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**Maximum Allowable Airspeed Instruments
(Reciprocating Engine Powered Aircraft)**

FOREWORD

This document has been declared "NONCURRENT". It is recommended, therefore, that this document not be specified for new designs. "NONCURRENT" refers to those documents which have previously been widely referenced and may continue to be required on some existing designs. "NONCURRENT" documents are available from SAE upon request.

1. PURPOSE:

This Aeronautical Standard establishes the essential minimum safe requirements for pitot-static type of Maximum Allowable Airspeed Instruments primarily for use in reciprocating engine powered civil transport aircraft, the operation of which may subject the instruments to the environmental conditions specified in paragraph 3.3.

2. SCOPE:

This Aeronautical Standard covers the basic types of maximum allowable airspeed instruments which give a continuous indication of both indicated airspeed and maximum allowable airspeed not exceeding 650 knots.

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.

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3.2 Identification:

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

- a. Name of instrument (Maximum Allowable Airspeed Instruments)
- b. SAE Aeronautical Standard AS 418
- c. Manufacturer's part number
- d. Manufacturer's serial number or date of manufacture
- e. Manufacturer's name and/or trademark
- f. Range

3.3 Environmental Conditions:

The following conditions have been established as design requirements 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 instrument shall function over the -30 to 50C ambient temperature range, and shall not be affected adversely by exposure to temperatures in range of -65C to 70C.
- 3.3.2 Humidity: The instrument shall function and shall not be affected adversely when exposed to any relative humidity in the range of 0 to 95 percent at a temperature of approximately 32C.
- 3.3.3 Altitude: The instrument shall function and shall not be affected adversely when subjected to a pressure temperature range equivalent to -1,000 to 40,000 feet standard altitude, per NACA Report Number 1235, except as limited by the application of paragraph 3.3.1. The indicator 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.
- 3.3.4 Vibration: When installed in accordance with the instrument manufacturer's instructions, the instruments shall function and shall not be affected adversely when subjected to vibrations having following characteristics:

<u>Instrument Location</u> <u>in Airframe</u>	<u>Cycles/Sec.</u>	<u>Maximum Double</u> <u>Amplitude (in.)</u>	<u>Maximum</u> <u>Acceleration</u>
Instrument Panel or Vibration Isolated Mount	5-50	0.020	1.5g

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

4. DETAILED REQUIREMENTS:

4.1 Indicating Method:

Indicated airspeed and maximum allowable airspeed shall be displayed by means of pointer (s) moving over a fixed dial which may be supplemented by a rotating drum with fixed indices. Clockwise pointer motion and right to left drum movement (apparent left to right movement of the index) shall indicate increasing speed.

4.2 Dial Finish:

Unless specified otherwise by the user, matte white material shall be applied to major graduations, numerals and pointers. Non-functional surfaces shall be durable dull black.

4.3 Visibility:

All pointer, drum and dial markings shall be visible from any point within the frustrum of a cone whose side makes an angle of not less than 30 degrees with the perpendicular to the dial, and whose small diameter is the aperture of the instrument case. The distance between the dial and the cover glass shall be a practical minimum and shall not exceed .250 inch.

4.4 Calibration:

4.4.1 The indicated airspeed pointer shall indicate airspeed in accordance with the following equation:

$$V_i = C_{s_0} \sqrt{\frac{2}{\gamma - 1} \left[\left(1 + \frac{q_c}{P_o} \right)^{\frac{\gamma - 1}{\gamma}} - 1 \right]}$$

Where:

V_i = Indicated Airspeed in Knots.

C_{s_0} = Standard Speed of Sound at Sea Level (15°C) = 661.48 Knots.

γ = Ratio of Specific Heats = C_p/C_v = 1.40.

q_c = Differential (Impact) Pressure = Stagnation (Total) Pressure Minus Static Pressure.

P_o = Standard Pressure at Sea Level (15°C) = 29.92126 inches Hg Absolute.

- 4.4.2 The maximum-allowable-airspeed pointer shall indicate the maximum allowable airspeed for any preset Mach number within the range of the instrument in accordance with the following equation:

$$V_m = C_{s_o} \sqrt{\frac{2}{\gamma-1} \left\{ \left[\frac{P}{P_o} \left(1 + \frac{\gamma-1}{2} M_m^2 \right)^{\frac{\gamma}{\gamma-1}} - 1 \right] + 1 \right\}^{\frac{\gamma-1}{\gamma}} - 1}$$

Where:

V_m = Maximum Allowable Indicated Airspeed in Knots.

C_{s_o} = Standard Speed of Sound at Sea Level (15°C) = 661.48 Knots.

γ = Ratio of Specific Heats = C_p/C_v = 1.40.

P = Ambient Static Pressure in Inches Hg Absolute.

P_o = Standard Pressure at Sea Level (15°C) = 29.92126 inches Hg Absolute.

M_m = Maximum Allowable Mach Number.

4.5 Adjustments:

- 4.5.1 Maximum-Allowable-Airspeed Pointer: An adjustable stop shall be provided in the instrument for limiting the movement of the maximum allowable airspeed pointer. The design of this adjustment shall be such that it will not affect the indication of the pointer when the altitude pressure conditions and Mach number setting are such that the limiting speed will be lower than that set by the adjustable stop.

- 4.5.2 Mach Number Setting: The preset value shall be visible from the front of the instrument when a readily accessible means is provided for setting the instrument at any desired Mach number within the range of the instrument. When the instrument does not contain an external Mach Number setting adjustment, the value of the permanent Mach number setting need not be visible from the front of the instrument, but shall be marked on the instrument nameplate.

4.6 Limitation of Indicated Airspeed Pointer Movement:

The pointer movement shall be limited by stops in the mechanism in such a way that the 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.

4.7 Case Markings:

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

"P" - Pitot Pressure connection.

"S" - Static Pressure connection.

4.8 Operational Markings:

Unless specified otherwise, instruments employing operational markings to designate airspeed limits shall be designed so that the markings change when maximum allowable airspeed changes.

5. TEST CONDITIONS:

5.1 Atmospheric Conditions:

Unless specified otherwise, all tests required by the Aeronautical Standard shall be conducted at an atmospheric pressure of approximately 29.92 inches of mercury and at an ambient temperature of approximately 25C. 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 vibration of 0.002 to 0.005 inch double amplitude at a frequency of 1,500 to 2,000 cycles per minute. 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 used which will vibrate at any desired frequency between 500 and 3,000 cycles per minute and shall subject the instrument to vibration such that a point on the instrument case will describe, in a plane inclined 45 degrees to the horizontal plane, a circle, the diameter of which is equal to the double amplitude specified herein.

5.4 Position:

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

5.5 Standard Pressures:

The altitude tables specified in NACA Report Number 1235 shall be used to determine the pressures corresponding to the altitude shown in this Aeronautical Standard.

6. INDIVIDUAL PERFORMANCE REQUIREMENTS:

All instruments shall be subjected to whatever tests the manufacturer deems necessary to demonstrate specific compliance with this Aeronautical 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. The maximum speed pointer stop shall be adjusted so that the maximum pointer indicates the highest dial indication. The Mach number setting shall be adjusted to the lowest Mach number. This setting shall be changed in accordance with the required settings in Table II. (When the instrument does not incorporate an external Mach number adjustment, it shall be tested for scale error only at the permanent Mach number setting.)

6.1.1 **Airspeed Scale Error:** The instrument shall be tested for scale errors at all points of the scale indicated in Table I. 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 errors at the test points shall not exceed the tolerances specified in Table I.

6.1.2 **Maximum-Allowable-Airspeed Scale Error:** The maximum speed pointer shall be tested for scale errors at all points of the scale indicated in Table II. The test shall be accomplished by adjusting the Mach number adjustment to the setting listed at the top of Table II and subjecting the indicator to pressures (Altitudes) specified in Table II. 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 not more than one minute before a test reading is taken. The scale errors shall not exceed the tolerances specified in Table II.

