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Directional Indicating System (Turbine Powered Subsonic Aircraft)

FOREWORD

Changes in this Revision are format/editorial only.

1. SCOPE:

This recommended practice covers the requirements for gyroscopically stabilized Directional Indicating Systems, which will operate as a 1°/hour latitude corrected, free directional gyro or as a slaved gyro, magnetic compass with 1/2° accuracy.

1.1 Purpose:

To recommend the essential minimum safe performance requirements for gyroscopically stabilized Directional Indicating System, primarily for use with turbine powered subsonic transport aircraft, the operation of which may subject the instruments to the environmental conditions specified in paragraph 3.3.

2. REFERENCES:

There are no referenced publications specified herein.

3. GENERAL REQUIREMENTS:

3.1 Material and Workmanship:

3.1.1 Materials: Materials should be of a quality which experience and/or tests have demonstrated to be suitable and dependable for use in aircraft instruments.

3.1.2 Workmanship: Workmanship should be consistent with high-grade aircraft instrument manufacturing practice.

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3.2 Identification:

The following information should be legibly and permanently marked on the instrument or nameplate attached thereto: (not necessarily in the order shown):

a. Name of Instrument
b. ARP416A
c. Manufacturer's part number
d. Manufacturer's serial number or date of manufacture
e. Manufacturer's name and/or trade-mark
f. Rating (Electrical, etc.)
g. Explosion Category

3.3 Environmental Conditions:

The following conditions have been established as design criteria only. Tests shall be conducted as specified in Sections 5, 6, and 7.

3.3.1 Temperature: When installed in accordance with the instrument manufacturer's instructions, the instruments should function over the range of ambient temperatures as listed in column A below and should not be adversely affected by exposure to the temperature shown in column B below.

TABLE 1

Instrument Location	A	B
Pressurized Areas	-30 to 50 °C	-65 to 70 °C
Non-Pressurized Areas	-55 to 70 °C	-65 to 70 °C

3.3.2 Altitude: When installed in accordance with the instrument manufacturer's instructions, the instruments should function from sea level up to the altitudes and temperatures listed below. Altitude pressures are per NACA Report 1235. The instrument should not be adversely affected following exposure to extremes in ambient pressure of 50 and 3 inches Hg absolute respectively.

TABLE 2

Instrument Location	Altitude Feet	Temperature °C
Pressurized Areas	15,000	50
Non-Pressurized or External Areas	60,000	40

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3.3.3 Vibration: When installed in accordance with the instrument manufacturer's instructions, the instrument should function and should not be adversely affected when subject to vibrations of the following characteristics:

TABLE 3

Instrument Location	Frequency Cycles Per Second	Max. Double Amplitude - Inches	Maximum Acceleration
Nacelle, Nacelle Mounts, Wings, Empennage and Wheel Wells	5-1000	0.036	10 g
Fuselage			
Forward of Spar Area	5-500	0.036	2 g
Center of Spar Area	5-1000	0.036	4 g
Aft of Spar Area	5-500	0.036	7 g
	500-1000	-	5 g
Vibration Isolated Rack	5-1000	0.030	1 g
Instrument Panel	5-30	0.020	-
	30-1000	-	0.25 g

3.3.4 Humidity: The instrument should function and should not be adversely affected following exposure to any relative humidity in the range from 0 to 95% at a temperature of approximately 70 °C.

3.4 Explosion Category:

All instrument components located in the uninhabited areas of non-pressurized aircraft or in the non-pressurized areas of pressurized aircraft should not cause an explosion when operated in an explosive atmosphere. Each component located in such an area should meet the requirements of one of the explosion proof categories given below.

If it is intended that a component which might be an ignition source will be located in an area where combustible fluid or vapor may occur in normal operation, such as a fuel tank, it should be designed to meet the requirements of Category II, below. If the intended location is an area where combustible fluid or vapor may occur only as a result of abnormal conditions, such as leakage of a fuel line, it should be designed to meet the requirements of Category I, below.

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TABLE 4

Category	Definition	Requirements
I	Explosion Proofed; case not designed to prevent flame or explosion propagation.	Test per paragraph 7.4.1.1
II	Explosion Proofed; case designed to prevent flame or explosion propagation.	Test per paragraph 7.4.1.2
III	Hermetically Sealed	Test per 7.7
IV	Instrument not capable of causing an explosion	Must not be capable of producing a spark with more than 0.2 millijoules of energy.

