirement paragraph	Test paragraph	Qualification sample				Conformance inspection
			1	2	3	4	
Crash hazard shock	3.4.2.6	4.5.24b		X			
Acceleration test (inertial loads)	3.4.2.8	4.5.35				X	
Reliability and Maintainability	3.10 and 3.11	4.5.36				X	

1/ The qualifying activity may conduct all of the environmental tests (*) on a conformance inspection sample, or the environmental inspection may be limited to selected tests.

2/ The 1000 hour endurance test may be conducted on two qualification samples, with each sample subjected to a minimum of 500 hours of endurance.

TABLE II. Electrical performance test conditions (see 4.5.3.1b).

Test	Input speed	Operating mode	Percent of rated AC load	Power factor	Footnotes
1	Nominal	Continuous	10	1.00	
2		Continuous	60		
3		Continuous	100		
4		Five-minute	*		1/
5		Five-second	**		2/
6	Max rated	Continuous	10	1.00	
7		Continuous	60		
8		Continuous	100		
9		Five-minute	*		1/
10		Five-second	**		2/
11	Min rated	Continuous	10	1.00	
12		Continuous	60		
13		Continuous	100		
14		Five-minute	*		1/
15		Five-second	**		2/
16	Nominal	Continuous	10	0.75	
17		Continuous	60		
18		Continuous	100		
19		Five-minute	*		1/
20		Five-second	**		2/
21	Max rated	Continuous	10	0.75	
22		Continuous	60		
23		Continuous	100		
24		Five-minute	*		1/
25		Five-second	**		2/
11	Min rated	Continuous	40	0.75	
12		Continuous	0		
13		Continuous	0		
14		Five-minute	*		1/
15		Five-second	**		2/

1/ Five-minute overload capacity (*) as required by 3.4.8.2 of the specification.

2/ Five-second overload capacity (**) as required by 3.4.8.2 of the specification.

TABLE III. Phase unbalance test conditions (see 4.5.3e and 4.5.8).

Step	Operating Mode	Phase Current (% of rated output) A-N	B-N	C-N	Foot-notes
1	Continuous	0	0	0	1/
2	Continuous	15	0	0	1/
3	Continuous	60	75	60	1/
4	Continuous	85	85	100	1/
5	5-minute	(A)	(B)	(B)	1/
6	5-second	(D)	(C)	(D)	1/
7	Continuous	(F)	(F)	(E)	2/
8	Emergency	30	0	0	
9	Emergency	10	40	10	
10	Emergency	70	70	100	
11	Abnormal	40	0	0	
12	Abnormal	0	60	0	
13	Abnormal	0	0	100	
14	Abnormal	60	60	0	
15	Abnormal	0	100	100	

1/ For step 5, value (A) is equal to the generator single-phase capacity for 5-minute overload operation. Obtain value (B) by subtracting value (X) from value (A). For step 6, value (C) is equal to the single-phase capacity for 5-second overload operation. Obtain value (D) by subtracting value (X) from value (C). Value (X) is equal to 15 percent of the single-phase rated current.

2/ Value (E) is equal to the single-phase rated current for blast-cooled operation. Obtain value (F) by subtracting value (X) from value (E). Value (X) is equal to 15 percent of the single-phase rated current for self-cooled operation.

TABLE IV. Test schedule for generator package attitude/duration (see 4.5.15a).

Step 1/	Pitch (±1°) 2/	Roll (±1°)	Duration (minutes)
1	+15	+10	60
2	+15	0	60
3	+15	-10	60
4	-10	+10	60
5	-10	0	60
6	-10	-10	60
7	0	+20	5
8	0	-20	5
9	+60	+10	5
10	+60	0	5
11	+60	-10	5
12	-45	+10	5
13	-45	0	5
14	-45	-10	5
15	-90	0	0.5
16	+90	0	0.5
17	-30	+90	0.5
18	-30	-90	0.5
19	+30	+90	0.5
20	+30	-90	0.5
21 3/	0	180	0.5

1/ Only steps 2, 5, 10, 13, 15, and 16 are required for air-cooled generator test.

2/ All pitch angles are with respect to the generator rotational axis. Roll angles are measured from the 0° roll angle indicated by the specification sheet.

3/ In Step 21, the 30-second test for generator operation in the inverted position (0° pitch/180° roll) is also used to simulate negative G conditions. Other test steps assume a gravitational force of 1 G on the generator under test.

TABLE V. Jet aircraft vibration exposure (see 4.5.23.2.2a and 4.5.23.2.2c).

VIBRATION LEVEL (acceleration spectral density in g^2/Hz): $W_0 = W_A + \Sigma (W_J)$	
VIBRATION INDUCED BY AERODYNAMICS: $W_A = a \times b \times c \times (q)^2$	
VIBRATION INDUCED BY JET ENGINE NOISE: $W_J = \{[0.48 \times a \times d \times \cos^2 (\theta_n)/R_n] \times [DC \times (V_c / V_r)^3 + D_f \times (V_f / V_r)^3]\}$	
FUNCTIONAL LEVEL (W_0 default value for jet aircraft): $W_0 = 0.20\ g^2/Hz$	
FACTORS:	
a	Interaction between aircraft platform and component (equation defined in MIL-STD-810; a = 1.0 for components weighing less than 36 kilograms)
b	Proportionality between vibration level and dynamic pressure (MIL-STD-810 equation: $b = 6.11 \times 10^{-5}$)
c	Mach number correction (c = 1.0 for Mach ≤ 0.9; factor c for Mach > 0.9 defined in MIL-STD-810)
q	Flight dynamic pressure (dynamic pressure equation defined in Annex C of method 514, per MIL-STD-810)
d	Engine afterburner (d = 1.0 without afterburner / d = 4.0 with afterburner)
R_n	Vector distance from center of each engine's exhaust plane to component's center of gravity (SI units: meters)
θ_n	Angle between R vector and engine exhaust vector, aft along engine exhaust centerline (Use $\theta_n = 70°$, if θ is between 70° and 180°)
DC	Engine core exhaust diameter (SI units: meters)
D_f	Engine fan exhaust diameter (SI units: meters)
V_r	Reference exhaust velocity (SI units: meters / second)
V_c	Engine core exhaust velocity, without afterburner (SI units: meters / second)
V_f	Engine fan exhaust velocity, without afterburner (SI units: meters / second)
$\Sigma (W_J)$	For multi-engine aircraft, add the W_J value for each engine to the sum total
NOTE: See MIL-STD-810 for guidance on detailed calculations and factor analyses.	

TABLE VI. Helicopter vibration exposure (see 4.5.23.2.2c).

Random vibration spectrum	Peak amplitude (A_X) / Source frequency (f_X)	
	FREQUENCY RANGE - Hz	PEAK SINE ACCELERATION - g
$W_0 = 0.020\ g^2/Hz$ $f_{min} = 10$ Hz $f_{max} = 2000$ Hz	3 to 5	$A_X = 0.70 \div (10.70 - f_X)$
	5 to 50	$A_X = 0.10 \times f_X$
	50 to 2000	$A_X = 5.00 + (0.01 \times f_X)$

Rotor rotation speed / frequency (Hz)			Drive train rotation (Hz)	
Source	Main rotor (f_X)	Tail rotor (f_X)	Source	Drive train
Fundamental	$f_1 = 1P$	$f_5 = 1T$	Fundamental	$f_{(X)} = 1S$
Blade passage	$f_2 = n \times 1P$	$f_6 = m \times 1T$	1st harmonic	$f_{(X)} = 2 \times 1S$
1st harmonic	$f_3 = 2 \times n \times 1P$	$f_7 = 2 \times m \times 1T$	2nd harmonic	$f_{(X)} = 3 \times 1S$
2nd harmonic	$f_4 = 3 \times n \times 1P$	$f_8 = 3 \times m \times 1T$	3nd harmonic	$f_{(X)} = 4 \times 1S$

Factors

1P	Helicopter main rotor shaft rotation speed
n	Number of main rotor blades
1T	Helicopter tail rotor shaft rotation speed
m	Number of tail rotor blades
1S	Drive train component rotation speed
n	Number of main rotor blades

TABLE VI. Helicopter vibration exposure (see 4.5.23.2.2c) – Continued.

Single main rotor platforms	Main rotor (1P)	Main blades (n)	Tail rotor (1T)	Tail blades (m)
H-53	3.0 Hz	7	11.7 Hz	4
H-60	4.3 Hz	4	19.8 Hz	4
Dual main rotor platforms	Main rotors (1P)	Main blades (n)	Drive train (1S)	Shaft
H-46	4.4 Hz	3	42.7 Hz	Synchro shaft
V-22 (Hover)	6.6 Hz	3	110.0 Hz	Cross-tie shafts

TABLE VII. Endurance schedule for air cooled generator systems (see 4.5.14a and 4.5.28.1).

Step	Time (Minutes)	Input Speed	Altitude (1,000 feet)	Temperature (°C) Generator (Air Inlet)	Temperature (°C) GCU (Ambient)	Cooling Mode	Percent of rated airflow	Percent of rated AC load	Foot - notes
1	30	Min rated	Sea level	0	0	Self	n/a	100	1/
2	30	Nominal	5	-10	-5	Self	n/a	100	1/
3	120	Nominal	15	-30	-15	Blast	100	100	
4	60	Nominal	35	-65	-35	Blast	100	100	2/
5	60	Nominal	20	-40	-20	Blast	100	100	
6	120	Nominal	10	-20	-10	Blast	100	100	
7	30	Max rated	5	-10	-5	Self	n/a	100	
8	30	Min rated	Sea level	25	35	Self	n/a	100	1/
9	30	Nominal	5	15	30	Self	n/a	100	1/
10	240	Nominal	15	-5	20	Blast	100	100	
11	60	Nominal	35	-45	-5	Blast	100	100	2/
12	60	Nominal	20	-20	15	Blast	100	100	
13	240	Nominal	10	5	25	Blast	100	100	
14	30	Max rated	5	15	30	Self	n/a	100	1/
15	15	Min rated	Sea level	80	* 3/	Self	n/a	60	1/
16	30	Nominal	Sea level	52	* 3/	Self	n/a	100	1/
17	30	Nominal	5	40	* 3/	Self	n/a	100	1/
18	120	Nominal	15	20	* 3/	Blast	100	100	
19	60	Nominal	35	-20	* 3/	Blast	100	100	2/
20	60	Nominal	20	10	* 3/	Blast	100	100	
21	120	Nominal	10	30	* 3/	Blast	100	100	
22	30	Max rated	5	40	* 3/	Self	n/a	100	1/

1/ Column 9 values (Percent of Rated AC Load) based on self-cooled rating. Blast air provided at altitudes above 5K feet.

2/ For generators with aircraft ceiling altitude of 25K feet, modify conditions of Steps 4, 11, and 19 (see 4.5.28.1).

3/ Hot Day GCU ambient temperatures (*) from Curve A or B on figure 1, as required by the specification sheet.

TABLE VIII. Endurance schedule for liquid cooled generator systems (see 4.5.28.2).

Step	Time (minutes)	Input speed	Altitude (1,000 feet)	Coolant temperature at inlet (°C)	Coolant flow & pressure drop	Ambient air temperature (°C) (Generator)	Ambient air temperature (°C) (GCU)	Percent of rated AC load
1	120	1/	2/	3/	5/	6/	7/	100
2	120	1/	2/	50 ± 10°	5/	60 ± 10°	25 ± 10°	50
3	120	1/	2/	3/	5/	6/	7/	70
4	120	1/	2/	50 ± 10°	5/	60 ± 0°	25 ± 10°	20
5	5	1/	2/	(Over-temp.) 4/	5/	6/	7/	100
6	120	1/	2/	70 ± 10°	5/	80 ± 10°	40 ± 10°	50
7	120	1/	2/	3/	5/	6/	7/	70
8	120	1/	2/	70 ± 10°	5/	80 ± 10°	40 ± 10°	20
9	120	1/	2/	3/	5/	6/	7/	100

1/ Unless otherwise required by the specification sheet, the input speed shall be in accordance with 4.5.28.2(a).

2/ Altitude for generator and control components, as required by the specification sheet.

3/ Maintain generator coolant temperature at maximum temperature for continuous operation, as required by the specification sheet.

4/ Maintain generator coolant temperature at maximum temperature for five-minute operation, as required by the specification sheet.

5/ Coolant flow, inlet pressure, and pressure drop, as required by the specification sheet.

6/ Generator ambient air at maximum temperature, as required by the specification sheet.

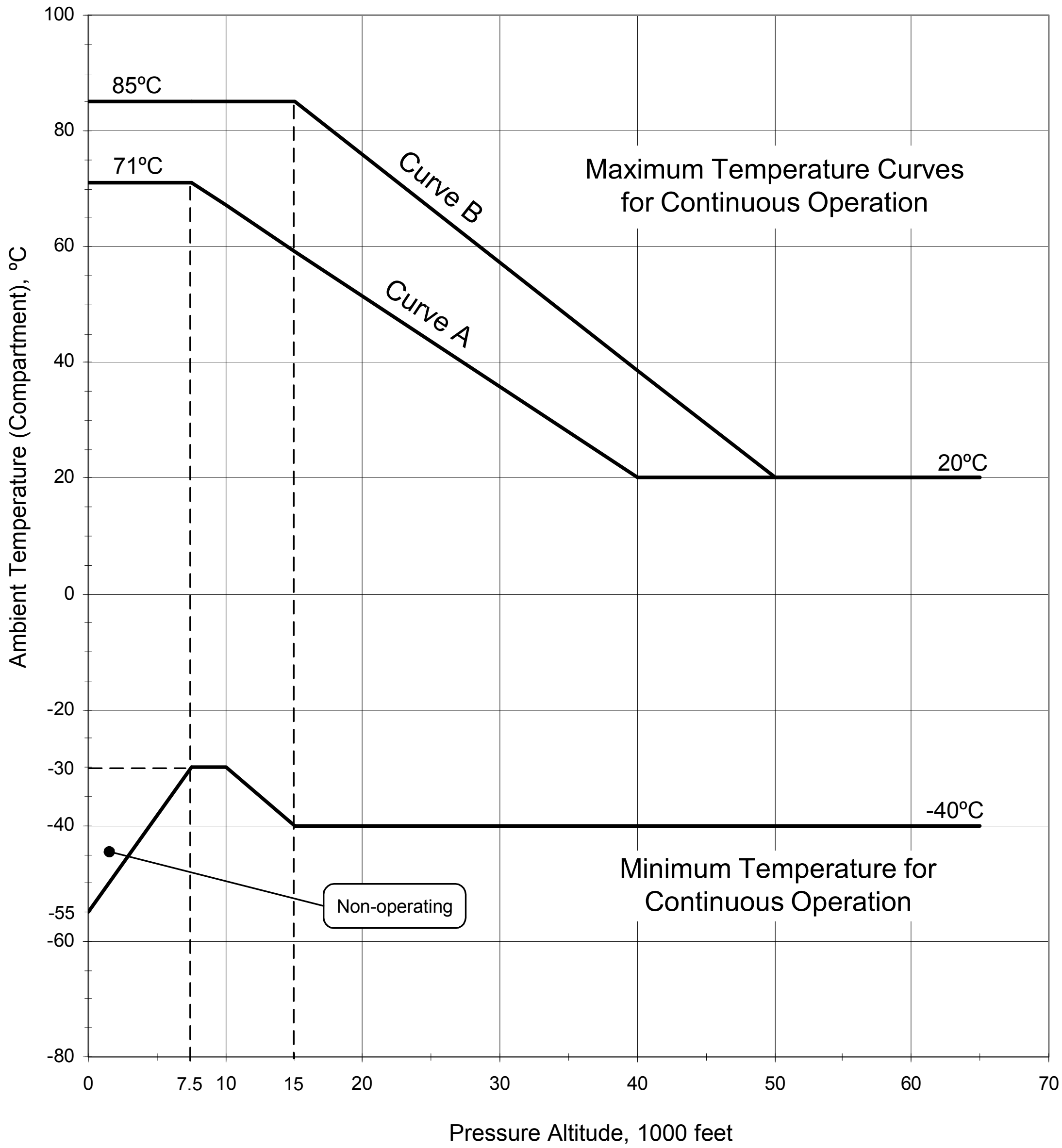
7/ Coolant component ambient at maximum temperatures for GCU and CTs, as required by the specification sheet.

TABLE IX. Specification sheet requirements (see 6.11).

MIL-PRF-21480 paragraph	As required by	Unless otherwise specified
3.4.2.1.1		x
3.4.2.1.2		x
3.4.2.7.1	x	
3.4.2.7.2b	x	
3.4.2.7.2c	x	
3.4.2.9	x	x
3.4.2.10		x
3.4.2.11		x
3.4.3		x
3.4.5	x	
3.4.6		x
3.4.7.1	x	
3.4.8	x	
3.4.8.2.2		x
3.4.8.3		x
3.4.8.4.2a	x	
3.4.9.1	x	
3.4.9.1.2	x	
3.4.9.2	x	
3.4.9.2.1	x	
3.4.9.2.2	x	
3.4.9.2.3	x	
3.4.9.2.4	x	
3.4.9.4	x	
3.4.9.5	x	
3.4.9.6.1a	x	
3.4.9.6.1b	x	
3.4.9.6.2 (a, b, c, d, e)	x	
3.4.12	x	
3.5.6		x
3.5.7.5		x
3.5.7.8	x	
3.5.7.9		x
3.5.7.10	x	
3.5.9		x
3.5.10	x	

TABLE IX. Specification sheet requirements - Continued.

MIL-PRF-21480 paragraph	As required by	Unless otherwise specified
3.11	x	
4.2.2	x	
4.2.3	x	
4.3	x	
4.4d	x	
4.4.2		x
4.4.7		x
4.4.9		x
4.5.1	x	
4.5.2	x	
4.5.3	x	
4.5.3.3 (a, c, g, h)	x	
4.5.6		x
4.5.14 (a - Air cooled only)	x	
4.5.14 (b - Liquid cooled only)	x	
4.5.15a		x
4.5.17d	x	
4.5.18		x
4.5.19	x	
4.5.20.1		x
4.5.22		x
4.5.23.2		x
4.5.23.2.1	x	
4.5.23.2.2 (b, c)	x	
4.5.24 (a, b)		x
4.5.26	x	
4.5.29b	x	
4.5.30	x	
4.5.31	x	
4.5.32		x
4.5.34	x	
4.5.35		x
4.5.36	x	
Table IV (2/)	x	
Table VII (3/)	x	
Table VIII (1/ through 7/)	x	

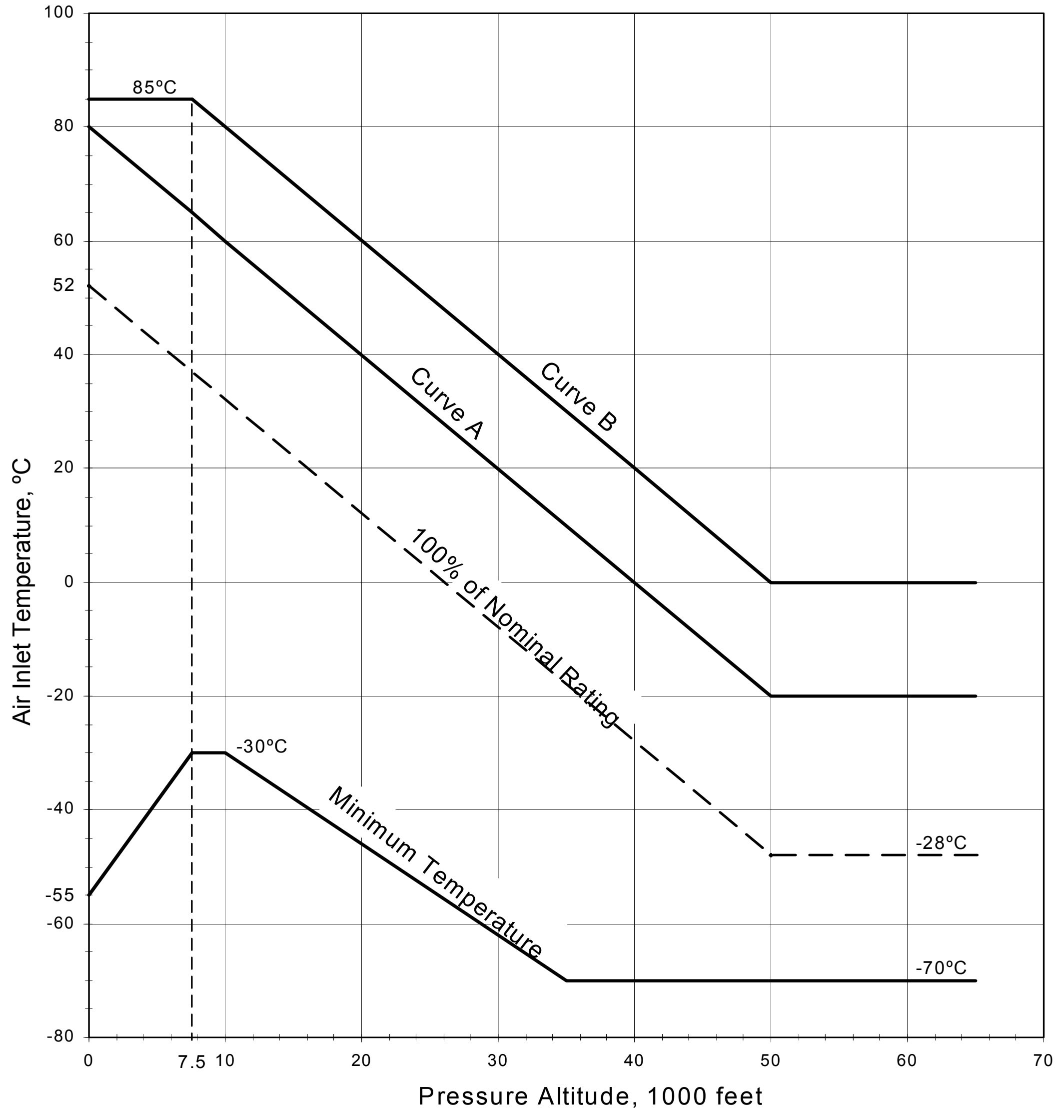


Parameters:

Curve A: maximum temperature for equipment operating in conditioned compartments or low altitude aircraft/helicopters.

Curve B: maximum temperature for equipment operating in engine or unconditioned compartments.

FIGURE 1. Aircraft compartment temperature-altitude ambient environment (see 3.4.2.1 and table VII).



Parameters:

Blast Cooled:	Under Curve A conditions, the de-rated capacity shall be not less than 70 percent of the nominal blast cooled rating. Under Curve B conditions, the de-rated capacity shall be not less than 50 percent of the nominal rating.
Self Cooled:	Under Curve A conditions, the de-rated capacity shall be not less than 60 percent of the nominal self cooled rating. Under Curve B conditions, the de-rated capacity shall be not less than 40 percent of the nominal rating.

