Society of Automotive Engineers, Inc.
400 COMMONWEALTH DRIVE, WARRENDALE, PA. 15096

AEROSPACE STANDARD

AS 8019

Issued 3-30-81
Revised

AIRSPEED INSTRUMENTS

1. PURPOSE: This standard establishes minimum performance standards for total and static pressure actuated airspeed instruments.

2. SCOPE:

2.1 Types: This standard covers Airspeed Instruments which display airspeed of an aircraft, as follows:

Type A - Air Driven, direct reading, self contained
Type B - Electrically operated, self contained
Tyep C - Electrically operated, input from a remote sensor

2.2 Applicable Documents: The following documents shall form a part of this specification to the extent specified herein:

a. Radio Technical Commission for Aeronautics (RTCA) Document DO-160 "Environmental Conditions and Test Procedures for Airborne Electronic/ Electrical Equipment and Instruments," dated 28 February 1975. (Copies may be obtained from the RTCA Secretariat, 1717 H Street N.W., Washington, D.C. 20006).

b. NASA Technical Note D-822, Tables of Airspeed, Altitude, and Mach Number Based on International Values for Atmospheric Properties and Physical Constants, by Livingston and Gracey August 1961.

3. GENERAL REQUIREMENTS:

3.1 Indicating Means: The airspeed shall be indicated by means of a pointer, dial, tape, drum, or other type of moving element, or by a digital display. Unless otherwise specified, relative motion of the index with respect to the scale (either the index or the scale may be the moving element) must be clockwise, up, or to the right for increasing airspeed.

3.2 Display:

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

a. The first graduation shall be at the lowest usable airspeed of the instrument, as specified by the manufacturer.

b. From the 10 knot, 10 mph, or 20 km/h graduation nearest to the first graduation and continuing to 250 knots, 250 mph, or 400 km/h major graduations shall be at least every 10 knots, 10 mph, or 20 km/h, with minor graduations at least every 5 knots, 5 mph, or 10 km/h.

c. Over 250 knots, 250 mph, or 400 km/h, graduations shall be at least every 50 knots, 50 mph, or 100 km/h.

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3.2.2 Numerals: The display shall include sufficient numerals positioned to permit quick and positive identification of each graduation.

3.2.3 Instrument Identification: The instrument face shall be marked with "Airspeed" or "IAS" and also with the units of measure applicable to the instrument.

3.2.4 Limits: The indicating means shall be limited in such a way that the moving element will not move more than (a) 10 degrees for circular display or (b) 0.25 in (6 mm) for linear displays beyond the greatest or least graduation in both increasing and decreasing directions.

For circular displays, positive means must be taken so that no ambiguity will exist when the indicator is at the maximum or minimum position, including the maximum overtravel of 10°. If a digital display is used a positive indication shall be provided on the display when the airspeed exceeds the instrument's calibrated range.

3.2.5 Visibility: The indicating means must be visible from all points within a space defined by a surface generated by lines making an angle of at least 30 degrees with the perpendicular to the display surface and diverging from the perimeter of the instrument window aperture. If integral lighting is provided, it must make all markings within the instrument easily readable, and not allow objectionable stray light to come from the instrument.

3.2.6 Range: The range of operation of the instrument shall be marked on the nameplate.

3.3 Fire Resistance: Except for small parts (such as knobs, fasteners, seals, grommets, and small electrical parts) that would not contribute significantly to the propagation of a fire, all materials used must be self-extinguishing when tested in accordance with the requirements of Federal Aviation Regulation 25.139(d) and Appendix F thereto, with the exception that materials tested may be configured in accordance with paragraph (b) of Appendix F or may be configured as used.

3.4 Self-Test Capability: If the equipment contains integral arrangements to permit pre-flight and/or in-flight self-test checks on the operation of the equipment in combination with other aircraft subsystems, a means shall be provided to deactivate any subsystem which might be adversely affected during the self-test cycle. In flight, self-test activating controls must provide a means to warn the pilot of this mode of operation. Self-test provisions shall automatically return to the normal operation mode following self testing.

3.5 Compatibility of Components: If instrument system components are individually acceptable but require matching for proper operation, they shall be identified on the equipment nameplate in a manner that will ensure proper matching.

