SAE Aerospace
An SAE International Group

AERONAUTICAL STANDARD

AS 391C

AIRSPEED INDICATOR (PITOT STATIC)
(RECIPROCATING ENGINE POWERED AIRCRAFT)

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1. PURPOSE: To establish the essential minimum safe performance standards for pitot static pressure type of airspeed indicators, primarily for use with reciprocating engine power transport aircraft, the operation of which may subject the instruments to the environmental conditions specified in Section 3.3.

2. SCOPE: This Aeronautical Standard covers five basic types of airspeed instruments as follows:

   Type I - 1 revolution
   Type II - 1 revolution (unequal scale)
   Type III - 1 1/2 to 1 3/4 revolutions
   Type IV - 7 revolutions
   Type V - 1 3/4 to 2 revolutions

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 attached thereto:

(a) Name of instrument (Airspeed Indicators)
(b) SAE AS 391C
(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 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 of -30C to 50C and shall not be adversely affected by exposure to temperatures of -65C to 70C.

3.3.2 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 70C.

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

Instrument Location in Airframe	Cycles Per Second	Maximum Double Amplitude (In.)	Maximum Acceleration
Panel or Rack (Vibration isolated)	5-50	0.020	1.5g

3.3.4 Altitude: The instrument shall function and shall not be adversely affected following exposure to a pressure and temperature range equivalent to -1000 to 40,000 feet standard altitude, per NACA Report 1235, except as limited by the application of Paragraph 3.3.1. The instrument shall not be adversely affected when subjected to an ambient pressure of 50 inches of mercury absolute.

3.4 Radio Interference: The instrument shall not be the source of objectionable interference, under operating conditions at any frequencies used on aircraft, either by radiation or feed-back, in electronic equipment installed in the same aircraft as the instrument.

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

4. DETAIL REQUIREMENTS:

4.1 Pressure Equivalents: The instruments shall be calibrated to indicate airspeed in accordance with the following pressure equivalents. (Table I)

TABLE I
DIFFERENTIAL PRESSURE - KNOTS AND MPH
Mercury at 0°C
Water at 15.8°C

Differential Pressures for Knots				Differential Pressures MPH		
Pounds Per Square Inch	Inches of Water	Inches of Mercury	Calibrated Airspeed	Inches of Mercury	Inches of Water	Pounds/ Sq. In.
.0094	.261	.0192	20	.0145	.197	.0071
.0377	1.05	.0768	40	.0579	.788	.0284
.0590	1.63	.120	50	.0905	1.23	.0444
.0850	2.35	.173	60	.130	1.77	.0640
.116	3.21	.236	70	.178	2.42	.0872
.151	4.19	.308	80	.232	3.16	.114
.192	5.31	.390	90	.294	4.00	.144
.237	6.56	.482	100	.363	4.94	.178
.342	9.47	.696	120	.524	7.13	.257
.467	12.9	.950	140	.715	9.73	.351
.612	17.0	1.25	160	.936	12.7	.460
.777	21.5	1.58	180	1.19	16.2	.583
.964	26.7	1.96	200	1.47	20.0	.723
1.17	32.5	2.39	220	1.79	24.3	.878
1.40	38.8	2.85	240	2.13	29.1	1.05
1.65	45.8	3.37	260	2.52	34.2	1.24
1.93	53.5	3.93	280	2.93	39.9	1.44
2.23	61.8	4.54	300	3.38	46.0	1.66
2.73	75.6	5.56	330	4.13	56.2	2.03
3.29	91.0	6.69	360	4.95	67.4	2.43
4.13	114.3	8.40	400	6.20	84.3	3.04
5.35	148.2	10.89	450	7.98	108.7	3.92
6.78	187.8	13.80	500	10.06	136.9	4.94
8.44	234.0	17.19	550	12.44	169.3	6.11
10.37	287.4	21.12	600	15.17	206.4	7.45
12.60	349.0	25.64	650	18.27	248.6	8.97
15.14		30.83	700	21.79	296.5	10.70

4.2 Indicating Method: The instruments shall indicate airspeed by means of a pointer moving over a fixed dial. Sensitive types shall have, in addition, an under-dial visible through an aperture in the fixed dial for indicating hundreds of miles per hour, or knots. Clockwise pointer motion shall indicate increasing airspeed.

4.3 Visibility: The pointer and all dial markings shall be visible from any point within the frustum 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 0.187 of an inch.

4.4 Dial Markings:

4.4.1 Finish: Unless otherwise specified by the user, Matte White material shall be applied to major graduations, numerals and pointers. Nonfunctional surfaces shall be a durable dull black.

4.4.2 Graduations: Graduations shall be used which will provide maximum dial readability. Where practical minor graduations shall be used at intervals not to exceed 5 miles per hour or 5 knots at applicable and major graduations shall be used at intervals not to exceed 10 miles per hour, or 10 knots.

4.4.3 Numerals: Sufficient numerals shall be marked to positively and quickly identify all graduations. Numerals shall distinctly indicate the graduations to which each applies.

4.4.4 Instrument Name: The word "Airspeed" may be marked and may be the same finish as the numerals. The inscription "MPH" or "KNOTS" may appear on the dial.

4.5 Limitation of Pointer Movements: The pointer movement shall be limited by stops in the mechanism in such a way that the pointer will not be permitted to 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.

4.6 Back of Case Markings: The back of the case, adjacent to the connections shall be marked as follows:

P - Pitot Pressure Connection
S - Static Pressure Connection

5. TEST CONDITIONS:

5.1 Atmospheric Conditions: Unless otherwise specified, all tests required by this Aeronautical Standard shall be conducted at an atmospheric pressure of approximately 29.92 inches of mercury and at an ambient temperature of approximately 250 and a relative humidity not greater than 85%. When tests are conducted with the atmospheric pressure or the temperature substantially different from these values, allowances shall be made for the variation from the specified conditions.

