INCH-POUND

MIL-G-83824
4 October 1991

MILITARY SPECIFICATION

GYROSCOPE, RATE, TYPE I, TYPE II, AND TYPE III

This specification is approved for use by the OO-ALC, Department of the Air Force, and is available for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 Scope. This specification covers the design and performance requirements for a rate gyroscope used in the F-4 aircraft Automatic Flight Control System.

1.2 Classification. Gyroscopes shall be of the following types and categories as specified (see 6.2).

1.2.1 Type The type of gyroscope is as follows.

Type I. Yaw rate gyroscope.
Type II. Pitch rate gyroscope.
Type III. Roll rate gyroscope.

2. APPLICABLE DOCUMENTS

2.1 Government documents.

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

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Ogden ALC/MMDSA, Hill Air Force Base, Utah 84056-5609.

AMSC N/A FSC 6615

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SPECIFICATIONS

FEDERAL

QQ-P-416	Plating, Cadmium (electric deposited)

MILITARY

MIL-P-116	Preservation, Methods of
MIL-C-4150	Case, Transit and Storage, Waterproof and Water-Vapor Proof
MIL-E-5400	Electronic Equipment, Aerospace General Specification for
MIL-C-5541	Chemical Conversion Coatings on Aluminum and Aluminum Alloys
MIL-S-7742	Screw Threads, Standard, Optimum Selected Series: General Specification for
MIL-A-8625	Anodic Coatings, for Aluminum and Aluminum Alloys
MIL-P-19834	Plates, Identification or Instructions, Metal Foil, Adhesive Backed General Specifications for

STANDARDS

MILITARY

MIL-STD-130	Identification Markings of U.S. Military Property
MIL-STD-454	Standard General Requirements for Electronic Equipment
MIL-STD-461	Electromagnetic Emissions and Susceptibility Requirements for the Control of Electromagnetic Interference
MIL-STD-462	Electromagnetic Interference Characteristic, Measurement of
MIL-STD-704	Aircraft Electric Power Characteristics
MIL-STD-794	Parts and Equipment, Procedures for Packing of
MIL-STD-810	Environmental Test Methods and Engineering Guidelines
MIL-STD-831	Test Reports, Preparation of
MIL-STD-889	Dissimilar Metals
MIL-STD-970	Standards and Specifications, Order of

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

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

3. REQUIREMENTS

3.1 Qualification. The rate gyroscope assembly furnished under this specification shall be products which are authorized by the qualifying activity for listing on the applicable qualified products list at the time of award of contract (see 4.3 and 6.3).

3.2 Parts and materials.

3.2.1 General. Parts and material shall meet the requirements of MIL-E-5400 for Class 2 equipment.

3.3 Selection of standards and specifications. Standards and specifications for necessary commodities and services not specified herein shall be selected in accordance with MIL-STD-970.

3.4 Materials.

3.4.1 Nonmagnetic materials. Nonmagnetic materials shall be used for all parts of the gyroscope assembly, except where magnetic materials are essential.

3.4.2 Protective treatment. Materials used in the construction of the gyroscope assembly that are subject to deterioration when exposed to climatic and environmental conditions likely to occur during service usage shall be protected against such deterioration in a manner that in no way will prevent compliance with the performance requirement of this specification. The use of any protective coating that will crack, chip, or scale with age or extremes of climatic and environmental conditions shall be avoided. Components contained within hermetically sealed containers shall be considered to be adequately protected against deterioration.

3.4.3 Fungus-proof materials. Materials that are nutrients for fungus shall not be used where it is practical to avoid them. If used, the material shall be treated with a fungicidal agent acceptable to the procuring activity. For materials used in a hermetically sealed enclosure, fungicidal treatment will not be necessary.

3.4.4 Corrosive fumes. The materials, as installed in the gyroscope assembly and under the service conditions specified herein, shall not liberate deleterious fumes.

3.4.5 Metals. Metals shall be of the corrosion resistant type or suitably treated to resist corrosion due to fuels, salt spray, or atmospheric conditions likely to be met during storage or normal service.

3.4.6 Dissimilar metals. Unless suitably protected against electrolytic corrosion, dissimilar metals shall not be used in intimate contact with each other. Dissimilar metals are defined in MIL-STD-889.

3.5 Design and construction.

3.5.1 Functional characteristics. This specification covers the requirements for 3 rate gyroscopes (identical gyroscopes except for orientation of input axis of each gyroscope and position of mounting holes in gyroscope mounting bases) to be used in the F-4 aircraft Automatic Flight Control System. These 3 rate gyroscopes will hereafter be referred to as Types I, II, and III, Type I will be used to furnish yaw rate signals, Type II will be used to furnish pitch rate signals, and Type III will be used to furnish roll rate signals. Each gyroscope shall furnish an electrical output signal that varies as a factor of the angular rate of rotation about its respective axis.

3.5.2 Size and configuration. The gyroscope assembly shall be within the configuration shown on the drawings for Types I, II, and III.

