SAE The Engineering Society For Advancing Mobility Land Sea Air and Space®
INTERNATIONAL
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AEROSPACE STANDARD

SAE AS437 REV. A

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MAXIMUM-ALLOWABLE-AIRSPEED INSTRUMENTS (TURBINE POWERED SUBSONIC AIRCRAFT)

FOREWORD

Changes in the revision are format/editorial only.

1. SCOPE:

This SAE Aerospace Standard (AS) covers one type of maximum-allowable-airspeed instrument which gives a continuous indication of both indicated airspeed and maximum allowable airspeed not exceeding 650 knots.

1.1 Purpose:

This Aerospace Standard establishes the essential minimum safe performance standards for pitot-static type of maximum-allowable-airspeed instruments primarily for use with turbine powered subsonic transport aircraft, the operation of which may subject the instruments to the environmental conditions specified in Section 3.3.

2. APPLICABLE DOCUMENTS:

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.1 NTIS Publications:

Available from NTIS, Springfield, VA 22161.

NACA Report 1235

3. GENERAL REQUIREMENTS:

3.1 Materials 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 attached thereto.

a. Name of instrument.
b. SAE AS437.
c. Manufacturer's part number.
d. Manufacturer's serial number or date of manufacture.
e. Manufacturer's name and/or trademark.

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 instrument shall function over the range of ambient temperature shown in column A below and shall not be adversely affected by exposure to the range of ambient temperature shown in column B below.

TABLE 1

Instrument Location	A	B
Pressurized Areas	-30 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 withstand an external case pressure of 50 inches Hg absolute when installed properly and vented to an atmospheric pressure of approximately 29.92 inches Hg absolute.

TABLE 2

Instrument Location	Altitude	Temperature
Pressurized Area	15,000 feet	50 °C

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

TABLE 3

Instrument Location	Frequency Cycles Per Second	Maximum Double Amplitude Inches	Maximum Acceleration
Instrument panel	5 - 30	0.020	
	30 - 1000	--	0.25 g

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.

3.3.5 Magnetic Effect: The magnetic effect of the instrument shall not adversely affect the performance of other instruments installed in the same aircraft.

4. DETAIL REQUIREMENTS:

4.1 Display Markings:

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

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

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

4.1.3 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.

4.1.4 Instrument Title: The instrument title (airspeed) shall 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 (Knots) shall appear on the dial in lettering noticeably smaller than either the numerals or title.

4.1.5 Visibility: The indicating means and all markings shall be visible from any point within the frustrum 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 shall be a practical minimum.

4.1.6 Indicating Means: Indicated airspeed and maximum-allowable-airspeed shall be displayed in such a manner that the numerical values on the scale(s) shall increase in a clockwise, left to right, or bottom to top direction.

4.2 Calibration:

4.2.1 Airspeed Pointer: The indicated airspeed pointer shall indicate airspeed in accordance with the following equation:

$$V_i = C_{so}\sqrt{\frac{2}{\gamma - 1}\left[\left(1+\frac{q_c}{P_o}\right)^{\frac{\gamma-1}{\gamma}} - 1\right]} \qquad \text{(Eq.1)}$$

where:

V_i = Indicated airspeed in Knots
C_{so} = Sea level speed of sound = 661.48 Knots
P_o = Pressure at sea level - 29.92126 inches Hg
q_c = Impact pressure in inch Hg = Total pressure - Static Pressure
γ = Ratio of specific heats = 1.40 for air

Values shown in Table 4 are in accordance with the above.

4.2.2 Maximum Allowable Airspeed Pointer: The maximum allowable airspeed pointer shall indicate the maximum allowable airspeed in accordance with the following equations, or in accordance with engineering data supplied by the purchaser.

For altitudes from sea level to altitude where $V_M = M_m$ (Figure 1).

$$V_M = C_{so}\sqrt{\frac{2}{\gamma-1}\left[\left(1+\frac{P}{P_o}\left[\left|\frac{V_{EM}{}^2}{5C^2{}_{so}\sigma}+1\right|^{\frac{\gamma}{\gamma-1}}-1\right]\right)^{\frac{\gamma-1}{\gamma}}-1\right]} \qquad \text{(Eq.2)}$$

For altitudes where M_m is limiting factor (Figure 1).

$$V_M = C_{so}\sqrt{\frac{2}{\gamma-1}\left[\left(\frac{P}{P_o}\left[\left|1+\frac{(\gamma-1)M_m{}^2}{2}\right|^{\frac{\gamma}{\gamma-1}}-1\right]+1\right)^{\frac{\gamma-1}{\gamma}}-1\right]} \qquad \text{(Eq.3)}$$

where:

V_M = Maximum allowable indicated airspeed in Knots
M_m = Maximum allowable Mach
γ = Ratio of specific heats = 1.40 for air
P_o = Pressure at sea level = 29.92126 inches Hg
P = Ambient static pressure in inch Hg
C_{so} = Speed of sound at sea level = 661.48 Knots
C_s = Speed of sound at altitude in Knots
σ = Density ratio at altitude
V_{EM} = Maximum equivalent airspeed in Knots

Maximum equivalent airspeed and maximum allowable Mach to be specified by the purchaser.

