

IEEE Standard Specification Format Guide and Test Procedure for Single- Axis Interferometric Fiber Optic Gyros

Sponsor

**Gyro and Accelerometer Panel
of the
IEEE Aerospace and Electronic Systems Society**

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Abstract: Specification and test requirements for a single-axis interferometric fiber optic gyro (IFOG) for use as a sensor in attitude control systems, angular displacement measuring systems, and angular rate measuring systems are defined. A standard specification format guide for the preparation of a single-axis IFOG is provided. A compilation of recommended procedures for testing a fiber optic gyro, derived from those presently used in the industry, is also provided.

Keywords: fiber gyro, fiber optic gyro, gyro, gyroscope, IFOG, inertial instrument, inertial sensor, interferometric fiber optic gyro, optical gyro, Sagnac effect, Sagnac gyro

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Introduction

(This introduction is not a part of IEEE Std 952-1997, IEEE Standard Specification Format Guide and Test Procedure for Single-Axis Interferometric Fiber Optic Gyros.)

This standard was prepared by the Gyro and Accelerometer Panel of the IEEE Aerospace and Electronic Systems Society and consists of two parts.

Part I is a specification format guide for the preparation of a single-axis interferometric fiber optic gyro (IFOG) specification. It provides a common meeting ground of terminology and practice for manufacturers and users. The user is cautioned not to over specify; only those parameters that are required to guarantee proper instrument performance in the specific application should be controlled. In general, the specification should contain only those requirements that can be verified by test or inspection. Parameters in addition to those given in this standard are not precluded.

Part II is a compilation of recommended procedures for testing a single-axis IFOG. These procedures, including test conditions to be considered, are derived from those currently in use. For a specific application, the test procedure should reflect the requirements of the specifications; therefore, not all tests outlined in this standard need to be included, nor are additional tests precluded. In some cases, alternative methods for measuring performance characteristics have been included or indicated.

The intent is for the specification writer to extract the applicable test conditions and equipment requirements from Clause 11 for inclusion in the appropriate subclauses listed under 6.5. Similarly, it is intended that the writer extract the applicable test procedures from Clause 12 for inclusion in the appropriate subclauses listed under 6.6. Part II can also be used as a guide in the preparation of a separate gyro test specification with appropriate clause numbering. In general, the intent is for the Part II test procedure to refer to Part I requirements for performance, mechanical, electrical, environmental, reliability, and quality assurance. To that end, a test should not be listed in Part II unless a related requirement exists in Part I.

Blank spaces in the text of this standard permit the specification writer to insert specific information such as parameter values and their tolerances, clause numbers, etc. Brackets are to be used to enclose alternative choices of dimensional units, signs, axes, etc. Boxed statements are included for information only and are not part of the specification or test procedures. The terminology used conforms to IEEE Std 100-1996 and IEEE Std 528-1994. The units used conform to ANSI 268-1992. The abbreviation of units conforms to IEEE Std 260.1-1993. The graphic symbols used conform to IEEE Std 315-1975.

This standard defines the requirements and test procedures for an IFOG in terms unique to that gyro. The requirements contained in this standard cover application where the gyro is used as an angular motion sensor in navigation and control systems.

The term “interferometric fiber optic gyro” is accepted to include the electronics necessary to operate the gyro and to condition the output signal.

Annex A lists various gyro design features for which this format is applicable. The table therein is not intended to make any suggestions regarding the selection of particular design features that might restrict the free choice of manufacturers.

Annex B is an overview of dynamic and stochastic modeling.

Annex C is an overview of noise process variance analysis as a method for determination of the drift rate coefficients and the quantization coefficient.

This standard represents a large scale, group effort. More than 116 individuals attended over 40 meetings of the Gyro and Accelerometer Panel during preparation of this standard. The following persons were on the Gyro and Accelerometer Panel:

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1. Overview

1.1 Scope

This standard defines requirements for a single-axis interferometric fiber optic gyro (IFOG), including any necessary electronics, to be used in [an attitude control system, an angular displacement measuring system, an angular rate measuring system, _____].

2. References

This standard shall be used in conjunction with the following publications. When the following standards are superseded by an approved revision, the revision shall apply.

ANSI 260.1-1993 American National Standard Letter Symbols for Units of Measurement (SI Units, Customary Inch-Pound Units, and Certain Other Units).¹

IEEE/ASTM SI 10-1997, Standard for Use of the International System of Units (SI): The Modern Metric System.²

IEEE Std 100-1996, IEEE Standard Dictionary of Electrical and Electronics Terms.

IEEE Std 280-1985 (Reaff 1996) IEEE Standard Letter Symbols for Quantities Used in Electrical Science and Electrical Engineering (ANSI/DoD).

¹ANSI publications are available from the Sales Department, American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036, USA.

²IEEE publications are available from the Institute of Electrical and Electronics Engineers, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331, USA.

IEEE Std 315-1975 (Reaff 1993), IEEE Graphic Symbols for Electrical and Electronics Diagrams (ANSI/DoD).

IEEE Std 315A-1986 (Reaff 1993), IEEE Supplement to Graphic Symbols for Electrical and Electronics Diagrams (ANSI/DoD).

IEEE Std 528-1994, IEEE Standard for Inertial Sensor Terminology (ANSI).

IEEE Std 812-1984, IEEE Standard Definitions of Terms Relating to Fiber Optics.³

Part I—Specification format

3. Definitions

Except for the term defined below, IEEE Std 100-1996, IEEE Std 528-1994, and the model equation of 8.3 define terminology used in this standard.

3.1 Shupe effect: A time-variant non-reciprocity due to temperature changes along the length of the fiber.

4. Applicable documents

The following documents form a part of the specification to the extent specified in this specification. In the event of any conflict between the requirements of this specification and the listed documents, the requirements of this specification shall govern.

Give identification number, title, date of issue, and revision letter of each listed document.
--

4.1 Specifications

4.1.1 Government

MIL-P116J Methods of Preservation 1 October 1991.

4.1.2 Industry/Technical

4.1.3 Company

³IEEE Std 812-1984 has been withdrawn; however, copies can be obtained from Global Engineering, 15 Inverness Way East, Englewood, CO 80112-5704, USA, tel. (303) 792-2181.

4.2 Standards

4.2.1 Government

MIL-STD-105E Sampling Procedure and Tables for Inspection by Attributes 1 February 1995.

MIL-STD-461D Electromagnetic Interference Characteristics, Emission and Susceptibility January 1993 Requirements for the Control of Electromagnetic Interference.

MIL-STD-462D+ Electromagnetic Interference Characteristics, Measurements of 1 April 1995.

MIL-STD-704E Aircraft Electric Power Characteristics January 1991.

MIL-STD-740B Airborne and Structure borne Noise Measurements and Acceptance 1 June 1965 Criteria of Shipboard Equipment.

MIL-STD-781D Reliability Design Qualification and Production Acceptance Tests: October 1986 Exponential Distribution.

MIL-STD-785B Reliability Program for Systems and Equipment Development and Notice 2 Production 2 August 1988.

MIL-STD-810E Environmental Test Methods and Engineering Guidelines 2 September 1993.

4.2.2 Industry/Technical

IEEE Std 100-1996, IEEE Standard Dictionary of Electrical and Electronics Terms.

IEEE Std 528-1994, IEEE Standard for Inertial Sensor Terminology.

4.2.3 Company

4.3 Drawings

4.3.1 Government

4.3.2 Industry/Technical

4.3.3 Company

4.4 Bulletins

4.4.1 Government

4.4.2 Industry/Technical

4.4.3 Company

4.5 Other publications

Other applicable documents should be listed under the appropriate subclause.

5. Requirements

5.1 Description

The design features of the gyro described in this specification are an enclosure and mounting means, a _____ light source, a sensing coil of _____, a photosensitive readout device, and the following additional optical and electronic components: _____. The gyro is intended for use as an angular [rate, displacement] sensor.

To fill in the blanks, refer to Annex A for examples.

5.2 General requirements

5.2.1 Precedence

In the event of conflict among the purchase agreement, this specification, and other documents referred to in this specification, the order of precedence shall be as follows:

- a) Purchase agreement.
- b) This specification and its applicable drawings (see 5.4.2 and 5.5.1).
- c) Other applicable documents (see Clause 4).

5.3 Performance

Performance characteristics shall be as specified in this subclause. The tolerances include a summation of manufacturing and test errors, and environmental effects. Any exception due to environmental effects shall be listed in 5.6.3.1.

When required by the application, the sensitivity of a gyro characteristic to variations in voltage, frequency, temperature, or other variables should be included in the subclause specifying that characteristic.

5.3.1 Input rate limits

5.3.1.1 Maximum

The input rate limits about the gyro input axis (IA) shall be $\pm$ _____ [$^{\circ}/s$, rad/s].

The positive and negative input rate limits need not be equal. Multiple rate limits may be specified.

5.3.1.2 Minimum (dead band)

The gyro dead band shall not exceed _____ [$^{\circ}/s$, rad/s].

