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LAND SEA AIR SPACE

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AEROSPACE RECOMMENDED PRACTICE

ARP 794

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Revised

AIRSTREAM DEVIATION INSTRUMENT (ADI)

1. PURPOSE

This Aerospace Recommended Practice recommends the industry standards for an Airstream Deviation Instrument primarily for use with turbine-powered, subsonic transport aircraft, the operation of which may subject the instruments to the environmental conditions specified in Paragraph 3.4.

2. SCOPE

This recommended practice covers an instrument which measures and displays angle of deviation of the airstream dependent on mounting location on the aircraft.

3. GENERAL REQUIREMENTS

3.1 Materials 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 instrument manufacturing practice.

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

a. Name of instrument – Airstream Deviation Instrument
b. SAE ARP 794 (show number and revision letter)
c. Manufacturer's part number
d. Manufacturer's serial number or date of manufacture
e. Manufacturer's name and/or trademark
f. Range
g. Rating (nominal voltage)
h. Explosion Category

3.3 Compatibility of Components: If components are individually acceptable, but require matching for proper operation, they should be identified in a manner that will assure proper matching.

3.4 Environmental Conditions: The following conditions have been established as design requirements. Tests should be conducted as specified in Sections 5, 6 and 7, to insure compliance with this Aerospace Recommended Practice.

3.4.1 Temperature: When installed in accordance with the instrument manufacturer's instructions, the instrument should function over the range of ambient temperature shown in Column A below and should not be adversely affected by exposure to the range of temperature shown in Column B below:

3.4.1.1 Housing: (That portion of instrument mounted inside of aircraft)

Instrument Location	A	B
Pressurized Areas	0 to 70 C	-65 to 70 C
Non-pressurized Areas	-55 to 70 C	-65 to 70 C

3.4.1.2 Sensing Element: (That portion of instrument mounted in airstream)

	A	B
External Areas	-55 to 70 C	-65 to 70 C

3.4.2 Altitude: When installed in accordance with the instrument manufacturer's instructions, the instrument should function from minus 1000 ft up to altitudes and temperatures listed below: Altitude pressure values are per NACA Report 1235. The instrument should not be adversely affected following exposure to extremes in ambient pressures of 50 and 2 inches of mercury absolute respectively.

3.4.2.1 Housing:

Instrument Location	Altitude	Temperature
Pressurized Areas	15,000 ft	See Paragraph 3.4.1
Non-pressurized Areas	60,000 ft	See Paragraph 3.4.1

3.4.2.2 Sensing Element:

	Altitude	Temperature
External Areas	60,000 ft	See Paragraph 3.4.1

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

Instrument Location	Frequency cps	Max Double Ampl. In.	Max Accel. g
Nacelle and Nacelle Mounts, Wings, Empennage and Wheel Wells	5-1000	0.036	10
Fuselage:			
Forward of Spar Area	5-1000	0.020	2
Center or Spar Area	5-1000	0.020	3
Aft of Spar Area	5-340	0.020	6
	340-1000	0.001	8
Flight Deck Area	5-1000	0.020	.5

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

3.4.5 Icing: The instrument should function and not be adversely affected when subjected to icing conditions of 1.00 ± 0.25 grams liquid water per cubic meter of air at temperatures of -15 ± 5 C and -30 ± 5 C.

3.5 Explosion Category: The instrument component, when intended for installation either in uninhabited areas of non-pressurized aircraft or in non-pressurized areas of pressurized aircraft, should not cause an explosion when operated in an explosive atmosphere. The component should 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 an area in which combustible fluid or vapor may result from abnormal conditions, e.g., fuel line leakage, should 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 should meet the requirements of Category II listed below:

Category	Definition	Requirement
I	Explosion proofed: Case not designed to preclude flame or explosion propagation.	Paragraph 8.3.1
II	Explosion proofed: Case designed to preclude flame or explosion propagation.	Paragraph 8.3.2
III	Hermetically sealed	Not applicable
IV	Instrument not capable of causing an explosion	Should not be capable of producing a capacitive or inductive spark of more than 0.2 millijoules of energy or a contact spark of more than 4.0 millijoules of energy.

3.6 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.

All materials should be non-combustible and should not liberate gases or fumes which will result in such corrosion as to cause malfunction of equipment or discoloration of dials or indicia, nor should toxic gases or fumes that are detrimental to performance of the aircraft or health of personnel be liberated under the operating conditions specified herein.

3.7 Radio Interference: The instrument should not be the source of objectionable interference, under operating conditions at any frequencies used on aircraft, either by radiation or feedback, in the electronic equipment installed in the same aircraft as the instrument, in accordance with the latest revision of MIL-I-6181.

3.8 Magnetic Effect: The magnetic effect of the instrument should not adversely affect the performance of other instruments installed in the same aircraft and should be in accordance with Paragraph 8.9.