5.2 Vibration: (To minimize friction) Unless otherwise specified, all tests for performance may be conducted with the instrument subjected to a vibration of 0.002 to 0.005 inch double amplitude at a frequency of 1500 to 2000 cycles per minute. The term "double amplitude" as used herein, indicates the total displacement from positive maximum to negative maximum.

5.3 Preconditioning: No pressure shall be applied to the diaphragm or any actuating element of the instrument, nor shall the diaphragm or other actuating element be flexed or exercized for a period of 24 hours prior to the start of the tests of Section 6.

5.4 Vibration Equipment: Vibration equipment shall be used which will provide frequencies and amplitudes consistent with the requirements of Section 3.3.3 with the following characteristics.

5.4.1 Circular Motion Vibrations: Vibration equipment shall be such that a point on the instrument case will describe a circle in a plane inclined 45 degrees to the horizontal plane, the diameter of which is equal to the double amplitude specified.

5.5 Position: Unless otherwise specified, all tests shall be conducted with the instrument mounted in its normal operation position.

6. INDIVIDUAL PERFORMANCE REQUIREMENTS: All instruments shall be subjected to whatever tests the manufacturer deems necessary to demonstrate specific compliance with this standard including the following requirements where applicable.

6.1 Scale Error: The instrument shall be tested for scale errors at approximately 12 essentially equal scale intervals per pointer revolution for Type I, II, III and V. For Type IV, the test shall be made at approximately 17 essentially equal intervals of the entire range. The tests shall be conducted 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 II.

6.2 Friction: The instrument shall be tested for friction at approximately four essentially equal scale intervals. The pressure shall be brought up to the desired reading and then held constant while two readings are taken; the first reading being taken before the instrument is vibrated, and the second one after the instrument is vibrated. The difference between any two readings shall not exceed the tolerance in Table III.

6.3 Position: A pressure equivalent to one-quarter, one-half and three-quarters scale deflection shall be applied. The change in reading at each deflection produced by rotating the instrument from the dial vertical to the dial horizontal position and 90 degrees to the right and left, while the instrument is vibrated shall not exceed the tolerance specified in Table II.

6.4 Leak: With both the pitot pressure and static pressure connections simultaneously evacuated to 15 inches of mercury, the leakage shall not cause more than 0.05 inch of mercury pressure drop during a one minute period. With the static pressure connection open and pressure equivalent to full scale pointer deflection applied to the pitot pressure connection, the leakage shall not cause more than 1 MPH or 1 knot decrease in indication during a one-minute period. This test shall be made with test apparatus containing the minimum practical volume.

6.5 Dielectric: If applicable, each instrument shall be tested by the method of inspection listed in Paragraphs 6.5.1 and 6.5.2.

6.5.1 Insulation Resistance: The insulation resistance measured at 200 volts DC for five seconds 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.

6.5.2 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 an R.M.S. value of five times the maximum circuit voltage, or per Paragraph 6.5.2.1 or 6.5.2.2, 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 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 shall not be applied to circuits where the potential will appear across elements such as windings, resistors, capacitors, etc.

6.5.2.1 Hermetically sealed instruments shall be tested at 200 volts R.M.S.

6.5.2.2 Circuits that operate at potentials below 15 volts are not to be subjected to overpotential tests.

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. The errors at the test points shall not exceed the tolerances of Table II by more than the amount specified in Table III.

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. The errors at the test points shall not exceed the tolerances of Table II by more than the amount specified in Table III.

7.3 Extreme Temperature Exposure: The instrument shall, after alternate exposures to ambient temperatures of -65C and 70C 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 temperatures specified herein.

7.4 Vibration:

7.4.1 Resonance: The instrument, while operating, shall be subjected to a resonant frequency survey of the appropriate range specified in Section 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 Section 3.3.3.

The instrument shall then be subjected to vibration at the appropriate maximum double amplitude or maximum acceleration specified in Section 3.3.3 at the resonant frequency for a period one hour in each axis or with circular motion vibration, whichever is applicable. 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 shall be considered most likely to produce failure. The test period shall not be less than one-half hour at any resonant mode. When resonant frequencies are not apparent within the specified frequency range, the instrument shall be vibrated for two hours in accordance with the vibration requirements schedule (Section 3) at the maximum double amplitude and the frequency to provide the maximum acceleration.

7.4.2 Cycling: The instrument, while operating, shall be tested with the frequency cycled between limits specified in Section 3.3.3 in 15-minute cycles for a period of one hour in each axis at an applied double amplitude specified in Section 3.3.3 or an acceleration specified in 3.3.3, whichever is the limiting value or a total of three hours for circular motion vibration, whichever is applicable. After completion of this vibration test, no damage shall be evident and the instrument shall meet the applicable requirements of Section 6.

7.5 Seasoning: The instrument shall be subjected to one hundred applications of a differential pressure sufficient to produce approximately full scale deflection. 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 scale error test shall not exceed the tolerance specified in Table II by more than the amount specified in Table III.

7.6 Drift: The instrument shall be subjected to a differential pressure sufficient to produce approximately 3/4 scale deflection. After being subjected to the pressure for a period of one hour, the instrument shall be tested as described in Paragraph 6.1 except scale errors shall be determined for increasing pressure only. The reading of the instrument shall not have increased by more than the amount specified in Table III.

7.7 Low Temperature Exposure: The instrument shall be subjected to a temperature of -64C for a period of 24 hours. With the temperature held at -63C, the instrument shall function. In addition, after the temperature is raised to -30C and held for a period of three hours, the instrument shall meet the requirements of Paragraph 7.1.