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Superseding AS406

Flight Directors
(Turbine-Powered Subsonic Aircraft)

RATIONALE

This document has been determined to contain basic and stable technology which is not dynamic in nature.

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1. PURPOSE:

   This standard establishes the essential minimum safe performance requirements for flight director instruments, 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. SCOPE:

   This standard covers flight directors for use on aircraft to indicate to the pilot, by visual means, the correct control application for the operation of an aircraft in accordance with a preselected flight plan.

3. GENERAL REQUIREMENTS:

3.1 Material and Workmanship:

3.1.1 Materials: Materials shall 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 shall be consistent with high-grade aircraft instrument manufacturing practice.

3.2 Identification:

The following information shall be legibly and permanently marked on the instrument or nameplate attached thereto:

a. Name of instrument
b. SAE AS 406
c. Manufacturer's part number
d. Manufacturer's serial number or date of manufacture
e. Manufacturer's name and/or trademark
f. Range (if applicable)
g. Rating (electrical, vacuum, etc.) (if applicable)
h. Explosion category (if applicable)

3.3 Environmental Conditions:

The following conditions have been established as minimum design requirements. 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 shall function over the range of ambient temperatures shown in column A below, and shall not be adversely affected by exposure to the temperatures shown in column B below:

Instrument Location	A	B
Pressurized areas	-30 to 70 C	-65 to 70 C
Nonpressurized or external areas	-55 to 70 C	-65 to 70 C

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

Instrument Location	Altitude (Ft)	Temperature (C)
Pressurized areas	15,000	50
Nonpressurized or external areas	60,000	40

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

Instrument Location	Frequency (CPS)	Max. Double Amplitude (In.)	Maximum Acceleration (g)
Nacelle, nacelle mounts wings, empennage, and wheel wells	5 - 1000	0.036	10
Fuselage			
Forward of Spar Area	5 - 500	0.036	2
Center of Spar Area	5 - 1000	0.036	4
Aft of Spar Area	5 - 500	0.036	7
	500 - 1000	-----	5
Vibration Isolated Rack	5 - 1000	0.030	1
Flight Deck Area	5 - 30	0.020	--
	30 - 1000	-----	0.25

3.3.4 Humidity: The instrument shall function and shall 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:

The instrument component, when intended for installation either in uninhabited areas of nonpressurized aircraft or in nonpressurized areas of pressurized aircraft, shall not cause an explosion when operated in an explosive atmosphere. The component shall meet the requirements applicable to the explosion category below. Specifically, any instrument component which can be an ignition source and is intended for installation in any area in which combustible fluid or vapor may result from abnormal conditions, e.g., fuel like leakage, shall meet the requirements of Category I. If the intended location is an area where combustible fluid or vapor can occur during normal operation, e.g., fuel tank, the instrument component shall meet the requirements of Category II, listed below:

Category	Definition	Requirements
I	Explosion proofed: case not designed to preclude flame or explosion propagation	Paragraph 7.5.1
II	Explosion proofed: case designed to preclude flame or explosion propagation	Paragraph 7.5.2
III	Hermetically sealed	Paragraph 6.2
IV	Instrument not capable of causing an explosion	Shall not be capable of producing a spark of more than 1.0 millijoule of energy and shall not have a short circuit current of more than 100 milliamperes.

3.5 Fire Hazard:

The instrument shall 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 shall not exceed 200 C due to self-heating.

3.6 Radio Interference:

The instruments shall not be the source of objectionable interference under operating conditions at any frequencies used on aircraft, either by radiation or feedback, in electronic equipment installed in the same aircraft as the instrument. Reference RTCA DO-108 including Appendix A.

3.7 Magnetic Effect:

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

3.8 De-Compression:

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 in. Hg in 2 sec.

4. DETAIL REQUIREMENTS:

4.1 Indication:

4.1.1 Flight Director Indicator:

4.1.1.1 Lateral Steering Control Indication: When a means of indication for lateral steering control is provided, the sensing of this command presentation should be such that the aircraft is flown toward the indication to satisfy the command (i.e., consistent with "fly-to-needle" type of instrumentation sensing).

While not limited to the following signals, any one, or combination of these signals, shall produce an indication of the correct control application to maintain flight along a prescribed flight path.

a. Angular displacement of the aircraft about the roll axis.
b. Angular displacement of the aircraft in heading from a reference heading.
c. Lateral displacement of the aircraft with respect to a selected course.

4.1.1.2 Vertical Steering Control Indication: When a means of indication for vertical steering control (pitch command) is provided, the sensing of this command presentation should be such that the aircraft is flown toward the indication to satisfy the command (i.e., consistent with "fly-to-needle" type of instrumentation sensing).

While not limited to the following signals, any one or combination of these signals shall produce an indication of correct control application to maintain flight along a prescribed flight path.

a. Angular displacement of the aircraft about the pitch axis from the (reference) pitch attitude.
b. Vertical displacement of the aircraft with respect to the glide slope.
c. Vertical displacement of the aircraft from an altitude reference, whenever altitude control is provided in the equipment.

4.1.1.3 Attitude Indication: When attitude indication is included in the flight director presentation, it shall conform with the following:

4.1.1.3.1 Display: The method of displaying bank and pitch attitude shall be as follows:

Bank attitude shall be pictorially displayed so that true relationship between bank attitude of the aircraft and the actual horizon of the earth is clearly presented over the range of indication.

Pitch attitude shall be pictorially displayed so that a change between the pitch attitude of the aircraft and the actual horizon of the earth is clearly presented in the proper relationship over the range of indication.

4.1.1.3.2 Indicating Range: The range of indication in pitch shall be at least ± 82 deg. The range of indication in bank shall be a full 360 deg.

4.1.1.3.3 Indicating Graduations: The attitude display shall be marked so that the aircraft attitude can be readily interpreted throughout the complete range. The markings should include a suitable contrast between the sky and ground segments of the display so that pitch up or pitch down attitudes are immediately recognizable.

4.1.1.3.4 Pitch Attitude Reference: A zero pitch reference shall be provided. An adjustable pitch reference marker or indicator may be provided to accommodate a range of pitch attitude trim.

4.1.1.4 Heading Indication: When heading indication is included in the flight director presentation, it shall conform with the following:

4.1.1.4.1 Indicating Range: The indicator shall indicate magnetic heading throughout the 360-deg scale range.

4.1.1.4.2 Indicating Graduations: The indicators shall be provided with degree graduations at intervals not to exceed 5 deg with major graduations every 10 deg and with numerals at intervals not greater than 30 deg, except that the 0-, 90-, 180-, and 270-deg positions may be marked N, E, S, and W, respectively.

4.1.1.4.3 Sensing: When the heading display utilizes a rotating vertical dial with a fixed lubber line, the dial shall rotate counterclockwise for right turns.

4.1.2 Display Markings:

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

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

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

4.1.2.3 Numerals: The display shall include sufficient numerals to permit quick and positive identification of each graduation.

Numerals shall distinctly indicate the graduation to which each applies.

4.1.2.4 Visibility: The indicating means shall have good visibility from all locations within a space defined by a window aperture projected 30 deg at the top and both sides and 0 deg at the bottom.

4.2 Heading and Course Selectors:

4.2.1 Heading Selector: If a means is provided to permit setting the desired heading into the flight direction system the indication of the heading selected shall be continuously provided.

4.2.2 Radio Course Selector: If a radio navigation reference is included, means shall be provided to permit setting the desired radio course into the flight direction system. Indication of the course selected shall be continuously provided.

4.3 Function Selector(s):

Means shall be provided for selecting the mode of operation (as applicable). The following are examples of possible modes of operation.

a. Hold attitude
b. Hold heading
c. Hold radio course
d. Approach (ILS)
e. Hold airspeed
f. Hold altitude

4.4 Attitude Limiter:

Provisions shall be made to limit, either electrically or visually, the control indications commanded by the system so that a preset maximum value of bank and pitch shall not be exceeded.

4.5 Safety Provisions:

4.5.1 Interlock Provisions: Provisions shall be made to prevent simultaneous applications of control signals which would result in unsafe command indications. As an example, simultaneous application of approach and constant altitude control signals would be considered unsafe.

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

4.5.3 Malfunction: The design of the instrument shall be such as to preclude (insofar as possible) any hazardous maneuver resulting from malfunction. Where practical an indicating means should be provided to warn against malfunctions.

4.6 Power Variation:

The instrument shall properly function with ± 15% variation in d-c voltage and/or ± 10% variation in a-c voltage and ± 5% variation in frequency.

4.7 Hermetic Sealing:

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

4.8 Gyro Caging:

If a gyro caging means is provided, it shall not be capable of locking the gyro in a caged position. Any malfunction which causes the gyro to remain caged shall be indicated in a positive manner.

5. TEST CONDITIONS:

5.1 Atmospheric Conditions:

Unless otherwise specified herein, all tests required by this standard shall be conducted at an atmospheric pressure of approximately 29.92 in. Hg and at an ambient temperature of approximately 25 C and a relative humidity of not greater than 85%. When tests are conducted with the atmospheric pressure or the temperature substantially different from these values allowance shall be made for the variation from the specified conditions.

5.2 Vibration to Minimize Friction:

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

5.3 Vibration Equipment:

Vibration equipment shall 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 herein, all tests shall be conducted at the power rating recommended by the manufacturer.

5.5 Position:

Unless otherwise specified herein, all tests shall be conducted with the instrument in its normal operating position.

6. INDIVIDUAL PERFORMANCE REQUIREMENTS:

All instruments shall be subjected to tests by the instrument manufacturer to demonstrate specific compliance with this standard, including the following requirements where applicable.

6.1 Dielectric:

Each instrument shall be tested by the methods of inspection listed in paragraphs 6.1.1 and 6.1.2.

6.1.1 Insulation Resistance: The insulation resistance measured at 200 v d-c for 5 sec between all electrical circuits connected together and the metallic case shall not be less than 5 megohms. Insulation resistance measurements shall 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.

6.1.2 Overpotential Tests: The instruments shall not be damaged by the application of a test potential between electrical circuits, and between electrical circuits and the metallic case. The test potential shall be a sinusoidal voltage of a commercial frequency with the rms value of five times the maximum circuit voltage or per paragraph 6.1.2.1 or 6.1.2.2, whichever applies. The potential shall start from zero and be increased at a uniform rate to its test value. It shall be maintained at this value for 5 sec, and then reduced at a uniform rate to zero.

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

6.1.2.1 Hermetically sealed instruments shall be tested at five times the maximum circuit voltage up to a maximum of 200 v rms.

6.1.2.2 Circuits that operate at potentials below 15 v are not to be subjected to overpotential tests.

6.2 Sealing:

Hermetically sealed components shall be tested for leaks by means of a mass spectrometer type of helium leak detector or equivalent. The leak rate shall not exceed 76 micron cubic feet per hour per cubic foot of filling gas at a pressure differential of one atmosphere.

7. QUALIFICATION TESTS:

As many instruments or components deemed necessary by the manufacturer to demonstrate that all instruments will comply with the requirements of this section shall be tested in accordance with his recommendations.

7.1 Temperature Characteristics:

7.1.1 Low Temperature Operation: The instrument shall be subjected to the applicable low ambient temperature listed in column A of paragraph 3.3.1 for a period of 5 hr without operating. The instrument shall meet, at that temperature, the applicable individual performance test (Section 6, except 6.1 and 6.2).

7.1.2 High Temperature Operation: The instrument shall be subjected to the applicable high ambient temperature listed in column A of paragraph 3.3.1 for a period of 5 hr without operating. (Electrical equipment shall be energized.) The instrument shall meet at that temperature the applicable individual performance tests (Section 6, except 6.1 and 6.2).

7.1.3 Extreme Temperature Exposure: The instrument shall be exposed to the applicable low and high temperatures listed in column B of paragraph 3.3.1 for a period of 24 hr at each extreme temperature, without operating. After a delay of 3 hr at room temperature, the instrument shall meet the applicable individual performance tests (Section 6, except 6.1 and 6.2) at room temperature. There shall be no evidence of damage as a result of exposure to the extreme temperatures specified.

7.1.4 Altitude: The instrument shall be subjected to the ambient temperature and pressure listed in paragraph 3.3.2 for a period of 3 hr while operating. The instrument shall then meet, at the conditions specified, the applicable individual performance tests (Section 6, except 6.1 and 6.2).

The instrument shall be exposed alternately to 50 in. Hg abs and 3 in. Hg. abs, nonoperating. The instrument shall meet the applicable individual performance tests (Section 6, except 6.1 and 6.2) at atmospheric pressure following this test.

7.2 Magnetic Effect:

Magnetic effect of the function selector and all indicators shall be determined in terms of the deflection of a free magnet approximately 1-1/2 in. long, in a magnetic field with a horizontal intensity of 0.18 (±.01) gauss when the units are held in various positions on an east-west line with their nearest part 12 in. from the center of the magnet. The maximum deflection of the magnet shall not exceed 5 deg. Tests shall be made with the instruments in both power-on and power-off conditions.

7.3 Humidity:

The instruments, unless hermetically sealed, shall be mounted in a chamber maintained at a temperature of 70 ± 2 C, and a relative humidity, of 95 ±5%, for a period of 6 hr. After this period the heat shall be shut off and the instrument shall be allowed to cool for a period of 18 hr in this atmosphere, in which the humidity rises to 100% as the temperature decreases to not more than 38 C. This complete cycle shall be conducted:

a. Five times for instruments located in uncontrolled temperature areas.
b. Once for instruments located in controlled temperature areas.

Immediately after recycling, there shall be no evidence of damage or corrosion, which affects performance. Following this test, the instrument shall meet the requirements of Section 6, except 6.1 and 6.2.

7.4 Vibration:

After the completion of the following vibration tests, no damage shall be evident and the instrument shall meet the applicable individual performance tests (Section 6, except 6.1 and 6.2).