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

3.10 Interchangeability: Instruments and components which are identified in accordance with Paragraph 3.2 should be directly and completely interchangeable.

3.11 Definitions: Definitions should be in accordance with AS 425A, Flight Control Compartment Nomenclature and Abbreviations, and as noted in the glossary of terms defined in Paragraph 9.

4. DETAIL REQUIREMENTS

4.1 Design: The instrument should be designed to measure the angles of airflow with respect to a pre-established aircraft reference line. The total range of measurement should be at least 50 angular degrees.

4.2 Operational Characteristics: The instrument should respond to a change of 0.1 deg of angular deviation of the local airstream throughout a speed range of 80 to 220 knots with an accuracy of ± 0.25 degrees. The instrument should respond to a change of 0.1 deg of angular deviation of the local airstream throughout the speed range of 220 to 660 knots with an accuracy of ± 0.2 degrees.

4.3 Heater: An electrical heating element should be provided for anti-icing purposes. A sufficient area of the heater should be concentrated near the base of the sensing element so that the junction of the sensing element and the aircraft fuselage will be kept free of ice. The heater should be automatically regulated so that the power dissipated through the heater is an inverse function of the heater element temperature.

4.4 Sensor Electrical Alignment: The mounting surface of the instrument should provide an indexing arrangement to insure that the sensing element electrical zero position can be related to the reference axis of the aircraft within tolerances specified in Paragraph 4.2.

4.5 Power Variation: The instrument should properly function with plus or minus 15% variation in DC voltage and/or plus or minus 10% variation in AC voltage and plus or minus 5% variation in frequency.

4.6 Synchro Requirements: The synchro requirements should be in accordance with the conditions specified in ARP 461B.

4.7 Fail-Safe Provisions: No single failure or malfunction of the instrument should introduce unsafe transients to associated interconnected instruments.

5. TEST CONDITIONS

5.1 Atmospheric Conditions: Unless otherwise specified herein, all tests required by this Aerospace Recommended Practice should be made at an atmospheric pressure of approximately 29.92 inches of mercury, 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 temperature substantially different from these values, allowance should be made for the variation from the specified conditions.

5.2 Power Conditions: Unless otherwise specified herein, all tests should be conducted at the power rating recommended by the manufacturer.

5.3 Position: Unless otherwise specified herein, all tests should be conducted with the instrument in its normal operating position.

6. INSTRUMENTATION FOR PERFORMANCE CHECKS

6.1 Vibration Equipment

6.1.1 Vibration Equipment (Turbine-Powered Subsonic Aircraft): 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 3.4.3.

6.2 Test Synchros: Synchro transmitters used to provide test output functions of the instrument should be in accordance with the requirements specified in ARP 461B - Synchros.

6.2.1 Phase Rotation: A positive or clockwise phase rotation of the standard test transmitter should result in increasing function.

6.3 Test Potentiometers: Potentiometers used to provide test output functions of the applicable instrument should be precision potentiometers with an accuracy of ±0.02%, a resolution of 0.01%, and a linearity of at least 0.005%. The total impedance of the test potentiometers should be a function of the instrument design and should be specified by the manufacturer.

6.4 Potentiometer Zero: Unless otherwise specified by the instrument manufacturer, where potentiometers are used as output functions, the low impedance end of the potentiometer should correspond to the low end of the function.

7. INDIVIDUAL PERFORMANCE TESTS

All instruments should be tested in accordance with the following recommended test procedures to show specific compliance with this recommended practice and any additional tests recommended by the manufacturer.

7.1 Electrical Zero and Rotation: When the sensing element is set to the center position (zero degrees with respect to a perpendicular to the reference axis of the indexing arrangement) the output of the instrument should be zero. When the sensing element is rotated in the direction of increasing positive function, the output should increase in terms of potentiometer voltage or clockwise test indicator rotation in terms of a synchro output. When the sensing element is rotated in the direction of decreasing positive function, the output should decrease in terms of potentiometer voltage or counterclockwise test indicator rotation in terms of a synchro output.

7.2 Aerodynamic Alignment: The instrument should be mounted in a suitable wind tunnel to simulate the aircraft installation. The airspeed in the working section of the wind tunnel should be adjusted to 110 ± 5 knots. The sensing element should then be displaced in increments of 5 deg from 0.3 to 25 deg inclusive in both directions. After being released, without impulse, the sensing element should return to zero within ± 0.1 degrees.

7.3 Scale Error at Room Temperature: The instrument moving element should be rotated in 5 deg increments throughout the full range of travel. The accuracy of the output for each of these positions should be the equivalent of ±0.1 deg of angle of attack.