3.5.3 Weight. The lightest practical design capable of the required performance shall be used. Maximum weight shall be 1.3 pounds.

3.5.4 Electrical connections. A connector shall be provided as part of the gyroscope assembly. The terminals will be connected internally to the appropriate circuitry in order to interface with the connector pins of the AN/ASA-32J, AN/ASA-32M, AN/ASA-32N Flight Control Systems. The gyroscope connector shall interface with the existing aircraft connectors M83723-13F1210 X, N, W used with Types I, II, and III gyros, respectively.

3.5.5 Hermetic sealing. The gyroscope assembly (gimbals, pick-off, motor damping bellows, etc.) shall be hermetically sealed. All parts not hermetically sealed shall be protected from corrosion.

3.5.6 Screw threads. Unless otherwise specified, the threads of all machine screws shall conform to MIL-S-7742.

3.5.7 Soldering. Soldering shall be accomplished in accordance with MIL-STD-454.

3.5.8 Finishes and protective coatings.

3.5.8.1 Aluminum alloy parts. Aluminum alloy parts shall be covered with an anodic film conforming to MIL-A-8625, except as follows:

a. Small holes and case inserts need not be anodized.

b. Aluminum alloys which do not anodize satisfactorily shall be coated with a chemical film in accordance with MIL-C-5541.

c. When the primary purpose of the treatment is to afford a suitable paint base, chemical treatments in accordance with MIL-C-5541 may be used in lieu of anodizing.

d. Castings containing non-aluminum alloy integral inserts may be treated with a chemical film in accordance with MIL-C-5541 in lieu of anodizing.

e. When abrasion resistance is a factor, chemical films in accordance with MIL-C-5541 shall not be used in lieu of anodizing.

f. Parts enclosed in a hermetically sealed container need not be anodized or plated.

g. When the part is plated with tin over copper flash, the part need not be anodized.

h. When necessary for electrical bonding, parts need not be anodized.

3.5.9 Steel parts. Where practicable, steel parts shall be cadmium plated in accordance with QQ-P-416, Type II or III, as applicable, and of a class that is adequate to achieve the degree of protective required.

3.5.10 Workmanship. The gyroscope, including all parts and accessories, shall be so fabricated and finished as to assure:

a. Freedom from blemishes, defects, chips, dents, burrs, and sharp edges, accuracy of dimensions, radii of fillets, and marking of parts and assemblies.

b. Soldering, welding and brazing shall be free of harmful defects such as cracks, porosity, undercuts, voids, and gaps. There shall be no burn-through. Fillets shall be uniform and smooth. Angular or thickness misalignment, warpage, or dimensional change due to heat from these operations shall not exceed permitted tolerances. There shall be no damage to adjacent parts resulting from soldering, welding of brazing.

c. Wires and cables shall be positioned or protected to avoid contact with rough or irregular surfaces and sharp edges.

If any gyroscopes are found to have any of the defects listed above it shall be cause for rejection.

3.5.11 Interchangeability. The gyroscope assembly shall meet the

interchangeability requirements of MIL-E-5400.

3.5.12 Nameplates. Nameplate approval for equipment identification shall be in accordance with MIL-P-19834.

3.5.13 Standard conditions. The following conditions shall be used to establish normal performance characteristics under standard conditions and for making laboratory bench tests.

Temperature - Room Ambient 25°C ± 10°C (77°F ± 18°F)
Altitude - Normal Ground Level
Vibration - None
Humidity - Room ambient up to 90% Relative Humidity
Excitation - a. 15 ± 0.15 VAC rms line-to-line 3-phase 400 ± 2 Hz. The total harmonic of the voltage wave form shall not exceed 5%. (Motor Excitation)
b. 15 ± 0.15 VAC, single phase, 400 ± 2 Hz. Total harmonic distortion as stated above (Pickoff Excitation)

Load - A load of 10K ohm in parallel with 0.056 MFD shall be connected across the pickoff output. All performance requirements shall be met with this load and with load variations of ± 20% in resistance or capacitance or both, except sensitivity and linearity load requirements shall be in accordance with 4.3.2.8.

3.5.14 Dielectric strength. The electrical insulation shall not break down with 500 volts RMS, 60 Hertz applied for 60 seconds between isolated electrical circuits and between isolated electrical circuits and case.

3.5.15 Insulation test. The insulation resistance shall be 50 megohms or greater when 500 VDC is applied between isolated electrical circuits and between electrical circuits and case.

3.5.16 Reliability.

3.5.16.1 Reliability in MTBF. The gyroscope shall be designed for, and capable of demonstration of, a specified Mean-Time-Between-Failures (MTBF) of 3500 hours at a 90% confidence level.

3.5.16.2 Shelf life. The gyroscope assembly shall be capable of immediate service use without operational conditioning of maintenance following storage periods of up to 24 months.

3.6 Environmental conditions. The gyroscope assembly shall be designed to meet the requirements of this specification when exposed to the following environmental conditions or natural combinations of these conditions except as modified herein.