4.3 Limitation of Indicated Airspeed Pointer Movement:

The pointer movement shall be limited by stops in the mechanism in such a way that a pointer will not rotate more than 10 degrees beyond the last graduation on the dial. Stops may also be incorporated in the instrument mechanism to limit counterclockwise motion of the pointer.

4.4 Case Markings:

The outlets in the rear of the case shall be marked:

"P" - Pitot pressure connection.
"S" - Static pressure connection.

5. TEST CONDITIONS:

5.1 Atmospheric Conditions:

Unless specified otherwise, all tests required by the Aerospace Standard shall be conducted 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 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 specified otherwise, all tests for performance may be made while the instrument is subjected to a maximum 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 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 Position:

Unless specified otherwise, all tests shall be made while the instrument is mounted in its normal operating position.

6. INDIVIDUAL PERFORMANCE REQUIREMENTS:

All instruments shall be subjected to whatever tests the manufacturer deems necessary to demonstrate specific compliance with this Aerospace Standard, including the following requirements where applicable.

6.1 Scale Error:

During the 12 hour period immediately preceding the test, the instrument shall not have been operated or been subjected to atmospheric pressure conditions substantially different from those specified in paragraph 5.1.

6.1.1 Airspeed Scale Error: The instrument shall be tested for scale errors at all points of the scale indicated in Table 4. The tests shall be made by subjecting the instrument to the pressure specified to produce these readings, first with pressure increasing, then with pressure decreasing.

With pressure increasing, the pressure shall be brought up to, but shall not exceed, the pressure specified to give the desired reading. With pressure decreasing, the pressure shall be brought down to, but shall not fall below, the pressure specified to give the desired reading. The scale errors at the test points shall not exceed the tolerances specified in Table 4.

6.1.2 Maximum Allowable Airspeed Scale Error: The maximum speed pointer shall be tested for scale errors at all points indicated in Table 6. The test shall be accomplished by subjecting the indicator to pressure (Altitudes) specified in Table 6. During this test, the pitot and static connections shall be connected together to a standard mercury barometer and to sources of vacuum and pressure. The reduction in pressure, as indicated by the barometer, shall be made at a rate corresponding to an increase in altitude of approximately 3,000 feet per minute. The indicator shall remain at the pressure corresponding to each test point for at least 1/2 minute but not more than 5 minutes before a test reading is taken. The scale errors shall not exceed the tolerances specified in Table 6. This test shall be combined with the hysteresis test.

6.2 Hysteresis:

Not more than 15 minutes after the indicator has been subjected to the pressure corresponding to the highest altitude specified in Table 6, the pressure shall be increased at a rate corresponding to a decrease in altitude of approximately 3,000 feet per minute until the pressure corresponding to the first test point specified in Table 5 is reached. The indicator shall remain at this pressure for at least 5 minutes, but not more than 15 minutes, before the test reading is taken. After the reading has been taken, the pressure shall be further increased at the above rate until the pressure corresponding to the second test point specified in Table 5 is reached. The indicator shall remain at the pressure for at least 1 minute, but not more than 10 minutes, before a test reading is taken. After the reading has been taken, the pressure shall be further increased at the above rate until atmospheric pressure is reached. The reading of the maximum speed pointer at either of the two test points shall not differ from the corresponding reading, with decreasing pressure, by more than the tolerances specified in Table 5.

6.3 After Effect:

Not less than 1 nor more than 5 minutes after the completion of the maximum speed scale error test at room temperature, the maximum speed pointer shall have returned to its original reading, corrected for any change in atmospheric pressure, within the tolerance specified in Table 5.

6.4 Friction:

6.4.1 Maximum Allowable Airspeed Pointer: The indicator shall be tested for friction at each point indicated by an asterisk in Table 6. The pressure shall be decreased to bring the pointer to the desired reading and held constant while the two readings are taken, the first before the indicator is vibrated and the second after the indicator is vibrated. The difference between any two readings shall not exceed the tolerance specified. The pointer shall move smoothly while the pressure is varied uniformly without vibration of the indicator. This test may be combined with the test for scale error.

6.4.2 Indicated Airspeed Pointer: The test specified for the maximum allowable airspeed pointer shall be repeated for the indicated airspeed pointer except the pressure shall be increased instead of decreased and Table 4 shall apply instead of Table 6.

6.5 Leak:

6.5.1 Case Leak: The pitot and static pressure connections of the indicator shall be joined with a "Y" connection and shall be connected together to the same mercury manometer and sources of suction and pressure. A suction of 15 inches of mercury shall be applied to the pitot and static pressure connections of the indicator. While the source is disconnected for a period of 1 minute, the difference between the mercury levels in the manometer shall not change by more than 0.05 inch.

6.5.2 Airspeed Diaphragm Leak: While the static pressure connection is open to atmosphere, a pressure sufficient to produce approximately full scale deflection of the indicated airspeed pointer shall be applied to the pitot connection of the indicator, at which point the connection tubing shall be pinched off or otherwise completely sealed. During a period of 1 minute there shall be no apparent change in pointer position.

