Society of Automotive Engineers, Inc.
29 West 39th Street
New York City

AERONAUTICAL STANDARD

AS 391 A

AIRSPEED INDICATOR (PITOT STATIC)

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1. PURPOSE: To specify minimum requirements for Pitot Static Pressure Type of Airspeed Indicators for use in aircraft, the operation of which may subject the instruments to the environmental conditions specified in Section 3.3.

2. SCOPE: This specification covers six types of instruments as follows:

TYPE I - 30 - 250 miles per hour range

TYPE II - 40 - 300 miles per hour range

TYPE III - 50 - 400 miles per hour range

TYPE IV - 50 - 450 miles per hour range

TYPE V - 50 - 700 miles per hour range

TYPE VI - 50 - 425 knots range

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 (Airspeed Indicator)
(b) SAE Specification. AS 391A
(c) Manufacturer's part number
(d) Manufacturer's serial number or date of manufacture
(e) Manufacturer's name or trademark
(f) Range

3.3 Environmental Conditions: The following are established design requirements only. All 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 temperatures from -30C to 50C and shall not be adversely affected by exposure to temperatures of -65C and 70C.

3.3.2 Humidity: The instrument shall function and shall not be adversely affected when exposed to any relative humidity in the range from 0 to 95 per cent at a temperature of approximately 32C.

3.3.3 Altitude: The instrument shall function and shall not be adversely affected when subjected to a pressure and temperature range equivalent to -1000 feet to 40,000 feet standard altitude, except as limited by the application of 3.3.1.

3.3.4 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 not more than 0.010 inch at a frequency from 500 to 3000 cycles per minute *or of not more than 1.3 g. When specified by the purchaser for use in rotary wing aircraft, the frequency range shall be 150-3000 cycles per minute.

*NOTE: It is understood that the unit shall withstand vibrations at higher frequencies, but the acceleration values need not exceed those shown above.

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

4. DETAIL REQUIREMENTS:

4.1 Pressure Equivalents: These instruments shall be calibrated to indicate airspeed in accordance with the following pressure equivalents. (TABLES I and II)

TABLE I

DIFFERENTIAL PRESSURES FOR AIRSPEEDS IN M.P.H.

Water and Mercury at 15C

Airspeed M. P. H.	Differential Pressure		
	Inches of Water	Inches of Mercury	Pounds Per Square Inch
20	.197	.0145	.0071
40	.788	.0581	.0284
50	1.231	.0907	.0444
60	1.774	.1307	.0640
70	2.416	.1780	.0872
80	3.158	.2327	.1140
90	4.000	.2948	.1444
100	4.942	.3642	.1784
120	7.130	.5254	.2573
140	9.726	.7167	.3510
160	12.736	.9385	.4577
180	16.167	1.191	.5835
200	20.025	1.476	.7227
210	22.117	1.630	.7982
240	29.054	2.141	1.049
250	31.592	2.328	1.140
270	37.014	2.728	1.336
300	46.033	3.392	1.661
330	56.15	4.138	2.026
360	67.42	4.968	2.433
400	84.32	6.214	3.043
450	108.66	8.007	3.922
500	136.87	10.086	4.940
550	169.31	12.476	6.110
600	206.40	15.210	7.449
650	248.62	18.321	8.973
700	296.50	21.849	10.701

TABLE II

DIFFERENTIAL PRESSURES FOR AIRSPEEDS IN KNOTS

Water and Mercury at 15C

Airspeed Knots	Differential Pressure		
	Inches of Water	Inches of Mercury	Pounds per Square Inch
50	1.634	.1204	0.0590
60	2.354	.1735	.0850
70	3.207	.2363	.1157
80	4.192	.3089	.1513
90	5.310	.3913	.1916
100	6.563	.4836	.2368
120	9.475	.6982	.3420
140	12.94	.9535	.4670
160	16.95	1.249	.6117
180	21.54	1.587	.7774
200	26.71	1.968	.9640
210	29.51	2.175	1.065
240	38.84	2.862	1.402
250	42.27	3.115	1.526
270	49.59	3.654	1.790
300	61.82	4.556	2.231
330	75.61	5.572	2.729
360	91.03	6.708	3.285
400	114.33	8.425	4.126
420	127.21	9.374	4.591

4.2 Indicating Method: These airspeed instruments shall indicate by a 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. 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 luminescent (self activating) material shall be applied to all major graduations, numerals and pointer.

4.4.2 Graduations: Minor graduations shall be used at intervals not to exceed 5 miles per hour, up to the 300 miles per hour mark. Major graduations shall be used to indicate every 10 miles per hour up to 300 miles per hour.

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" shall be marked and may be the same finish as the numerals. The inscription "MPH" or "KNOTS" shall 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 specification shall be conducted at an atmospheric pressure of approximately 29.92 inches of mercury, and at an ambient temperature of approximately 22C. When tests are made with the atmospheric pressure or the temperature substantially different from these values allowances shall be made for the variations from the specified conditions.

5.2 Vibration: (To minimize friction) Unless otherwise specified, all tests for performance may be made with the instrument subjected to a vibration of 0.002 to 0.005 inch amplitude at a frequency of 1500 to 2000 cycles per minute. The term 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 exercised 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 vibrate at any desired frequency between 500 and 3000 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 amplitude specified herein.

6. INDIVIDUAL PERFORMANCE REQUIREMENTS:

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

6.1 Scale Error: The instrument shall be tested for scale errors at the points of the scale indicated in Table III. 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 III.

6.2 Friction: The instrument shall be tested for friction at the test points indicated by an asterisk (*) in Table III. 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 IV.

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 vertical to the horizontal position, or 90 degrees to the right or left, while the instrument is vibrated shall not exceed the tolerance specified in Table III.

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 0.4 inch of Mercury pressure drop during a 10 second 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 decrease in indication during a one minute period.

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 III by more than the amount specified in Table IV.

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 III by more than the amount specified in Table IV.

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 Section 6.1. There shall be no evidence of damage as a result of exposure to the extreme temperatures specified herein.

7.4 Vibration: With a pressure applied, sufficient to give half scale deflection, the instrument shall be vibrated at 500 cycles per minute and describe a circle of .003 - .005 inch diameter. The frequency shall be slowly increased to 3000 cycles per minute and then 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 IV and the instrument pointer shall not oscillate more than the tolerance specified in Table IV. After three hours exposure to vibration amplitude as specified in Section 3.4.4 and at natural frequency, if between 500 and 3000 cycles per minute, otherwise at 2000 cycles per minute, the instrument shall meet the requirements of Section 6. No damage shall be evident after this test.

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 III by more than the amount specified in Table IV.

7.6 Drift: The instrument shall be subjected to a differential pressure sufficient to produce approximately 3/4 scale deflection. After being subjected to a 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 IV.

7.7 Low Temperature Exposure: The instrument shall be subjected to a temperature of -65C for a period of 24 hours. With the temperature held at -65C 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.

7.8 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 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.

7.9 Humidity Test: The instrument shall be subjected to the extreme conditions specified in paragraph 3.4.2 for a period of 10 hours, after which it shall meet the requirements of Section 6.