INCH-POUND

MIL-S-22820B
28 November 1990
SUPERSEDING
MIL-S-22820A
3 March 1966

MILITARY SPECIFICATION
SERVOMOTOR-TACHOMETER GENERATOR, AC; GENERAL SPECIFICATION FOR

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

1. SCOPE

1.1 Scope. This specification covers the general requirements for servomotor-tachometer generators integrally built in the same housing utilizing the same shaft. It is not complete in itself, but must be used in conjunction with MIL-S-81963 which forms an inherent part of this specification. The servomotor section is a precision two-phase induction motor of low inertia. The generator section is a dual winding device in which the rotor accomplishes magnetic coupling, upon being rotated, between the input and output windings, producing an output proportional to speed and a polarity as a function of direction of rotation. The generator output frequency is identical to the energizing frequency.

1.2 Classification.

1.2.1 Nomenclature. The nomenclature consists of the item name, Servomotor-Tachometer Generator, followed by a type designation and a modification letter. All servomotor-tachometer generators having the same nomenclature should be electrically and mechanically interchangeable for all military applications. The type designation is made up of a combination of digits and letters as explained in the following paragraphs. The type designation should be preceded by the rated voltage of the motor reference winding followed by the letter "V" when the voltage is other than 115 volts. The complete nomenclature of a frame size 15, 115 volt (rated reference winding) servomotor-tachometer generator is illustrated in Table I.

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Systems Engineering and Standardization Department (Code 53), Naval Air Engineering Center, Lakehurst, NJ 08733-5100, by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

AMSC - N/A FSC 6105

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

1.2.1.1 Illustration. If the servomotor-tachometer generator illustrated in Table I was a unit whose servomotor required a rated input voltage of 26 volts, the nomenclature would become 26V-15SM-DG4A. This unit would be a size 15 servomotor-damping tachometer generator whose servomotor is normally excited with a rated voltage of 26 volts, 400 Hz and would also be the basic issue of the unit.

1.2.1.2 Size. The first two digits designate the maximum diameter in tenths of an inch of the servomotor section of the servomotor-tachometer generator. If the diameter is not exactly a whole number of tenths, the next higher tenth is used.

1.2.1.3 Function. The succeeding two groups of letters separated by a hyphen designates the function of the servomotor and the tachometer generator sections, respectively, in accordance with the following code:

First two-letter group	Function
SM	Servomotor

Second two-letter group	Function
DG	Damping Tachometer Generator
RG	Rate Tachometer Generator
IH	Integrating Tachometer Generator, Heater Compensated
IN	Integrating Tachometer Generator, Network Compensated

1.2.1.4 Supply frequency. The succeeding digit indicates the design frequency of the servomotor section of the servomotor-tachometer generator in accordance with the following code:

Frequency	Code
60	6
400	4

1.2.1.5 Design modification. An upper case letter "A" (in the illustration) following the frequency digit indicates the basic issue of a standard servomotor-tachometer generator. The first modification that significantly affects the external dimensions or the electrical characteristics of either the servomotor section or the tachometer generator will be indicated by the upper case letter "B". Succeeding modifications should be indicated by "C", "D", etc., except the use of letters "I", "L", "O", and "Q" is prohibited.

1.2.2 Part identifying number. The part identifying number (PIN) should consist of the letter "M", the basic number of the specification sheet (not including the revision letter), an assigned dash number and an upper case suffix letter denoting the latest modification letter in the type designation, as shown in Table II.

1.3 Types.

1.3.1 General. A servomotor-tachometer generator is a unit consisting of a servomotor and a tachometer generator integrally coupled on a common shaft and enclosed in the same housing.

1.3.1.1 Physical arrangement. All standard servomotor-tachometer generators must be arranged to ensure that the normal mounting and pilot surfaces are contained on the servomotor section.

1.3.2 Characteristics. Ideal characteristics of all tachometer generators include low inertia rotors, high output-to-null ratios, a strictly linear relationship of output voltage as a function of rotor speed over a broad range of ambient temperatures, and a minimum phase shift between the fundamental output and input voltages. The maximum degree to which any one of the ideal characteristics is achieved is often at the expense of the remaining. General practice is to group tachometer generators in accordance with their anticipated application.

1.3.2.1 Damping tachometer generators. Tachometer generators in this group are characterized by high theoretical stall acceleration figures and low null output, and are employed to stabilize the parent system.

1.3.2.2 Rate tachometer generators. A rate tachometer generator is a generator characterized by a relatively high output-to-null ratio, and as such, is employed in high-gain rate and computing servomechanism applications. The rotor is of relatively low moment of inertia. Such applications require a high degree of linearity over the range of speeds of the generator.

1.3.2.3 Integrating tachometer generators. An integrating tachometer generator is a generator used in computing applications requiring integration of a variable with respect to time. This type of tachometer generator is characterized by very small deviations of the output voltage as a function of temperature and a minimum warm-up time. Temperature control and compensation networks are usually integral parts of integrating generators.

2. APPLICABLE DOCUMENTS

2.1 Government documents.

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

SPECIFICATIONS

FEDERAL

QQ-A-250/4	Aluminum Alloy, 2024, Plate and Sheet

MILITARY

MIL-C-13924	Coating, Oxide, Black for Ferrous Metals
MIL-S-81963	Servocomponents, Precision Instrument, Rotating, Common Requirements and Tests: General Specification for
MIL-W-16878/4	Wire, Electrical, Polytetraflouroethylene (PTFE), Insulated, 200°C, 600 Volts, Extruded Insulation
MIL-S-22820/1	Servomotor Tachometer Generator, Type 15SM-RG4A
MIL-S-22820/7	Servomotor Tachometer Generator, Type 18SM-RG4D
MIL-S-22820/34	Servomotor Tachometer Generator, Type 15SM-IH4A (Heat compensated)

STANDARDS

MILITARY

MIL-STD-105	Sampling Procedures and Tables for Inspection by Attributes
MIL-STD-202	Test Methods for Electronic and Electrical Component Parts
MIL-STD-1334 (AS)	Process for Barrier Coating of Anti-Friction Bearings
MS17182	Terminal, Lug, Crimp Style, Copper, Insulated (Servocomponents), Type II, Class I, for 125° Centigrade Total Conductor Temperature
MS35276	Screw, Machine-Drilled Fillister Head, Slotted, Corrosion-Resisting Steel, Passivated, UNF-2A
MS35338	Washer, Lock-Spring, Helical, Regular (Medium) Series

(Unless otherwise indicated, copies of federal and military specifications, standards and handbooks are available from the Naval Publications and Forms Center, (ATTN: Documents Order Desk), Bldg. 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.)

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

AMERICAN GEAR MANUFACTURERS ASSOCIATION (AGMA)

AGMA 207.06	Tooth Proportions for Fine Pitch Involute Spur and Helical Gears
AGMA 2000-A	Gear Classification and Inspection Handbook Tolerances and Measuring Methods for Unassembled Spur and Helical Gears (Including Metric Equivalents)

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

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

2.3 Order of precedence. In the event of a conflict between the text of this specification and the references cited herein (except for associated detail specifications, specification sheets or MS standards), the text of this specification takes precedence. Nothing in this specification, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. REQUIREMENTS

3.1 Specification sheets for individual servomotor-tachometer generators. The individual item requirements shall be as specified herein, in MIL-S-81963, and in accordance with the applicable specification sheets. In the event of conflict between the requirements of this specification and those of the specification sheet, the latter shall govern.

3.2 First article. When specified in the contract or purchase order (see 6.3), a sample shall be subjected to first article inspection (see 4.5).

3.3 Design and construction. Servomotors shall be of the design, construction and physical dimensions specified (see 3.1).

3.3.1 Direction of rotation. The standard (positive) direction of rotation of the shaft is counterclockwise when the servomotor-tachometer generator is viewed from the shaft extension end.

3.3.2 Parts, materials and processes. Parts, materials and processes shall conform to the specifications of MIL-S-81963.

3.3.2.1 Bearings. Bearings shall conform to the stipulations of MIL-S-81963 and, when required by the specification sheet, shall be barrier coated in accordance with MIL-STD-1334.

3.3.2.2 Housings. Finish of the housing may be black in accordance with MIL-STD-13924, if required.

3.3.3 Terminal and lead wire identification. When screw and solder pin terminals are designated, the terminals shall conform to the specifications of MIL-S-81963. When wire leads are used, the wire shall be in accordance with MIL-W-16878/4. Unless otherwise specified, wire leads shall be a minimum of 18 inches long, and shall be capable of being pulled, bent, and twisted as required in MIL-S-81963, with a 5-pound weight attached to the extreme end. Terminal and wire lead identification shall be in accordance with Figure 1 and Tables III and IV. Terminal hardware is listed in Table V.

3.3.4 Rated voltages. The rated voltages of a servomotor-tachometer generator are those voltages specified on the applicable specification sheet for the reference, control, and energizing windings.

3.3.5 Dimensions. Outline drawings for the different sizes of servomotor-tachometer generators are included as Figures 2 and 3. Lettered dimensions shown on the outline drawings are provided in Table VI.

3.3.6 Storage. Servomotor-tachometer generators shall be capable of storage ranging in ambient temperatures from -62° ± 2°C to 100°C ± 2°C.

3.3.7 Spur gear data. Spur gears shall be designed in accordance with AGMA 207.06 and tested in accordance with AGMA 2000-A. Tooth form shall be full depth involute.

3.4 Performance requirements.

3.4.1 Visual and mechanical inspection. Visual and mechanical inspection shall be performed in accordance with 4.7.1 and shall meet the requirements of 4.8.1 of MIL-S-81963.

3.4.2 Shaft radial and end play. Radial play and end play shall not exceed the values specified in the specification sheet when measured with a dial indicator gauge graduated to 0.0001 inch (see 4.7.2).

3.4.3 Total runout. When tested in accordance with 4.7.3, the total runout of the smooth portion of the shaft shall not exceed the value specified in the applicable specification sheet.

3.4.4 Rotor moment of inertia. The moment of inertia of the rotor shall not be greater than that specified in the applicable specification sheet (see 4.7.4).

3.4.5 Dielectric withstanding voltage. When tested in accordance with 4.7.5 and Table VII, the servomotor-tachometer generator shall meet the requirements of MIL-S-81963.

3.4.6 Insulation resistance. When tested in accordance with 4.7.6, insulation resistance measurements shall meet the requirements of MIL-S-81963. Insulation resistance measurements shall be performed at a relative humidity no greater than 55 percent.

3.4.7 Current and power of heater windings. When tested in accordance with 4.7.7, the maximum value of the current drawn and the maximum value of the power consumed in the heater winding(s) shall not exceed those values specified on the applicable specification sheet.

3.4.8 Current. When tested in accordance with 4.7.8, the current drawn by each individual winding (reference, control and energizing) shall be within the limits specified on the applicable specification sheet.

3.4.9 Power. When tested in accordance with 4.7.9, the power consumed by each individual winding (reference, control and energizing) shall be within the limits specified on the applicable specification sheet.

3.4.10 Impedance. When tested in accordance with the requirements of 4.7.10 and MIL-S-81963, the impedance of each individual winding (reference, control, energizing and output) shall be within the limits specified on the applicable specification sheet.

3.4.11 Direction of rotation and polarity. When tested in accordance with 4.7.11, the shaft of a standard servomotor-tachometer generator shall rotate in a positive direction when the voltage at terminal 2 (red) leads the voltage at terminal 1 (yellow) by 90 degrees. When the shaft rotates in a positive direction, the instantaneous voltage at terminal 8 (blue) shall be approximately 180 electrical degrees from the instantaneous voltage at terminal 7 (orange). The standard positive direction of rotation is counterclockwise.

3.4.12 Single phasing. When tested in accordance with 4.7.12, the servomotor-tachometer generator shall be considered a failure if the shaft continues to rotate longer than 15 seconds after removal of either the control or reference winding voltage.

3.4.13 No-load speed. When tested in accordance with 4.7.13, the speed of the shaft in both directions shall be no less than the value specified on the applicable specification sheet.

3.4.14 Electrical breakaway torque (starting voltage). When tested in accordance with 4.7.14, the minimum starting voltage shall not be greater than the voltage specified on the applicable specification sheet.

3.4.15 Stall torque. When tested in accordance with 4.7.15, the stall torque, in control winding excitation (both series and parallel), shall be no less than the value specified on the applicable specification sheet.

3.4.16 Stall torque linearity. When tested in accordance with 4.7.16, the stall torque linearity shall not deviate from linearity by more than 10 percent.

3.4.17 Speed at one-half measured stall torque. Unless otherwise specified on the applicable specification sheet, when the servomotor-tachometer generator develops one-half of the measured stall torque, the speed in rpm shall not be greater than 60 percent of the specified synchronous speed. The servomotor-tachometer generator shall be tested in accordance with 4.7.17.

3.4.18 Axis error voltages. When tested in accordance with 4.7.18, the axis error voltages measured at any convenient speed in the specified speed range shall not be greater than those values specified on the applicable specification sheet.

3.4.19 Zero-speed output voltages. When tested in accordance with 4.7.19, the zero-speed output voltages which are specified on the applicable specification sheet, shall not be greater than those values indicated on the applicable specification seet.

3.4.20 Position error voltages. When tested in accordance with 4.7.20, the position error voltages which are specified on the applicable specification sheet, shall not be greater than those values indicated on the applicable specification sheet.

3.4.21 In-phase speed-sensitive transformation ratio. When tested in accordance with 4.7.21, the in-phase speed-sensitive transformation ratio shall be within the limits specified for those calibration speeds indicated on the applicable specification sheet.

3.4.22 In-phase linearity. When tested in accordance with 4.7.22, the percent deviation from the in-phase linearity at any speed in the specified speed range shall not be greater than those values specified on the applicable specification sheet. Unless otherwise specified, the calibration speed, Nc, shall be 3,000 rpm.

3.4.23 Phase shift. When tested in accordance with 4.7.23, the phase shift at any speed in the specified speed range shall not be greater than those values specified on the applicable specification sheet.

3.4.24 Voltage sensitivity. When tested in accordance with 4.7.24, the servomotor section shall not single phase when the reference winding voltage is changed ± 10 percent from the rated standard voltage. In addition, when the energizing voltage of the tachometer generator section is changed ± 10 percent from the rated standard voltage, the total rms null voltage as well as the in-phase speed-sensitive transformation ratio and phase shift at the specified calibration speed shall not exceed those values or tolerances specified on the applicable specification sheet.

3.4.25 Frequency sensitivity. When tested in accordance with 4.7.25, the servomotor section shall not single phase when the frequency of the reference voltage is changed ± 5 percent from the rated value. In addition, when the frequency of the energizing voltage of the tachometer generator section is changed ± 5 percent from the rated value, the total rms null voltage as well as the in-phase speed-sensitive transformation ratio and phase shift at the specified calibration speed shall not exceed those values or tolerances specified on the applicable specification sheet.