3.5 Fire Hazard:

The instrument should be so designed to safeguard against hazards to the aircraft in the event of malfunction or failure, and the maximum operating temperature of surfaces of any instrument component contacted by combustible fuel or vapor should not exceed 200 °C due to self-heating.

3.6 Radio Interference:

The instrument should not be the source of objectionable interference under operating conditions at any frequencies used in aircraft, either by radiation or feedback in the electronic equipment installed in the same aircraft as the instrument.

3.7 Magnetic Effect:

The magnetic effect of the instruments should not adversely affect the performance of other instruments installed in the same aircraft.

3.8 Decompression:

When installed in accordance with the instrument manufacturer's instructions, the instrument shall function and not be adversely affected following exposure to a pressure decrease from 22 to 2 inches of mercury in 2 seconds.

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4. DETAIL REQUIREMENTS:

4.1 Display Markings:

4.1.1 Finish: Unless otherwise specified by the user, matte white material should be applied to all graduations, numerals, and indication means.

Non-functional surfaces and markings should be durable dull black.

4.1.2 Graduations: The graduations should be arranged to provide the maximum of readability consistent with the accuracy of the instrument.

4.1.3 Numerals: The display should include sufficient numerals to permit quick and positive identification of each graduation. Numerals should distinctly indicate the graduation to which each applies.

4.1.4 Instrument Title: The instrument title, when used, should be of the same approximate size but no larger than the numerals. The title may be of the same finish as the numerals. The units of measure should appear on the dial in lettering noticeably smaller than either the numerals or title.

4.1.5 Visibility: The indicating means and all markings should be visible from any point within the frustum of a cone the side of which makes an angle of at least 30 degrees with the perpendicular to the dial and the small diameter of which is the aperture of the instrument case. The distance between the dial and the cover glass should be a practical minimum.

4.2 Power Variation:

The instrument should properly function with plus or minus 15 percent variation in D.C. voltage and/or plus or minus 10 percent variation in A.C. voltage and plus or minus 5 percent variation in frequency.

4.3 Power Malfunction Indication:

Means should be incorporated in the instrument to indicate when adequate power (voltage and/or current) is not being made available to all phases required for the proper operation of the instrument. The indicating means should indicate a failure or a malfunction in a positive manner.

4.4 Hermetic Sealing:

When hermetically sealed, the case should be filled with an inert gas, free of dust particles, and sufficiently dry so that fogging of the indicator glass does not occur during the low temperature and fogging tests of this Aerospace Standard.

4.5 Synchro Requirements:

The synchro requirements should be in accordance with the conditions specified in ARP461.

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4.6 Gyro Caging Provisions:

Unless the gyro assembly can be made to accommodate extreme maneuvers of the aircraft without tumbling, means should be provided for caging and/or releveling the gyro. Means should be provided to indicate when the gyro is caged, except when it is not possible to leave the gyro in caged condition.

4.7 Modes of Operation:

A means should be provided to select the mode of operation of the directional indicating system. In magnetic mode, the system should operate as a magnetic compass and synchronize with the earth's magnetic field. In the Directional Gyro mode, the system should operate as a latitude corrected directional gyro.

4.8 Operating Limits:

The instrument should indicate heading throughout the 360 degree scale range. During dives, climbs or banks up to at least 60 degrees displacement from level flight, the instrument should remain functional; however, the heading error involved through the gimbal system need not be corrected. The system should be provided with means to permit deactivating the slaving means during maneuvers.

4.9 Synchronizing Provisions:

Initial automatic or manual means should be provided to bring the indicating heading into alignment with the magnetic heading. Thereafter, in the magnetic mode, the indicated heading should be automatically and continuously aligned with magnetic heading within 0.5 degree. An indication of alignment should also be provided.

4.10 Directional Gyro Transmitting Synchros:

At least one synchro transmitter, electrically isolated from the compass system, should be provided on the output or azimuth axis of the gyro to transmit signals proportional to the position of the gyro. This synchro should comply with ARINC, Index and rotation reference standards. The output impedance should be 100 ohms or less and have an output voltage, at maximum coupling, of 11.8 volts line-to-line open circuit.