3.6.1 Vibration. The vibration requirements shall be in accordance with MIL-STD-810, Method 514.2, Proc. IA (Table 514.2-IIA, figure 514.2.2A). $W_o = 0.12g^2/hz$.

3.6.2 Shock.

3.6.2.1 Operational shock. The shock requirements shall be in accordance with MIL-STD-810, Method 516.2, Proc. I (Figure 516.2-2) and Proc III, except that the crash safety shall be 40 g's in lieu of 30 g's.

3.6.2.2 Handling shock. The gyro shall be capable of meeting the performance requirements in paragraph 3.7 after being subjected to shock pulses of 500 g's for 1 millisecond along each mutually perpendicular axis.

3.6.3 Temperature. The temperature requirements shall be in accordance with MIL-STD-810, Methods 501.1 and 502.1 Proc I.

3.6.3.1 Operating. The gyroscope assembly shall operate continuously without failure over the temperature range of -54°C to +71°C and for 30 minutes at +102°C and 5 minutes at +121°C. Temperature may vary as fast as 1° per second for temperature shock.

3.6.3.2 Nonoperating. The gyroscope assembly in a nonoperating condition, shall withstand long periods of exposure to temperature extremes from -62°C to +85°C.

3.6.4 Altitude. The gyroscope assembly, during continuous operation and exposure in a nonoperating condition shall withstand altitude conditions from sea level (30.0 in Hg) to 60,000 feet.

3.6.5 Temperature-altitude. The gyroscope assembly shall be capable of continuous operation over the temperature-altitude range as defined by MIL-STD-810, Method 504.1, Table 504.1-1 (equipment category 6), Proc I, except that the maximum altitude shall not exceed 60,000 feet.

3.6.6 Temperature shock. The gyroscope shall be capable of withstanding temperature shocks caused by abrupt temperature drops from +71°C to -54°C as defined in Method 503.1 of MIL-STD-810.

3.6.7 Acceleration. The gyroscope assembly shall operate satisfactorily up to ±10 g acceleration.

3.6.8 Sand and dust. The sand and dust requirements shall be in accordance with MIL-STD-810, Method 510.1, Proc I.

3.6.9 Fungus. The fungus requirements shall be in accordance with MIL-STD-810, Method 508.1, Proc I.

3.6.10 Salt atmosphere. The salt atmosphere requirements shall be in accordance with MIL-STD-810, Method 509.1, Proc I.

3.6.11 Explosive atmosphere. The explosive atmosphere requirements shall be in accordance with MIL-STD-810, Method 511.1, Proc I.

3.6.12 Humidity. The humidity requirements shall be in

accordance with MIL-STD-810, Method 507.1, Proc I.

3.6.13 Electromagnetic interference. The gyroscope assembly shall meet the radio interference requirements of MIL-STD-461, notice 3.

3.6.14 Acoustic noise. The acoustic noise requirements shall be in accordance with MIL-STD-810, Method 515.2, Proc I (category B).

3.7 Performance.

3.7.1 Excitation. The gyroscope shall be capable of operating from an electrical system conforming to MIL-STD-704 as follows:

3.7.1.1 Motor. The motor power consumption when excited by 15 ± 0.1 VAC, 400 ± 2 Hertz 3-phase line-to-line, connected per Figure 1 and running at synchronous speed shall not exceed 4 watts and a minimum power factor of 0.4.

3.7.1.2 Pickoff. The pickoff shall be excited by 15 ± 0.1 VAC RMS, 400 ± 2 Hertz, single phase. The power requirements shall not exceed 2 watts.

3.7.2 Pickoff output. The nominal output voltage shall be 0.28 volts, 400 hz per degree per second input rate into any load of 8.0 - 12.0K ohms resistance in parallel with .045 - 0.67 MFD capacitance except sensitivity and linearity load requirements shall be in accordance with 4.3.2.8.

3.7.2.1 Full-scale range. The full scale rate shall be 50 degrees per second minimum.

3.7.3 Mechanical stops. Mechanical stops shall be provided to prevent electrical discontinuity and damage at angular beyond the usable range of the gyroscope assembly. The gyroscope assembly stops shall be set to limit gimbal deflection between 50 to 65 deg/sec in both CW and CCW directions.

3.7.4 Spin-up time. Over the operating temperature range of the gyroscope assembly, the spin motor rotor shall accelerate to its operating speed within 30 seconds after excitation voltage is applied.

3.7.5 Natural frequency. The gyroscope assembly shall have a natural frequency of 20 to 30 hertz with the rotor running at rated speed. Natural frequency shall be defined as the frequency at which the pickoff output voltage lags the rate input by 90 degrees.

3.7.6 Damping ratio. The damping ratio of the gyroscope shall be 0.4 to 1.0 over the full operating temperature range. The above damping ratio requirements shall be temperature compensated with out the use of heaters.

3.7.7 Gyro polarity. CW rates about the gyro input axis (B down) (see Fig. 1), shall cause the input voltage, Pin E with respect to Pin D, to be in phase (0° ± 5°) with the input voltage, Pin G with respect to Pin F (refer to Fig. 1) with Pins D, F, and H common. CCW rates about the gyro input axis shall cause the input voltage to be 180° ± 5° out of phase with the output voltage.