5.3.2 Gyro scale factor, S

_____ [$^{\circ}/p$, $\mu\text{rad}/p$, _____] + _____ %.

In the angular rate sensing mode, the scale factor is normally specified in $(^{\circ}/h)/V$, $(^{\circ}/h)/\text{Hz}$. In the angular displacement sensing mode, the scale factor is normally specified in $^{\circ}/p$. Different values and tolerances may be specified for different input ranges.

The scale factor range includes the manufacturing tolerance. The test procedure will result in a nominal scale factor that is defined in the model equation in 8.3.

5.3.2.1 Gyro scale factor errors

- a) Linearity Error. _____ [ppm, %] of full scale and/or _____ [ppm, %] of output, [maximum 1σ , _____].

Scale factor linearity error may have a component periodic in rate due to optical feedback to the source.

- b) Asymmetry. The difference between the scale factor measured with positive input rates and negative input rates shall not exceed _____ [ppm, %] of half the sum of the magnitudes of the scale factor determined for positive and negative inputs.
- c) Repeatability. [ppm, %], [maximum spread, 1σ , _____].

Repeatability involves changes in scale factor that occur between periods of operation. Thermal cycles and other environmental exposures, shutdowns, time between runs, remounting, and additional factors pertinent to the particular application should be specified.

- d) Stability. _____ [ppm, %], [maximum spread, 1σ , _____] for _____ [hours, days, _____].

5.3.2.2 Gyro scale factor sensitivities

- a) Temperature. The change in gyro scale factor resulting from a change in steady-state operating temperature shall not exceed _____ ppm from that measured at _____ °C over the range _____ °C to _____ °C.
- b) Other sensitivities.

Additional sensitivities may be specified such as those due to variations in supply voltage, rate of temperature change, temperature gradient, orientation, acceleration, vibration, magnetic field, radiation, and other environments pertinent to the particular application.

5.3.3 Drift rate, D, E**5.3.3.1 Bias and random, D****5.3.3.1.1 Bias, D_F**

_____ $\pm$ _____ °/h.

Repeatability. _____ °/h [maximum spread, 1σ , _____].

Thermal cycles and other environmental exposures, shutdowns, time between runs, remounting, and additional factors pertinent to the particular application should be specified.

5.3.3.1.2 Random, D_R

Random drift rate is usually defined in terms of the Allan variance components. These components should be specified. See D_R terms under 8.3 and Annex C.

- a) Angle random walk (rate white noise) coefficient, N . _____ $^{\circ}/h^{1/2}$ maximum.
- b) Bias instability coefficient, B . _____ $^{\circ}/h$ maximum.
- c) Rate random walk coefficient, K . _____ $(^{\circ}/h)/h^{1/2}$ maximum.
- d) Ramp coefficient, R . _____ $(^{\circ}/h)/h$ maximum.

For some applications it may be sufficient to define random drift as the standard deviation of the output. The time interval and integration time should be specified.

5.3.3.1.3 Measurement noise, D_Q

Quantization noise coefficient, Q _____ [", μrad] maximum.

Measurement noise is usually defined as the Allan variance component Q . See 8.3 and Annex C.

5.3.3.2 Environmentally sensitive, E

5.3.3.2.1 Thermal

- a) Temperature. The change in gyro bias resulting from a change in steady-state operating temperature shall not exceed _____ $^{\circ}/h$ from that measure at _____ $^{\circ}C$ over the range _____ $^{\circ}C$ to _____ $^{\circ}C$.
- b) Temperature ramp. The change in gyro bias resulting from a temperature ramp of _____ $^{\circ}C/min$ shall not exceed _____ $^{\circ}/h$.

The characteristics of the ramp should be representative of the intended application.

- c) Time-dependent temperature gradient. The maximum change in gyro bias resulting from a change in temperature ramp of _____ $^{\circ}C/min$ shall not exceed _____ $^{\circ}/h$.

The magnitude of the temperature ramp should be representative of the intended application. This is intended to specify the bias error associated with the Shupe effect, which arises from the time-dependent temperature gradient with respect to the center of the fiber length. The magnitude of the effect is dependent on gyro design, including coil-winding techniques and thermal packaging, and exhibits differences depending on the direction of thermal input. The mounting arrangements and method of thermal input should be specified if required by the installation design.

5.3.3.2.2 Magnetic

The change in gyro bias resulting from a change in steady-state flux density shall not exceed _____ $^{\circ}/h$ over the range _____ to _____ [mT, G, _____].

Gyro axis and characteristics of the field should be defined. If exposure to a varying field is required, the nature of the variation should be described. Demagnetization may be necessary following exposure.

5.3.3.2.3 Other sensitivities

Additional sensitivities may be specified such as those due to variations in supply voltage, rate of temperature change, orientation, acceleration, vibration, radiation, and other environments pertinent to the particular application.