3.4.26 Temperature sensitivity. When the tachometer generator section is tested in accordance with 4.7.26, the requirements of Table VIII shall not exceed those values or tolerances specified on the applicable specification sheet.

3.4.27 Temperature rise. When measured in accordance with 4.7.27, the temperature rise shall be no greater than that value specified on the applicable specification sheet.

3.4.28 Coupling in split or center-tapped control windings. When tested in accordance with 4.7.28, the voltage of mutual inductance shall be at least that value, expressed as a fraction of the input voltage, specified on the applicable specification sheet.

3.4.29 Warm-up time. The time required for the measured in-phase speed-sensitive transformation ratio and the in-phase axis error voltage to be within the limits of the applicable specification sheet is the warm-up time. When tested in accordance with 4.7.29, the time shall conform to the requirements of the applicable specification sheet.

3.4.30 Security of terminals or wire leads. The security of each screw type or solder pin type of terminal or of each wire lead, as applicable to the particular type of servomotor-tachometer generator, shall be tested in accordance with 4.7.30 and shall meet the requirements of MIL-S-81963.

3.5 Environmental.

3.5.1 Vibration. After testing in accordance with 4.8.1, all servomotor-tachometer generators shall meet the requirements of MIL-S-81963 and Table VIII herein.

3.5.2 Shock.

3.5.2.1 Shock, low impact. When tested in accordance with 4.8.2.1, the servomotor-tachometer generator shall meet the requirements of MIL-S-81963 and Table VIII herein.

3.5.2.2 Shock, high impact. All servomotor-tachometer generators shall be capable of withstanding shock blows of 2,000 foot-pounds without suffering damage. After testing in accordance with 4.8.2.2, all servomotor-tachometer generators shall be operable and shall meet the applicable requirements of MIL-S-81963 and Table VIII herein.

3.5.3 Altitude. Servomotor-tachometer generators shall be capable of operation from sea level to 100,000 feet in combination with any ambient temperature from -55°C to that high ambient temperature specified on the applicable specification sheet.

3.5.3.1 Altitude, low temperature. When tested in accordance with 4.8.3.1, the servomotor-tachometer generator shall meet the requirements of Table VIII herein.

3.5.3.2 Altitude, high temperature. When tested in accordance with 4.8.3.2, the servomotor-tachometer generator shall meet the requirements of Table VIII herein.

3.5.4 Ambient temperature.

3.5.4.1 Ambient low temperature. When tested in accordance with 4.8.4.1, the servomotor-tachometer generator shall meet the requirements of Table VIII herein.

3.5.4.2 Ambient high temperature. When tested in accordance with 4.8.4.2, the servomotor-tachometer generator shall meet the requirements of Table VIII herein.

3.5.5 Endurance. When tested in accordance with 4.8.5, the servomotor-tachometer generator shall meet the requirements of Table VIII herein.

3.5.6 Moisture resistance. When tested in accordance with 4.8.6, the servomotor-tachometer generator shall meet the requirements of Table VIII herein.

3.5.7 Audible noise structureborne. When required by the applicable specification sheet, structureborne noise shall be tested in accordance with 4.8.7 and shall meet the requirements of MIL-S-81963.

3.5.8 Salt atmosphere resistance. When required by the applicable specification sheet, the servomotor-tachometer generator shall be tested in accordance with 4.8.8 and shall meet the requirements of MIL-S-81963.

3.5.9 Explosion resistance. When required by the applicable specification sheet, the servomotor-tachometer generator shall be tested in accordance with 4.8.9 and shall meet the requirements of MIL-S-81963.

3.6 Identification markings. Identification markings shall be as specified in MIL-S-81963.

3.7 Workmanship. Workmanship of the servomotor-tachometer generator shall conform to the requirements of MIL-S-81963.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. The responsibility for performance of all inspection requirements shall be in accordance with MIL-S-81963.

4.1.1 Responsibility for compliance. The responsibility for compliance with all requirements of sections 3 and 5 shall be in accordance with MIL-S-81963.

4.1.2 Test equipment and inspection facilities. The accuracy of test equipment and inspection facilities shall conform to MIL-S-81963.

4.1.3 Alternate test methods. Alternate test methods shall conform to MIL-S-81963.

4.2 Test conditions.

4.2.1 Standard test conditions. Unless otherwise specified, the standard test conditions shall conform to MIL-S-81963, and each test shall be carried out with the servomotor-tachometer generator in the applicable test fixture of Figures 4 and 5.

4.2.2 Ambient test conditions. Unless otherwise specified herein, all measurements and tests shall be made within the following temperature, atmospheric pressure, and relative humidity limits.

Temperature - 23° ± 5°C
Pressure - 28 to 32 inches Hg
Humidity - No greater than 55 percent

4.2.3 Temperature, stabilized non-operating. The stabilized non-operating temperature of the servomotor-tachometer generator shall be as specified in MIL-S-81963. The rated standard test voltages shall be applied to the reference and control windings of the servomotor portion and the applicable standard test voltage applied to the energizing winding of the tachometer generator section during the test. The control winding shall be used for the periodic DC resistance measurements.

4.2.4 Temperature, stabilized operating. The stabilized operating temperature of a servomotor-tachometer generator shall be as specified in MIL-S-81963, after the applicable rated standard test voltages have been applied to the reference winding, the energizing winding, and any heater windings for a period of one hour. The output voltage winding shall be loaded with the standard load specified on the applicable specification sheet. The control winding shall be used for the periodic DC resistance measurements.

4.2.5 Standard test voltages. Unless otherwise specified, the standard test voltage sources shall possess the characteristics delineated in 4.2.5.1, 4.2.5.2, 4.2.5.3, and 4.2.5.4.

4.2.5.1 Amplitude.

4.2.5.1.1 Servomotor section. The amplitude of the standard test voltages for the servomotor section shall be the rated or specified voltages ± 1 percent.

4.2.5.1.2 Tachometer generator section. The amplitude of the standard test voltage for the tachometer generator section shall be the rated or specified value ± 1 percent. The standard test voltages shall be derived from a source capable of being maintained within 0.1 percent for damping types over the length of time the tests require. For integrating types, the source shall be maintained within .01 percent of the required value.

4.2.5.2 Frequency.

4.2.5.2.1 Servomotor section. The frequency of the standard test voltages applied to the servomotor section of the servomotor-tachometer generator shall be within 1 percent of the rated or specified value.

4.2.5.2.2 Tachometer generator section. The frequency of the standard test voltage applied to the tachometer generator section of the servomotor-tachometer generator shall be within 0.1 percent of the rated or specified value for damping and rate types, and within 0.01 percent of rated or specified value for integrating types.

4.2.5.3 Total harmonic distortion.

4.2.5.3.1 Servomotor section. The total harmonic content of the standard test voltages applied to the servomotor section of the servomotor-tachometer generator shall not exceed 3 percent.

4.2.5.3.2 Tachometer generator section. The total harmonic content of the standard test voltage applied to the tachometer generator section of the servomotor-tachometer generator shall be less than 1 percent for damping and rate types, and less than 0.1 percent for integrating types.

4.2.5.4 Electrical phase. The electrical phase angle between the two standard test voltages applied to the servomotor section of the servomotor-tachometer generator shall be 90 degrees ± 3 degrees.

4.2.6 Standard servomotor-tachometer generator diagram. Unless otherwise delineated in the applicable specification sheet, the standard servomotor-tachometer generator shall conform to the schematic of Figure 1. Application of the standard test voltages is also shown in Figure 1.

4.2.7 Standard load. The standard load of a servomotor-tachometer generator shall be as specified on the applicable specification sheet.

4.3 Speed-sensitive output measuring equipment. The required speed-sensitive transformation ratios, phase shift angles, and axis errors of servomotor-tachometer generators shall be measured according to Figure 6, or by a method which produces equivalent results. For integrating tachometer generators, the input capacitance of the output measuring device shall be no greater than 30 pF.

4.4 Classification of tests. The methods of sampling, inspection, and tests conducted on servomotors shall be classified as follows:

a. First Article (4.5)

b. Quality Conformance (4.6)

4.4.1 Degradation of performance. The following minor relaxations may be permitted at the discretion of the qualifying activity.

4.4.1.1 Quality conformance tests. All specified performance requirements shall be attained.

4.4.1.2 Environmental tests. As appropriate, the following minor relaxations in specified requirements may be permitted during or following each of the environmental tests. It should be noted that the relaxations are not cumulative; for example, if the no-load speed is accepted at 98 percent of the specified minimum value following vibration, it shall not be less than 98 percent of the specified minimum value following low impact shock.

4.4.1.2.1 Shaft radial play. The maximum permissible radial play is 1.5 times the maximum value specified in the specification sheet. Following high impact shock, radial play shall not exceed 2.25 times the maximum value specified on the specification sheet.

4.4.1.2.2 Shaft end play. Irrespective of the limits specified in the specification sheet, a minimum end play of 0.0002 inch is required. The maximum permissible end play is 1.66 times the maximum value specified in the specification sheet. Following high impact shock, end play shall not exceed 2.5 times the maximum value specified on the specification sheet.

4.4.1.2.3 Dielectric withstanding voltage. Following high impact shock, the winding leakage current shall not exceed 1.5 mA peak maximum with 80 percent of the initial test voltage applied.

4.4.1.2.4 Insulation resistance. Following high impact shock and having been immediately preceded by dielectric withstanding voltage, a reduction to 25 megohms insulation resistance is permissible.

4.4.1.2.5 Electrical breakaway torque (starting voltage). An increase of 10 percent of the specified value on the specification sheet is permitted. Following high impact shock, a minimum starting voltage not exceeding 1.5 times the voltage specified on the specification sheet is permissible.

4.4.1.2.6 No-load speed. A reduction of 2 percent of the minimum value specified on the specification sheet is permitted. Following high impact shock, the no-load speed in either shaft direction shall be no less than 95 percent of the value specified on the specification sheet.

4.4.1.2.7 Stall torque. A reduction of 2 percent of the minimum value specified on the specification sheet is permissible.

4.4.1.2.8 Axis error voltages, zero speed output voltages, position error voltages. A ± 5 percent variation of the specified value on the specification sheet is permitted.

4.4.1.2.9 In-phase speed-sensitive transformation ratio. A ± 5 percent variation of the specified value on the specification sheet is permitted. Following high impact shock, the in-phase speed sensitive transformation ratio shall be within ± 20 percent of the value specified in the specification sheet.

4.4.1.2.10 Major failures during or following environmental tests. Allowances having been made for the relaxations quoted above, failures experienced during or following environmental tests shall be cause for refusal to grant first article approval.

4.5 First article sample inspection. When required by the contracting activity, first article testing shall be as specified in MIL-S-81963.

4.6 Quality conformance inspection. Quality conformance inspection shall be as specified in MIL-S-81963 and Table VIII herein.

4.6.1 Quality conformance inspection sampling. Statistical sampling and inspection shall be as specified in MIL-S-81963. When MIL-STD-105 specifies an action by the Government, it shall, at the option of the Government, be performed either by the Government or by the contractor under the supervision of the Government.

4.6.2 Quality conformance inspection routine. The minimum of inspection to be verified by the Government Inspector shall be the requirements of MIL-S-81963 and Table VIII herein. The Government Inspector may substitute 100 percent inspection for all or part of the sampling procedure.

4.6.3 Quality conformance sample failure. Action following quality conformance sample failure shall be as specified in MIL-S-81963.

4.7. Test methods and examinations.

4.7.1 Visual and mechanical inspection. The servomotor-tachometer generator shall be examined in accordance with MIL-S-81963 and shall meet the requirements of 3.4.1 herein.

4.7.2 Shaft radial and end play. Shaft radial and end play shall be tested in accordance with MIL-S-81963 and shall meet the requirements of 3.4.2 herein.

4.7.3 Total shaft runout. Total shaft runout shall be performed in accordance with MIL-S-81963 and shall meet the requirements of 3.4.3.

4.7.4 Rotor moment of inertia. The rotor moment of inertia shall be measured in accordance with MIL-S-81963 and shall meet the requirements of 3.4.4 herein.

4.7.5 Dielectric withstanding voltage. The dielectric withstanding voltage test shall be conducted as specified in MIL-S-81963 and Table VII herein and shall meet the requirements of 3.4.5. Quality conformance tests shall be performed at the standard ambient temperature of 4.2.2 and as specified in MIL-S-81963. Qualification and First Article tests shall be performed at the -55°C ambient temperature and at the stabilized operating temperature of 4.2.4 for the high temperature extremes.

4.7.6 Insulation resistance. The DC resistance between the terminal locations specified in Table VII shall be measured as specified in MIL-S-81963 and shall meet the requirements of 3.4.6 herein. A minimum of 500 volts DC shall be applied between the points specified in Table VII. Qualification and quality conformance tests shall be performed at the -55°C ambient temperature and at the stabilized operating temperature of 4.2.4 for the high temperature extremes.

4.7.7 Current and power of heater windings. After the servomotor-computing tachometer generator has remained unexcited for a period of three hours at the standard ambient conditions of 4.2.2, the voltage of proper amplitude and frequency specified on the applicable specification sheet shall be applied to the heater winding or windings and the total current drawn by and the total power consumed in the heater circuit shall conform to the requirements of 3.4.7.

4.7.8 Current. The servomotor-tachometer generator shall be mounted on the standard test fixture and the output winding loaded with the standard load specified on the applicable specification sheet. The servomotor-tachometer generator shall then be brought to the stabilized operating temperature of 4.2.4 and the current drawn by the reference winding and the energizing winding shall be measured and shall conform to the requirements of 3.4.7. With the reference winding voltage removed and the control winding energized with the rated standard test voltage, the current drawn by the control winding shall conform to the requirements of 3.4.7.

4.7.9 Power. The servomotor-tachometer generator shall be mounted on the standard test fixture and the output winding loaded with the standard load specified on the applicable specification sheet. The servomotor-tachometer generator shall then be brought to the stabilized operating temperature of 4.2.4 and the power consumed by the reference winding and the energizing winding shall be measured and shall conform to the requirements of 3.4.7. With the reference winding voltage removed and the control winding energized with the rated standard test voltage, the power consumed by the control winding shall conform to the requirements of 3.4.7.

4.7.10 Impedance. The servomotor-tachometer generator shall be mounted on the standard test fixture and the output winding loaded with the standard load specified on the applicable specification sheet. The servomotor-tachometer generator shall then be brought to the stabilized operating temperature of 4.2.4. The impedance of the reference and energizing windings shall be measured in accordance with MIL-S-81963 while each winding is energized with the rated standard voltage of 4.2.5. The reference winding shall then be disconnected and the control winding energized with the rated standard voltage. The impedance of the control winding shall be measured while the winding is energized. The control winding shall then be disconnected and the reference winding re-energized with the rated standard voltage. The standard load shall be removed from the output winding and the impedance of the output winding shall be measured while energized with a fundamental frequency rms voltage equivalent to that developed at the calibration speed. All impedance measurements shall conform to the requirements of 3.4.10.