3.7.8 Balance and position change transient. With the gyro oriented in any of the six different mutually perpendicular positions, the difference in the output voltage shall not exceed 20 millivolts. Maximum output with position change, including hysteresis, zero offset, unbalance, any position change transient, and all other effects except normal rate outputs generated by movement about the input axis during position change, shall not exceed 60 millivolts. Any transient output associated with position change shall decay smoothly without oscillation or erratic indication to a stable output in less than 1 minute after the gyro is placed in position. Any oscillation or fluctuation of output shall not exceed 3 millivolts peak to peak.

3.7.9 Threshold. The threshold of the sensitive axis shall not exceed 0.03 degrees per second. Threshold is defined as the minimum value of the input rate that will produce approximately 8 mv change in phase sensitive component of output voltage.

3.7.10 Resolution. Resolution of the gyro sensitive axis shall not exceed 0.03 degrees per second. Resolution is defined as the smallest change of input rate which will produce approximately 8 mv change in phase sensitive component of the of the pickoff output voltage.

3.7.11 Hysteresis. The total hysteresis of the sensitive axis shall be a maximum of 30 millivolts. Hysteresis is defined as the total algebraic difference of the output (in-phase component) zero rate voltages obtained after applying a maximum CW and CCW input rate to the gyroscope.

3.7.12 Cross coupling. When the gyroscope is operating normally, the maximum rate applied about the spin axis shall not cause a change of the pickoff output in-phase component voltage by more than 0.4% of full scale output (56 mv).

3.7.13 Zero offset. With the gyro oriented in normal operating position, the null at room ambient shall be 0.03 volts maximum. At any temperature between -54°C and +71°C, the null voltage shall not differ by more than 0.04 volts from the null voltage obtained at room temperature.

3.7.14 Sensitivity and linearity. The ratio of output volts to angular velocity about the input axis shall be 0.28v/deg/sec.

a. Standard temperature - 0.28v ± 10%/deg/sec.

b. From - 54°C to +71°C - 0.28v ± 15%/deg/sec.

3.7.15 Stability and noise. The gyro output signal shall be stable. Oscillations, fluctuations, spiking, hash, or other aberration in the output signal shall not exceed 40 millivolts peak to peak with the gyro motor running at rated speed.

3.8 Identification. Identification of the time shall be in accordance with MIL-STD-130 for Source Control Drawings, except the vendor's manufacturing code and part number shall be included on the nameplate.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order, the supplier is responsible for all inspection requirements (examinations and test) as specified herein. Except as otherwise specified in the contract or purchase order, the contractor may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to ensure supplies and services conform to prescribed requirements.

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

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

a. Qualification Inspection (4.3)

b. Acceptance Inspection (4.4)

c. Analysis and Inspection (4.5)

4.3 Qualification inspection. Compliance with the following requirements of Section 3 shall be demonstrated by the performance of the gyroscope designated in 3.5.1 which is subjected to qualification testing by the supplier at no cost to the Government. Three gyroscopes, representative of the production units, shall be selected for the test sample. The three gyros shall be subjected to all tests except reliability. Qualification shall consist of successful completion of tests in 4.4. The environmental tests shall be conducted in accordance with the procedures of MIL-STD-810, and operation of test item during tests is required unless otherwise specified. All testing performed toward qualification to this specification shall be certified by authorized government representatives. Evidence of certification shall be provided in the qualification test report submitted for Government approval.

4.3.1 Inspection conditions.

4.3.1.1 Atmospheric conditions. Unless otherwise specified, all tests required by this specification shall be made in accordance with the requirements of 3.5.13.

4.3.1.2 Attitude. Unless otherwise specified, the rate gyroscope shall be mounted and mechanically secured to a leveled rate table with the sensitive axis perpendicular to the rate of table.

4.3.1.3 Excitation.

4.3.1.3.1 Motor excitation. The gyroscope assembly spin motor excitation shall be 15 $\pm$ 0.1 VAC RMS line-to-line, 400 $\pm$ 2 Hertz, 3-phase voltage input. With this motor excitation the gyroscope shall meet the power requirements of 3.7.1.1.

4.3.1.3.2 Pickoff excitation. The gyroscope assembly spin motor excitation shall be 15 $\pm$ 0.1 VAC RMS; 400 $\pm$ 2 Hz, single phase. With this pickoff excitation, the gyroscope shall meet the power requirements of 3.7.1.2.

4.3.1.4 Pickoff output. The pickoff output shall be a 400 Hz signal measured across a shunt load as specified in 3.7.2.

4.3.1.5 Normal operation. Unless otherwise specified, normal operation shall be with power applied to gyros and outputs loaded as specified in 3.5.13.

4.3.1.6 Warmup time. Unless otherwise specified, a 1.0 minute warmup shall be allowed before conduction of any tests, except warmup time shall not waive the motor speed tests (Sync).

4.3.2 Performance inspections (test procedures/methods).

4.3.2.1 Visual inspection. The gyro assembly is examined visually to insure conformance to the requirements of workmanship, identification, markings, finish, and dimensional accuracy and shall be consistent with accepted electrical and mechanical practices.

4.3.2.2 Insulation resistance. Apply a 500 VDC potential for 10 seconds between Pin A and case, between Pin G and case, between Pin E and case. Determine that the insulation resistance is greater than 50 megohms. Record accept or reject.

4.3.2.2.1 Dielectric strength. Repeat the above procedure with 500 volts 60 Hz applied for 60 seconds to each point. There should be no insulation breakdown. Record accept or reject.

4.3.2.3 Frequency response - natural frequency. Mount the rate gyro on an oscillating table. A frequency response test shall be conducted at 25°C and at the frequencies from static through 30 Hz. Record frequency at 90 deg phase lag between the gyro input and the pickoff output signal. This is indicative of the gyro natural frequency. Record on data sheet. Repeat at -54°C and +71°C gyro case temperature.

4.3.2.4 Damping ratio. After the natural frequency is determined, the frequency of vibration is adjusted to one-half of the gyro natural frequency and the resultant change in phase lag is determined. (Measurement made with gyro case at temperature of +25° ± 3°C.) Damping ratio is then read from a graph prepared from the rate gyro second order differential equation.

$$\text{Damping Ratio} = \frac{\left[1-\left[\frac{Wo}{Wn}\right]^2\right]\tan\theta}{2\left[\frac{Wo}{Wn}\right]}$$

Where:

Wo = Input frequency
Wn = Natural frequency
θ = Dynamic phase lag

Record results on the data sheet.
Repeat at -54°C and +71°C gyro case temperatures.

4.3.2.5 Balance and position change transient. Energize the gyro motor. Beginning with the gyro longitudinal (output) axis horizontal, mounting base down, rotate the gyro 1 revolution about its longitudinal axis in 90 degree increments. At each position, including the beginning position, read the gyro phase sensitive component output immediately (within 1/2 second) after the gyro is placed in each position. Also, read the gyro output when the output stabilizes, and note whether the output stabilizes in less than 1 minute. Repeat, rotating the gyro about its latitudinal axis in the opposite direction. Repeat, rotating the gyro in 90 degree increments from a beginning position of gyro longitudinal axis horizontal to connector up to beginning position to connector down and back to beginning position about the spin axis and again about the input axis. Each position change shall be made in less than 1 second. At each position the immediate reading shall not exceed 600 millivolts, and any transient output shall decay smoothly without oscillation or erratic indication to a stable output in less than 1 minute after the gyro is placed in position. All stabilized output readings, except those taken for rotation about the input axis, shall be within 20 millivolts (algebraic difference) of each other. Also observe the gyro output for oscillation or fluctuation in all above positions and position changes using an AC voltmeter. Any oscillation or fluctuation as observed on the AC voltmeter shall not exceed 3 millivolts peak to peak.

CAUTION

In changing to positions to which the 20 millivolt maximum difference requirement applies, minimize rotation about the input axis to avoid introducing hysteresis.

4.3.2.6 Spin-up. Determine spin-up time by energize the gyro motor with 15 volts, 400 Hz, Sine Wave, three-phase power. Using an AC voltmeter, measuring the A phase voltage (Pin A), which flutters at the instant synchronous speed is reached, to determine spin-up time. Record the time on the data sheet.

4.3.2.7 Gyro polarity. CW rates about the gyro input axis (B down) (see Figure 1), shall cause the input voltage, Pin E, with respect to Pin D, to be in phase (0 deg ± 5 deg) with the output voltage, Pin G with respect to Pin F (refer to Figure 1) with Pins D, F, and H common. CCW rates about the gyro input axis shall cause the input voltage to be 180 deg ± 5 deg out of phase with the output voltage.

4.3.2.8 Sensitivity and linearity. Apply rates to gyro CW direction as listed below with load of 10K ohms resistance in parallel with 0.056 mfd. capacitance. Read the corresponding gyro RMS output voltages. Record values on data sheet.

CW (zero phase)	Output Voltage
3 degrees/sec	0.84v ± 10%
15 degrees/sec	4.2v ± 10%
45 degrees/sec	12.6v ± 10%

Repeat with load of 9K ohms in parallel with 0.067 mfd. capacitance and then with a load of 11K ohms resistance in parallel with 0.045 mfd. capacitance. Record values on data sheet. Output shall not change more than 6% due to the change in load.

4.3.2.8.1 Repeat 4.3.2.8 at -54°C and +71°C except that the tolerance shall be ± 15% and the output change due to load shall not exceed 9%.

4.3.2.9 Threshold. Note the gyro output at 0deg/sec rate. Apply a CW rate of 0.03 deg/sec and a clearly discernible (approximately 8 millivolts) output change from the 0 deg/sec rate value, measured on a phase-sensitive voltmeter, indicates acceptable threshold. Repeat in CCW direction.

4.3.2.9.1 Resolution. Apply a CW input rate of 15 deg per sec. Increase input rate until there is a clearly discernible (approximately 8 millivolts) change on the gyro output from that caused by the 15 deg per sec input rate value. The change in gyro input rate requirement to produce a clearly discernible change in gyro output voltage shall not exceed 0.03 deg/sec. Repeat test at 30 deg per sec input rate.

4.3.2.10 Stops. The gyro is subjected to increasing angular rate inputs in each direction in excess of nominal full scale range. The stops for the gyro are measured by noting the rate at which the output voltage stops following the input rate. This should occur between 50-65 deg/sec. Record on data sheet. The table should be totaled at a rate of 75 deg per second for a period of 3 minutes. At the completion of this test, the gyro shall pass the tests specified in 4.3.2.8.

4.3.2.11 Hysteresis. Apply a CW full scale rate to the gyro for a period of one (1) second and remove. Ten (10) seconds after cessation of the rate, the IN PHASE output of the gyro is measured. This procedure is repeated in the CCW direction. The algebraic difference between the two IN PHASE readings is computed and is recorded as Hysteresis, and the difference shall not exceed 30 MV.

4.3.2.12 Zero offset. Mount gyro in normal operating position. Energize motor and allow to reach synchronous speed. Minimize hysteresis. Measure the IN PHASE output of the gyro, record values on the data sheet. The null voltage shall not exceed 0.03 volts. Repeat at -54°C and +71°C temperatures and algebraically subtract the IN PHASE value from those recorded at room ambient, and record the results on the data sheet. The difference shall not exceed 0.04 volts. See 3.7.13. Measure the total output of the gyro at room temperature. The total output shall not exceed 50 MV.

4.3.2.13 Gyro polarity and phase shift. Apply rates of 45 deg/sec, 30 deg/sec, 15 deg/sec, 3 deg/sec and rate as necessary to produce a phase sensitive component output of 100 MV in the CW and CCW direction, and measure the phase shift between the primary excitation voltage pins (E and D) and the secondary output voltage (pins G to F). See Figure 1. Record values on the data sheet. Phase shift shall be in compliance with 3.7.7.

4.3.2.13.1 Repetition. Repeat 4.3.2.13 at 30 deg/sec only with load variations of paragraph 3.5.13.

4.3.2.14 Cross-axis coupling. Mount the gyro on the rate table with the spin axis vertical, D down (see Figure 1). Measure the IN PHASE output. Apply a clockwise rate of 50 deg/sec. Measure the IN PHASE output. Cross coupling is equal to algebraic difference between the output measured at 50 deg/sec rate and the output measured at 0 degree per second input rate. Repeat the above procedure for the encounter clockwise direction. Record values on the data sheet. Repeat with the output axis vertical (F down) (see 3.7.12).

4.3.2.15 Electromagnetic interference. The gyroscope shall be subjected to the electromagnetic interference test specified in MIL-STD-462. The test methods shall be as specified in MIL-STD-461 for Class A1 equipment.

4.3.2.16 Leak rate inspections. The sealed gyroscope assembly shall be tested for leaks using an appropriate leak detector or any means approved by the procuring agency. The leak rate shall not be sufficient to cause more than ten percent loss of contamination of filling medium after 1,000 hours at a differential pressure equivalent to 100,000 feet.

4.3.2.16.1 Leak rate requirements. Leak rate shall be considered satisfactory if the following requirements are met.

a. Place the painted gyro in the temperature test chamber (chamber stabilized at +165°F) for a period of 60 minutes.

b. At the completion of the sixty (60) minute period, place gyro under the Bell Jar at 1.5 in Rg (65,000 Ft min) for a 30 minute period.

c. At the completion of the thirty (30) minute period, open the vacuum valve, remove the gyro from the test chamber, and examine the instruments for any evidence of oil leakage. There shall be no evidence of oil leakage.

d. Place the gyro on the test bench until the gyro is stabilized at room temperature.

e. Re-examine the gyro for any evidence of oil leakage. There shall be no evidence of oil leakage.

4.3.2.17 Stability and noise. Connect the demodulated gyro

output signal to the input of a 100 Hz low pass filter as shown in Figure 6. The demodulator and filter circuit shall be so designed that signals of 90 Hz or less are not attenuated more than three percent. Connect the output of the low pass filter to the vertical input of an oscilloscope. Set the rate table speed at zero. With the gyro motor running at rated speed, observe and record the total "ac" signal including all oscillations, fluctuations, spiking, hash, or other aberration in the signal. Repeat with the rate table speed set at one (1) degree per second. The total observed "ac" signal shall not exceed 40 millivolts peak to peak.

4.3.2.18 Rough handling inspection. the test performed on a prototype example shall be Rough Handling, Dummy Load and Preproduction Test of MIL-STD-794. All testing shall be done on all axes and in each direction in each axes and with actual equipment as packed for shipment. After tests, the gyroscopes shall not suffer damage or subsequently fail to provide performance as specified. the contractor shall notify the procuring activity in sufficient time in advance of prototype testing to permit Government representation at the site.

4.3.3 Environmental inspection (inspection procedures/methods). The following Post Environmental Inspection shall be performed at room temperature after each environmental test unless specified otherwise:

4.3.2.2 (Insulation Resistance only); 4.3.2.3; 4.3.2.4; 4.3.2.5; 4.3.2.6; 4.3.2.8; 4.3.2.9; 4.3.2.10; 4.3.2.11; 4.3.2.12; 4.3.2.13; 4.3.2.17

4.3.3.1 Temperature and temperature-altitude.

4.3.3.1.1 High temperature inspection. The rate gyro shall be subjected to high temperature testing in accordance with MIL-STD-810, Method 1, Procedure I. Testing shall comply with temperature details of 3.6.3 and performance specifications of 3.7.14.

4.3.3.1.2 Low temperature inspection. The gyro shall be subjected to low temperature testing in accordance with MIL-STD-810, Method 502.1, Procedure I. Testing shall comply with temperature details of 3.6.3 and performance specifications of 3.7.14.

4.3.3.1.3 Temperature-altitude. The gyroscope assembly shall be subjected to temperature-altitude tests in accordance with MIL-STD-810, Method 504.1, Category 6, Procedure I, except the maximum altitude shall be 60,000 feet. The gyroscope shall operate satisfactorily. After returning to room temperature and atmospheric pressure, the unit shall pass the Post Environmental Tests. It shall operate properly throughout this test and there shall be no damage that would affect subsequent operation.

4.3.3.2 Vibration. The vibration test shall proceed in accordance with MIL-STD-810, Procedure IA, 4.7.2. As directed in .6.2, Table 514.2-IIA (random Vibration Test Criteria for Jet Aircraft Equipment, Category b.2) W_e = 0.12g^2/hz shall be used. Gyro shall be mounted with the gyro input, spin, and output axes parallel to the input vibration in their test sequence. During the cycling, note all resonances. Time at each resonance shall be 30 minutes.

4.3.3.2.1 Repetition of the post environmental inspection. Repeat the Post Environmental Tests, 4.3.3 at the completion of the Vibration Test.

4.3.3.3 Shock.

4.3.3.3.1 Shock (operational). The gyro shall be subjected to 18 shocks of 15 g's with a duration of 11 milliseconds one-half (1/2) sine wave with excitation applied. The shock shall be applied three times, in each direction, along each axis (input, Spin, and Output). The inphase output (null) of the gyro shall be recorded after each shock pulse.

4.3.3.3.1.1 Repetition. Repeat 4.3.3.3.1 except no excitation shall be applied and the shock level shall be 40 g's with only 2 shocks applied in each direction for a total of 12 shocks.

4.3.3.3.2 Shock (handling). The gyroscope shall be subjected to hock pulses of 500 g's for one millisecond along each mutually perpendicular axis. The gyroscope shall then pass the Post Environmental Tests of 4.3.3.

4.3.3.3.3 Repetition of the post environmental inspection. At the completion of each shock test, repeat Post Environmental Tests of 4.3.3.1.

4.3.3.4 Humidity. The humidity test shall be conducted in accordance with MIL-STD-810, Method 507.1, Procedure I. Following completion of tests, repeat the Post Environmental Tests of 4.3.3.

4.3.3.5 Temperature-shock. The temperature-shock test shall be conducted in accordance with Method 503.1 of MIL-STD-810. After the gyroscope assembly has returned to room temperature, the terminal, header, and meals shall be examined. There shall be no evidence of cracked terminals or leaks around the header or seals. The gyroscope shall then pass the Post Environmental Tests of 4.3.3.

4.3.3.6 Reliability. Eight gyroscopes shall be used in the reliability tests, The gyroscope shall be properly connected with rated power applied and placed in a test chamber which shall meet the environmental cycling conditions of Figure 5. After each 160 hours of cycling, the gyroscopes shall pass the Post Environmental tests. The acceptability of the gyroscopes is the time required for the fourth failure to occur in the sample size of eight. If the fourth occurs prior to the testing time, T = 2037 hours for each gyroscope, or 16,296 hours for eight gyroscopes, the testing sample is considered to have

failed to meet acceptability.

4.3.4 System compatibility inspections. Three (3) gyroscopes (one each of types I, II, and III) manufactured in accordance with this specification, submitted at no cost to the Government, shall be forwarded to a designated Government installation for System Compatibility Tests. At the contractor's option, these may be either the items from the qualifications testing or three identical items. These gyroscopes will be tested by the Government for system compatibility. Failure to perform properly will be cause for rejection as system incompatible.

4.3.5 Inspection failure. A gyro failure is any malfunction which causes the gyro to fail to meet the minimum performance requirements specified herein. In the event of failure, the inspection shall be stopped and the appropriate Government official notified by TWX or telecon. A failure report which includes a failure analysis shall be submitted within 30 days of failure occurrence.