5.3.4 IA alignment characteristics

5.3.4.1 IA misalignment

_____ [' mrad], maximum with respect to the input reference axis (IRA).

The specific direction of IA misalignment may be important in some applications and should be specified with respect to XRA and YRA gyro case reference axes. Note that these axes are defined in 5.4.3.

5.3.4.2 IA alignment repeatability

_____ [" μ rad], [maximum spread, 1σ , _____].

Thermal cycles and other environmental exposures, shutdowns, time between runs, remounting, and additional factors pertinent to the particular application should be specified.

5.3.4.3 IA alignment sensitivities

IA alignment sensitivities may be specified, such as those due to temperature, thermal gradients, rate of temperature change, acceleration, vibration, and additional environments pertinent to the particular application.

5.3.5 Operating temperature

_____ $\pm$ _____ $^{\circ}\text{C}$.

The operating temperature above applies only to temperature-controlled gyros. For gyros intended to operate without temperature control, see 5.6.4.4.

5.3.6 Warm-up time

_____ [s, _____], maximum.

The limits of gyro performance during that portion of warm-up time following the turn-on time should be specified for certain applications. These limits could be fixed bounds or functions of time. More than one function may be specified for different temperatures at the time of turn-on, or different functions may be specified for each performance parameter (i.e., scale factor, bias, etc.).

5.3.7 Turn-on time

The gyro output rate shall be within _____ [$^{\circ}/\text{h}$] of the input rate within _____ [s, _____] after the application of power.

5.3.8 Polarities

5.3.8.1 Input axis (IA)

The positive IA shall conform to [drawing number _____, Figure _____].

5.3.8.2 Output signals

The output signals representing gyro rotation shall conform to [drawing number _____, Figure _____].

5.3.9 Reference constants

These constants are for reference only. They are not specified independently, because they may vary within the framework of the specification, or because they are difficult or impossible to measure independently in a complete gyro. Nominal values are listed.

5.3.9.1 Light source wavelength

_____ [nm, _____].

5.3.9.2 Number of turns

_____.

5.3.9.3 Effective area per turn

_____ [m², _____].

5.3.9.4 Physical pathlength

_____ [m, _____].

5.4 Mechanical requirements

Mechanical characteristics shall be as specified hereinafter.

5.4.1 Exterior surface

Additional requirements controlling surface finish, workmanship, processing, etc., may be specified.

5.4.2 Outline and mounting dimensions

Outline and mounting dimensions, and accuracy requirements of mounting surface shall conform to [drawing number _____, Figure _____].

Specify center of gravity if required.

5.4.3 Gyro axes

The X gyro case reference axis (XRA) and Y gyro case reference axis (YRA) are mutually perpendicular and are located by means of the gyro mounting surface and the reference index on the gyro case [notch, pin, scribe line, ____]. The IRA, XRA, and YRA are reference axes defined with respect to the mounting provisions. These axes are nominally parallel to IA, XA, and YA respectively, and define a right-handed coordinate system. The IRA is perpendicular to the gyro mounting surface and shall conform to [drawing number _____, Figure _____] (see Figure 1).

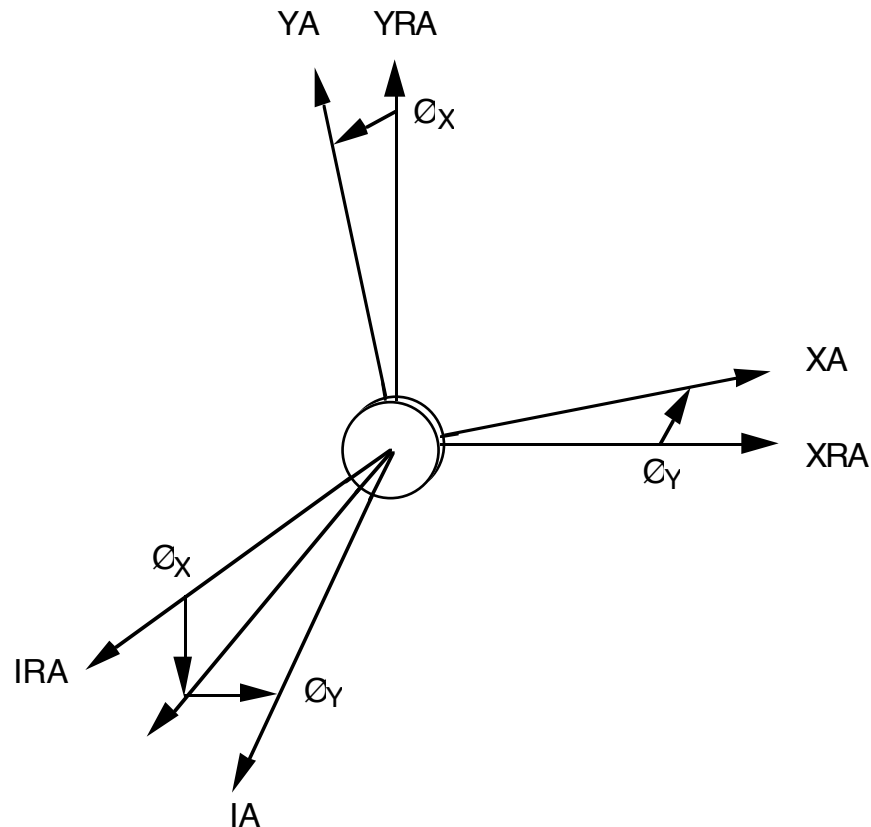


Figure 1—Gyro axes and misalignment angles

5.4.4 Weight

_____ + _____ [g, ____].

Specify those components such as cables, connectors, and electronics that are to be included in the weight.

5.4.5 Seal

The gyro shall be sealed such that the equivalent helium leak rate is less than _____ [cm^3/s , ____] when subjected to a pressure of _____ $\pm$ _____ Pa and gyro temperature of _____ $\pm$ _____ $^{\circ}\text{C}$ for a minimum of _____ minutes.

5.4.6 Identification of product

The gyro shall be identified on the surface and in the manner indicated in drawing number _____. Identification shall include the following:

- a) Fiber optic gyro or IFOG
- b) Specification number
- c) Unit serial number
- d) Axis identification marking as shown in [drawing number _____, Figure _____]
- e) Manufacturer's name or symbol

The purchase agreement may require additional identification such as date of manufacture and safety warnings.

5.4.7 Acoustic noise

The acoustic noise emissions shall conform to _____.

5.5 Electrical requirements

Electrical characteristics shall be as specified in this subclause.

5.5.1 Schematic

The electrical circuits shall be connected as shown in [drawing number _____, Figure _____].

The schematic may include preamplifiers, temperature sensing circuits, heater circuits, trim components, test points, etc.

5.5.2 Impedances

The gyro impedances shall be _____ Ω .

Load impedances and impedances of excitation, monitoring, temperature sensing, and test circuits should be specified.

5.5.3 Input power

The input power shall not exceed _____ W.

Requirements such as power factor for each circuit, frequency, voltage, ripple, starting, and operating current should be specified. Transient conditions may need to be specified.

Gyros with environmental controls may exhibit substantial changes in input power requirements over the operation temperature range.

5.5.4 Test points

Test points required for monitoring and testing of the gyro should be specified. These may include excitation voltages, other control signals, or temperature sensor(s). Any special buffering or scaling requirements should be specified.

5.5.5 Grounding

Electrical grounding design requirements (for example, requirements for isolation between input, output power returns and the grounding requirements for shields, chassis and critical components) should be specified.

5.5.6 Output signals

The type and characteristics of output signal(s) required, such as analog voltage or current, parallel or serial digital, or incremental angle pulses should be specified. For example:

Type: Pulses indicating positive angular increments on one signal line and pulses indicating negative angular increments on a second line.

Characteristics:

Source impedance

Load impedance

Wave shape (see Figure 2)

Maximum pulse rate

5.5.7 Temperature sensors

The output of the temperature sensor(s) shall be _____ $\pm$ _____ [Ω , V, _____] in the operating temperature range specified in 5.6.4.4 of this standard. The temperature rise of the sensor due to self-heating shall not exceed _____ $^{\circ}\text{C}$ at _____ mA. The scale factor of the temperature sensor(s) shall be [$\pm$] _____ $\pm$ _____ [$\text{V}/^{\circ}\text{C}$, _____].

Thermistors, thermocouples, or other temperature sensors may be specified. Temperature sensors may be built into the gyro for use in characterizing its temperature sensitivity. If sensors are required, specify quantity, locations, and characteristics. The temperature range over which the scale factor should be specified is given by 5.3.5 for temperature-controlled gyros and 5.6.4.4 for all other gyros.

5.5.8 Insulation resistance

The insulation resistance between isolated interface circuits and between the case(s) and circuits isolated from the case(s) shall not be less than _____ $\text{M}\Omega$ measured at _____ $\pm$ _____ V dc, applied for _____ $\pm$ _____ s.

Different voltages may be specified for different circuits.

5.5.9 Dielectric strength

The leakage current shall not exceed _____ nA when _____ $\pm$ _____ V RMS, at _____ Hz, are applied between isolated interface circuits, and between the case(s) and circuits isolated from the case(s) for _____ $\pm$ _____ s.

Different voltages may be specified for different circuits. In some instances, lower voltages may be specified for subsequent tests.

5.5.10 Electromagnetic interference

The electromagnetic emissions and susceptibilities shall conform to _____.

Describe the requirements. In the United States, a common standard is MIL-STD-461.

5.5.11 Electromagnetic compatibility

Describe the requirements. In the United States, a common standard is MIL-STD-461.

5.6 Environmental requirements

This subclause contains environmental requirements only. Test procedures that are to be used, including required combinations of environments, are covered in 6.6 of this standard.

5.6.1 Storage

The gyro shall conform to all requirements of this specification after exposure to the following environments or specified combinations thereof, while packaged as specified in Clause 7.

The procuring organization should list the applicable environments from 5.6.4 of this standard and specify the limits for each based on the storage conditions expected.

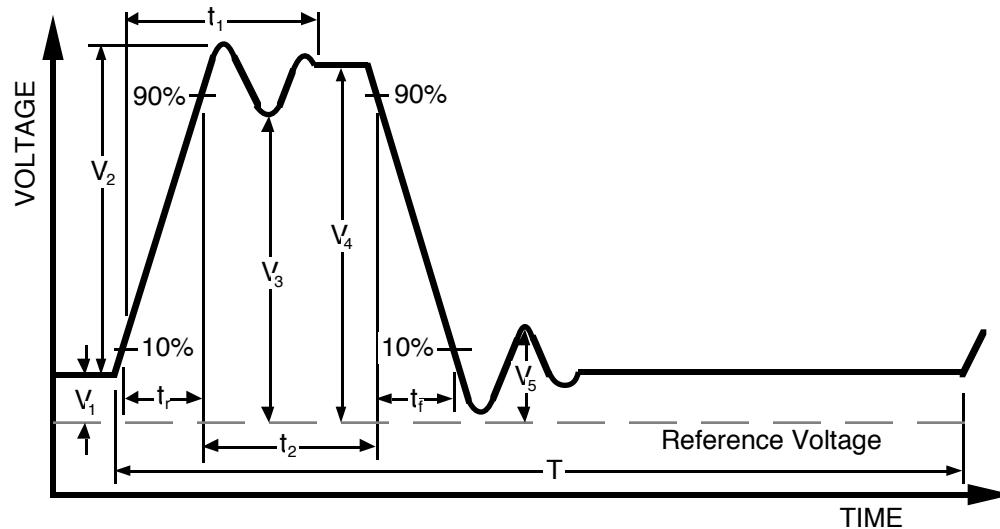
5.6.2 Transport

The gyro shall conform to all requirements of this specification after exposure to the following environments or specified combinations thereof, while packaged as specified in Clause 7.

The procuring organization should list the applicable environments from 5.6.4 of this standard and specify the limits for each based on the transportation conditions expected.

5.6.3 Operation

In order to properly specify the environmental requirements for a gyro, three different sets of environments or environmental limits, or both, as defined in 5.6.3.1, 5.6.3.2, and 5.6.3.3 of this standard may need to be described.



	UNITS	MAXIMUM	MINIMUM	REMARKS
V_1	volts	_____	_____	Steady-state low voltage
V_2	volts	_____	N/A	Overshoot voltage
V_3	volts	N/A	_____	Undershoot voltage
V_4	volts	_____	_____	Steady-state high voltage
V_5	volts	_____	N/A	Maximum low voltage transient
t_r	seconds	_____	_____	Rise time
t_f	seconds	_____	_____	Fall time
t_1	seconds	_____	_____	Turn-on transient time
t_2	seconds	_____	_____	High voltage on time
t_1/t_2	_____	_____	N/A	Ratio of turn-on transient to required on time
T	seconds	_____	_____	Waveform period
t_2/T	_____	_____	_____	Duty cycle

Figure 2—Wave shape requirements for direct coupled pulse-type signals

5.6.3.1 Operating environment

The gyro shall conform to all requirements of this specification during exposure to the following environments or specified combinations thereof (except during exposure to _____ where the deviations of this specification are given in the following clauses).

Where degraded performance is to be allowed, include the parenthetical phrase in 5.6.3.1 of this standard and list in the blank space those environments for which degraded performance is allowed. The procuring organization should list the applicable environments from 5.6.4 of this standard and specify the limits for each based on the conditions expected when the gyro is in use. For those environments where degraded performance is allowed, specify the performance deviation in the clause that specifies the environment.

5.6.3.2 Survival environment, operating

The gyro shall conform to all requirements of this specification after the operating gyro has been exposed to the following environments or specified combinations thereof.

The procuring organization should list the applicable environments from 5.6.4 of this standard and specify the limits for each based on the conditions expected when the gyro is operating, but not in use.

5.6.3.3 Survival environment, nonoperating

The gyro shall conform to all requirements of this specification after the nonoperating gyro has been exposed to the following environments or specified combinations thereof.

The procuring organization should list the applicable environments from 5.6.4 of this standard and specify the limits for each based on the conditions expected when the gyro is not operating. Such conditions are expected to occur when the gyro is mounted in the system and the system is stored or transported in severe environments.

5.6.4 Environments

Environmental characteristics shall be as specified in this subclause.

This list is intended as an aid to the selection of the applicable environments under 5.6.1, 5.6.2, and 5.6.3 of this standard. 5.6.4 in this form would not be included in a final specification.

5.6.4.1 Vibration

Axes should be defined.

When available, supply the specific vibration characteristics including dwell frequencies, frequency spectrum, time duration, etc.

If exposure to random vibration is required, power spectral density (PSD), bandwidth, peak acceleration level, and duration should be specified.

5.6.4.1.1 Linear

Sinusoidal: _____ [cm, inches] DA (double amplitude) _____ to _____ Hz; _____ [m/s², g] peak, _____ to _____ Hz. Sweep rate: _____ min/octave (continuous). Exposure time: _____ [min, ____] per axis.

5.6.4.1.2 Angular

Sinusoidal: _____ [°/s², rad/s²] _____ to _____ Hz. Sweep rate shall be _____ min/octave (continuous). Exposure time: _____ [min, ____] per axis.

5.6.4.2 Mechanical shock

_____ [m/s², g, ____] peak, _____ wave shape, _____ ms, _____ shock(s) per axis.

Gyro axes and direction of shock should be defined. A figure may be included to describe more complex waveforms. A shock spectrum may be specified.

5.6.4.3 Acceleration

Gyro axes and direction of acceleration should be defined.

5.6.4.3.1 Linear acceleration_____ [m/s², g], exposure time _____ [min, ____].**5.6.4.3.2 Angular acceleration**_____ [°/s², rad/s²], exposure time _____ [min, ____].**5.6.4.4 Temperature**

_____ °C to _____ °C.

5.6.4.5 Thermal shock

_____ °C to _____ °C within _____ [s, ____].

If exposure to cyclic conditions is required, temperature limits for each level, dwell times, and sequence should be specified. A figure may be included to describe more complex profiles.

5.6.4.6 Time-dependent temperature gradient

_____ °C between specified gyro surfaces to _____ °C within _____ [s, ____].

5.6.4.7 Thermal radiation_____ W/cm² of radiation of wavelength from _____ to _____ meters; exposure time: _____ [min, ____].**5.6.4.8 Ambient air pressure**

_____ to _____ [Pa, ____].

If exposure to cyclic conditions is required, pressure limits for each level, dwell times and sequence should be specified. A figure may be included to describe more complex profiles.

5.6.4.9 Acoustic noise_____ dB referenced to $2 \cdot 10^{-5}$ Pa, _____ to _____ Hz; exposure time: _____ [s, ____].

When available, the specific sound pressure versus frequency for the application should be specified. Sweep rate may be specified as _____ min/octave (continuous), if applying sinusoidal acoustic noise.

5.6.4.10 Humidity

_____ % relative humidity for _____ h obtained from steam or distilled water having a pH value of _____ + _____.

5.6.4.11 Air currents

_____ [m/s, ft/s].

Gyro axes and direction of air flow should be defined.

5.6.4.12 Fungus

Fungi organisms, length of exposure, temperature, and humidity conditions during exposure should be specified.

5.6.4.13 Salt spray

_____ % salt solution; exposure time: _____ [s, _____].

5.6.4.14 Nuclear radiation

_____ [J/kg, rad(Si)] with an exposure of _____ [(J/kg)/s, rad(Si)/s] and/or combinations of _____ particles at a fluence of _____ /cm² with energy greater than _____ MeV.

Radiation field characteristics and direction with respect to gyro axes should be defined. If exposure to varying fields is required, the nature of the variation should be described.

5.6.4.15 Magnetic fields

_____ [mT, G]; exposure time: _____ [s, _____].

Gyro axes and direction of field should be defined. If exposure to varying fields is required, the nature of the variation should be described.

5.6.4.16 Electromagnetic fields

Electromagnetic fields shall conform with _____.

In the United States, a common standard is MIL-STD-461.

5.6.4.17 Sand and dust

_____ [Kg/m³, _____] at a velocity of _____ + _____ [m/s, _____]; exposure time: _____ [s, _____].

Particle size, shape, and chemical composition should be specified.

5.6.4.18 Solar radiation

_____ + _____ [W/m², W/ft²] of wavelength _____ to _____ meters; exposure time: _____ [min, ____].

Distribution of power density versus wavelength should be specified.

5.6.4.19 Rain

_____ + _____ [mm/h, ____] consisting of droplets having a minimum diameter of _____ mm; exposure time: _____ [s, ____].

5.6.4.20 Excitation variation

The variations of excitation voltage and frequency shall conform with _____.

In the United States, a common standard is MIL-STD-704.

5.6.4.21 Life**5.6.4.21.1 Storage**

_____ [years, ____].

5.6.4.21.2 Operating

_____ [h, ____].

5.6.4.21.3 Start cycles

_____ minimum.

Life may need to be specified under varying environmental conditions.

5.7 Reliability**5.7.1 Reliability program**

The reliability program required shall conform with _____.

In the United States, a common standard is MIL-STD-785.

5.7.2 Mean time between failure (MTBF)

The MTBF shall be _____ h minimum.

Conditions, methods of analysis, and failure criteria should be specified.

6. Quality assurance provisions

6.1 Classification of tests

Inspection and testing shall be classified as follows:

- a) Acceptance tests. Acceptance tests are those tests performed on gyros submitted for acceptance under contract.
- b) Qualification tests. Qualification tests are those tests performed on gyros submitted for qualification as a satisfactory product.
- c) Reliability tests. Reliability tests are those tests performed to demonstrate the reliability specified in 5.7 of this standard.

6.2 Acceptance tests

6.2.1 Individual tests

Each gyro shall be subjected to the following tests as described in 6.6.

The list and sequence of individual tests should be specified by the procuring organization based on individual requirements. Those tests that are usually specified are listed below. A burn-in period under specified conditions may be required before beginning individual tests.

6.6.1	Examination of product (mechanical)
6.6.2.1	Insulation resistances
6.6.2.2	Impedances
6.6.4	Input power and circuit excitations
6.6.5	Turn-on time
6.6.6	Warm-up time
6.6.7	Polarity
6.6.9.1	Gyro scale factor
6.6.9.2	Gyro scale factor errors
6.6.10	Input rate test series
6.6.11.1	Bias repeatability
6.6.11.1	Bias sensitivities
6.6.11.3	Random drift
6.6.12.1	IA misalignment (nominal)

There are other individual tests that are not generally specified but that may be included under individual tests based on specific application. In some cases the gyros are subjected to specific environmental tests.

6.2.2 Sampling plans and tests

6.2.2.1 Sampling plans

This subclause is intended to designate a sampling plan if required. Sampling plans are up to the discretion of the procuring organization based upon usage, size of contract, individual requirements, etc.

Gyros selected shall be subject to the tests specified in 6.2.2.2, which are described in 6.6.

In the United States, selection according to MIL-STD-105 is common.

6.2.2.2 Sampling tests

In addition to the individual tests listed in 6.2.1 of this standard, the procuring organization should specify from 6.6 those tests that should be performed on gyros selected by 6.2.2.1. Sampling plan units may be used for delivery unless the procuring agency specifies life tests or other destructive type tests under the sampling plan.

6.2.2.3 Rejection and retest

When one item selected from a production run fails to meet the specification, the procuring organization shall be immediately notified of the failure, and at the discretion of the procuring organization no items still on hand or later produced shall be accepted until the extent and cause of failure are determined. After corrections have been made, all necessary tests shall be repeated. For operational and production reasons, individual tests may be continued pending the investigation of a sampling plan failure.

Other requirements suitable to an individual contract may be substituted for this subclause.

6.2.2.4 Defects in items already accepted

The investigation of a test failure could indicate that defects may exist in items already accepted. If so, the manufacturer shall fully advise the procuring organization of defects likely to be found and of methods for correcting them.

6.3 Qualification tests

6.3.1 Qualification test samples

A sample of _____ gyros manufactured in accordance with the requirements of this clause shall be subjected to qualification tests specified in this specification at an activity designated by the procuring organization.

If the gyro is later modified in any way, the modified gyro shall be subjected to and pass those qualification tests designated by the procuring organization.

The qualification test samples shall be identified with the manufacturer's part number and/or any other information required by the procuring organization.

6.3.2 Qualification tests

The procuring organization should specify from 6.6, those tests, or combinations of tests, that should be performed on gyros submitted for qualification.

6.4 Reliability tests

The reliability tests may be performed at the gyro or higher assembly level, or both.