4.7.11 Direction of rotation and polarity. The servomotor-tachometer generator mounted on the standard test fixture shall be energized to attain the no-load speed. The output winding shall be loaded with the standard load specified on the applicable specification sheet. The sense (or polarity) of the output voltage shall be determined and shall conform to the requirements of 3.4.11.

4.7.12 Single phasing. Unless otherwise specified, the servomotor-tachometer generator shall be mounted on the applicable test fixture and allowed to remain unenergized for three hours at the ambient temperature of 4.2.3 while being shielded from stray air currents. Both servomotor windings shall then be energized with the rated standard test voltage of 4.2.5. While operating at the resultant free speed, the control voltage shall be removed and the unit observed for evidence of single phasing. This test shall be performed in both directions of rotation. The test sequence shall then be repeated with the reference winding being removed. The unit shall conform to the requirements of 3.4.12 for each observation.

4.7.13 No-load speed. The servomotor-tachometer generator shall be mounted on the standard fixture and the output winding loaded with the standard load specified on the applicable specification sheet. The servomotor-tachometer generator shall then be brought to the stabilized operating temperature of 4.2.4. The control winding shall then be energized with the applicable rated standard test voltage and the speed of the rotor determined. This test shall be performed in both directions of rotation. The speed in both directions shall be as specified in 3.4.13. The speed of the rotor shall be determined within 10 rpm.

4.7.14 Electrical breakaway torque (starting voltage). The servomotor-tachometer generator shall be mounted on the standard test fixture and the output winding loaded with the standard load specified on the applicable specification sheet. The servomotor-tachometer generator shall then be brought to the stabilized operating temperature of 4.2.4.

With the shaft in any angular position, the test voltage applied to the control winding shall be slowly increased from zero until the shaft starts to rotate continuously. This starting voltage shall then be slowly reduced to a value that just stops rotation and the process repeated. This test shall be performed in both directions of rotation for a total of six measurements. The highest voltage observed shall be recorded as the starting voltage, and shall conform to the requirements of 3.4.14.

4.7.15 Stall torque. The servomotor-tachometer generator shall be mounted on the standard test fixture and brought to the stabilized operating temperature of 4.2.4; then one of the following stall torque tests shall be performed.

4.7.15.1. Increased torque load method. The servomotor shall be operated under standard test conditions. The stall torque shall be determined by applying a gradually increasing torque loading to a value that will just permit the rotor to turn (shaft speed less than 1 rpm). The stall torque may be determined by any suitable means having an accuracy compatible with the torque magnitude and shall meet the requirements of 3.4.15.

4.7.15.2. Lever arm and weight assembly method. The shaft of the unit shall be rigidly coupled to a fixture consisting of a suitable lever arm and weight assembly which is entirely free to rotate to 90 degrees from its free-hanging position. A combination of weights and lever arm lengths shall be chosen which effect angular deflections of at least 40 degrees. The control winding shall then be energized with the rated standard test voltage. The stall torque in ounce-inches shall be determined from the resultant angular deflection of the lever arm and weight assembly. The stall torque shall be measured in both directions of shaft rotation, and shall conform to the requirements of 3.4.15.

4.7.16 Stall torque linearity. The servomotor-tachometer generator shall be mounted on the standard test fixture and brought to the stabilized operating condition of 4.2.4. At this stabilized condition, the stall torque in ounce-inches shall be determined and shall be referred to as the stall torque at 100 percent of the rated control voltage. The control voltage shall then be reduced to 20 percent of the rated control voltage and the stall torque measured. The stabilization cycle shall be repeated with successive control voltages of 40 percent, 60 percent, 80 percent and 110 percent of the rated control voltage applied and the corresponding stall torque measured. The stall torque linearity is a function of the deviation between the actual measured stall torque readings at 20, 40, 60, 80 and 110 percent of the rated control voltage and the reading at 100 percent. Stall torque linearity shall meet the requirements of 3.4.16. The expression as a percent linearity error would be:

$$\frac{T_S}{T_{100}} - A \times 100\%$$

where:

T_S = stall torque at 20, 40, 60, 80 and 110 percent of rated control voltage

T_{100} = measured stall torque at 100 percent of rated control voltage

A = 20%, 40%, 60%, 80% and 110% expressed as a decimal; for example, 0.20, 0.40, 0.60, etc.

4.7.17 Speed at one-half measured stall torque. The servomotor-tachometer generator shall be mounted on the standard test fixture and brought to the stabilized operating temperature of 4.2.4. The shaft shall then be coupled to a suitable dynamometer and the control winding energized with the rated standard test voltage of 4.2.5. A load equivalent to one-half the measured stall torque shall be applied; the speed shall be measured (in rpm) and shall meet the requirements of 3.4.17.

4.7.18 Axis error voltages. The servomotor-tachometer generator shall be mounted on the standard test fixture and the output winding loaded with the standard load specified on the applicable specification sheet. The servomotor-tachometer generator shall then be brought to the stabilized operating temperature of 4.2.4. At the calibration speed specified, the in-phase and the quadrature-phase axis error voltages, as required by the applicable specification sheet, shall be determined and shall conform to the requirements of 3.4.18. (See Figure 6)

4.7.19 Zero-speed output voltages. The servomotor-tachometer generator shall be mounted on the standard test fixture and the output winding loaded with the standard load specified on the applicable specification sheet. The servomotor-tachometer generator shall be brought to the stabilized operating temperature of 4.2.4. At a constant speed of no greater than one-half rpm, the required zero speed output voltages shall be measured and determined for one complete revolution of the shaft and shall conform to the requirements of 3.4.19.

4.7.20 Position error voltages. The servomotor-tachometer generator shall be mounted on the standard test fixture and the output winding loaded with the standard load specified on the applicable specification sheet. The servomotor-tachometer generator shall then be brought to the stabilized operating temperature of 4.2.4. At a constant speed of no greater than one-half rpm, the in-phase and the quadrature-phase position error voltages as required shall be determined and shall conform to the requirements of 3.4.20. (See Figure 7)

4.7.21 In-phase speed-sensitive transformation ratio. The servomotor-tachometer generator shall be mounted on the standard test fixture and the output winding loaded with the standard load specified on the applicable specification sheet. The servomotor-tachometer generator shall then be brought to the stabilized operating temperature of 4.2.4. At each speed required on the applicable specification sheet, the in-phase speed-sensitive output voltage shall be measured and the transformation ratio determined. The results shall conform to the requirements of 3.4.21.

4.7.22 In-phase linearity. The servomotor-tachometer generator shall be mounted on the standard test fixture and the output winding loaded with the standard load specified on the applicable specification sheet. The servomotor-tachometer generator shall then be brought to the stabilized operating temperature of 4.2.4. Unless otherwise specified, the in-phase speed-sensitive output voltage shall be measured at the calibration speed of 3000 rpm. The in-phase speed-sensitive output voltage at the speeds specified on the applicable specification sheet shall be measured. The percent deviation from linearity shall be calculated at each required speed and shall conform to the requirements of 3.4.22. (See 6.5.10)

4.7.23 Phase shift. The servomotor-tachometer generator shall be mounted on the standard test fixture and the output winding loaded with the standard load specified on the applicable specification sheet. The servomotor-tachometer generator shall then be brought to the stabilized operating temperature of 4.2.4. At each required speed, the in-phase and quadrature-phase speed-sensitive output voltages shall be measured and shall conform to the requirements of 3.4.23.

4.7.24 Voltage sensitivity. The servomotor-tachometer generator shall be mounted on the standard test fixture and brought to the stabilized operating temperature of 4.2.4. The reference winding voltage shall then be adjusted to 110 percent of the rated standard test voltage of 4.2.5, and the control winding shall be energized at the rated voltage. After the shaft has reached the final no-load speed at this condition, the control winding voltage shall be disconnected, and the shaft observed for single phasing. The test shall be repeated with the reference winding voltage reduced to 90 percent of the rated standard voltage. Both tests shall be performed for each direction of shaft rotation. The reference winding voltage shall then be returned to the rated standard voltage and the required generator voltage sensitivity characteristics determined. The test sequence shall then be repeated with the control winding adjusted to 110 and 90 percent of the rated voltage and the reference winding being removed. The servomotor-tachometer generator shall be considered a failure if the shaft continues to rotate longer than 15 seconds after either winding has been disconnected.

4.7.24.1 In-phase transformation ratio-voltage sensitivity. With the servomotor-tachometer generator at the stabilized operating temperature of 4.2.4 and mounted on the standard fixture, the in-phase speed-sensitive transformation ratio, at the specified calibration speed, shall be measured and shall conform to the requirements of 3.4.24 when the energizing winding voltage is first 110 percent, and then 90 percent of the rated standard value.

4.7.24.2 Phase shift-voltage sensitivity. With the servomotor-tachometer generator at the stabilized operating temperature of 4.2.4 and mounted on the standard fixture, the phase shift at the specified calibration speed shall be measured and shall conform to the requirements of 3.4.24 when the energizing winding voltage is first 110 percent of the rated standard value, and then 90 percent of the rated standard value.

4.7.24.3 RMS null voltage-voltage sensitivity. With the servomotor-tachometer generator at the stabilized operating temperature of 4.2.4 and mounted on the standard fixture, the total rms null voltage shall be measured and shall conform to the requirements of 3.4.25, when the energizing winding voltage frequency is first 105 percent and then 95 percent of the rated value.

4.7.25 Frequency sensitivity. The servomotor-tachometer generator shall be mounted on the standard test fixture and brought to the stabilized operating temperature of 4.2.4 with the shaft unloaded. The frequency of the standard test voltages shall then be adjusted to 105 percent of the rated value and the control winding energized with a voltage equal in amplitude to the rated standard test voltage. When the shaft has reached its final no-load speed under these conditions, the control winding shall be disconnected and the shaft observed for single phasing. The control voltage shall then be reapplied in reverse phase and disconnected after the shaft has reached the final speed. The frequency of the test voltages shall be adjusted to 95 percent of the rated value and the above test sequence repeated. The frequency of the standard test voltages shall then be returned to the rated value and the required generator frequency sensitivity characteristics determined. The test sequence shall be repeated for both directions of rotation with the control winding adjusted to 105 and 95 percent of the rated voltage and the reference winding removed. The servomotor-tachometer shall be considered a failure if the shaft continues to rotate for more than 15 seconds after either winding has been disconnected.

4.7.25.1 In-phase transformation ratio-frequency sensitivity. With the servomotor-tachometer generator at the stabilized operating temperature of 4.2.4 and mounted on the standard fixture, the in-phase speed-sensitive transformation ratio at the specified speed shall be measured and shall conform to the requirements of 3.4.25, when the energizing winding voltage frequency is first 105 percent and then 95 percent of the rated value.

4.7.25.2 Phase shift-frequency sensitivity. With the servomotor-tachometer generator at the stabilized operating temperature of 4.2.4 and mounted on the standard fixture, the phase shift at the specified calibration speed shall be measured and shall conform to the requirements of 3.4.25, when the energizing winding voltage frequency is first 105 percent and then 95 percent of the rated value.

4.7.25.3 RMS null voltage-frequency sensitivity. With the servomotor-tachometer generator at the stabilized operating temperature of 4.2.4 and mounted on the standard fixture, the total rms null voltage shall be measured and shall conform to the requirements of 3.4.25, when the energizing winding voltage frequency is first 105 percent and then 95 percent of the rated value.

4.7.26 Temperature sensitivity. The unit shall be placed in a temperature chamber capable of being maintained at any temperature in the temperature sensitivity range within ± 2 degrees C. The servomotor-tachometer generator shall be shielded from direct air currents and the chamber shall be initially brought to 23°C ± 2°C. At this temperature, the unit shall be allowed to remain for a period of at least three hours. At the end of this time, the unit shall be energized and allowed to reach the stabilized operating temperature of 4.2.4. The unit shall then be driven at the specified calibration speed until the measured in-phase and quadrature-phase speed-sensitive transformation ratios cease to change. The applicable measurements of 3.4.26 shall be performed. The chamber temperature shall be reduced at a rate not to exceed 35°C per hour to that low temperature associated with the temperature sensitivity requirements of the applicable specification sheet. The component shall then be driven at the specified calibration speed and the applicable tests repeated as described above. The chamber temperature shall then be increased at a rate not to exceed 35°C per hour to that high temperature associated with the temperature sensitivity requirement of the applicable specification sheet and the tests repeated.

4.7.27 Temperature rise. Temperature rise shall be conducted in accordance with MIL-S-81963 and shall meet the requirements of 3.4.27. The reference, control and energizing windings (also heater windings if applicable) shall be energized with the rated standard voltage as specified in 4.2.5 and the rotor stalled.

4.7.28 Coupling in split or center-tapped control winding. The servomotor-tachometer generator shall be brought to the stabilized operating condition of 4.2.4. The reference winding shall then be disconnected and a voltage equal in amplitude to one-half the rated control winding voltage shall be applied to one-half of the split or center-tapped control winding. A voltmeter and network having a combined impedance equivalent to a 100K ohm resistor in parallel with a capacitance of 30 microfarads shall be connected across the remaining half of the control winding. The ratio of the resultant voltmeter reading to one-half the rated control winding voltage, expressed as a fraction, shall meet the requirements of 3.4.28.

4.7.29 Warm-up time. When required by the applicable specification sheet, the servomotor-tachometer generator shall be mounted on the standard test fixture and stored for a period of three hours at that ambient temperature or temperatures specified on the specification sheet for warm-up time. Unless otherwise specified, at the end of this period the reference winding, the energizing winding, and the heater winding, if applicable, shall be energized with the rated standard test voltages and the in-phase speed-sensitive transformation ratio and the in-phase axis error voltage measured at the calibration speed. The time required for the in-phase speed-sensitive transformation ratio and the in-phase axis-error voltage to be within the limits specified and subsequently remain within those limits is the warm-up time at the indicated temperature. This time shall conform to the requirements of 3.4.29.

4.7.30 Security of terminals or lead wires. The security of each screw type or solder pin type of terminal or of each lead wire shall be tested in accordance with MIL-S-81963 and shall meet the requirements of 3.4.30.

4.8 Environmental.

4.8.1 Vibration. All servomotor-tachometer generators shall be tested in accordance with MIL-S-81963. During this test, one-half of the total quantity of servomotor-tachometer generators shall be energized in accordance with 4.2.5. The remaining half shall not be energized. Immediately after the test, each servomotor-tachometer generator shall be examined for loose or damaged parts and shall meet the requirements of 3.5.1. The servomotor-tachometer generators shall then be subjected to the shock testing of 4.8.2.

4.8.2 Shock.

4.8.2.1 Shock, low impact. All servomotor-tachometer generators shall be tested in accordance with MIL-S-81963. During the test, the units shall be unenergized and the rotors mechanically free to rotate. Following the test, the servomotor-tachometer generators shall meet the requirements of 3.5.2.1.

4.8.2.2 Shock, high impact. All servomotor-tachometer generators shall be tested in accordance with MIL-S-81963. During the test, the units shall be unenergized and the rotors mechanically free to rotate. Following the test, the servomotor-tachometer generators shall meet the requirements of 3.5.2.2.

4.8.3 Altitude tests.

4.8.3.1 Altitude, low temperature. Servomotor-tachometer generators shall be tested in accordance with MIL-S-81963. The control winding shall be energized in accordance with 4.2.5 and the output winding loaded with the standard load of the applicable specification sheet. A high impedance voltmeter shall be placed across the output winding. There shall be no abrupt fluctuations of the output voltage indicating failure. The units shall then meet the requirements of 3.5.3.1.

4.8.3.2 Altitude, high temperature. Servomotor-tachometer generators shall be tested in accordance with MIL-S-81963. The control winding shall be energized in accordance with 4.2.5 and the output winding loaded with the standard load of the applicable specification sheet. A high impedance voltmeter shall be placed across the output winding. There shall be no abrupt fluctuations of the output voltage indicating failure. The units shall then meet the requirements of 3.5.3.2.

4.8.4 Ambient temperature.

4.8.4.1 Ambient low temperature. The unenergized servomotor-tachometer generator shall be placed in a test chamber and the temperature reduced to -62°C ± 5°C. This temperature shall be maintained for a period of three hours. With the output voltage winding loaded with the standard load, the chamber temperature shall be increased to -55°C ± 5°C and maintained at this temperature for one hour. The motor-generator shall then be subjected to the dielectric withstanding test of 4.7.5. After successfully withstanding the Table VII test potentials, the reference and energizing windings shall be energized with the rated standard test voltage and, at the same time, the control winding shall be energized with a test voltage equal in amplitude to two times the minimum starting voltage requirement specified in the specification sheet. The shaft shall rotate and continue to rotate, or the motor is considered a failure. Following the determination of shaft rotation, both test voltages shall be removed. The rated standard test voltage shall then be applied to all windings and the shaft allowed to attain its final speed. Disconnect the voltage from the control winding and observe the shaft for evidence of single phasing. This test shall be performed for both directions of rotation. The test sequence shall then be repeated with the reference winding being removed. If the shaft continues to rotate longer than 15 seconds after removal of either voltage, the motor is considered a failure. The servomotor-tachometer generator shall be energized to attain the stabilized operating temperature of 4.2.4. While in this environment, the unit shall be tested to the requirements of 3.5.4.1.

4.8.4.2 Ambient high temperature. The unenergized servomotor-tachometer generator shall be placed in a test chamber and the temperature increased to the high ambient temperature specified in the applicable specification sheet ± 2°C and maintained at this temperature for a period of three hours. With the output voltage winding loaded with the standard load, the reference, control and energizing windings shall then be energized at the rated voltage of 4.2.5. When the shaft has attained its no-load speed, the control winding shall be disconnected and the motor-generator observed for single phasing. This test shall be performed for both directions of rotation. The test sequence shall then be repeated with the reference winding being removed. If the shaft continues to rotate longer than 15 seconds after removal of either voltage, the motor is considered a failure. If the shaft continues to rotate for longer than 15 seconds after removal of either voltage, the servomotor-tachometer generator is considered a failure. With the reference and energizing windings still energized, the motor-generator shall be allowed to attain the stabilized operating temperature condition of 4.2.4. After reaching this condition, and while still in the same high temperature environment, the units shall meet the requirements of 3.5.4.2.

4.8.5 Endurance. The servomotor-tachometer generator shall be mounted in the standard test fixture and the output winding loaded with the standard load. The servomotor-tachometer generator shall be tested to 1000 hours in accordance with the combination of speed conditions, ambient temperatures and shaft positions indicated in Table IX. For approximately one-half the time at each combination of temperature, speed/load condition and shaft position, the servomotor-tachometer generators shall be energized to cause the opposite shaft rotation. After completion of the 1000 hour test, the servomotor-tachometer generators shall meet the requirements of 3.5.5 and shall then be subjected to the moisture resistance test of 3.5.5.

4.8.6 Moisture resistance. Servomotor-tachometer generators shall be subjected to the moisture resistance test in accordance with MIL-S-81963. One unit shall be unenergized and one unit shall have the reference winding energized in accordance with the standard voltage of 4.2.5. Following completion of step 6 with the humidity controlled at 90 to 98 percent, both servomotor-tachometer generators shall be energized with the standard rated voltage and allowed to attain the no-load speed. The units shall remain at this condition for five minutes. This procedure shall be followed during each of the total 10 cycles. After completion of the final cycle, the motors shall remain unenergized at the standard ambient conditions for 24 hours. The servomotor-tachometer generators shall subsequently be subjected to and shall meet the requirements of 3.5.6.

4.8.7 Audible noise structureborne. When required by the applicable specification sheet, the structureborne noise test shall be conducted in accordance with MIL-S-81963 while mounted in the test fixture of Figure 8. The unit and fixture combination shall be suspended as shown in Figure 9, in such a manner that the shaft axis and the top edge of the mounting plate are horizontal within 5 degrees. After determination of the prevailing ambient noise level for the broad, one-third octave, and narrow bands with the unit unenergized, the reference and energizing windings shall be energized with the rated voltage, and the control winding energized at one-half the rated standard voltage in accordance with 4.2.5. The required vibration levels shall be recorded and shall meet the requirements of 3.5.7.

4.8.8 Salt atmosphere. When required by the applicable specification sheet, servomotor-tachometer generators shall be subjected to the salt atmosphere test in accordance with MIL-S-81963 and shall meet the requirements of 3.5.8.

4.8.9 Explosion resistance. When required by the applicable specification sheet, servomotor-tachometer generators shall be subjected to explosion resistance in accordance with MIL-STD-202, Method 109, while being vibrated according to 4.7.1 and energized as specified in 4.2.5. The servomotor-tachometer generator shall meet the requirements of 3.5.9. Additional information on explosion resistance is given in 4.10.8 of MIL-S-81963.

5. PACKAGING

5.1 Packaging requirements. The requirements for packaging shall be in accordance with MIL-S-81963.

6. NOTES

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

6.1 Intended use. The intended use for servomotor-tachometer generators covered by this specification should be in accordance with MIL-S-81963.

6.2 Acquisition requirements. Acquisition documents should contain the information specified in MIL-S-81963; and should also specify if a black finish is required on the housing.

6.3 First article inspection. Information pertaining to first article inspection of servomotor-tachometer generators should be obtained as specified in MIL-S-81963.

6.4 Rated voltage and frequency. Normal tolerances for field power supplies are ± 10 percent on voltage and frequency and ± 5 percent on harmonic content. It should be understood that the characteristics required in the applicable specification sheets for servomotor-tachometer generators are based upon tolerances of ± 1 percent on voltage and frequency and ± 3 percent on harmonic content (see 4.2.5) unless otherwise noted in the specification sheet. Therefore, servomotor-tachometer generator performance characteristics may be degraded under normal field power supply tolerances.

6.5 Definitions.

6.5.1 Speed range. The speed range of a servomotor-tachometer generator is the specified band of speeds within which performance characteristics are applicable.

6.5.2 Calibration speed. The calibration speed of a servomotor-tachometer generator is a specified speed within the specified speed range used for standardization and reference purposes. The calibration speed is usually five-sixths of the maximum speed in the speed range.

6.5.3 Damping coefficient. The damping coefficient of a servomotor-tachometer generator is the slope of the speed-torque curve. The value, the average damping constant, is approximately equal to:

$$D = \frac{T_S}{N_O} \times 6.74 \times 10^5 \text{ dyne-centimeter-seconds per radian}$$

where:

T_S = the stall torque in ounce-inches

N_O = the no-load speed in revolutions per minute (rpm)

6.5.4 Time constant. The time constant (TC) of a servomotor-tachometer generator is the time required for the motor to reach 63.2 percent of the no-load speed after both windings have been energized with rated voltages. It is equal to:

$$TC = \frac{J_r}{D} \text{ seconds}$$

where:

J_r = rotor moment of inertia in gram-centimeters^2

D = damping constant

6.5.5 Reversing time. The reversing time (RT) of a servomotor-tachometer generator is the time required for the motor to reach 63.2 percent of the no-load speed upon the phase reversal of the control winding voltage after initially running at the no-load speed in the opposite direction. It is approximately equal to:

$$RT = (TC) \times 1.69 \text{ seconds}$$

6.5.6 Theoretical acceleration at stall. The theoretical acceleration at stall (A) of a servomotor-tachometer generator is a ratio that indicates the ability of the motor to accelerate from the stall condition with rated voltage. It is equal to:

$$A = \frac{T_s}{J_r} \times 7.06 \times 10^4 \text{ radians per second}^2$$

6.5.7 Maximum power output. The power output of a motor is the power measured at the shaft due to the rotation of a torque load. It is equal to:

$$P_o = T \times N \times 7.4 \times 10^{-4} \text{ watts}$$

where:

T = the torque developed in ounce-inches

N = shaft speed for a torque load T in rpm

For a servomotor-tachometer generator defined by this document, maximum power output is essentially realized when the reference, control, and energizing windings are excited with rated voltages; and a torque load necessary to reduce the shaft speed to one-half the measured no-load speed is applied to the shaft.

6.5.8 Output voltage. The output voltage of a servomotor-tachometer generator is the voltage across the output winding.

6.5.8.1 Speed-sensitive output voltage. The speed-sensitive output voltage is that portion of the output voltage of the fundamental frequency that is a function of speed only (see Figure 6). It is numerically equal to one-half the sum of the fundamental output voltages measured at the same speed and test conditions in both directions of rotation as follows:

$$\frac{V_{ccw} + V_{cw}}{2}$$

where:

V is the magnitude of the fundamental component of the output voltage.

6.5.8.1.1 In-phase speed-sensitive output voltage. The in-phase speed-sensitive voltage is that component of the speed-sensitive output voltage that has a phase which is the same or 180° from the reference phase. It is equal to one-half the algebraic difference between the in-phase speed-sensitive output voltages measured at the same speed and test conditions in both directions of rotation as follows:

$$\frac{V_{iccw} - V_{icw}}{2}$$

where:

Vi is the in-phase speed-sensitive output voltage.

6.5.8.1.2 Quadrature-phase speed-sensitive output voltage. The quadrature-phase speed-sensitive output voltage is that component of the speed-sensitive output voltage that has a phase which is 90° or 270° from the reference phase. It is equal to one-half the algebraic difference between the quadrature-phase speed-sensitive output voltages measured at the same speed and test conditions in both directions of rotation as follows:

$$\frac{V_{qccw} - V_{qcw}}{2}$$

where:

Vq is the quadrature-phase speed-sensitive output voltage.

6.5.8.2 Zero-speed output voltage. The zero-speed output voltage of a servomotor-tachometer generator is the voltage present across the output winding that is a function of rotor position only.

6.5.8.2.1 Total rms null voltage. The total rms null voltage of a servomotor-tachometer generator is the magnitude of the total rms zero-speed output voltage at that rotor position which produces a maximum value.

6.5.8.2.2 Fundamental rms null voltage. The fundamental rms null voltage of a servomotor-tachometer generator is the magnitude of the rms zero-speed output voltage of fundamental frequency at the rotor position which produces a maximum value.

6.5.8.2.3 In-phase null voltage. The in-phase null voltage of a servomotor-tachometer generator is the magnitude of that component of rms zero-speed output voltage that has a phase which is the same or 180° from the reference phase and is measured at a rotor position which produces a maximum value for the in-phase null voltage.

6.5.8.2.4 Quadrature-phase null voltage. The quadrature-phase null voltage of a servomotor-tachometer generator is the magnitude of that component of rms zero-speed output voltage that has a phase which is 90° or 270° from the reference phase and is measured at a rotor position which produces a maximum value for the quadrature-phase null voltage.

6.5.8.3 Position error voltage. The position error voltage of a servomotor-tachometer generator is one-half the difference between the fundamental rms null voltage and the magnitude of the rms zero-speed output voltage of fundamental frequency at that rotor position which produces a minimum value.

6.5.8.3.1 In-phase position error voltage. The in-phase position error voltage of a servomotor-tachometer generator is one-half the algebraic difference between the in-phase null voltage and the magnitude of that component of the rms zero-speed output voltage of fundamental frequency that has a phase which is 180° from the phase of the in-phase null voltage at that rotor position which produces a maximum value, if it exists. If it does not exist, the in-phase position error voltage is one-half the algebraic difference between the in-phase position error voltage and the magnitude of that component of the rms zero-speed output voltage of fundamental frequency that has a phase which is the same as the phase of the in-phase null voltage at a rotor position which produces a minimum value. (See Figure 7)

6.5.8.3.2 Quadrature-phase position error voltage. The quadrature-phase position error voltage of a servomotor-tachometer generator is one-half the algebraic difference between the quadrature-phase null voltage and the magnitude of that component of the rms zero-speed output voltage of fundamental frequency that has a phase which is 180° from the phase of the quadrature-phase null voltage at that rotor position which produces a maximum value, if it exists. If it does not exist, the quadrature-phase position error voltage is one-half the algebraic difference between the quadrature-phase null voltage and the magnitude of the component of the rms zero-speed output voltage of fundamental frequency that has a phase which is the same as the phase of the quadrature-phase null voltage at a rotor position which produces a minimum value. (See Figure 7)

6.5.8.4 Axis error voltage. The axis error voltage of a servomotor-tachometer generator is that portion of the output voltage of fundamental frequency that is neither a function of rotor position nor rotor speed. It is numerically equal to one-half the sum of the fundamental output voltages measured at the same speed and test conditions in both directions of rotation as follows:

$$\frac{Vccw + Vcw}{2}$$

where:

V is the magnitude of the fundamental component of the output voltage.

6.5.8.4.1 In-phase axis error voltage. The in-phase axis error voltage of a servomotor-tachometer generator is that component of the axis error voltage that has a phase which is the same or 180° from the reference phase. It is equal to one-half the algebraic sum of the in-phase speed-sensitive output voltages measured at the same speed and test conditions in both directions of rotation as follows:

$$\frac{Viccw + Vicw}{2}$$

where:

Vi is the in-phase speed-sensitive output voltage.

In terms of the in-phase (zero-speed output voltage) rotor position error voltage, refer to Figure 6.

6.5.8.4.2 Quadrature-phase axis error voltage. The quadrature-phase axis error voltage of a servomotor-tachometer generator is that component of the axis error voltage that has a phase which is 90° or 270° from the reference time phase. It is equal to one-half the algebraic sum of the quadrature-phase speed-sensitive output voltages measured at the same speed and test conditions in both directions of rotation as follows:

$$\frac{Vqccw + Vqcw}{2}$$

where:

Vq is the quadrature-phase speed-sensitive output voltage.

In terms of the quadrature-phase (zero-speed output voltage) rotor position error voltage, refer to Figure 6.

6.5.8.5 Speed-sensitive transformation ratio. The speed-sensitive transformation ratio of a servomotor-tachometer generator is the ratio of the speed-sensitive output voltage to the fundamental energizing voltage at any specified speed in the speed range, usually the calibration speed.

6.5.8.5.1 In-phase speed-sensitive transformation ratio. The in-phase speed-sensitive transformation ratio (3.4.21) of a servomotor-tachometer generator is the ratio of the in-phase speed-sensitive output voltage to the fundamental energizing voltage at the specified calibration speed or speeds. When tested in accordance with 4.7.21, the in-phase speed-sensitive transformation ratio shall be within the limits specified for those calibration speeds indicated on the military specification sheet. The in-phase speed-sensitive transformation ratio at the calibration speed after high impact shock shall be within 20 percent of the normal value specified on the applicable specification sheet.

6.5.8.5.2 Quadrature-phase speed-sensitive transformation ratio. The quadrature-phase speed-sensitive transformation ratio of a servomotor-tachometer generator is the ratio of the quadrature-phase speed-sensitive output voltage to the fundamental energizing voltage at any specified speed in the speed range, usually the calibration speed.

6.5.9 Output gradient. The output gradient of a servomotor-tachometer generator is the approximate slope of the curve of the speed-sensitive output voltage as a function of speed. It is expressed in volts per 1000 rpm at any specified speed in the speed range.

6.5.10 Linearity. The linearity of a servomotor-tachometer generator is a ratio of the difference between the measured output voltage (Eo), and the calculated output voltage (Eoc), to the calculated output voltage at maximum speed (Emax), expressed in percent.

$$E_{oc} = \frac{N_o}{N_c} (E_c)$$

$$E_{max} = \frac{N_{max}}{N_c} (E_c)$$

where:

N_o = any speed in the speed range

N_c = the calibration speed

N_{max} = the maximum speed in the speed range

E_o = the output voltage measured at speed, N

E_c = the output voltage measured at the calibration speed, Nc then:

$$\text{Linearity} = \frac{E_o - E_{oc}}{E_{max}} (100\%)$$

6.5.10.1 <u>In-phase linearity</u>. The in-phase linearity, expressed in percent, is defined as:

$$\text{In-phase linearity} = \frac{ITR_o - \frac{N_o}{N_c} \times ITR_c}{\frac{N_{max}}{N_c} \times ITR_c} (100\%)$$

where:

ITR_o is the in-phase speed-sensitive transformation ratio at any speed, N_o, in the specified speed range.

ITR_c is the in-phase speed-sensitive transformation ratio at the calibration speed, N_c.

6.5.11 <u>Reference winding</u>. The reference winding (phase 1) of a servomotor-tachometer generator is that winding, associated with the servomotor section, that is excited by a specified fixed voltage and frequency.

6.5.12 <u>Control winding</u>. The control winding (phase 2) of a servomotor-tachometer generator is that winding, associated with the servomotor section, that is energized by a control voltage with a phase difference of 90 degrees from the voltage energizing the reference winding.

6.5.13 <u>Energizing winding</u>. The energizing winding of a servomotor-tachometer generator is that winding, associated with the tachometer generator section, that is energized with a specified fixed voltage and frequency. This could also be called the tachometer input winding.

6.5.14 <u>Output winding</u>. The output winding of a servomotor-tachometer generator is the winding, associated with the tachometer generator section, whose voltage output is proportional to the angular velocity of the rotor when the energizing winding is energized. The frequency of the output voltage is the rated frequency.

6.5.15 <u>Reference phase</u>. The reference phase of a servomotor-tachometer generator is the phase of the fundamental voltage applied to the energizing winding and is zero degrees (0°).

6.5.16 Electrical breakaway torque (starting voltage). The electrical breakaway torque or minimum starting voltage of a servomotor-tachometer generator is the rated frequency voltage applied to the control winding of the servomotor section necessary to cause the shaft to start and continue to rotate. This rotation is from any initial angular position when the reference and energizing windings are energized with the rated voltages and frequency with no load attached to the shaft.

6.5.17 Single phasing. Single phasing of a servomotor-tachometer generator is the tendency of the shaft to start when only one winding of the servomotor section is energized, or the tendency to continue rotating when either winding of the servomotor section is disconnected from all of its associated energization source impedances after the motor-generator has first attained maximum speed with no load attached to the shaft.

6.5.18 Stall torque. The stall torque of a servomotor-tachometer generator is the torque developed at zero rotor speed when rated voltages and frequency are applied to all windings, except the output winding.

6.5.19 Direction of rotation. Clockwise and counterclockwise directions of rotation are determined when viewing the motor from the shaft extension associated with the mounting surfaces. The standard positive direction of rotation is counterclockwise.

6.5.20 No-load speed. The no-load speed of a servomotor-tachometer generator is the speed of the shaft, mechanically unloaded, when rated voltages and frequency are applied to the reference, control and energizing winding.

6.5.21 Effective resistance. The equivalent pure DC resistance which, when substituted for the winding being checked, will consume the same power. It is equal to the impedance of a circuit consisting of a capacitance in parallel with the winding being checked when the capacitor is adjusted for unity power factor or maximum impedance of the circuit.

6.5.22 Temperature rise. The temperature rise of a servomotor-tachometer generator is the increase of the internal temperature of the unit above the ambient temperature due to the dissipation of energization power and heater element power.

6.5.23 Phase shift. The phase shift of a servomotor-tachometer generator is the difference between the reference phase and the phase of the fundamental output voltage. It is equal to the arc tangent of the ratio of the quadrature-phase speed-sensitive output voltage (or the quadrature-phase speed-sensitive transformation ratio) to the in-phase speed-sensitive output voltage (or the in-phase speed sensitive transformation ratio) in degrees, measured at the same speed and test conditions.

6.5.24 Warm-up time. The warm-up time of a servomotor-tachometer generator is the time required for the unit to meet the performance requirements after being stored for three hours at a specified ambient temperature.

6.5.25 Temperature sensitivity. The temperature sensitivity of a servomotor-tachometer generator is the change in the electrical or mechanical characteristic due to prescribed deviations in the ambient temperature from 23°C ± 2°C.

6.5.26 Coupling in center-tapped and split windings. The coupling is that voltage of mutual induction present across one-half of a split or center-tapped winding when the remaining one-half is energized with one-half rated voltage. The coupling is expressed in percent of energization and is intended to approximate 100 percent for servomotor-tachometer generator control windings.

6.5.27 Voltage sensitivity. The voltage sensitivity of a servomotor-tachometer generator is the change in the applicable electrical or mechanical characteristic due to prescribed deviations from the rated value of either the reference winding voltages or energizing winding voltages or both. It may be specified as a percent change of rated voltage.

6.5.28 Frequency sensitivity. The frequency sensitivity of a servomotor-tachometer generator is the change in the applicable electrical characteristic due to prescribed deviations from the rated value of the fundamental frequency. It is sometimes expressed as a percent change of rated frequency.

6.5.29 Units of measurement. Unless otherwise specified, units of measurement are as follows:

a. Angles = degrees, minutes
b. Potential = volts, rms
c. Impedance = ohms
d. Current = amperes, rms
e. Temperature = degrees, centigrade
f. Time Phase = degrees
g. Torque = ounce-inches
h. Time = seconds
i. Angular velocity = revolutions per minute (rpm)

6.6 Subject term (key word) listing.

Axis-error voltage
Calibration speed
Control winding
Damping constant
Effective resistance
First article
Frequency sensitivity
In-phase speed-sensitive transformation ratio
Linearity
Position-error voltage
Quadrature-phase speed-sensitive transformation ratio
Qualification
Qualified products list (QPL)
Quality conformance
Reference winding
Servomotor
Stall torque linearity
Tachometer generator
Voltage sensitivity
Zero-speed output voltage

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

6.8 International standardization agreements. Certain provisions of this specification are the subject of international standardization agreements reached by the NATO Working Group on Analogue and Digital Servocomponents (AC/301(SG/A)(WG/5)). When amendment, revision, or cancellation of this specification is proposed which affects or violates the international agreement concerned, the preparing activity will take appropriate reconciliation action through international standardization channels, including departmental standardization offices, to change the agreement or make other appropriate accommodations.

6.9 Applicable international documentation. NATO documents applicable to this specification are Allied Standard Publication (AStanP)-3, Volume 6105 Chapter 3, NATO Electronic/Electrical Preferred Parts List, Servomotor-Tachometer Generators, AC; AStanP-4, Volume 6105 Chapter 7, NATO Electronic/Electrical Technical Recommendation, Servomotor-Tachometer Generators, AC; and AStanP-5, Volume 6105 Chapter 7, NATO Quality Assessment Recommendation for Electronic/Electrical Parts, Servomotor-Tachometer Generators, AC.

TABLE I. Nomenclature

Servomotor Tachometer Generator	15	SM-DG	4	A
Item Name (1.2.1)	Size (1.2.1.2)	Function (1.2.1.3)	Supply Frequency (1.2.1.4)	Modification (1.2.1.5)

TABLE II. Example of part identifying number.

M	22820/1	-01	C
Military Designation	Specification Sheet No.	Dash No.	Latest Modification Letter

TABLE III. Servomotor termination identification marking.

Terminal No.	Wire Lead Color	Winding
1	Yellow	Reference
3	White	Reference
2	Red	Control
5	Red-Black	Control
6	Green	Control
4	Black	Control

TABLE IV. Tachometer generator termination identification marking.

Terminal No.	Wire Lead Color	Winding
7	Orange	Energizing
10	Gray	Energizing
8	Blue	Output
9	Brown	Output

TABLE V. Terminal hardware.

Hardware	Number Required	Military Standard	Servomotor Size
Machine Screw	10 EA	MS-35276-202	11
		MS-35276-212	15, 18
Lock Washer	10 EA	MS-35338-134	11
		MS-35338-135	15, 18
Terminal Lug	10 EA	MS-17182-1	11
			15, 18

TABLE VI. Standard dimensions for servomotor-tachometer generators.

(See Figures 2 and 3 for location of lettered dimensions)

Dimension 1/	A	B 2/	C	D	E
Motor-Tach Size	±0.010	± 0.010	+0.003 -0.005	+0.000 -0.005	+0.0000 -0.0005
05	0.375	0.250	0.750	—	0.375
08	0.375	0.250	0.750	—	0.500
11	0.375	0.250	1.062	1.000	0.625
15	0.437	0.312	1.437	1.312	0.875
18	0.562	0.437	1.750	1.562	0.9375

SPUR GEAR DATA F				Outside Diameter	Pitch Diameter	Testing Radius
Motor-Gen Size	No. of Teeth	Diametral Pitch	Pressure Angle	+0.000 -0.001	+0.0000 -0.0005	+0.0000 -0.0012
05	13	120	20°	0.1247	—	—
08	13	120	20°	0.1247	—	—
11	13	120	20°	0.1247	0.1083	—
15	15	96	20°	0.1770	0.1562	0.0786
18	15	96	20°	0.1770	0.1562	—

NOTES:

1/ Unless otherwise specified, dimensions are in inches.

2/ B is length for full depth of tooth.

TABLE VI. Standard dimensions for servomotor-tachometer generators - Continued.

(See Figures 2 and 3 for location of lettered dimensions)

Dimension	Pitch Radius	Testing Pressure, Oz	G	H	I
Motor-Gen Size	+0.0000 -0.0008	Maximum	Maximum	±0.005	±0.005
05	—	—	AS SPECIFIED ON SPECIFICATION SHEET	0.040	—
08	—	—		0.040	—
11	—	—		0.062	0.062
15	0.786	6.00		0.040	0.132
18	—	—		0.040	0.132

Dimension	J	K	L	O	R 3/
Motor-Gen Size	±0.005	±0.005	±0.005	±0.003	± 0.005
05	0.040	0.437	—	—	—
08	0.062	0.062	0.687	—	—
11	0.093	0.062	0.975	0.812	0.843
15	0.093	0.078	1.312	1.100	1.031
18	0.093	0.078	1.625	1.250	1.031

NOTE:

3/ R is applicable for terminal blocks only.

TABLE VII. Test voltages and application points.

Maximum rated voltage, rms	Initial Test Voltages, rms (50 or 60 Hz)		Subsequent Test Voltages rms (50 or 60 Hz)	
	1/ Each winding to housing and 3 to 4 3 to 2	1/ 5 to 6	1/ Each winding to housing and 3 to 4 3 to 2	1/ 5 to 6
Up to 50	242 to 250	242 to 250	194 to 200	194 to 200
51 to 100	485 to 500	242 to 250	388 to 400	194 to 200
101 to 200	870 to 900	242 to 250	720 to 740	194 to 200

NOTES:

1/ If the servomotor-tachometer generator is furnished with a center-tapped or single-ended control winding, the application of the test potential between lead 2 and the housing, between leads 3 and 2, and leads 5 and 6 is not necessary.

2/ See Table III and Table IV for corresponding color-coded wire leads for the servomotor and tachometer-generator terminations.

TABLE VIII. First article and quality conformance inspection tests.

Test No.	Require-ment	Test	Test method for examination	Inspection	
				First article Sample Number	Quality Conformance
1	3.4.1	4.7.1	Visual and mechanical inspection	1, 2, 3, 4	X
2	3.4.2	4.7.2	Shaft radial and end play	1, 2, 3, 4	X
3	3.4.3	4.7.3	Total shaft runout (smooth portion)	1, 2, 3, 4	X
4	3.4.4	4.7.4	Rotor moment of inertia	1, 2, 3, 4	-
5	3.4.5	4.7.5	Dielectric withstanding voltage	1, 2, 3, 4	X
6	3.4.6	4.7.6	Insulation resistance	1, 2, 3, 4	X
7	3.4.7	4.7.7	Heater winding, Current and Power	1, 2, 3, 4	X
8	3.4.8	4.7.8	Current	1, 2, 3, 4	X
9	3.4.9	4.7.9	Power	1, 2, 3, 4	X
10	3.4.10	4.7.10	Impedance	1, 2, 3, 4	-
11	3.4.11	4.7.11	Direction of rotation	1, 2, 3, 4	X
12	3.4.12	4.7.12	Single phasing	1, 2, 3, 4	X
13	3.4.13	4.7.13	No-load speed	1, 2, 3, 4	X
14	3.4.14	4.7.14	Electrical breakaway torque	1, 2, 3, 4	X

TABLE VIII. First article and quality conformance inspection tests - Continued.

Test No.	Require-ment	Test	Test method for examination	Inspection	
				First article Sample Number	Quality Conformance
15	3.4.15	4.7.15	Stall torque	1, 2, 3, 4	X
16	3.4.16	4.7.16	Stall torque linearity	1, 2, 3, 4	-
17	3.4.17	4.7.17	Speed at one-half stall torque	1, 2, 3, 4	-
18	3.4.18	4.7.18	Axis-error voltage	1, 2, 3, 4	X
19	3.4.19	4.7.19	Zero-speed output voltage	1, 2, 3, 4	X
20	3.4.20	4.7.20	Position-error voltage	1, 2, 3, 4	X
21	3.4.21	4.7.21	In-phase speed-sensitive transformation ratio	1, 2, 3, 4	X
22	3.4.22	4.7.22	In-phase linearity	1, 2, 3, 4	-
23	3.4.23	4.7.23	Phase shift	1, 2, 3, 4	X
24	3.4.24	4.7.24	Voltage sensitivity	1, 2, 3, 4	-
25	3.4.25	4.7.25	Frequency sensitivity	1, 2, 3, 4	-
26	3.4.26	4.7.26	Temperature sensitivity, during test nos. 18, 19, 20, 21, 22, and 23	1, 2, 3, 4	-

TABLE VIII. First article and quality conformance inspection tests - Continued.

Test No.	Requirement	Test	Test method for examination	Inspection	
				First article Sample Number	Quality Conformance
27	3.4.27	4.7.27	Temperature rise	1, 2, 3, 4	-
28	3.4.28	4.7.28	Coupling in split or center-tapped control winding	1, 2, 3, 4	-
29	3.4.29	4.7.29	Warm-up time 1/	1, 2, 3, 4	-
30	3.4.30	4.7.30	Security of terminals or wire leads	1, 2, 3, 4	-
31	3.5.1	4.8.1	Vibration followed by test no. 33	1, 2, 3, 4	-
32	3.5.2.1	4.8.2.1	Shock, low impact followed by test nos. 2, 5, 6 , 13, 14, 15, 18, 19, 20, 21, 22, and 23	1, 2, 3, 4	-
33	3.5.2.2	4.8.2.2	Shock, high impact followed by test nos. 2, 5, 6, 13, 14, and 21	1, 2, 3, 4	-
34	3.5.3.1	4.8.3.1	Altitude, low temperature followed by test nos. 21, 22, and 23	1, 2	-
35	3.5.3.2	4.8.3.2	Altitude, high temperature followed by test nos. 6 and 14	1, 2	-
36	3.5.4.1	4.8.4.1	Ambient, low temperature followed by test nos. 5, 6, 13, and 14	3, 4	-

TABLE VIII. First article and quality conformance inspection tests - Continued.

Test No.	Require- ment	Test	Test method for examination	Inspection	
				First article Sample Number	Quality Conformance
37	3.5.4.2	4.8.4.2	Ambient, high temperature followed by test nos. 5, 6, 13, 14, and 15	3, 4	-
38	3.5.5	4.8.5	Endurance followed by test Nos. 2, 5, 6, 13, 14, 15, 18, 19, 20, 21, 22, and 23	1, 2	-
39	3.5.6	4.8.6	Moisture resistance followed by test nos. 5, 6, 13, 14, 15, 18, 19, 20, 21, 22, and 23	3, 4	-
40	3.5.7	4.8.7	Audible noise structureborne 1/	1, 2, 3, 4	-
41	3.5.8	4.8.8	Salt atmosphere 1/	1, 2	-
42	3.5.9	4.8.9	Explosion resistance 1/	3, 4	-

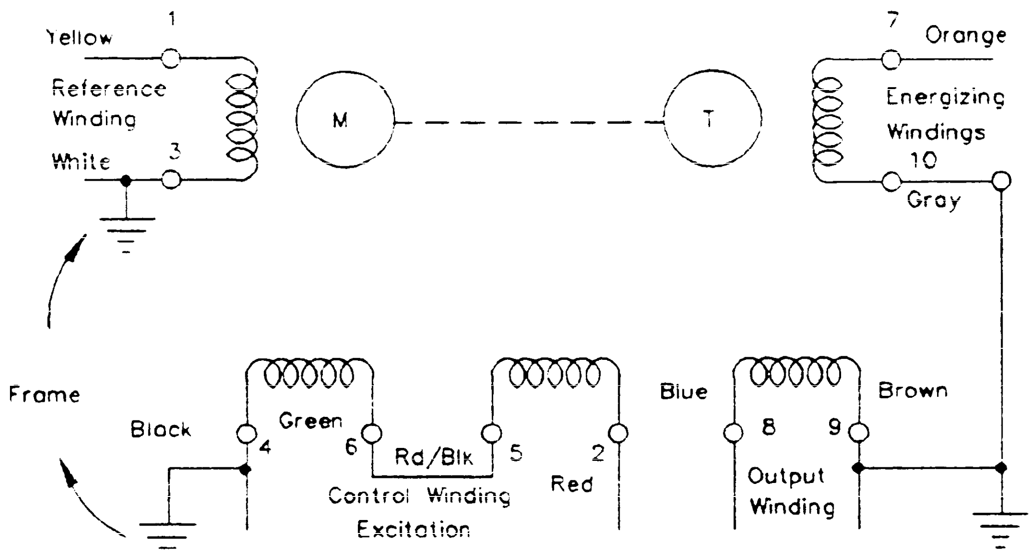
*Test Nos. 29, Warm-up time; 40, Audible noise structureborne; 41, Salt atmosphere; and 42, Explosion resistance shall be performed only when required by the specification sheet.

TABLE IX. Conditions for endurance tests.

Time (hours)	Speed/load condition	Temperature (C°)	Shaft position
64 ± 2	No-load speed	-55°C ± 5°C	Horizontal
24 ± 2	No-load speed	Th 1/	Vertical (Up)
24 ± 2	No-load speed	Th 1/	45° (Up)
24 ± 2	No-load speed	Th 1/	45° (Down)
24 ± 2	No-load speed	Th 1/	Vertical (Down)
740 ± 4	No-load speed	Standard (4.2.2)	Horizontal
100 ± 3	Maximum power output 2/	100°C ± 5°C	Horizontal

NOTES: 1/ This is the high ambient temperature specified in the detail specification sheet.

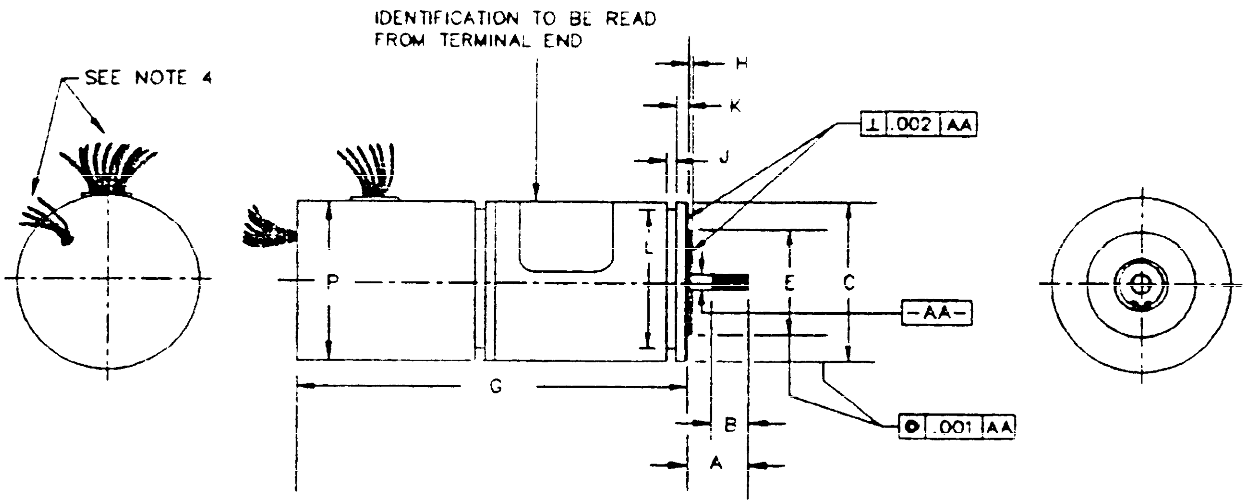
2/ Maximum power output is defined in 6.5.7.

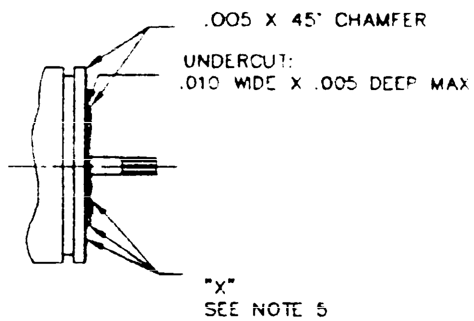


Notes:

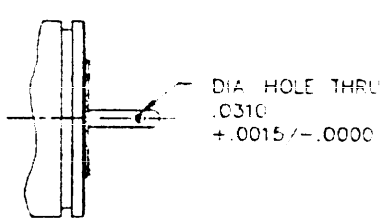
1. Voltage at terminal 2 (Red) must lead voltage at terminal 1 (Yellow) by 90° ± 3° for CCW rotation.
2. When a center-tapped control winding is furnished, a Red/Black wire or terminal number 5 shall be used.
3. During testing, terminals 3 and 4 (for CW rotation) are strapped and returned to frame.
4. When the shaft rotates in a postive (CCW) direction and terminals 9 and 10 are common, the voltage at terminal 8 (Blue) shall be 180 degrees from the voltage at terminal 7 (Orange).
5. Terminal designation on lead wire color codes not conforming to the standard identification will be contained in the Military Specification Sheets.
6. Terminals and lead wires associated with compensating networks and elements will be shown in the Military Specification Sheets.
7. For series operation of control windings, terminals 5 and 6 are strapped and rated series voltage of Table I is applied across terminals 2 and 4.
8. For multiple or parallel operation of control windings, terminals 6 and 2 are strapped and terminals 4 and 5 are strapped; then rated parallel voltage of Table I is applied across terminals 2 and 4.

FIGURE 1. Standard servomotor-tachometer generator test connection diagram.





VIEW 1

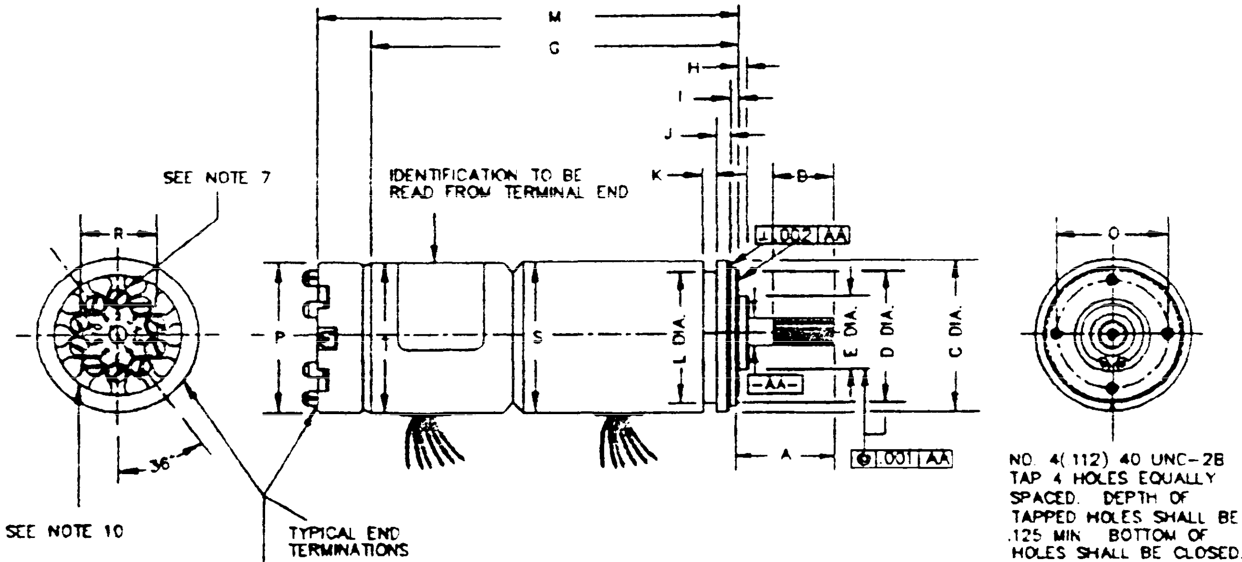


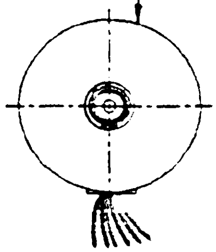
VIEW 2

NOTES:

1. PERPENDICULARITY AND CONCENTRICITY SHALL BE MEASURED WITH THE UNIT IN A VERTICAL POSITION SUPPORTED BY THE SHAFT WHILE ROTATING THE HOUSING.
2. RUNOUT OF FEATURE -AA- (SMOOTH PORTION) OF SHAFT SHALL NOT EXCEED .0014 FIM.
3. END PLAY AND RADIAL PLAY SHALL BE MEASURED DURING REVERSAL OF THE FOLLOWING LOADS:
   END PLAY-1 POUND RADIAL PLAY-1/2 POUND
4. TERMINAL LEAD WIRES SHALL DEPART THROUGH THE BACK SURFACE OF THE TERMINAL END OF THE SERVOMOTOR OR TACHOMETER GENERATOR IN ANY ACCEPTABLE MANNER.
5. SURFACES MARKED "X" SHALL BE BRIGHT CORROSION-RESISTANT STEEL PER MIL-S-81963.
6. UNLESS OTHERWISE SPECIFIED, DIMENSIONS ARE IN INCHES. UNSPECIFIED TOLERANCES SHALL BE: FRACTIONS ±1/64, DECIMALS ±0.005, AND ANGLES ±2°.
7. (VIEW 2) GEAR RATIO SHALL BE 243 TO 1.
8. LETTERED DIMENSIONS ARE GIVEN IN TABLE V.

FIGURE 2. Outline drawing for sizes 05 and 08 servomotor-tachometer generator.





NOTES:

1. PERPENDICULARITY AND CONCENTRICITY SHALL BE MEASURED WITH THE UNIT IN A VERTICAL POSITION, SUPPORTED BY THE SHAFT, WHILE ROTATING THE HOUSING.

2. TOTAL RUNOUT OF MAJOR DIAMETER OF FEATURE -AA- SHALL NOT EXCEED .0014 FIM.

3. END PLAY AND RADIAL PLAY SHALL BE MEASURED DURING REVERSAL OF THE FOLLOWING LOADS:

SIZE 11	END PLAY 1/2 POUND	RADIAL PLAY 1 POUND
SIZE 15	END PLAY 1 POUND	RADIAL PLAY 1/2 POUND
SIZE 18	END PLAY 1 POUND	RADIAL PLAY 1 POUND

4. SURFACES MARKED "X" SHALL BE BRIGHT CORROSION-RESISTANT STEEL (AS PER MIL-S-81963).

5. UNLESS SPECIFIED OTHERWISE, DIMENSIONS ARE IN INCHES. UNSPECIFIED TOLERANCES SHALL BE: FRACTIONS ±1/64, DECIMALS ±0.005, AND ANGLES ±2°.

6. FOR TAPPED HOLE IN CENTER OF SHAFT, USE NO. 4(.112)48 UNF-2, DEPTH .375 MAX., 60° CENTER, .125 DIA.

7. TERMINAL #2 TO BE ALIGNED WITH TAPPED HOLE IN CENTER OF SHAFT WITHIN ±5°.

8. THE END CAP DESIGN SHALL BE SUCH THAT THE TERMINAL LUGS MAY BE INSTALLED WITH THE BARREL INBOARD OR 180° POSITION OUTBOARD. RECESSES FOR LUGS SHALL BE OF WIDTH AND DEPTH TO PREVENT TURNING OF THE LUGS.

9. TERMINAL LEAD WIRES SHALL DEPART THROUGH THE BACK SURFACE OF THE SERVOMOTOR AND TACHOMETER GENERATOR IN ANY ACCEPTABLE MANNER.

10. THE DESIGN OF THE UNIT SHALL PROVIDE FOR THE TERMINAL BLOCK TO REMAIN FIXED WHEN THE TERMINAL SCREWS ARE REMOVED.

11. LETTERED DIMENSIONS ARE GIVEN IN TABLE V.

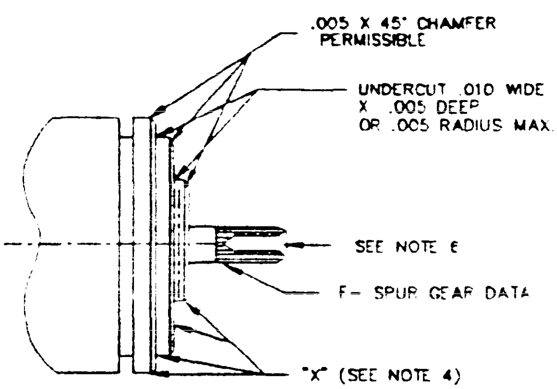
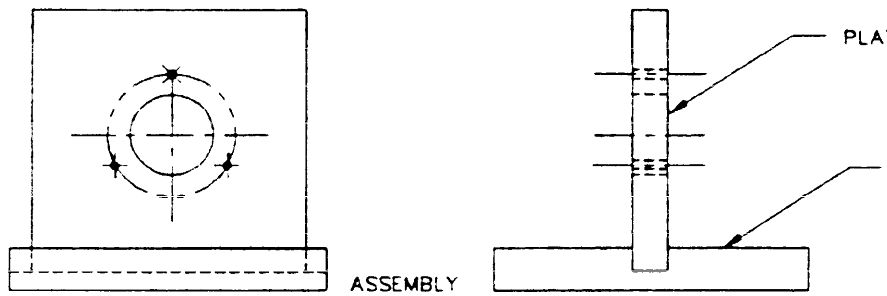


FIGURE 3. Outline drawing for servomotor-tachometer generators, sizes 11, 15 and 18.



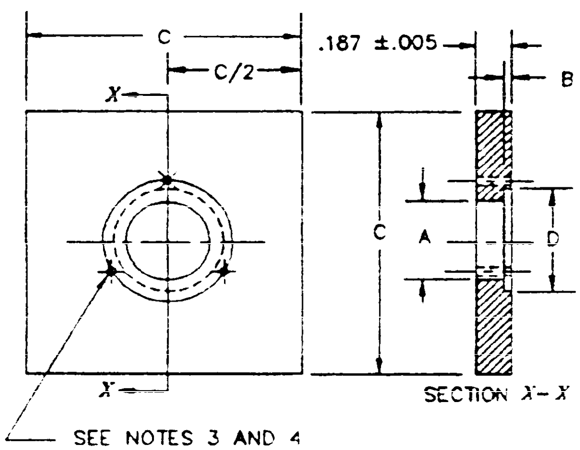
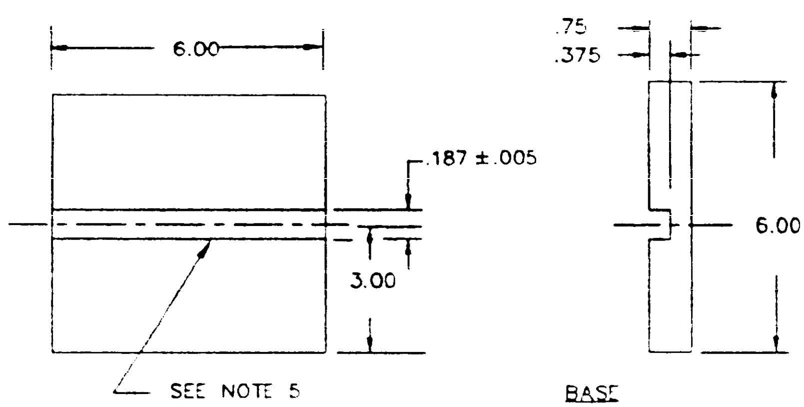


TABLE OF LETTERED DIMENSIONS				
SIZE	A	B	C	D
05	0.376	----	2.214	----
08	0.501	----	2.250	----
11	0.626	0.057	3.200	1.005
15	0.876	0.127	4.300	1.317
18	0.938	0.127	5.250	1.567

PLATE

MATERIAL: ALUMINUM ALLOY, QQ-A-250/4
FINISH: ANODIZE PER MIL-A-8625, TYPE II, CLASS 2 BLACK



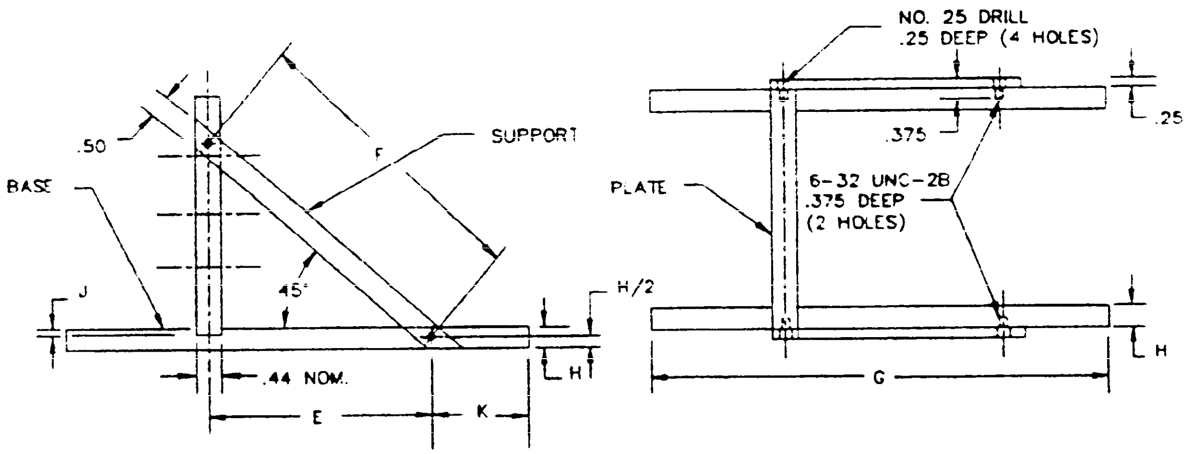
BASE

MATERIAL: LAMINATED PHENOLIC

NOTES:

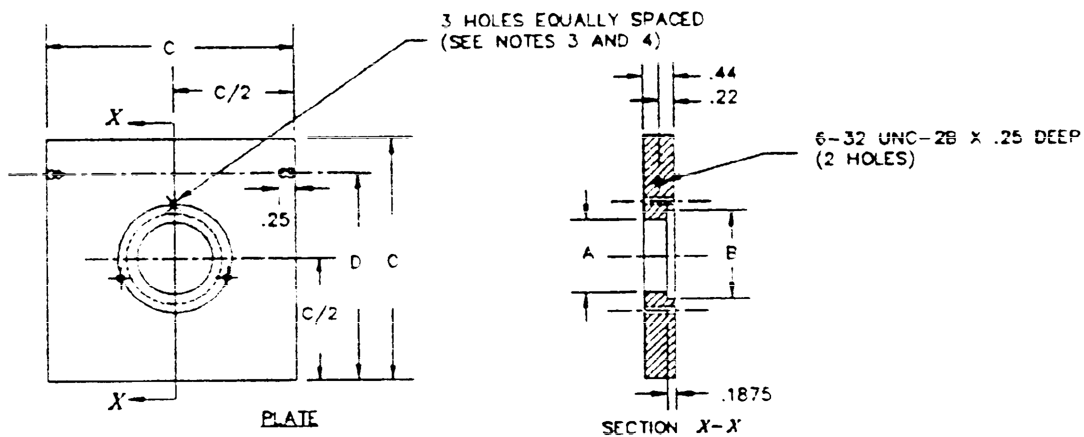
1. ALL DIMENSIONS ARE IN INCHES.
2. UNLESS OTHERWISE SPECIFIED, TOLERANCES SHALL BE: 2 PLACE DECIMALS ±.02
   3 PLACE DECIMALS $^{+.010}_{-.000}$
3. THREE THREADED HOLES EQUALLY SPACED ON A DIAMETER APPROPRIATE FOR THE MOUNTING HARDWARE USED.
4. MOUNTING HARDWARE CLAMP ASSEMBLY PER MS17183, OR EQUIVALENT, DIMENSIONED FOR THE PARTICULAR SERVOCOMPONENT.
5. SLOT IN BASE SHALL BE LIGHT PRESS FIT WITH PLATE.

FIGURE 4. Standard test fixture for size 18 and smaller servomotor-tachometer generators.



BASE AND SUPPORT

MATERIAL: LAMINATED PHENOLIC



PLATE

MATERIAL: 7/16" STOCK ALUMINUM ALLOY, QQ-A-250/4

FINISH: ANODIZE PER MIL-A-8625, TYPE II, CLASS 2 BLACK

TABLE OF LETTERED DIMENSIONS										
SIZE	A	B	C	D	E	F	G	H	J	K
23	0.938	2.012	5.998	4.75	4.875	6.892	9.00	0.75	0.25	1.00

NOTES:

1. ALL DIMENSIONS ARE IN INCHES
2. UNLESS OTHERWISE SPECIFIED, TOLERANCES SHALL BE: 2 PLACE DECIMALS ±.02; 3 PLACE DECIMALS +.010 −.000
3. THREE THREADED HOLES EQUALLY SPACED ON A DIAMETER APPROPRIATE FOR THE MOUNTING HARDWARE USED.
4. MOUNTING HARDWARE CLAMP ASSEMBLY PER MS17183 OR EQUIVALENT, DIMENSIONED FOR THE PARTICULAR SERVOCOMPONENT.

FIGURE 5. Standard test fixture for size 23 or larger servomotor-tachometer generators.

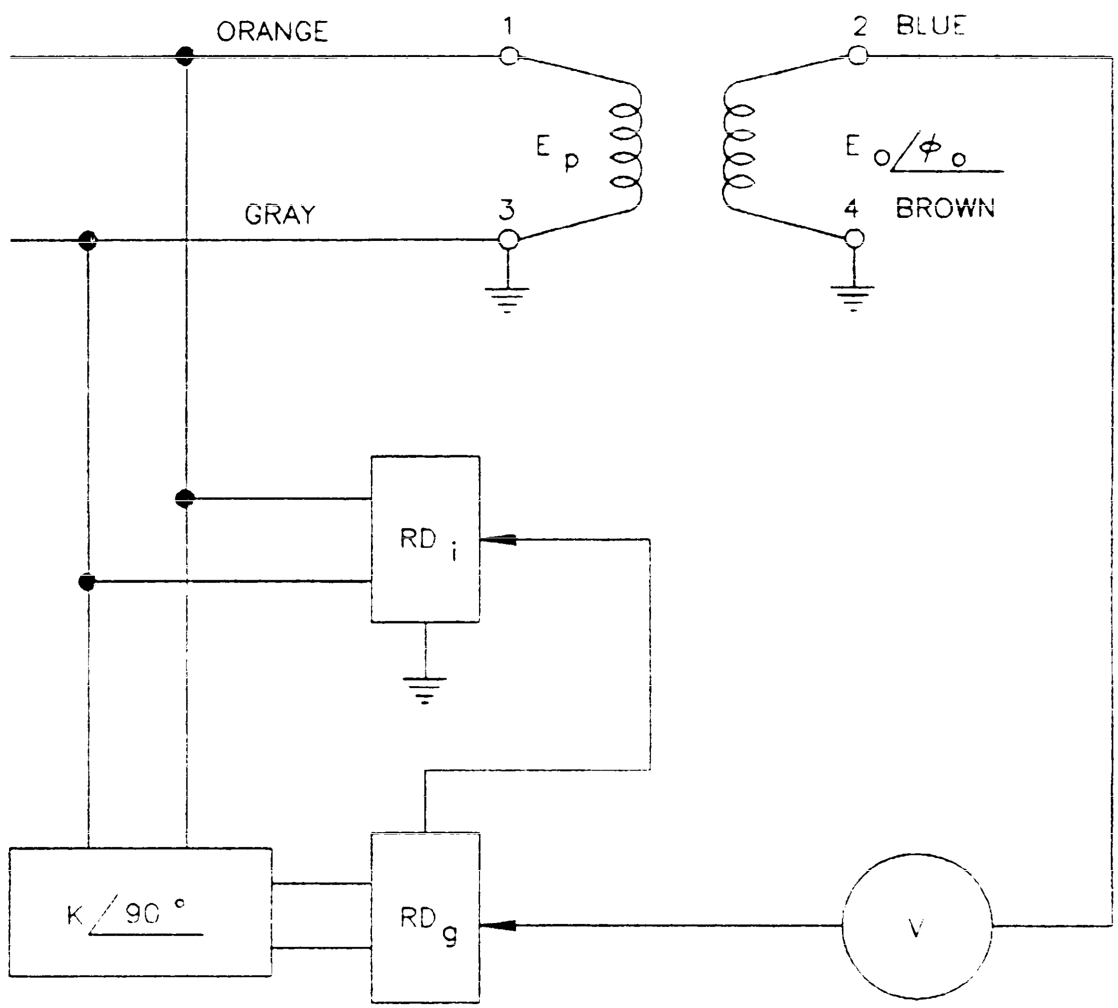


FIGURE 6. Speed-sensitive output measuring equipment.

NOTES: (FIGURE 6)

Where:

1. RD_i is a ratio device which the indicated ratio associated with the lowest measured specified speed in the speed range shall be accurate to within ±0.007 percent for integrating tachometers; shall be accurate to within ±0.1 percent for rate tachometers; and shall be accurate to within ±0.5 percent for damping tachometers.