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 shall be tested in accordance with his recommendations.

7.1 Temperature Characteristics:

7.1.1 Low Temperature Operations: 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 hours without operating. The instrument shall meet, at that temperature, the scale error tests of paragraph 6.1 except that the test points shall be the points in Table 4 and 6 marked with an asterisk. The errors at the test points shall not exceed the tolerance specified in Tables 4 and 6 by more than the amount specified in Table 5. The test for hysteresis and after effect shall not be repeated at low temperature.

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 hours without operating. The instrument shall meet, at that temperature, the scale error tests of paragraph 6.1 except that the test points shall be the points in Table 4 and 6 marked with an asterisk. The errors at the test points shall not exceed the tolerance specified in Tables 4 and 6 by more than the amount specified in Table 5. The test for hysteresis and after effect shall not be repeated at high temperature.

7.1.3 Extreme Temperature Exposure: The instrument shall 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 temperature without operating. After a delay of 3 hours at room temperature the instrument shall meet the scale error tests of paragraph 6.1 at room temperature. There shall be no evidence of damage as a result of exposure to the extreme temperatures specified.

7.2 Vibration:

7.2.1 Resonance: The instrument, while operating at any altitude and any indicated airspeed within the range specified in Table 5, shall 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 shall 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 1 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 shall not be less than 1/2 hour at any resonant mode. When resonant frequencies are not apparent within the specified frequency range, the instrument shall be vibrated for 2 hours in accordance with the vibration requirements schedule, paragraph 3, at the maximum double amplitude and the frequency to provide the maximum acceleration.

7.2.2 Cycling: The instrument, while operating, shall be tested with the frequency cycled between limits specified in paragraph 3.3.3 in 15 minute cycles for a period of 1 hour in 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.

After the completion of this vibration test, no damage shall be evident and the instrument shall meet the scale error tests of paragraph 6.1.

7.3 Position Error:

7.3.1 Maximum Pointer: The maximum speed pointer reading taken while the instrument is held in any desired position and while it is being tapped, shall not differ from its reading when held in normal operating position, by more than the amount specified in Table 5. This test shall be made at the points indicated by an asterisk in Table 6.

7.3.2 Indicated Airspeed Pointer: The indicator reading, while the instrument is held in any desired position and while it is being tapped, shall not differ from its reading when held in the normal operating position, by more than the amount specified in Table 5. This test shall be made at the points of the scale indicated by an asterisk in Table 4.

7.4 Seasoning:

The instrument shall be subjected to one hundred applications of a differential pressure sufficient to produce approximately full scale deflection of the indicated airspeed pointer. Not less than 1 hour following this test the instrument shall be tested for scale errors as described in paragraph 6.1 except that the maximum speed scale error test described in paragraph 6.1.2 and 6.2 shall not be conducted. The scale error shall not exceed the tolerances specified in Table 4 by more than the amount specified in Table 5.

7.5 Magnetic Effect:

The magnetic effect of the instrument shall be determined in terms of the deflection of a free magnet, approximately 1-1/2 inches long, in a magnetic field with a horizontal intensity of 0.18, (plus or minus 0.01) gauss, when the indicator is held in various positions on an east-west line with its nearest part 12 inches from the center of the magnet. (An aircraft compass with the compensating magnets removed therefrom may be used as the free magnet for this test.) The maximum deflection of the magnet shall not exceed 5 degrees from any indicating or reference position.

7.6 Humidity:

The instrument 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 hours. After this period, the heat shall be shut off and the instrument shall be allowed to cool for a period of 18 hours 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 cycling, there shall be no evidence of damage or corrosion which affects performance following this test and the instrument shall be subjected to the scale error at room temperature test of paragraph 6.1. The change in reading between this test and the original scale error at room temperature test shall not exceed 2% of full scale reading.

7.7 Overpressure:

With the static port open to atmosphere the pressure specified in Table 5 shall be applied to the pitot pressure connection for a period of 10 minutes. With the pitot port open to atmosphere the pressure specified in Table 5 shall be applied to the static connection for a period of 10 minutes. Not less than 5 minutes following the application of this overpressure, the instrument shall be tested for scale error in accordance with paragraph 6.1 over the altitude range and airspeed range specified in Table 5. The errors at the test points shall not exceed those specified in Table 4 and 6 by more than the amount specified in Table 5.

TABLE 4

Speed Knots	Impact Pressure Inches of Mercury	Tolerance Knots
50	0.1198	±4.0
*60	0.1727	2.0
80	0.3075	2.0
*100	0.4814	2.0
120	0.6950	2.0
*150	1.090	2.5
180	1.580	3.0
*200	1.959	3.0
230	2.610	3.0
*250	3.100	3.0
280	3.924	3.5
*300	4.534	3.5
320	5.195	3.5
*350	6.286	4.0
370	7.082	4.5
*400	8.385	5.0
430	9.826	5.5
*450	10.87	6.0
480	12.56	7.0
*500	13.78	7.0
520	15.07	7.0
*550	17.16	8.5
570	18.66	8.5
*600	21.07	9.0
630	23.71	9.5
*650	25.59	10.0