4.4 Acceptance inspection. The contractor shall perform acceptance test in all production gyros. All inspection and testing shall be under the supervision of the Government inspector. Contractors not having testing facilities satisfactory to the procuring activity shall engage the services of a commercial testing laboratory acceptable to the procuring activity. The contractor shall furnish test reports to the Government Inspector showing quantitative results for all acceptance tests. Such reports shall be signed by an authorized representative of the contractor or laboratory as applicable. A data sheet shall be packaged with each gyro showing the results of the gyro's acceptance test. Acceptance tests shall consist of the individual tests of 4.4.1 only at ambient temperature, except that one out of every 50 gyroscopes or fraction thereof, randomly selected, shall be subjected to the individual tests with temperatures of -54° and +71°C.

4.4.1 Individual inspection.

Inspection/Examination	Applicable Para.
Visual Inspection	4.3.2.1
Insulation Resistance and Dielectric Strength	4.3.2.2
Natural Frequency (Frequency response)	4.3.2.3
Damping Ratio	4.3.2.4
Balance and Position Change Transient	4.3.2.5
Gyro Polarity	4.3.2.7
Sensitivity and Linearity	4.3.2.8
Threshold and Resolution	4.3.2.9
Stops	4.3.2.10
Hysteresis	4.3.2.11
Zero Offset	4.3.2.12
Phase Shift	4.3.2.13
Cross Axis	4.3.2.14
Leak Rate Requirements	4.3.2.16.1

Stability and Noise	4.3.2.17
Rough Handling	4.3.2.18

4.5 Analysis and inspection. Compliance with the following requirements shall be demonstrated through analysis and/or inspection of the engineering documentation and test data associated with the gyroscope. Test data available from other sources or obtained during early stages of development testing will be used to the maximum.

Analysis/Data	Applicable Para.
Materials	3.4
Weight	3.5.2
Workmanship	3.5.10
Interchangeability	3.5.11
Reliability	3.5.16
Power	3.7.1.1
Scale Factor over Temperature	3.7.2.1
Over-Range	3.7.3
Null Offset	3.7.13
Identification	3.8

5. PACKAGING.

5.1 Packaging. The gyroscope shall be packed in accordance with MIL-STD-794, Level A or C as specified in the Contract or order. For Level A packaging, the method of preservation shall be in accordance with MIL-P-116, Method 1C, utilizing a rectangular container. Unless otherwise specified by the procuring activity, the container shall conform to MIL-C-4150.

5.2 Packing. The gyroscope shall be packed in accordance with MIL-STD-794, Level B or C as specified in the contract or order. The package and exterior shipping container may be one and the same container.

5.3 Rough handling tests. Rough handling tests shall apply to all levels of packaging and packing (see 4.3.2.18)

5.4 Marking requirements. In addition to the normal markings required by MIL-STD-794, the following special markings are required: Containers shall be marked "DELICATE INSTRUMENT" in letters at least 2 inches high on two opposite sides.

6. NOTES

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

6.1 Intended use. This specification covers the requirements for 3 rate gyroscopes used in the F4 aircraft Automatic Flight Control System.

6.2 Acquisition requirements. Acquisition documents must specify

the following.

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

b. Issue of DODISS to be cited in the solicitation, and if required, the specific issue of the individual documents referenced (see 2.1)

6.3 Qualification. With respect to products requiring qualification, awards will be made only for products which are, at the time of award of contract, qualified for inclusion in Qualified Products List QPL No. 83824 whether or not such products have actually been so listed by that date. The attention of the contractors is called to these requirements, and manufactures are urged to arrange to have the products that they propose to offer to the Federal Government tested for qualification in order that they may be eligible to be awarded contracts or purchase orders for products covered by this specification. The activity responsible for the Qualified Products List is Ogden ALC/MMDSA, Hill Air Force Base and information pertaining to qualification of products may be obtained from that activity.

6.4 Deviations. Deviations to this specification are not authorized without prior written approval from the Government.

6.5 Contractor's publication-option. The contractor may use a later issue of any publication listed in this specification provided the following requirements are met.

b. The requirements of this specification are met in all other aspects.

c. There is no increase in cost.

6.6 Definitions.

6.6.1 Hermetic Seal. Hermetic sealing is the process by which an item is totally enclosed by suitable metal structure or case and sealed airtight by fusion of metallic or ceramic materials.

This includes fusion of metals by welding, brazing, or soldering; the fusion of ceramic materials under heat or pressure; and the fusion of ceramic materials into a metallic support. Elastomeric or resinous materials or combination of these materials may be used as a cover-glass seal provided that the specific leak-rate requirements are met under all tests and environmental conditions listed herein and prior approval of the contracting activity. A hermetic seal is not intended to include seals accomplished by gaskets.

6.7 Subject term (key word) listing.

Gyro polarity
Pickoff
Spin-up time

CUSTODIAN:
AIR FORCE - 99

PREPARING ACTIVITY:
AIR FORCE - 70

AGENT:
AIR FORCE - 99

(Project 6615-F305)