6.2 Hysteresis:

Within 15 minutes after the highest altitude in the scale error test has been initially achieved, pressure shall be increased at a rate approximately (but not exceeding) 20,000 fpm until within 3,000 feet of the first test point, in Table III, when the rate shall be decelerated gradually until the test point is reached. A reading shall be taken 10 ± 5 minutes after stabilization. Pressure shall be increased in accordance with the above procedure until the second test point, in Table III, is reached. A reading shall be taken 5 ± 4 minutes after stabilization. Pressure shall be increased to ambient pressure. The readings at the two test points shall not differ from the corresponding scale error readings by more than the tolerance allowed in Table III.

6.3 After Effect:

Not less than one nor more than five 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 III. When the full range of the instrument is less than the maximum speed for the lowest Mach number this test cannot be conducted.

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 II. 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 tapped, and the second after the indicator is tapped. The difference between any two readings shall not exceed the tolerance specified in Table III. 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 I shall apply instead of Table II. Tolerances as specified in Table III.

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 one minute there shall be no change in pointer position.

6.6 Maximum Allowable Airspeed Pointer Stop:

The maximum airspeed pointer shall be tested for compliance with Paragraph 4.5.1.

7. QUALIFICATION TESTS:

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

7.1 Low Temperature:

The instrument shall be subjected to a temperature of -30C for a period of three hours. With the temperature held at -30C the instrument shall be tested for scale errors as described in Paragraph 6.1 except that the test points shall be the points in Tables I and II marked with an asterisk. The errors at the test points shall not exceed the tolerance specified in Tables I and II by more than the amount specified in Table III. During and after this test the maximum speed pointer stop adjustment shall operate properly.

7.2 High Temperature:

The instrument shall be subjected to a temperature of 50C for a period of three hours. With the temperature held at 50C, the instrument shall be tested for scale errors as described in Paragraph 6.1 except that the test points shall be the points in Tables I and II marked with an asterisk. The errors at the test points shall not exceed the tolerance specified in Tables I and II by more than the amount specified in Table III. During and after this test the maximum speed pointer stop adjustment shall operate properly.

7.3 Extreme Temperature Exposure:

The instrument shall, after alternate exposures to ambient temperatures of -65C and 50C for periods of 24 hours each and a delay of 3 hours at room temperature following completion of the exposure, meet the requirements of Paragraph 6.1. There shall be no evidence of damage as a result of exposure to the extreme temperature specified herein.

7.4 Vibration:

The indicator shall be subjected to any altitude and any indicated airspeed within the range specified in Table II while being vibrated at 500 cycles per minute and an amplitude such that a point on the instrument case will describe a circle of .003 - .005 inch diameter. The frequency shall be slowly increased to 3,000 cycles per minute and slowly decreased to 500 cycles per minute, to determine whether the natural frequency of the instrument is in this range. The drift of the pointer shall not exceed the tolerances of Table III and the instrument pointer shall not oscillate more than the tolerance specified in Table III. After three hours exposure to vibration amplitude as specified in Paragraph 3.3.4 and at the natural frequency, if between 500 and 3,000 cycles per minute, otherwise at 2,000 cycles per minute, the instrument shall meet the requirements of section 6. No damage shall be evident after test.

7.5 Position Error:

7.5.1 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 III. This test shall be made at the points indicated by an asterisk in Table II.

7.5.2 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 III. This test shall be made at the points of the scale indicated by an asterisk in Table I.

7.6 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 one 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 I by more than the amount specified in Table III.

7.7 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 oersted, when the indicator is held in various positions on an east-west line with its nearest part five 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 one degree for any pointer deflection.

7.8 Humidity Test:

The instrument shall function and not be adversely affected when exposed to the extreme condition specified in Paragraph 3.3.2 for a period of 10 hours.

7.9 Overpressure:

The pressures specified in Table III shall be applied to the pitot pressure connection for a period of ten minutes; then the pressure specified in Table III shall be applied to the static pressure connection. Not less than five 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 III. The errors at the test points shall not exceed those specified in Table I and II by more than the amount specified in Table III.

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