4.11 Data Transmitters:

A minimum of two synchro heading data transmitters, whose rotors are postitioned by the heading output shaft of the system, should be provided for the electrical transmission of heading reference to auxiliary equipment. All connections to rotors and stators should be brought out to separate pins in the electrical connector. These synchros should comply with ARINC Index and rotation reference standards. Each synchro should have an output impedance of 30 ohms or less and an output voltage, at maximum coupling, of 11.8 volts line-to-line open circuit.

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4.12 Latitude Correction:

A manually set control should be provided to correct the system, in the compass and DG modes of operation (preferably combined with the mode selection means), for the apparent drift of the gyro due to earth's rotation. The correction should be at a rate equal to the product of 15° per hour multiplied by the sine of the local latitude. Provision should be made for both northern and southern hemisphere correction. A means should be provided to prevent accidental application of the wrong hemisphere correction. The correction scale should be graduated in degrees per hour with 2° increments and major divisions and numerals every 5° or degrees of latitude with 5° increments and major divisions and numerals every 10°.

4.13 Power Indication:

Means shall be incorporated in the instrument to indicate when adequate power (voltage and/or current) is not being made available to all phases required for the proper operation of the instrument. The indicating means shall indicate a failure or malfunction in a positive manner.

5. TEST CONDITIONS:

5.1 Atmospheric Conditions:

Unless otherwise specified, all tests required by this specification should be made at an atmospheric pressure of approximately 29.92 inches of mercury and at an ambient temperature of approximately 25 °C, and at a relative humidity of not greater than 85%. When tests are made with the atmospheric pressure or the temperature substantially different from these values, allowance should be made for the variations from the specified conditions.

5.2 Vibration to Minimize Friction (Turbine Powered Subsonic Aircraft):

Unless otherwise specified herein, all tests for performance may be conducted with the instrument subjected to a vibration of 0.001 inch double amplitude at a frequency of 10 to 60 cycles per second. The term double amplitude, as used herein, indicates the total displacement from positive maximum to negative maximum.

5.3 Vibration Equipment:

Vibration equipment should be such as to allow vibration to be applied along each of three mutually perpendicular axes of the instrument at frequencies and amplitudes consistent with the requirements of paragraph 3.3.3.

5.4 Power Conditions:

Unless otherwise specified, all tests should be conducted at the power rating recommended by the manufacturer.

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5.5 Position:

Unless otherwise specified, all tests should be made with the instrument (indicators, amplifiers, transmitters, etc.) mounted in normal operating position.

5.6 Magnetic Field Strength:

Unless otherwise specified, all tests required by this specification should be made with a horizontal field strength of approximately 0.18 gauss and a vertical field strength of approximately 0.54 gauss in the direction normal in the northern hemisphere. When tests are made with field strength values substantially different from these values, allowance should be made for variations from the specified tolerances.

6. INDIVIDUAL PERFORMANCE REQUIREMENTS:

All instruments or all components of the system should be subjected to whatever tests the manufacturer deems necessary to demonstrate specific compliance with this recommended practice, including the following requirements where applicable.

6.1 Starting:

The time for the compass system to attain full operating status should not exceed three minutes. The gyro should have attained 85% of full speed.

6.2 Scale Error:

A magnetic transmitter with known error should be mounted on a suitable turntable in an area having magnetic quality which will permit the performance of this test. The compass should be connected and set into operation as a magnetic compass and synchronized on magnetic north. The transmitter should be rotated in 15° increments through 360° clockwise and the system manually set to a synchronized null on each heading. A unit containing a synchro of known calibration mounted in an accurate positioning device and a null reading meter, or their equivalents, should be electrically connected to the data transmitter for accurate determination of compass heading. These readings should be recorded for each position of the magnetic transmitter. The test should be repeated for each successive 15° heading, from 0°, with a counterclockwise rotation of the magnetic transmitter. The deviation, thus determined, should be added algebraically and the result divided by the number of readings. This result should be the index error and should not exceed plus or minus 1/4°. The individual reading should not differ from the correct heading, less the index error by more than 0.5°. The difference of like readings as a result of clockwise and counterclockwise rotation should not exceed plus or minus 0.5°.