7.4 Heater Operation: The heater should be checked to insure proper operation by applying the nominal rated voltage for a period of five minutes. The power consumption should meet the rated value.

7.5 Dielectric: Each instrument should be tested by the method of inspection listed in Paragraphs 7.5.1 and 7.5.2.

7.5.1 Insulation Resistance: The insulation resistance measured at 200 v 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.

7.5.2 Overpotential Tests: The instrument 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 sinusoidal voltage of a commercial frequency with an rms value of five times the maximum circuit voltage. 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.

8. QUALIFICATION TESTS

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

8.1 Temperature Characteristics

8.1.1 Low Temperature Operation: The instrument should be subjected to the applicable low ambient temperature listed in Column A of 3.4.1 for a period of three hr without operating. The instrument should then meet, at that temperature, the individual performance tests.

8.1.2 High Temperature Operation: The instrument should be subjected to 70 C for a period of three hrs without operating. At the end of this period, the temperature should be increased to 93 ± 2 C, and a heater should heat the sensing element to 150 ± 2 C for a period of 5 minutes during which the instrument should be operating and the sensing element should be moved slowly from one extreme of travel to the other. At the end of this period, the air temperature should be allowed to return to ambient and the instrument should be subjected to and should meet the individual performance tests.

8.1.3 Extreme Temperature Exposure: The instrument should be exposed alternately to the applicable low and high temperatures listed in Column B of Paragraph 3.4.1 for a period of 24 hr at each extreme temperature, without operating. After a delay of three hr at room temperature, the instrument should meet the individual performance tests of Paragraphs 7.2 and 7.3 at room temperature. There should be no evidence of damage as a result of exposure to the extreme temperatures specified.

8.1.4 Altitude: The instrument should be subjected to room ambient temperature and the maximum altitude listed in Paragraph 3.4.2 for a period of three hr while operating. The instrument should then meet the requirements of Paragraph 7.3.

8.1.5 Decompression: The instrument while operating should be exposed to a pressure decrease from 22 to 2 inches of mercury in two seconds. There should be no evidence of damage as a result of exposure to the specified pressure change. The instrument should meet the applicable individual performance tests (Section 7, except Paragraph 7.5) at atmosphere pressure following this test.

8.2 Vibration

8.2.1 Resonance: The instrument, while electrically excited, should be subjected to a resonant frequency survey of the appropriate range specified in Paragraph 3.4.3 in order to determine if there exists any resonant frequencies of the parts. The amplitude may be any convenient value that does not exceed the maximum double amplitude and the maximum acceleration specified in Paragraph 3.4.3. The instrument should then be subjected to vibration at the appropriate maximum double amplitude or maximum acceleration specified in Paragraph 3.4.3 at the resonant frequency for a period of one hr on each axis. When 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 should be considered most likely to produce failure. The test period should not be less than one-half hr at any resonant mode.

When resonant frequencies are not apparent within the specified frequency range, the instrument should be vibrated for two hr along each axis in accordance with the vibration requirements schedule (Paragraph 3.4.3) at the maximum double amplitude and the frequency to provide the maximum acceleration.

8.2.2 Cycling: The instrument, while electrically excited, should be tested with the frequency cycled between limits specified in Paragraph 3.4.3 in 15-minute cycles for a period of one hr in each axis at an applied double amplitude or an acceleration specified in Paragraph 3.4.3 whichever is the limiting value. After completion of this vibration test, no damage should be evident and the instrument should meet the individual performance tests of Paragraphs 7.1, 7.2, 7.3, 7.4 and 7.5.

8.3 Explosion Proof: The instrument should be subjected to whatever requirements are applicable for the specific category listed in Paragraph 3.5. The following requirements cover only two categories.

8.3.1 Category I: The instrument should be subjected while in the test chamber to an ambient temperature in the range of 20 to 50 C. The test should be conducted while the component is operating, and if applicable, it should be connected electrically to related system components located externally to the test chamber. It should be possible to operate the electrical and/or the mechanical controls and to apply electrical and/or mechanical loads, as appropriate to the component. All making and breaking electrical contacts should be operated at least ten times while the component is being tested.

The test chamber pressure should be reduced to a pressure approximately 10,000 ft above the altitude pressure test point at which the test is to be conducted to compensate for increase in pressure when fuel is introduced. Tests should be conducted at pressure altitudes in feet at approximately sea level, 10,000, 20,000, 30,000 and 40,000 feet. The introduction of the explosive mixture into the test chamber should be made at each test altitude, the amount of fuel used should be appropriate for the test chamber, the test altitude pressure, and the prevailing atmospheric conditions. The test should be conducted utilizing an explosive mixture in the lean sector of the explosive range, and capable of producing an instantaneous explosion when ignited by a spark plug. The fuel used for conducting the tests should be aviation grade 100/130 gasoline or commercial butane.