2. RD_g is the same as RD_i.

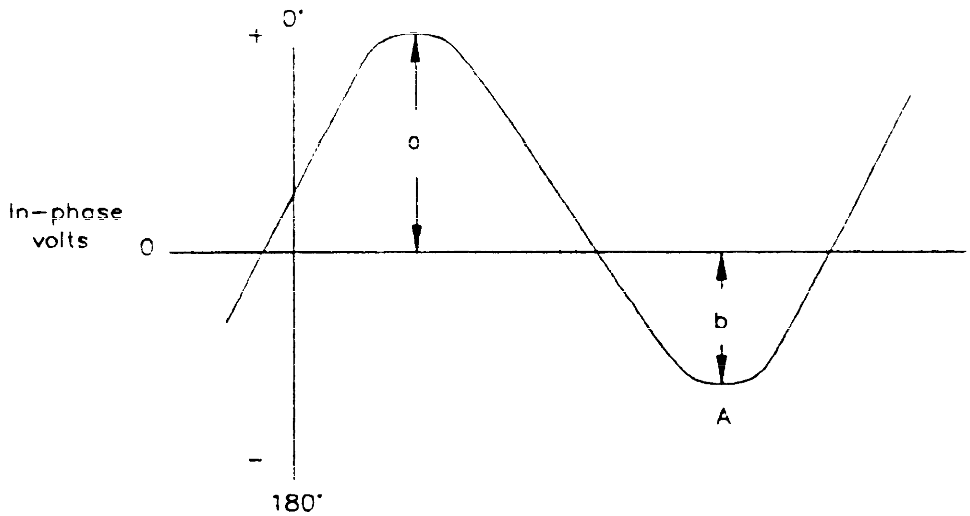
3. K±90° is a quadrature-generating device that shifts the time-phase of E_p 90 degrees ±1 degree, and which must be maintained to within 0.25 degree during linearity tests.

4. K is the gain of the device and must be known and maintained to within 0.01 percent.

5. V is a high impedance voltmeter of the type which is tuned to the fundamental frequency. The response of the filter shall be such that all frequencies above twice the fundamental and frequencies below one-half the fundamental shall be attenuated at least 40 decibels. V may also be a high-impedance phase-sensitive type voltmeter and possess characteristics such that the voltmeter quadrature-detecting axis is within 89 to 91 electrical degrees of the reference time axis. The signal input shall be filtered at the fundamental frequency, and the filter shall possess the characteristic that the response at frequencies greater than twice the fundamental be attentuated at least 40 decibels. The maximum full scale sensitivity shall be at least 1 millivolt.

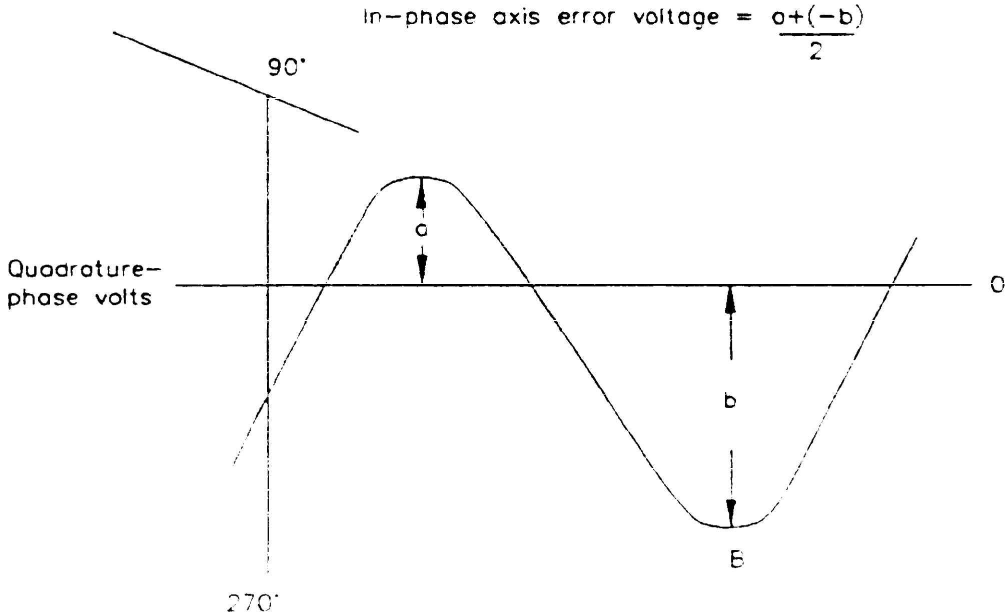
6. E_o is the fundamental speed-sensitive output voltage of the tachometer under test.

7. ϕ'_o is the electrical time-phase of the output voltage, E_o, with respect to the time-phase of the primary energizing voltage, E_p. ϕ'_o is the phase shift of the tachometer by definition.



In-phase position error voltage = $\frac{a-(-b)}{2}$

In-phase axis error voltage = $\frac{a+(-b)}{2}$



Quadrature-phase position error voltage = $\frac{a-(-b)}{2}$

Quadrature-phase axis error voltage = $\frac{a+(-b)}{2}$

FIGURE 7. Position voltages.

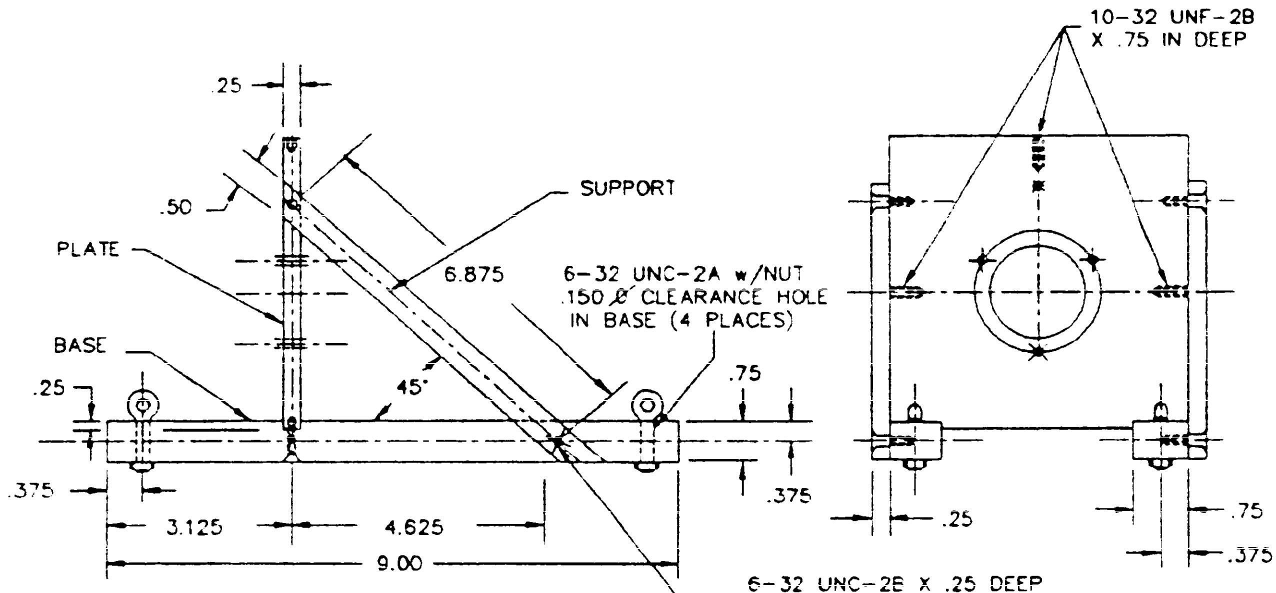


PLATE MATERIAL: ALUMINUM ALLOY, QQ-A-250/4
BASE AND SUPPORT MATERIAL: LAMINATED PHENOLIC

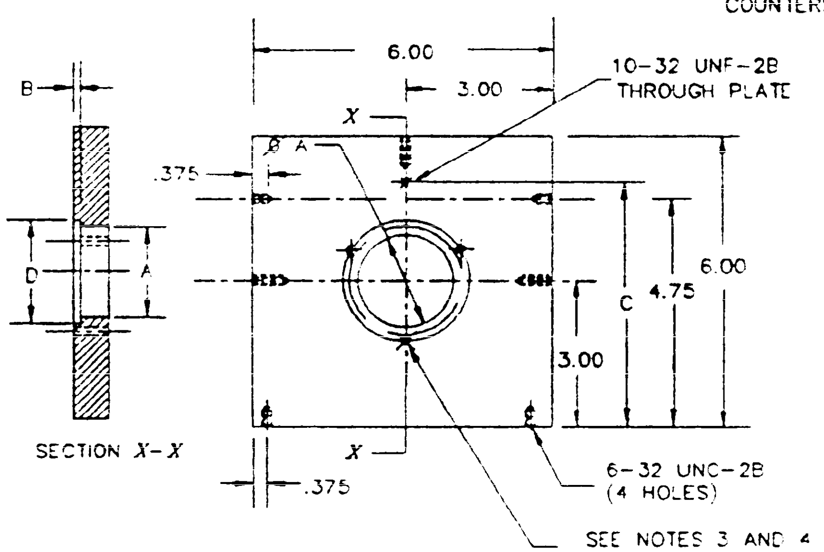


TABLE OF LETTERED DIMENSIONS				
SIZE	A	B	C	D
05	0.376	----	3.504	----
08	0.501	----	3.738	----
11	0.626	0.057	3.988	1.005
15	0.876	0.127	4.145	1.317
18	0.938	0.127	4.278	1.567
23	0.938	0.187	4.805	2.012

NOTES:

1. ALL DIMENSIONS ARE IN INCHES.
2. UNLESS OTHERWISE SPECIFIED, TOLERANCES SHALL BE: 2 PLACE DECIMALS ±.02
   3 PLACE DECIMALS +.010 −.000
3. THREE THREADED HOLES EQUALLY SPACED ON A DIAMETER APPROPRIATE FOR THE MOUNTING HARDWARE USED.
4. MOUNTING HARDWARE CLAMP ASSEMBLY PER MS17183, OR EQUIVALENT, DIMENSIONED FOR THE PARTICULAR SERVOCOMPONENT.

FIGURE 8. Servomotor-tachometer generator structureborne noise test fixture.

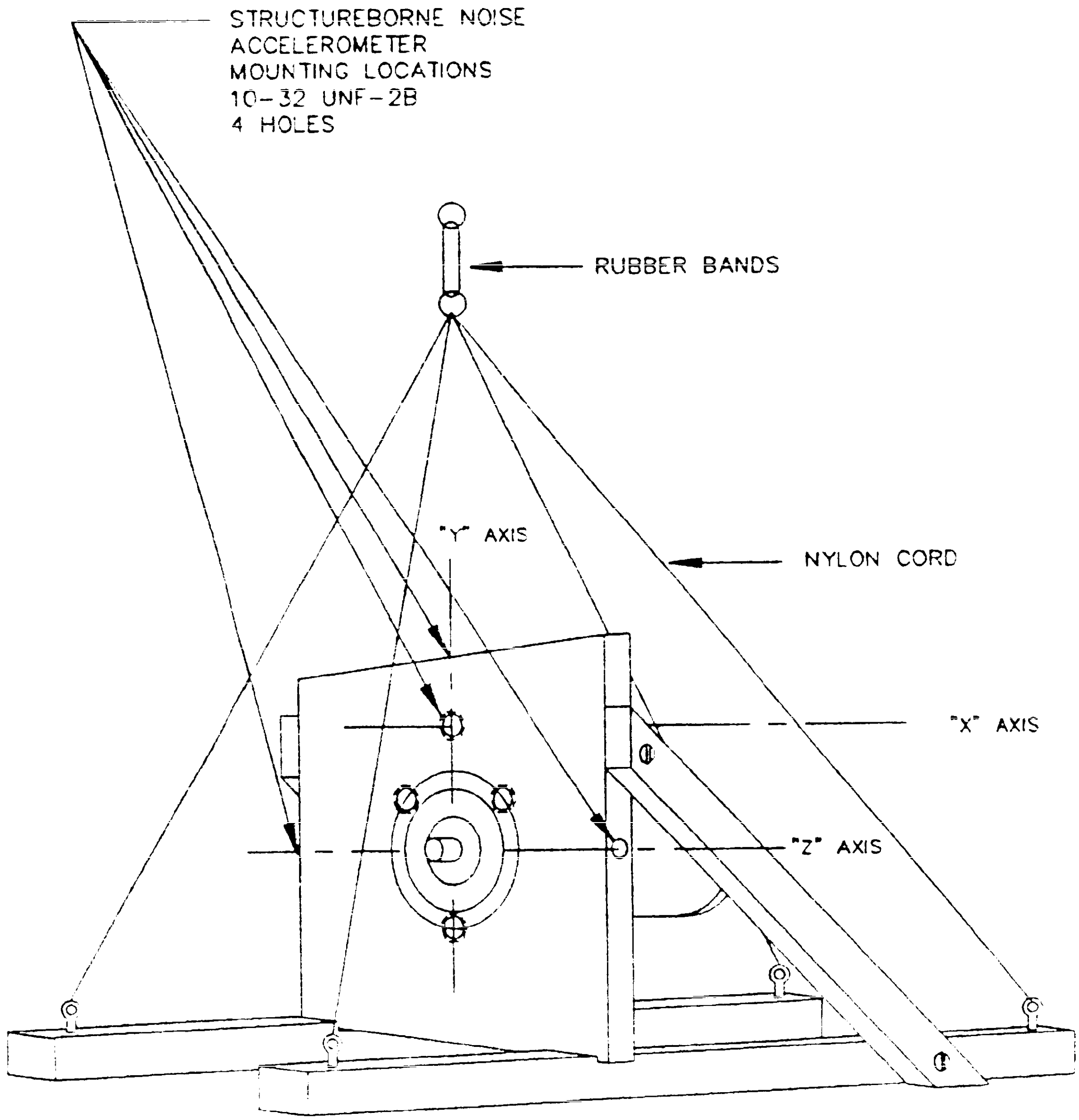


FIGURE 9. Test fixture application for structureborne noise test.

INDEX

INDEX - Continued

INDEX - Continued

INDEX - Continued

INDEX - Continued

INDEX - Continued

Custodians:
  Army - AR
  Navy - AS

Review Activities:
  Army - MI, ER
  Air Force - 79

User Activities:
  Navy - MC

Preparing Activity:
  Navy - AS

(Project 6105-0161)

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

INSTRUCTIONS

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

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

I RECOMMEND A CHANGE:	1. DOCUMENT NUMBER MIL-S-22820 B	2. DOCUMENT DATE (YYMMDD) 28 NOV 1990

3. DOCUMENT TITLE
SERVOMOTOR-TACHOMETER GENERATOR, AC

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

5. REASON FOR RECOMMENDATION

6. SUBMITTER

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

8. PREPARING ACTIVITY

a. NAME	b. TELEPHONE *(Include Area Code)*
SYSTEMS ENGINEERING AND STANDARDIZATION DEPT (53)	(1) Commercial 908 323-2258 (2) AUTOVON 624-2258
c. ADDRESS *(Include Zip Code)* NAVAL AIR ENGINEERING CENTER LAKEHURST, NJ 08733-5100	IF YOU DO NOT RECEIVE A REPLY WITHIN 45 DAYS, CONTACT: Defense Quality and Standardization Office 5203 Leesburg Pike, Suite 1403, Falls Church, VA 22041-3466 Telephone (703) 756-2340 AUTOVON 289-2340