FIGURE 2. Air inlet temperature-altitude environment for air-cooled generators (see 3.4.2.1.1, 3.4.9.6.1b, and 6.6.1).

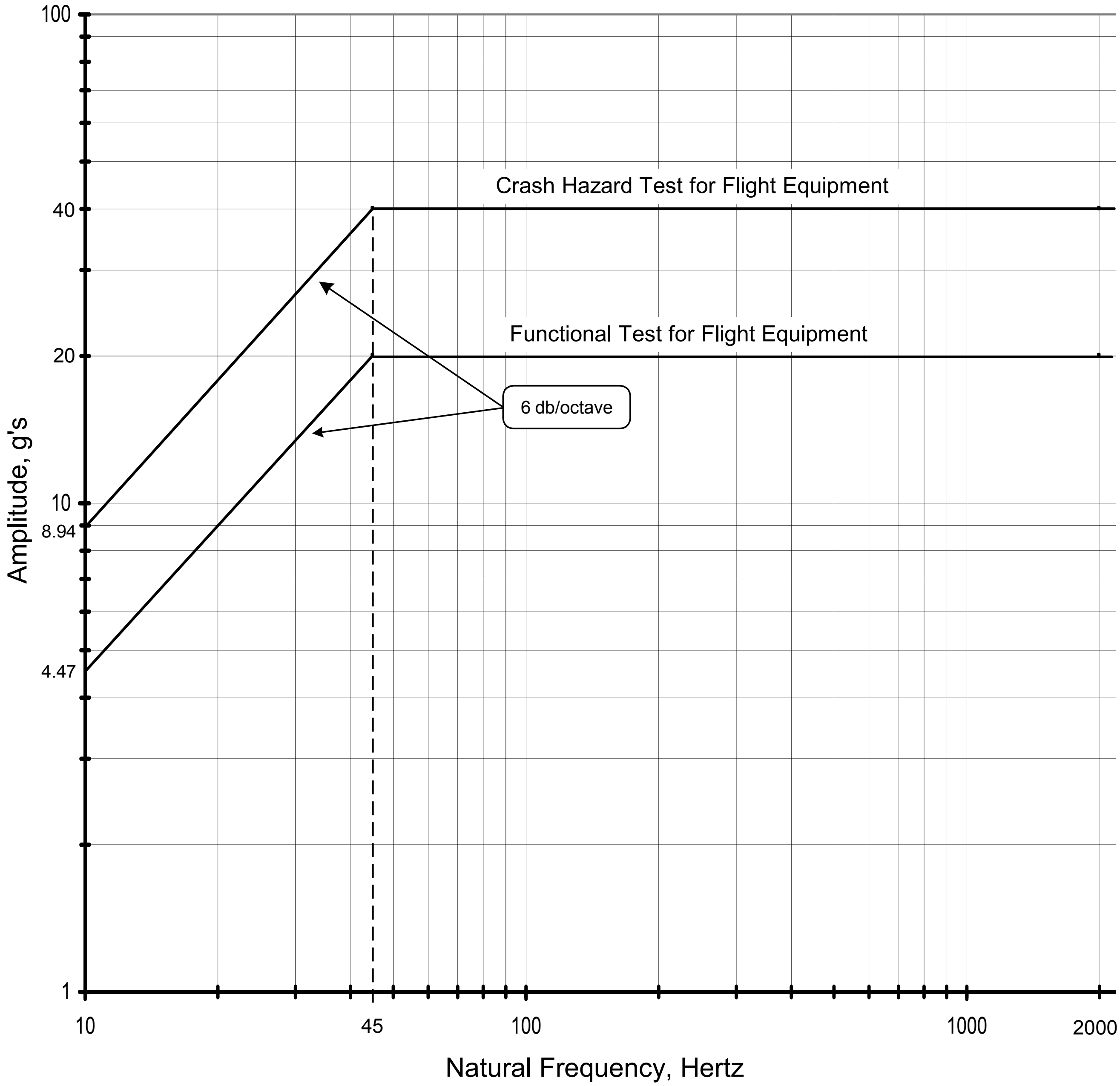
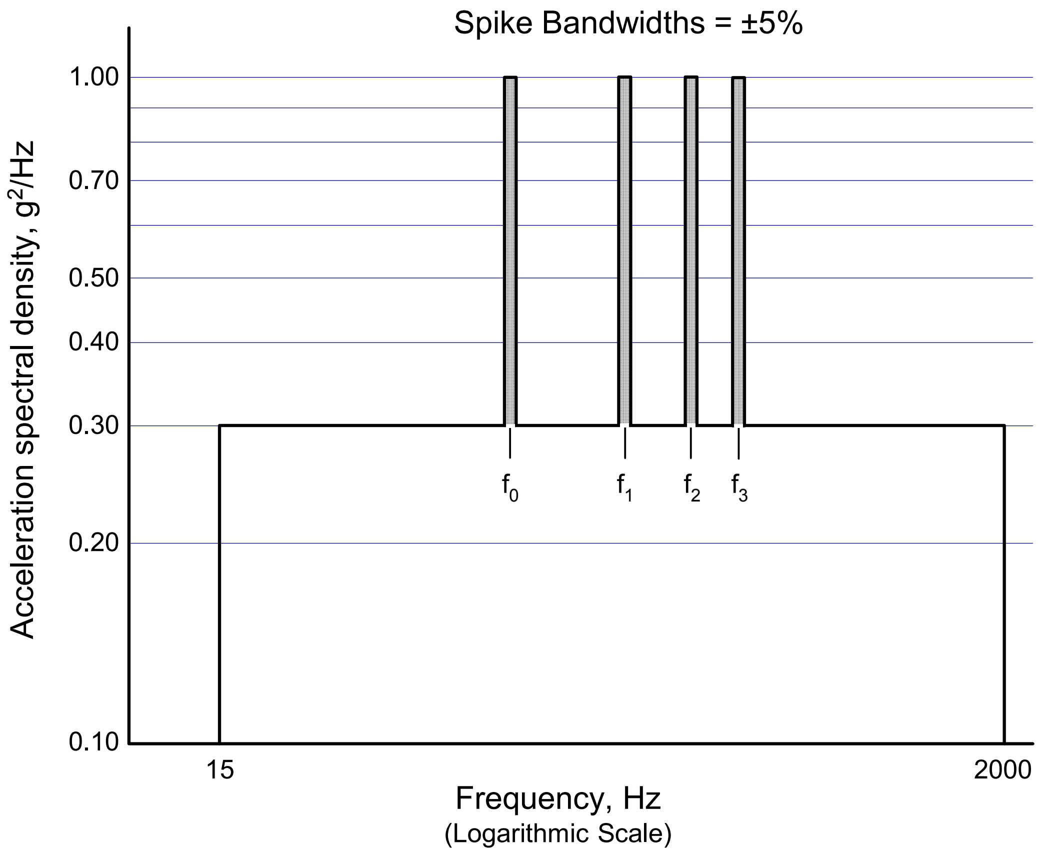


FIGURE 3. Shock response spectra (see 3.4.2.6, 4.5.24, 4.5.24a, and 4.5.24b).



NOTE:
f_o = shaft rpm/60
$f_1 = 2\ f_o$
$f_2 = 3\ f_o$
$f_3 = 4\ f_o$

FIGURE 4. Turbine engine vibration exposure (see 3.4.2.7.1, 4.5.2.3.2.1, and 6.6.3.2a).

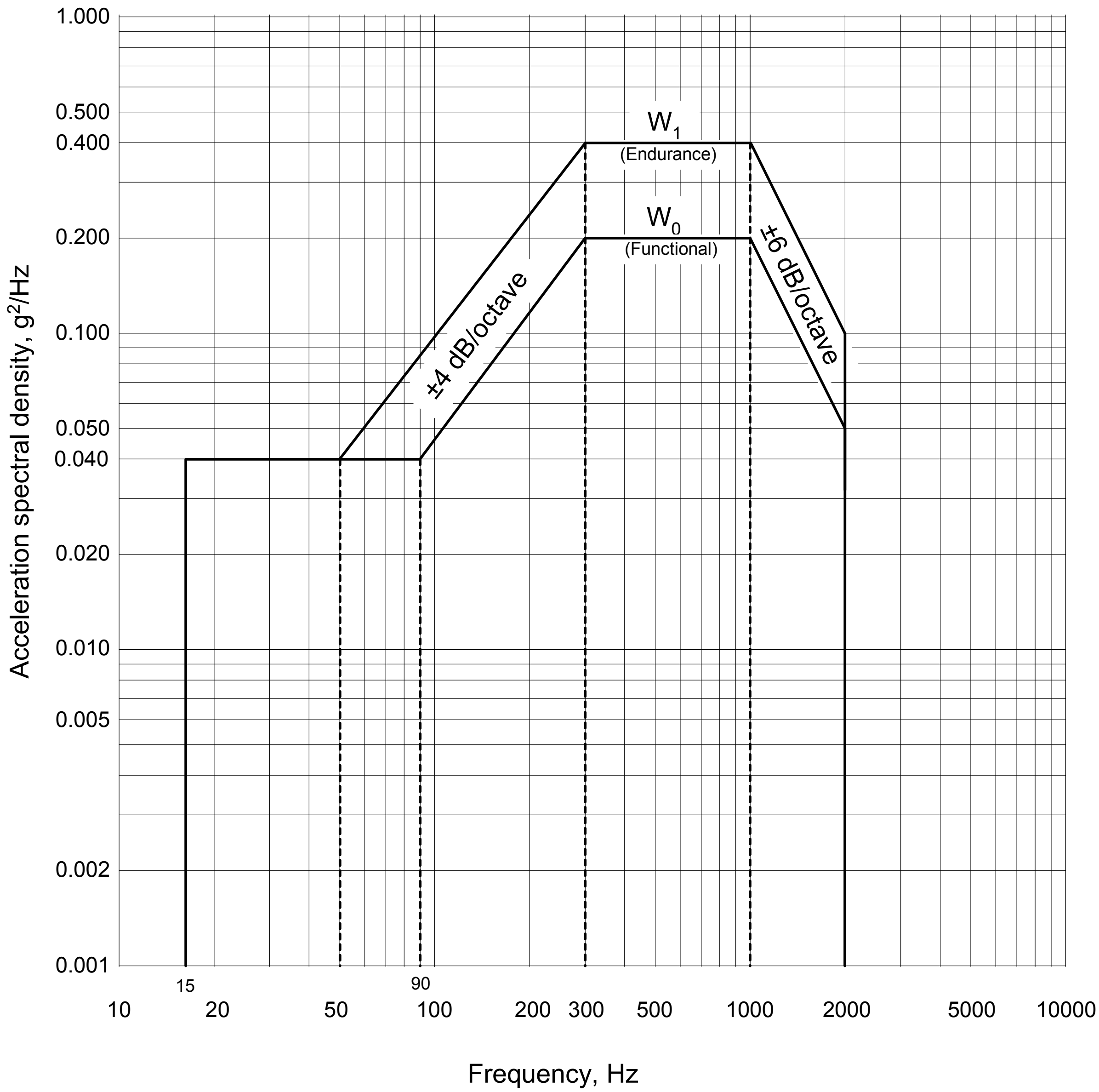
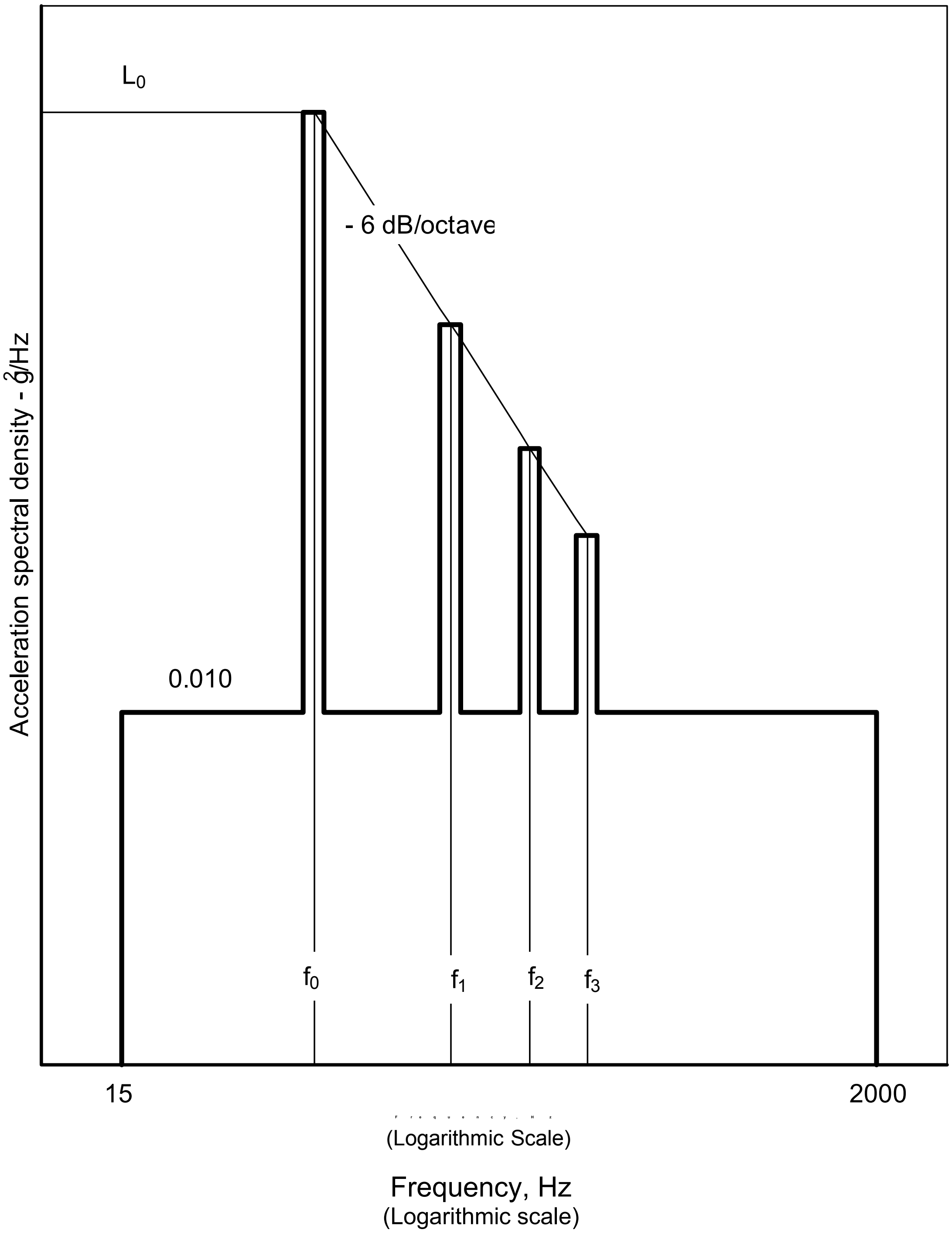


FIGURE 5. Jet aircraft vibration exposure (see 3.4.2.7.2a, 4.5.23.2.2a, and 6.6.3.2b).



NOTE: Unless otherwise specified, the magnitude first spike (L_0) is 0.3 g^2/Hz.

FIGURE 6. Propeller aircraft vibration exposure (see 3.4.2.7b and 4.5.23.2.2b).

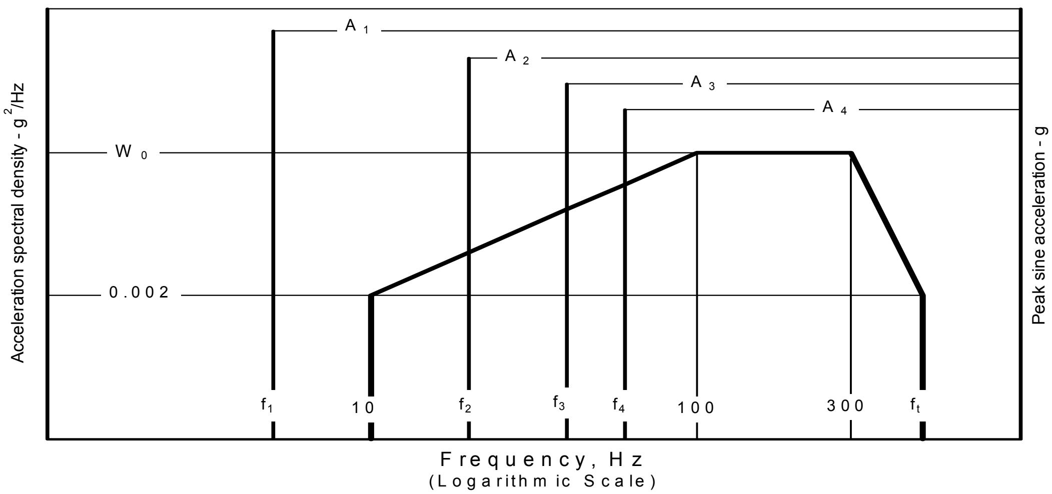


Figure 7A. Helicopter vibration exposure

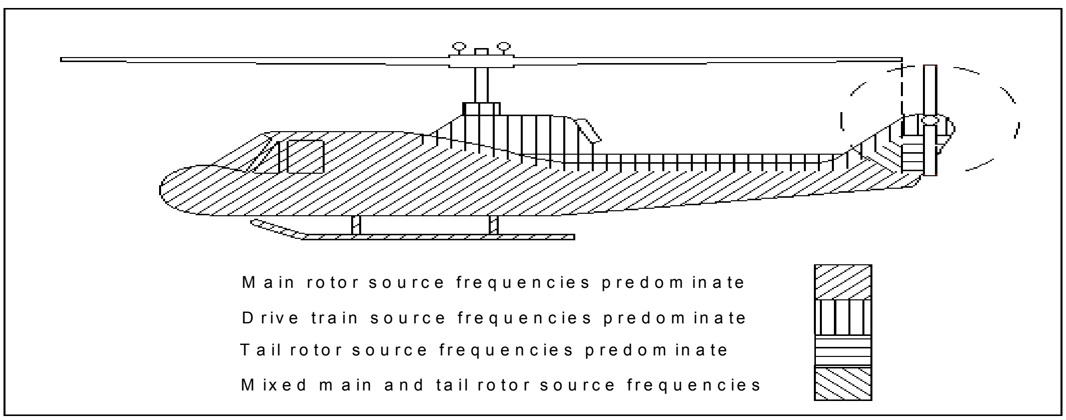
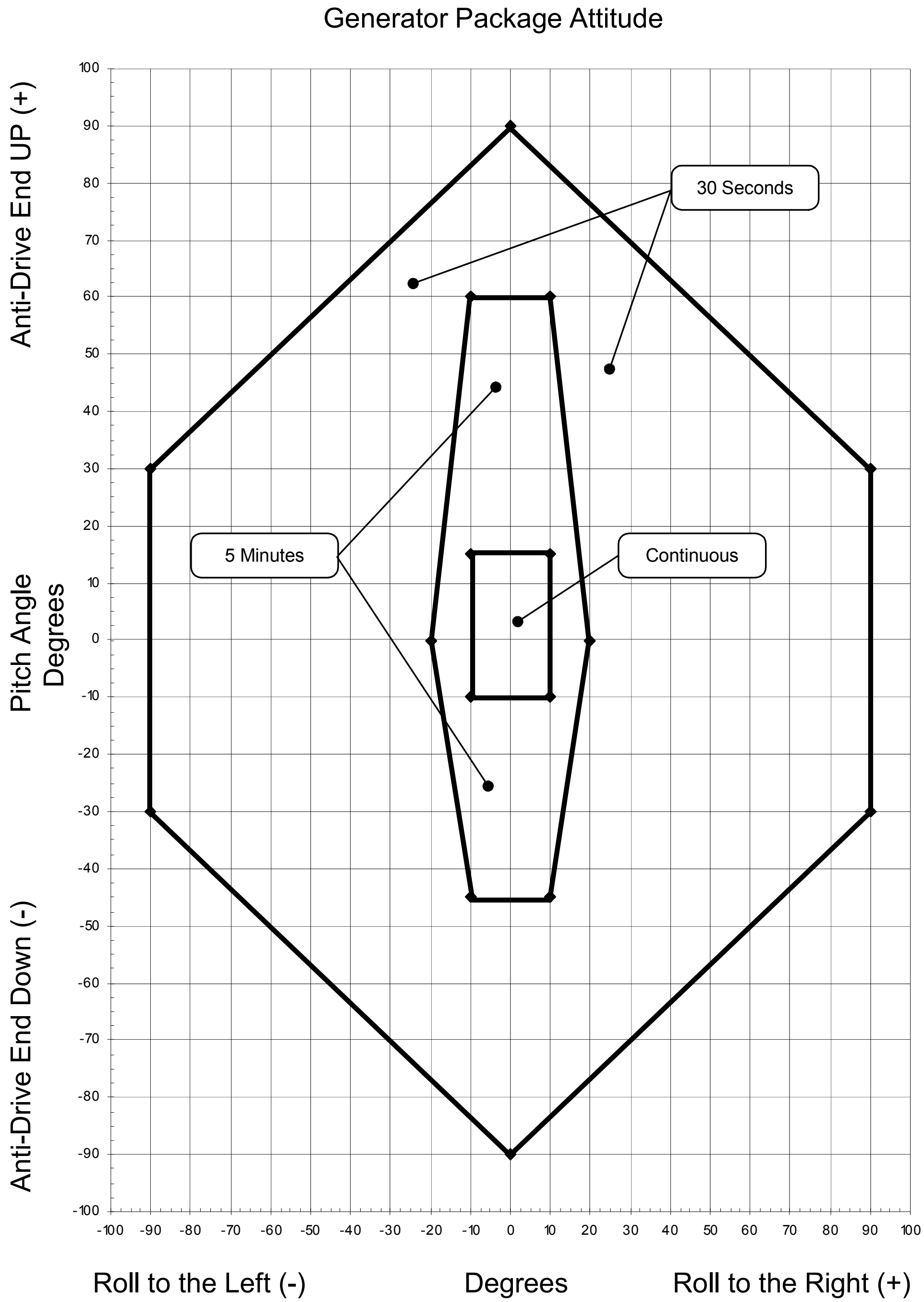


Figure 7B. Helicopter vibration zones

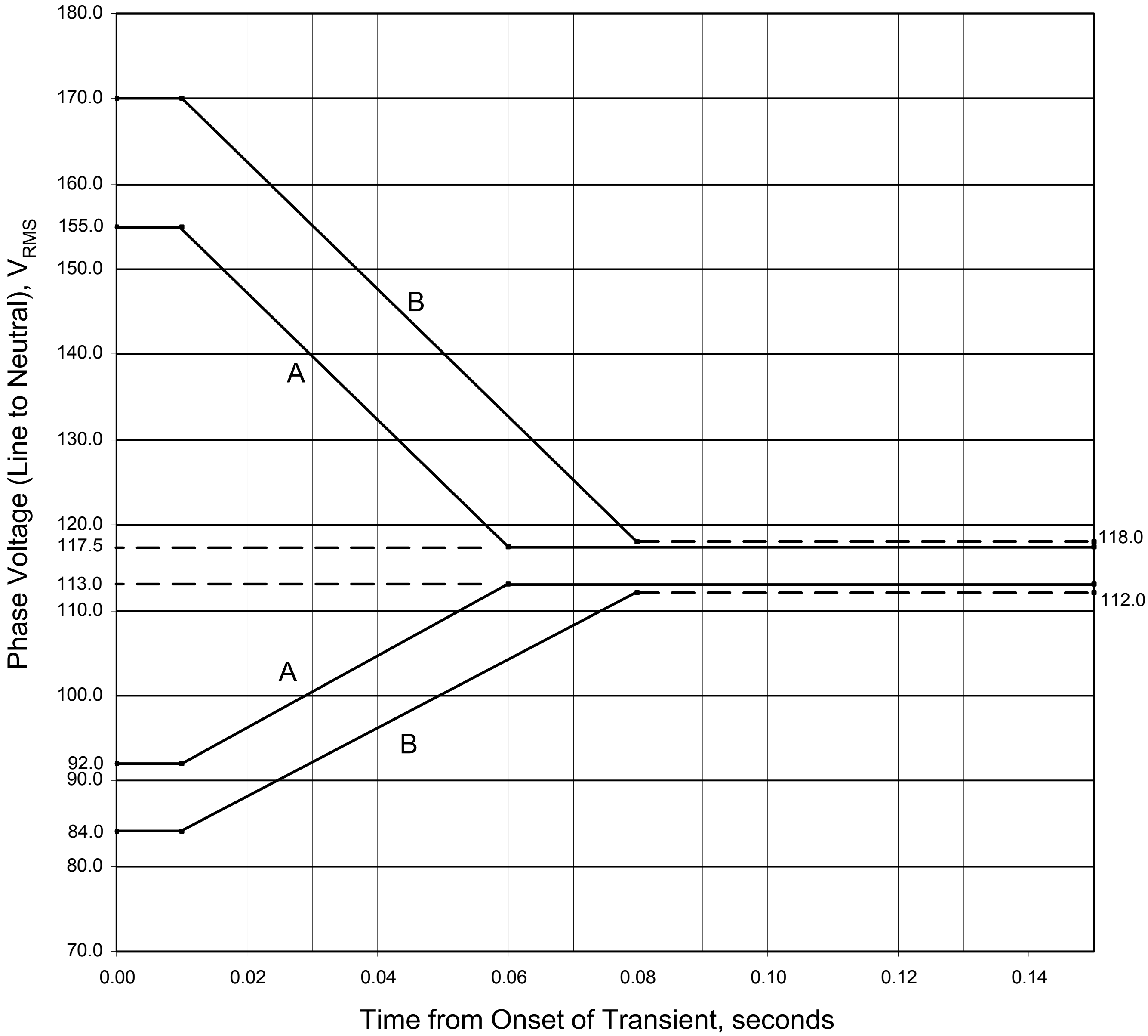
FIGURE 7. Helicopter vibration (see 3.4.2.7.2c, 4.5.23.2.2c, and 6.6.3.1d).



Notes:

1. All dive and climb angles are with respect to the rotational axis of the generator. Roll angles are to be measured from the 0° roll angle identified by the detail specification.
2. This figure assumes only a gravitational force on the unit under test.
3. The total requirement includes 30 seconds in a zero gravity, negative 1G condition or inverted.

FIGURE 8. Generator package attitude (pitch and roll) (see 3.4.3).

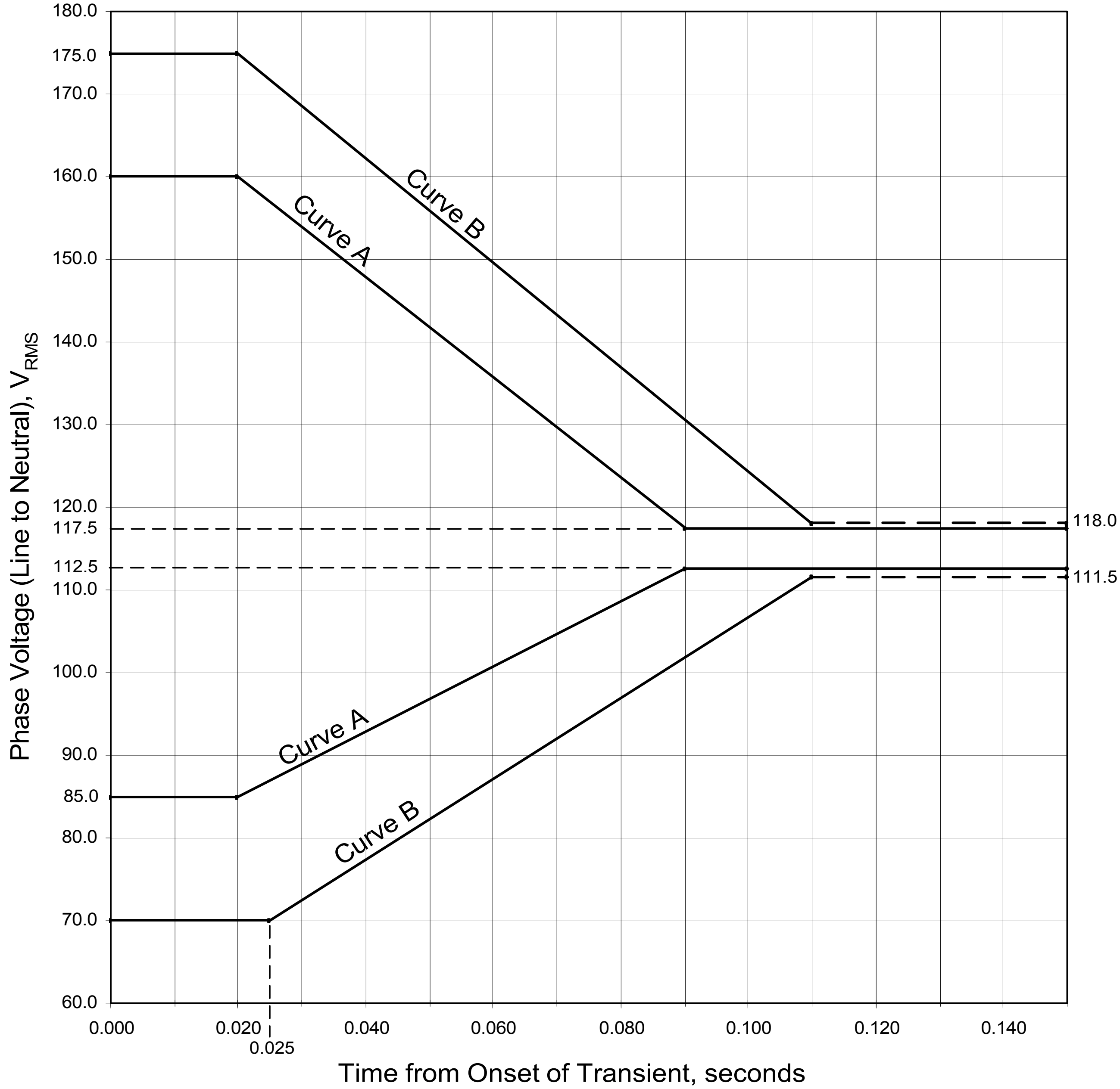


Parameters:

Curve A: Maximum voltage transient upon application and removal of any load up to rated continuous load, including normal load unbalance (3.5.3a). Steady state voltage limits are 113.0 to 117.5 V_{RMS}.

Curve B: Maximum voltage transient upon application and removal of all overloads up to the 5-second overload capacity, including normal load unbalance (3.5.3a). During overloads, steady state limits are 112.0 to 118.0 V_{RMS} for up to 5 seconds before returning to normal steady state 113.0 to 117.5 V_{RMS}.

FIGURE 9. Normal voltage limits for AC power source (class N) (see 3.5.1.1).

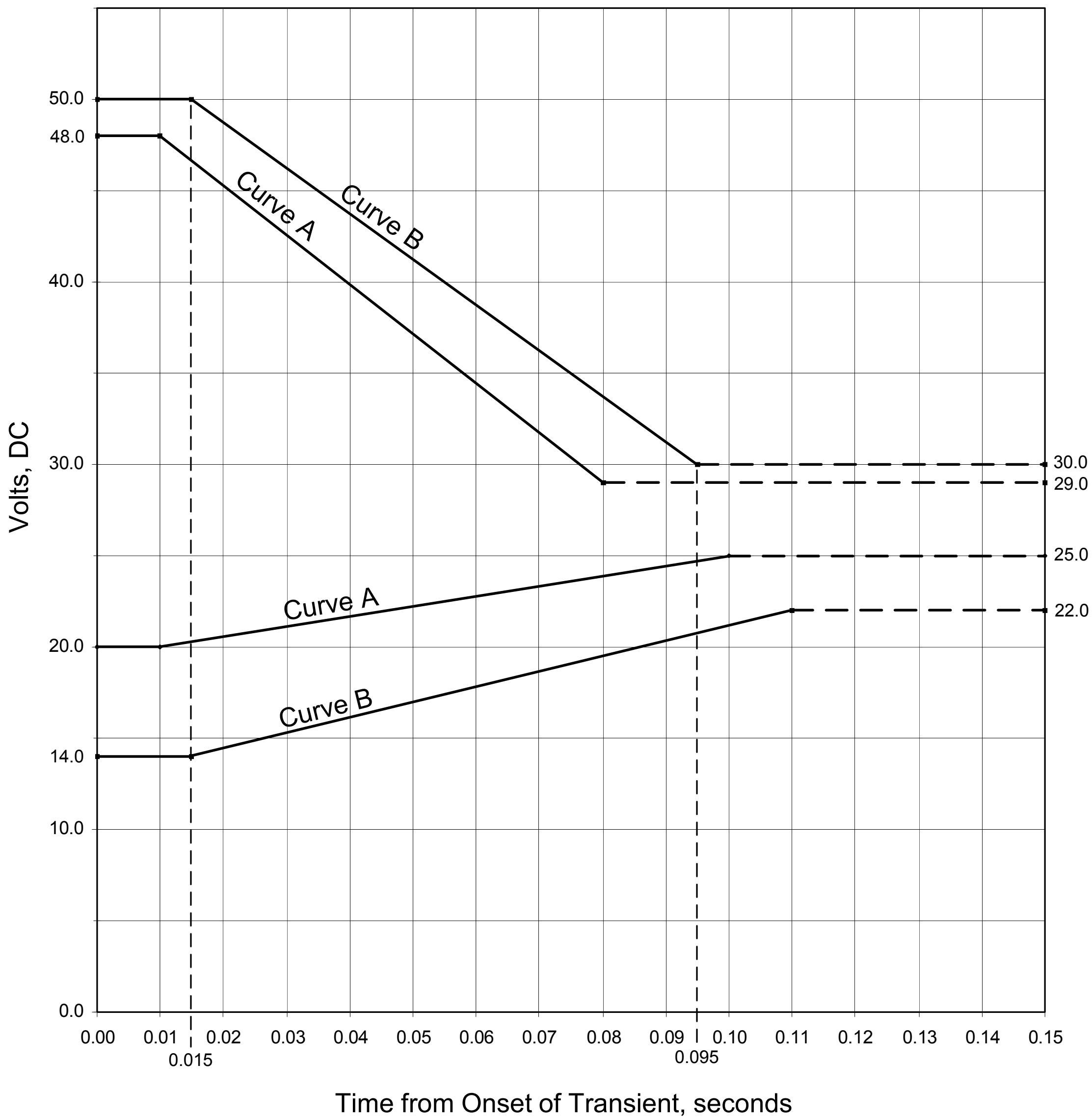


Parameters:

Curve A: Maximum voltage transient upon application and removal of any load up to rated continuous load, including normal load unbalance (3.5.3a). Steady state voltage limits are 112.5 to 117.5 V_{RMS}.

Curve B: Maximum voltage transient upon application and removal of all overloads up to the 5-second overload capacity, including normal load unbalance (3.5.3a). During overloads, steady state limits are 111.5 to 118.0 V_{RMS} for up to 5 seconds before returning to normal steady state 112.5 to 117.5 V_{RMS}.

FIGURE 10. Normal voltage limits for AC power source (class W) (see 3.5.1.1).



Parameters:

Curve A: Class N maximum voltage transient upon application and removal of all DC loads up to 200% of rated capacity. During overload, steady state limits are 25.0 to 29.0 V_{DC} for up to 5 seconds before returning to normal steady state limits of 26.0 to 29.0 V_{DC}.

Curve B: Class W maximum voltage transient upon application and removal of all DC loads up to 200% of rated capacity. During overload, steady state limits are 22.0 to 30.0 V_{DC} for up to 5 seconds before returning to normal steady state limits of 24.0 to 29.0 V_{DC}.

FIGURE 11. Voltage limits for DC power source (see 3.5.1.2 and 4.5.2).

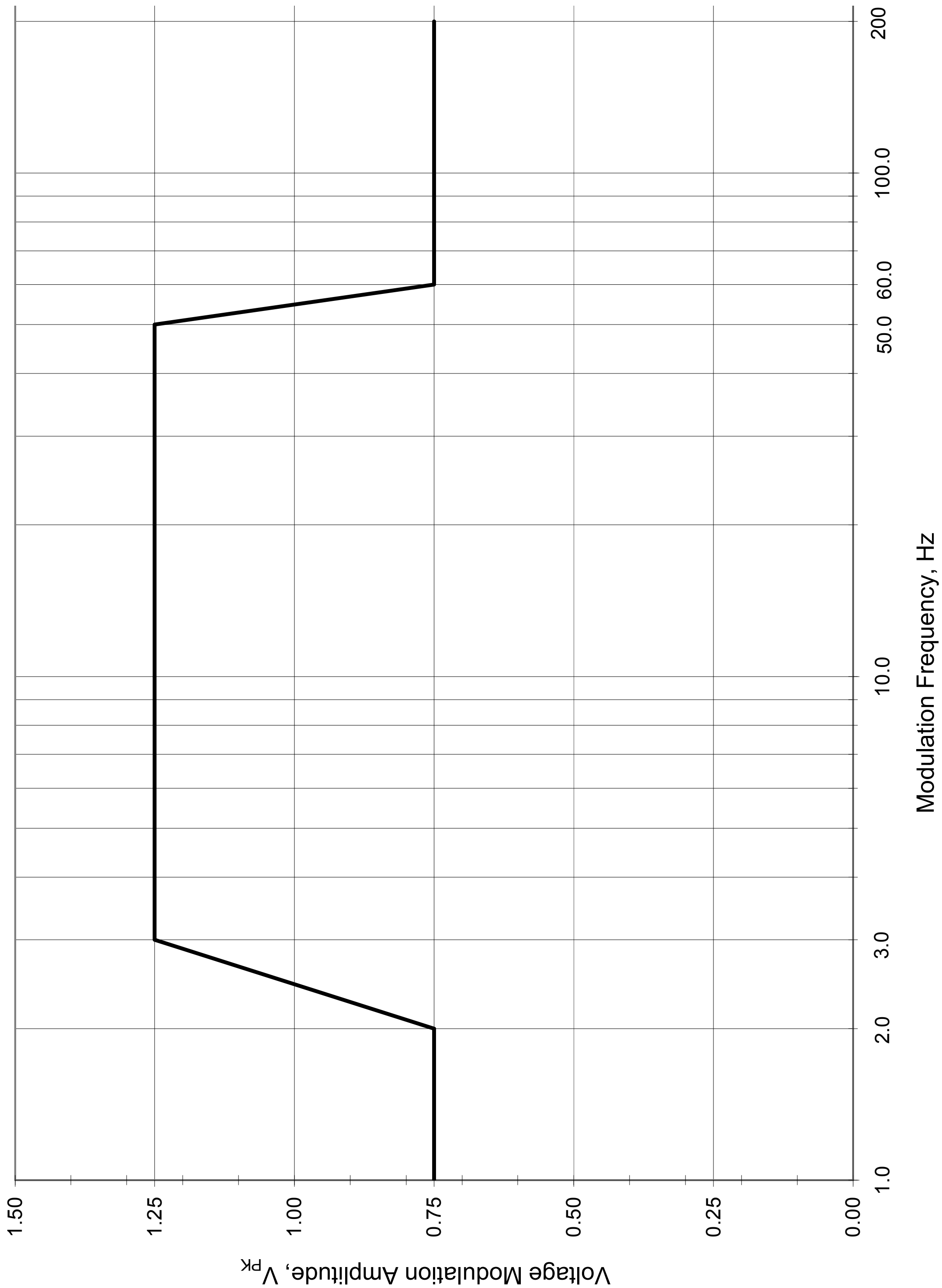


FIGURE 12. Voltage modulation characteristics for AC power source (see 3.5.2).

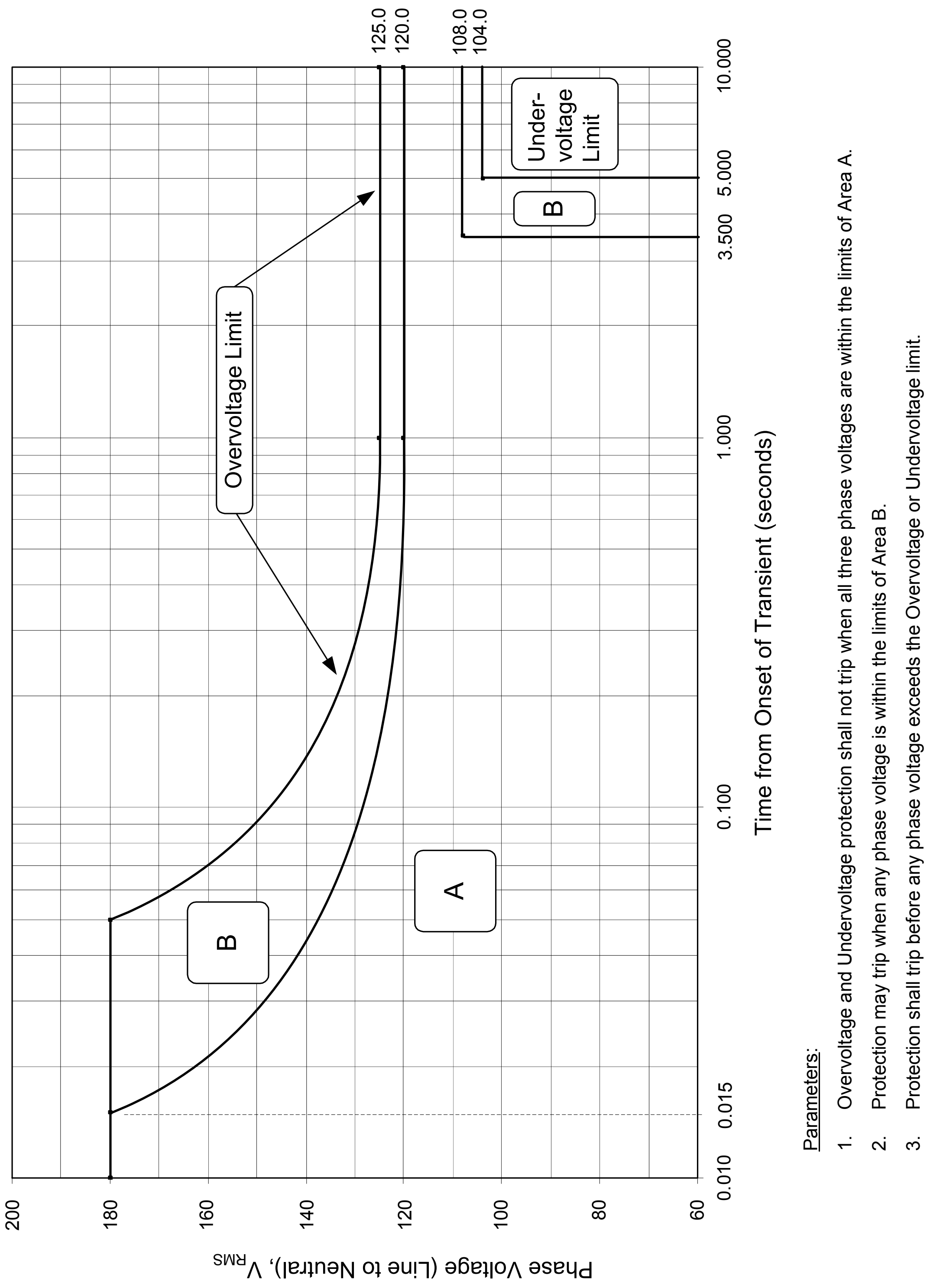
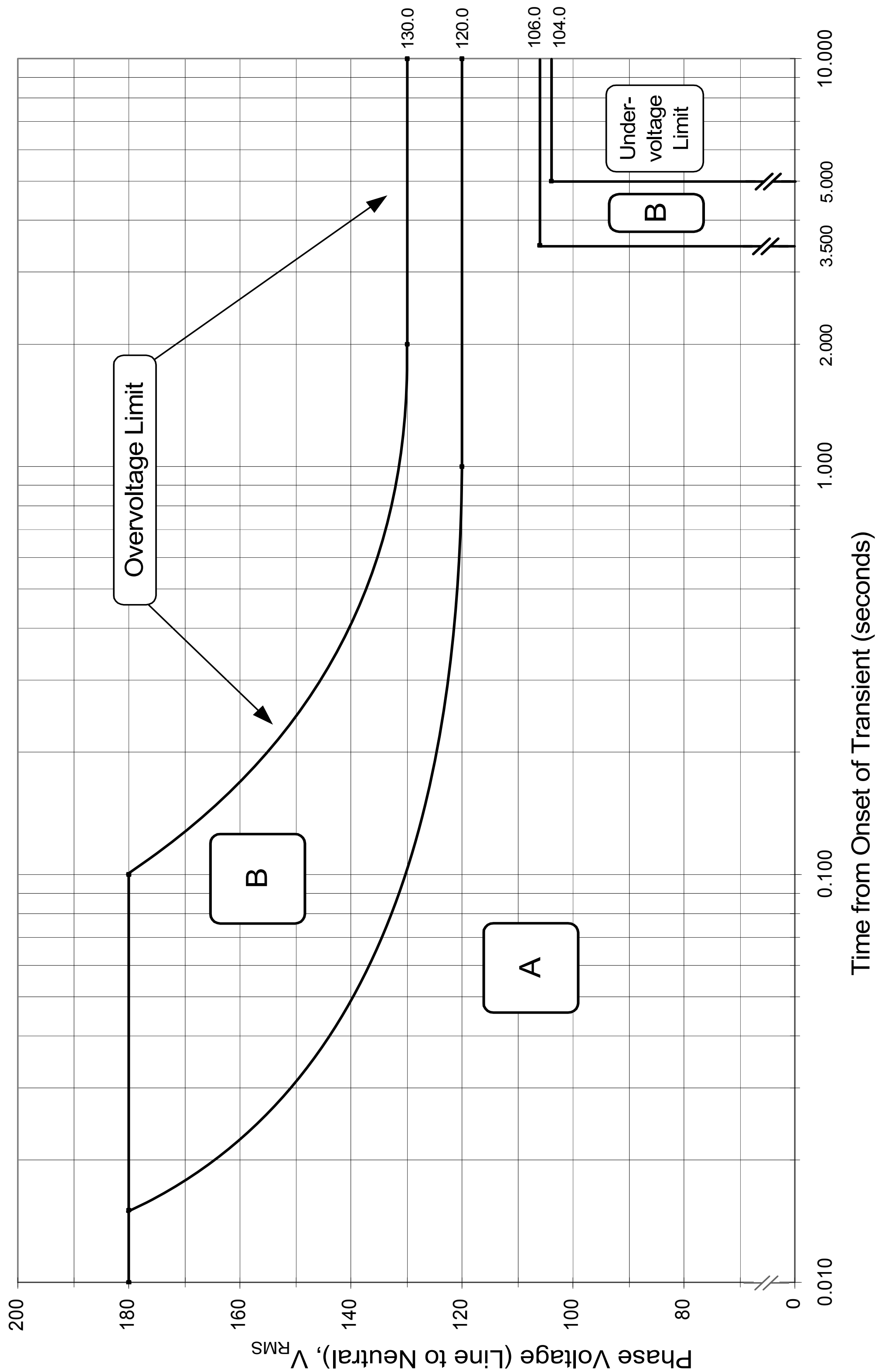


FIGURE 13. Abnormal voltage limits for AC power source (class N) (see 3.5.3.b, 3.5.7.3, 4.5.17a, and 4.5.17b).



Parameters:

1. Overvoltage and Undervoltage protection shall not trip when all three phase voltages are within the limits of Area A.
2. Protection may trip when any phase voltage is within the limits of Area B.
3. Protection shall trip before any phase voltage exceeds the Overvoltage or Undervoltage limit.

FIGURE 14. Abnormal voltage limits for AC power source (Class W) (see 3.5.3.b, 3.5.7.2, 3.5.7.3, 4.5.17a, and 4.5.17b)).

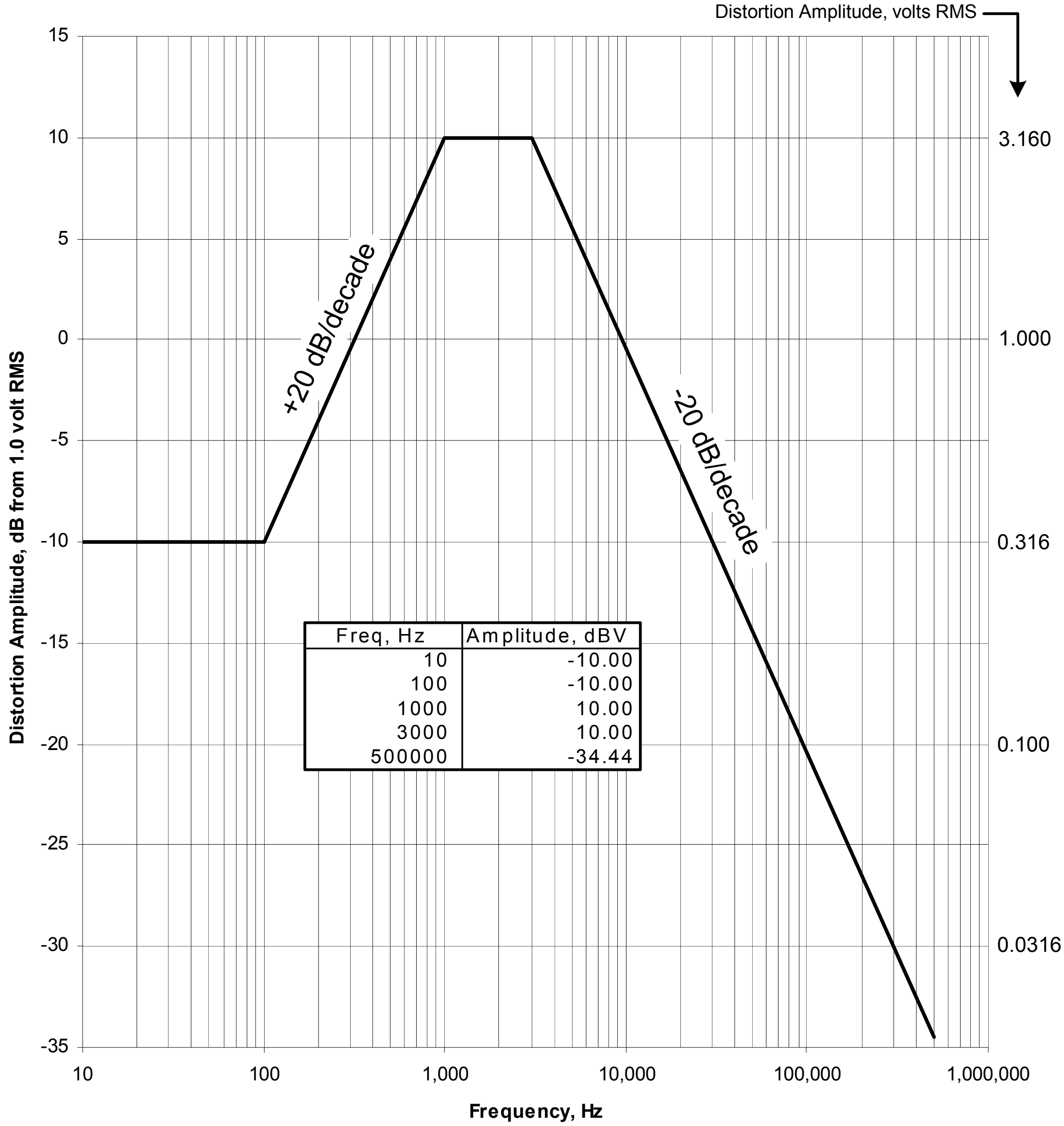


FIGURE 15. Distortion spectrum limits for AC power source (see 3.5.4b).

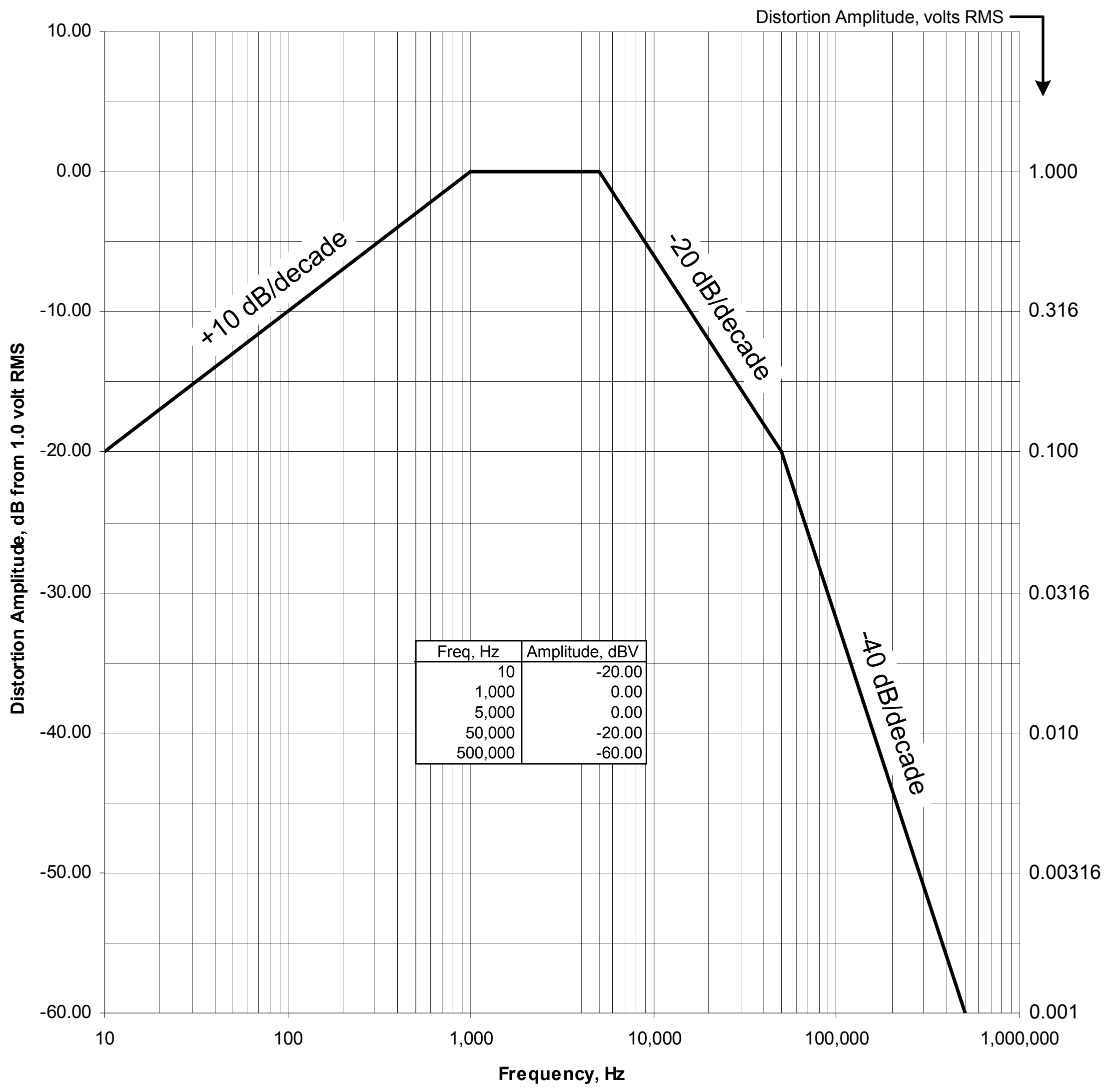
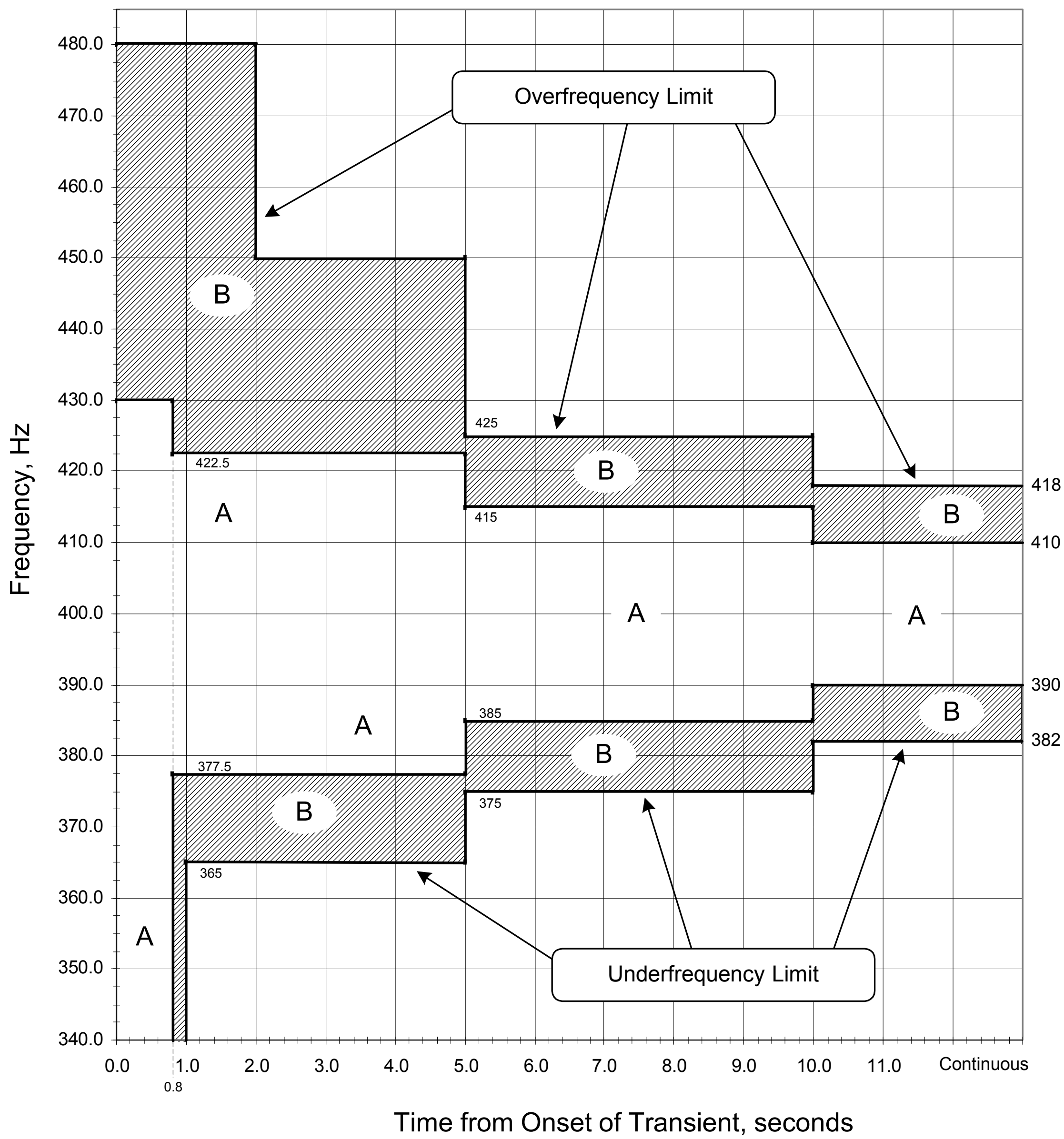