The above tests should be repeated utilizing explosive mixtures in the "intermediate" and "rich" sectors respectively of the explosive range and also at approximately sea level and at 40,000 ft pressure altitude with the instrument component at the lowest applicable ambient temperature listed in Column A of Paragraph 3.4.1.

Operation of the instrument component during the above conditions without an explosion resulting in the test chamber should be considered as evidence that the instrument component fulfills the requirements of this explosion category.

8.3.2 Category II: The instrument component should be installed in the test chamber, and both the case of the instrument component and the test chamber should be subjected to an explosive mixture circulated in a positive manner. The instrument component need not be operated during this test. Upon energizing the ignition means located within the case, an explosion should take place within the test chamber external to the case in order for the case design characteristics to be considered as fulfilling the requirements of this explosion category.

This test should be repeated at least five times using any pressure altitude between sea level and 5,000 feet. It should be repeated utilizing explosive mixtures in the "intermediate" and "rich" sectors respectively of the explosive range. Any burned gases should be cleared from the test chamber after completing each test.

8.4 Heating Element Endurance: The heating element should be operated at rated voltage in still air temperature of 20 to 30 C for a period of 200 hours. There should be no damage to the heater or deterioration of instrument performance during this period of time. The instrument should meet the requirements of Paragraph 7.4.

8.5 Anti-Icing: The instrument should be mounted in an icing wind tunnel and tested at indicated airspeeds of 100, 200, 300 and 350 $\pm$ 5 knots at the temperature of -15 $\pm$ 5 C and -30 $\pm$ 5 C.

The liquid water content of the air flowing over the sensing element should be 1.00 $\pm$ 0.25 grams per cubic meter of air. Minimum voltage (Ref. Paragraph 4.5) applied to the heater elements of the instrument should prevent the formation of ice on the sensing element.

8.6 Damping and Time Constant: With the instrument mounted in a wind tunnel as in the aerodynamic alignment test and with the airspeed adjusted to 110 ± 5 knots, the sensing element should be displaced 3 deg in both directions. Upon release the sensing element should return to 0 deg without greater than 0.5 deg overshoot. Maximum flutter about this position, discounting airstream turbulence should be ± 0.15 degrees. Repeat the above procedure and the time required for the sensing element displacement to be reduced to 36.7% of its maximum value should not exceed 0.075 seconds. This test may be simulated for the external vane type of angle-of-attack instrument by the use of suitable jig and springs to simulate the aerodynamic forces of the wind tunnel.

8.7 Rain: The instrument should be tested in a water spray wind tunnel at an indicated airspeed of approximately 20 knots at room temperature for a period of 2 hours. Water spray equivalent to a heavy rain (0.80 in. per hr) should be introduced into the wind stream. Only the sensing element should be exposed to the wind stream; the remainder of the instrument should be enclosed to simulate installed conditions. The sensing element should be horizontal and facing upstream. After the 2-hr exposure to the wind stream containing the water spray, the inside of the instrument should be examined and no moisture should be present which will affect instrument performance.

8.8 Humidity: The instrument, unless hermetically sealed, should be mounted in a chamber maintained at a temperature of 70 ± 2 C and a relative humidity of 95 ± 5% for a period of six hours. After this period, the heat should be shut off and the instrument 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 should be conducted:

a. Five times for components located in uncontrolled temperature areas.

b. Once for components located in controlled temperature areas.

Immediately after recycling, there should be no evidence of damage or corrosion, which affects performance. Following this test, the instruments should meet the individual performance tests of Paragraph 7.

8.9 Magnetic Effect: The magnetic effect of the instrument should 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 ± 0.01 gauss when the instrument is held in various positions on an east-west line with its nearest part 12 in. from the center of the magnet. With the instrument operating, the maximum deflection of the free magnet should not exceed 5 deg from any indicating or reference position.

8.10 Dielectric Test: After completion of all the qualification tests, the instrument should meet the dielectric test of Paragraph 7.5.

8.11 Endurance: The sensing element of the instrument should be cycled through the range of travel for 1,000,000 cycles at a rate of 2500 cycles per hour. At the conclusion of this test, the transmitter should be subjected to and should meet all the requirements specified in the individual performance tests.

8.12 Attitude Error: Each instrument should be electrically excited and a reading should be taken while the instrument is in each of the following positions:

a. Normal operating position.

b. Instrument rotated clockwise around its X (longitudinal) axis, 180 deg from its normal position.

A change in output from that obtained when tested in the normal position (Item a. above) should be considered "balance error" and should not exceed the requirements of Paragraphs 7.2 and 7.3.

8.13 Sand and Dust

8.13.1 Characteristics of Sand and Dust: Sand and dust used in the test should be of angular structure and should have characteristics as follows: