

Single-Degree-of-Freedom
Spring-Restrained Rate Gyros

INTRODUCTION

In the interest of standardization, SAE Committee SC-22 has written this specification for a subminiature single-degree-of-freedom, spring-restrained rate gyro. The actual specifications are based upon data from rate gyro manufacturers and represent the performance capabilities and design characteristics of the majority of gyros used in today's systems.

This specification is not meant to limit the system designer but serves to advise him of rate gyro characteristics which have been established and verified by usage over the years.

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1. SCOPE:

This specification covers that gyroscopic instrument normally defined as a "subminiature rate gyro." The rate gyro, when subjected to an angular rate about its input axis, provides an AC output voltage proportional to the angular rate. The subminiature size category generally includes gyro instruments of one (1) inch diameter or less and three and one-half (3 1/2) inches length or less. This specification defines the requirements for a subminiature spring-restrained, single-degree-of-freedom rate gyro for aircraft, missile, and spacecraft applications.

2. APPLICABLE DOCUMENTS:

The following documents shall form a part of this specification to the extent specified herein. The applicable issue of each shall be that in effect on the date of this specification unless otherwise specified in the manufacturers detail specifications. Supplementary specifications, standards, or the like, which by reference in any of the following publications are indicated to be a part thereof, shall not be considered effective except as specifically stated in the manufacturers detail specification or as may be otherwise mutually agreed upon between the vendor and the purchaser.

2.1 Government and Military:

MIL-E-5272 Environmental
MIL-E-26600 RFI
MIL-P-116 Preservation
MIL-STD-129 Marking
MIL-STD-105 Sampling Inspection

2.2 Other:

AIA EETC Report No. 5, Revision A, Standard Gyro Terminology
IEEE Test Procedure for Single-Degree-of-Freedom, Spring-Restrained Rate Gyros

3. REQUIREMENTS:

3.1 Description:

The major components of the rate gyroscope (refer to figure 1) herein specified are an external case with provisions for mounting and electrical connection, a variable reluctance pickoff, a spring-restrained output member which rotates through a limited travel path, a damping regulator, and necessary electrical circuits and interconnections. The spring-restrained output member contains a synchronous spin motor (the rate sensing element) and supports the rotor for the variable reluctance pickoff. The elastic restraint is accomplished by some form of mechanical spring. A torquer and a rotor rotation detector are included as optional self-test features. The prescribed means of defining subminiature rate gyros is in accordance with Paragraph 6 and Figure 4 of this specification.

3.2 General:

- 3.2.1 Precedence: In the event of conflict between the purchase agreement and this specification, or other documents referred to herein, the order of precedence shall be defined by the purchase agreement.
- 3.2.2 Definitions: EETC Report No. 5, Revision A, Standard Gyro Terminology, shall be used as a guide for definition of terms cited herein.

3.3 Performance:

- 3.3.1 Full Scale Rate (degrees per second): The gyro shall be capable of measuring rates up to and including the specified full scale rate. The full scale rate of the unit shall be selected and specified from the following list of nominal standard full scale rates.

TABLE I - Nominal Standard Full Scale Rates

a. ± 20 deg/sec.	g. ± 350 deg/sec.
b. ± 40 deg/sec.	h. ± 500 deg/sec.
c. ± 60 deg/sec.	i. ± 1000 deg/sec.
d. ± 100 deg/sec.	j. ± 2500 deg/sec.
e. ± 150 deg/sec.	k. ± 5000 deg/sec.
f. ± 200 deg/sec.	l. $\pm 10,000$ deg/sec.

- 3.3.2 Input Limit Stops: The gyro shall contain mechanical stops to limit the rate to no less than the full scale specified and no more than the full scale specified plus 20 percent (%).
- 3.3.3 Mechanical Overload: The gyro shall be capable of withstanding an angular rate of 1000 deg/sec. or two times the full scale range, whichever is greater.
- 3.3.4 Gyro Scale Factor (volts/degree/second): The gyro scale factor shall be determined by dividing the full scale voltage output by the specified full scale rate. The full scale voltage output will vary with excitation frequency as follows:
- a. 400 Hz. - 5.6 volts $\pm 5\%$
 - b. 800 Hz. - 8.0 volts $\pm 5\%$
 - c. 4800 Hz. - 15.0 volts $\pm 5\%$

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- 3.3.5 Undamped Natural Frequency (hertz): The gyro undamped natural frequency about the output axis shall be selected and specified from the following table:

TABLE II - Subminiature Rate Gyro Undamped Natural Frequencies

10 - 15 hertz (Hz)	61 - 65
16 - 20	66 - 70
21 - 25	71 - 75
26 - 30	76 - 80
31 - 35	81 - 85
36 - 40	86 - 90
41 - 45	91 - 95
46 - 50	96 - 100
51 - 55	over 100
56 - 60	

- 3.3.6 Damping Ratio ($\times$ critical): The damping ratio shall be specified between 0.2 and 5.0 nominal at 80 F and shall vary over the operating temperature range as follows:

TABLE III - Subminiature Rate Gyro Damping Ratios

0 F to + 185 Fahrenheit	± 30 % of nominal
-40 F to 0 Fahrenheit	± 50 % of nominal
-65 F to -40 Fahrenheit	± 100 % of nominal

If compensated damping over the temperature range is not required by the user, an alternate may be specified as follows:

TABLE IV - Subminiature Rate Gyro Damping Ratio
(without compensated damping over the temperature range)

80 Fahrenheit	0.4 to 0.6
-40 F to +180 Fahrenheit	0.25 to 5.0
-65 F to -40 Fahrenheit	6.0 max.

- 3.3.7 Ready Time: The gyro shall meet the performance requirement of this specification within 60 sec. of the application of spin motor and pickoff excitation.
- 3.3.8 Self Test Torquer: If applicable, the gyro shall be capable of continuous torquing of ± 5 deg sec.
- 3.3.9 Spin Motor Rotation Detector: If applicable, the gyro shall produce a signal of 100 mv. minimum when the spin motor has attained synchronization. This signal will be at a frequency proportional to the motor excitation frequency.
- 3.3.10 Threshold and Resolution: The threshold and resolution shall be 0.01 deg/sec. or 0.1% of full scale whichever is greater.
- 3.3.11 Hysteresis: The hysteresis shall be 0.20% of full scale maximum.

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3.3.12 Zero Offset:

- a. The zero offset at room ambient conditions, prior to exposure to either storage or operating environments, shall be not more than 0.25% of nominal full scale rate.
- b. The zero set at room ambient conditions, after exposure to the storage and operating environments, shall be not more than 0.25% of nominal full scale rate.

3.3.13 Zero Offset Shift with Temperature and Vibration:

- a. The zero offset shall not shift more than 0.25% of nominal full scale rate when the gyro is exposed to extremes of the operating temperature range.
- b. The zero offset shall not shift more than 0.5% of nominal full scale rate when the gyro is exposed to the operating vibration specification.

3.3.14 Linear Acceleration Sensitivity: The linear acceleration sensitivity shall be not more than 0.1% of nominal full scale rate per g acceleration.

3.3.15 Signal Modulation Noise: The induced noise in the pickoff shall not exceed 20 mv. over the frequency range of 0-100 Hz. while the gyro motor is excited at operating voltage and frequency and with all other circuits open.

3.3.16 Linearity: The signal generator output shall vary no more than 0.5% of the nominal full scale rate from the nominal sensitivity from zero to half scale and no more than 2.0% of nominal full scale rate from the nominal sensitivity from half scale to full scale.

3.3.17 Rate Sensitivity About the Spin Reference Axis:

3.3.17.1 The misalignment of the actual spin axis with the spin reference axis shall be such that at zero rate about the input reference axis, the error rate shall be 0.005 deg./sec. per deg./sec. maximum.

3.3.17.2 The gimbal output angle at full scale range shall be such that with full scale rate about the input reference axis, the error rate shall be 0.03 deg/sec. per deg/sec. maximum.

3.3.18 Angular Acceleration Sensitivity About the Output Axis: A function of gimbal moment of inertia and rotor angular momentum (I_{OA}/H); this parameter shall not exceed 0.075 deg./sec./rad./sec.².

3.3.19 Polarity:

3.3.19.1 Pickoff: The voltage from the pickoff secondary line to return shall be in phase, within the allowed pickoff phase shift, with the voltage from the pickoff primary line to return for positive input rates (CW about 1A with 1A vector down).

3.3.19.2 Rotor: The rotor shall rotate in the direction indicated by the spin reference vector when connected as specified in para. 3.5.1.