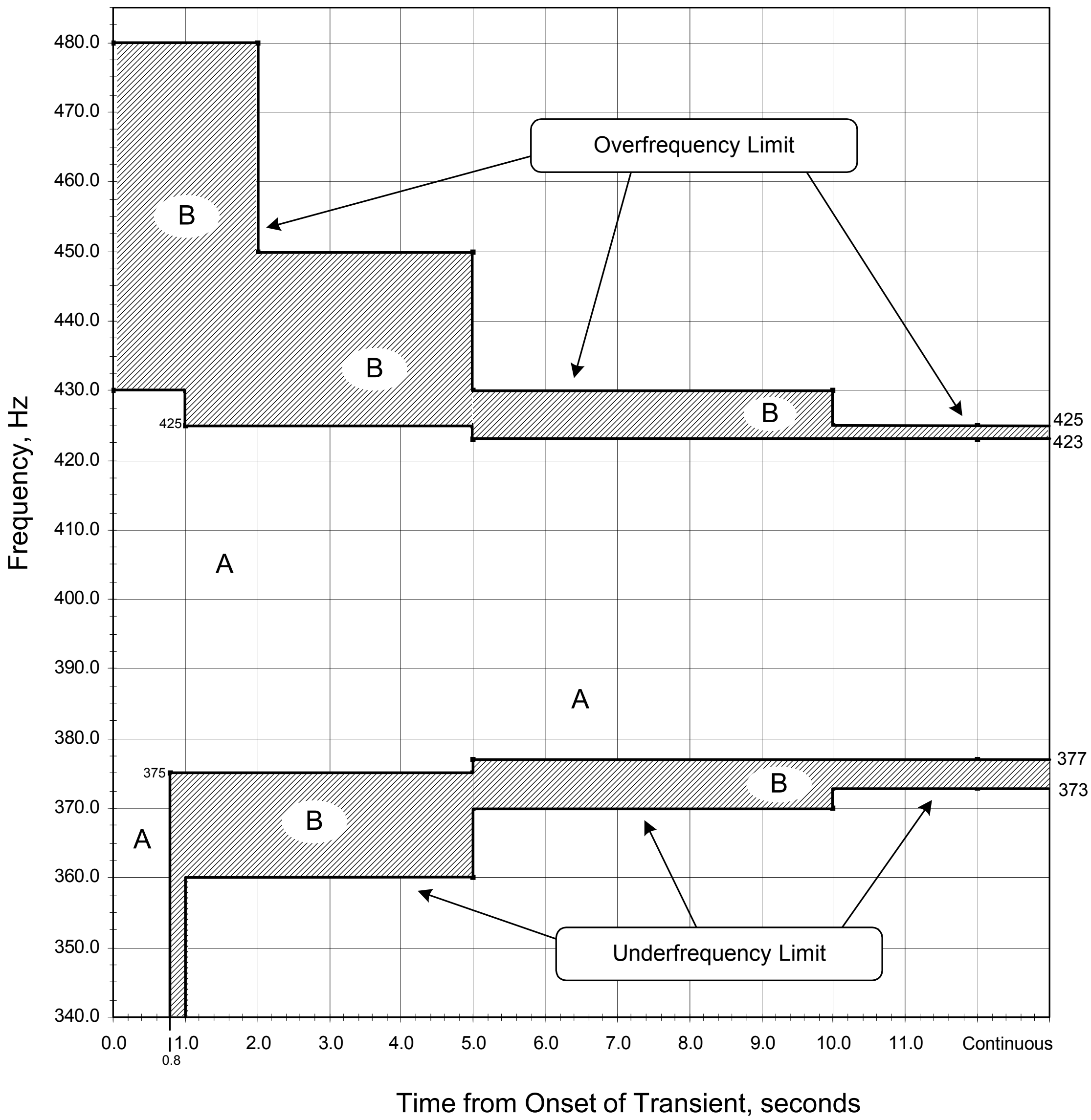
FIGURE 16. Distortion spectrum limits for DC power source (see 3.5.5).



Parameters:

1. Protection shall NOT trip when frequency is within the no trip area A.
2. Protection may trip when the frequency is within area B.
3. Protection shall trip before the Overfrequency or Underfrequency limits are exceeded.

FIGURE 17. Protection limits for AC power source frequency (class N) (see 3.5.7.4a and 4.5.17c).



Parameters:

1. Protection shall NOT trip when frequency is within the no trip area A.
2. Protection may trip when the frequency is within area B.
3. Protection shall trip before the Overfrequency or Underfrequency limits are exceeded.

FIGURE 18. Protection limits for AC power source frequency (class W) (see 3.5.7.4b and 4.5.17c).

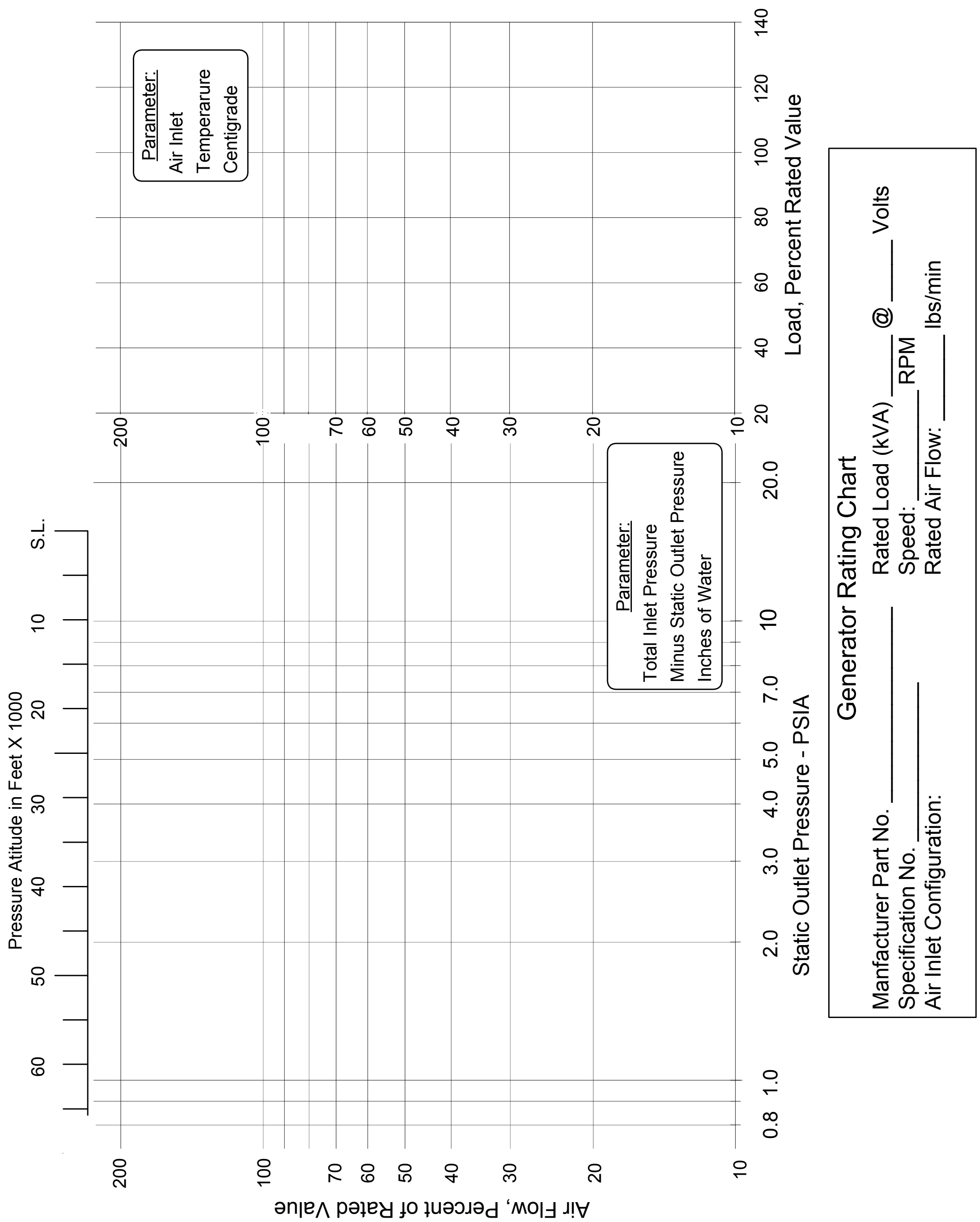


FIGURE 19. Altitude rating chart for air-cooled generators (see 6.2c).

CONCLUDING MATERIAL

Custodians:
Army - AV
Navy - AS
Air Force - 11

Preparing activity:
Navy-AS
(Project 6115-2005-001)

Review activity:
DLA - GS

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