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6.3 Random Wander:

The directional gyro control should be mounted in its normal operating position on a Scorsby table (or equivalent roll, pitch and yaw testing apparatus which should provide 5 to 7 oscillations per minute) with the table in a level position and the remainder of the compass placed on a test bench. The gyro should be permitted to reach operating speed and settle on a random heading. Magnetic slaving and latitude correction should be cut out for this test. The Scorsby table should be made to oscillate in yaw, pitch and roll approximately 1/2 degree either side of the reference axis. Heading indications should be read and recorded for each half-hour period for a total time not less than 4 hours. The gyro drift rate for each hourly period should be determined and should not differ from the computed drift rate for the local latitude by more than plus or minus 3/4° hour.

6.4 Latitude Correction:

The system should be operated with the latitude correction control set for periods not less than one hour each at 0° latitude and 90° N and 90° S. Otherwise the system should be tested in accordance with 6.3. The drift rate of the gyro for each hourly period should not differ by more than plus or minus 1° per hour from the difference between the drift rate computed for the local latitude and the drift rate computed for the latitude of correction control setting.

6.5 Heeling:

When the directional gyro control (unslaved but with local latitude correction) is tilted 10 degrees about the inner gyro axis, the indicated heading should not differ from the indicated heading with the instrument in normal level position by more than 2 degrees in 5 minutes.

6.6 Turn Error:

Magnetic slaving and latitude correction should be cut out for this test. The gyro should be brought up to speed. The directional gyro control should be mounted on a tilt table and titled 55° plus or minus 1° from the vertical. The directional control should then be rotated one complete revolution about a vertical axis at a speed of approximately 360° per minute. The drift of the gyro should not exceed 2° as a result of this rotation. This test should be repeated, rotating the directional control in the opposite direction.

6.7 Gimbal Freedom:

The directional gyro control mounted on a turntable and operating at full speed should be tilted 80° out of the horizontal plane. The directional gyro control should then be rotated through 360° in azimuth in 1 minute or less. There should be no indication of gimbal interference.

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6.8 Settling Test:

The system, connected as in Section 6.2 and with the gyro mounted on a Scorsby table (reference section 6.3), should be set into operation and set to a synchronized null. The directional gyro control should then be rotated 10° from the null position. The output of the data transmitter should be read after a period of 15 minutes has elapsed. This procedure should be followed for both sides of null. The difference between the final settling position, in each test, and the synchronized null should not be greater than 1/4°. (If applicable, the latitude setting should be set to the local latitude.)

6.9 Field Strength Variation:

With magnetic detector component at a total field of .57 ± .02 gauss at a dip angle of 72 degrees ± 1 degree and the compass at a null, the null should not vary more than ± 2 degrees when the dip angle is changed to 80 degrees ± 1 degree.

6.10 Magnetic Slaving Rate:

The indicated heading should drive into alignment with the magnetic heading at a rate not to exceed 4 degrees per minute. A 10° error between indicated heading and magnetic heading should be reduced to 2° in not less than 2 minutes nor more than 3 minutes. (Refer to manufacturer's specification.)

6.11 Dielectric:

Each instrument should be tested by the methods of inspection listed in paragraphs 6.11.1 and 6.11.2.

6.11.1 Insulation Resistance: The insulation resistance measured at 200 volts DC for five seconds between all electrical circuits connected together and the metallic case should not be less than 5 megohms. Insulation resistance measurements should not be made to circuits where the potential will appear across elements such as windings, resistors, capacitors, etc., since this measurement is intended only to determine adequacy of insulation.

6.11.2 Overpotential Tests: Equipment should not be damaged by the application of a test potential between electrical circuits and between electrical circuits and the metallic case. The test potential should be a sinusoidal voltage of a commercial frequency with an R.M.S. value of five times the maximum circuit voltage or per paragraphs 6.11.2.1 or 6.11.2.2, whichever applies. The potential should start from zero and be increased at a uniform rate to its test value. It should be maintained at this value for five seconds and then reduced at a uniform rate to zero.

Since these tests are intended to insure proper electrical isolation of the circuit components in question, these tests should not be applied to circuits where the potential will appear across elements such as windings, resistors, capacitors, etc.

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6.11.2.1 Hermetically sealed instruments should be tested at 200 volts RMS.

6.11.2.2 Circuits that operate at potentials below 15 volts and contain low voltage elements such as transistors, diodes, capacitors, and special signal generators are not to be subjected to overpotential tests.

7. QUALIFICATION TESTS:

As many instruments as deemed necessary by the manufacturer to demonstrate that all instruments will comply with the requirements of this section should be tested in accordance with the manufacturer's recommendations.

Performance of the instrument when tested under environmental conditions listed below should not deviate from that obtained at standard conditions in a manner which will significantly degrade its operation.

7.1 Temperature Characteristics:

7.1.1 Low Temperature Operation: The instrument should be subjected, for a period of five hours without operating, to the applicable low ambient temperature listed in column A of paragraph 3.3.1. The instrument, in the magnetic mode, should meet, at that temperature, the requirements of section 6.8. The instrument, in the Directional Gyro mode, should meet the requirements of Section 6.4 with the tolerance increased to ±2°/hour.

7.1.2 High Temperature Operation: The instrument should be subjected, for a period of five hours without operating, to the applicable high ambient temperature listed in column A of paragraph 3.3.1. The instrument, in the magnetic mode, at that temperature, should meet the requirements of section 6.8. The instrument, in the Directional Gyro mode, should meet the requirements of section 6.4 with the tolerance increased to ± 2°/hour.

7.1.3 Extreme Temperature Exposure: The instrument should be exposed alternately to the applicable low and high temperatures listed in column B of paragraph 3.3.1 for a period of 24 hours at each extreme temperature without operating. After a delay of three hours at room temperature, the instrument should meet the Individual Performance Tests (section 6.4 and 6.8) at room temperature. There shall be no evidence of damage as a result of exposure to the extreme temperature specified.

7.1.4 Altitude: The instrument should be subjected for a period of three hours, while operating, to the ambient temperature and pressure listed in paragraph 3.3.2. The instrument should then meet, at the conditions specified, the Individual Performance Tests, section 6.4 and 6.8.

The instrument should be exposed alternately to 50 inches Hg absolute and three inches Hg absolute non-operating. The instrument should meet the Individual Performance Tests, Section 6.4 and 6.8, at atmospheric pressure following this test.

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7.2 Vibration:

7.2.1 Resonance: The instrument while operating should be subjected to a resonant frequency survey of the appropriate range specified in Paragraph 3.3.3 in order to determine if there exists any resonant frequencies of the parts. The amplitude used may be any convenient value that does not exceed the maximum double amplitude and the maximum acceleration specified in Paragraph 3.3.3.

The instrument should then be subjected to vibration at the appropriate maximum double amplitude or maximum acceleration specified in Paragraph 3.3.3 at the resonant frequency for a period of one hour along each axis. If more than one resonant frequency is encountered with vibration applied along any one axis, a test period may be accomplished at the most severe resonance, or the period may be divided among the resonant frequencies, whichever shall be considered most likely to produce failure. The test period should not be less than one-half hour at any resonant mode. When resonant frequencies are not apparent within the specified frequency range, the instrument should be vibrated for two hours along each axis in accordance with the vibration requirements schedule (Paragraph 3.3.3) at the maximum double amplitude and the frequency to provide the maximum acceleration.

7.2.2 Cycling: The instrument, while operating, should be tested with the frequency cycled between limits specified in Paragraph 3.3.3 in 15-minute cycles for a period of one hour along each axis at an applied double amplitude specified in Paragraph 3.3.3 or an acceleration specified in Paragraph 3.3.3, whichever is the limiting value, or a total of three hours for circular motion vibration, whichever is applicable.

After the completion of this vibration test, no damage shall be evident, and the instrument shall meet the requirements of Section 6 (other than 6.11 Dielectric).

7.3 Explosion Proof:

7.3.1 Test Chamber: The test should be conducted in an explosion chamber designed for this purpose.

7.3.1.1 Operating Conditions - Category I: The following test should be used to determine the explosion producing characteristics of instruments not equipped with cases designed to prevent flame or explosion propagation.

The instrument should be installed in the chamber in such a manner that normal electrical operation is possible and mechanical controls may be operated through the pressure seals from the exterior of the chamber. Instrument components may be tested one or more at a time by extending electrical connections to the balance of the instrument located externally.

Mechanical loads on drive assemblies and servomechanical and electrical loads on switches and relays may be simulated when necessary. In all instances it should be considered preferable to operate the equipment as it normally functions in the system.

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