3.6 Reflectance, Cover Glass: The total reflectance of the instrument cover glass including the integral lighting wedge, if applicable, shall not exceed 10 percent of the incident light. This reflectance applies over the visible light spectrum from 450 milli-microns to 600 milli-microns, and over an incident solid angle of 60° perpendicular to the viewing plane.

3.7 Accessibility of Controls: Controls not normally adjusted in flight must not be readily accessible to flight personnel.

3.8 Case Markings (Types A & B): The back of the case, adjacent to the connections shall be permanently marked as follows:

P - for pitot pressure connection.
S - for static pressure connection

3.9 Interchangeability: Instruments which are identified with the same manufacturer's part number shall be interchangeable. When an instrument is characterized for a particular type aircraft it shall be so marked on the instrument nameplate.

3.10 Effects of Tests: Unless otherwise stated, the application of the specified tests shall not produce a condition which would be detrimental to the continued performance of the instrument.

3.11 Mounting Attitude: Should the capability of an instrument to meet its stated performance be limited to a specific relationship of its axes to the axes of the aircraft, this limitation must be stated.

3.12 Accuracy: Accuracy requirements for this standard are related to the instrument output for a specified sensor input. For Type A & B instruments, the accuracy relates output to pressure input to the instruments, since they are self contained. For Type C instruments, the accuracy relates output to the input at the remote sensor; if matching of the instrument to the remote sensor is necessary to maintain the required overall accuracy, this must be so stated on the instrument nameplate.

3.13 Power Malfunction Indication: For Type B & C instruments, means must be incorporated in the instrument to indicate the loss of adequate electrical power or loss of signal to the instrument. The indicating means must indicate a failure or malfunction in a positive manner.

4. MINIMUM PERFORMANCE REQUIREMENTS UNDER STANDARD TEST CONDITIONS: The test conditions applicable to a determination of the performance of airspeed instruments are set forth in Appendix A of this Standard. All instruments shall be tested in accordance with the manufacturer's recommendations. The manufacturer shall conduct sufficient tests to prove compliance with these Minimum Performance Standards.

4.1 Scale Error: The airspeed instruments shall be tested for scale error at the proper pressure to produce all the differential pressure test points shown on Table I, Table II, or Table III (knots, mph, or km/h), within the instrument range, first with pressure differential increasing, and then with pressure differential decreasing. With the differential pressure increasing it shall be brought up to, but shall not exceed, the specified differential pressure; with the differential pressure decreasing, it shall be brought down to, but shall not go below, the specified differential pressure. The errors at the test points shall not exceed the tolerances specified in Table I, Table II, or Table III as applicable.

4.2 Friction: Type A. The instrument shall be tested for friction at four approximately equal scale intervals appropriate to the total range. The differential pressure shall be brought up to the desired test point and be held constant while two instrument readings are taken: the first reading shall be taken before the instrument is vibrated, and the second reading after the instrument is vibrated. The difference between any pair of readings shall not exceed the tolerance shown in Table IV. The vibration applied shall be sufficient to remove all the friction from the instrument, and may be more than that given in Appendix A.

Types B & C. The instrument operation and indication shall be smooth and free from irregular motion as the differential pressure or its electrical equivalent is increased and decreased smoothly. Irregular motion shall be defined to be compatible with the type of display used.

4.3 Balance Error: A pressure equivalent to one quarter, one half, and three quarters of full scale deflection shall be applied to the instrument successively as test points. The difference in readings at each test point between that with the instrument in its normal operating position and that with the instrument in any other position, while being vibrated, shall not exceed the tolerance of Table IV.

TABLE I

SCALE ERROR

KNOTS

Indicated Airspeed knots	Differential Pressure in Hg	Differential Pressure kPa	Tolerance ± knots
20	.0192	.065	5
30	.0431	.15	5
40	.0767	.26	5
50	.120	.41	5
60	.173	.59	5
70	.235	.76	4
80	.308	1.04	4
90	.390	1.32	4
100	.481	1.63	3
120	.695	2.35	3
140	.949	3.21	3
160	1.24	4.20	3
180	1.58	5.35	5
200	1.96	6.64	5
220	2.38	8.06	5
250	3.10	10.50	5
300	4.53	15.34	5
350	6.29	21.30	5
400	8.39	28.41	8
450	10.87	36.81	8
500	13.78	46.66	8
550	17.16	58.11	8
600	21.08	71.39	10
650	25.63	86.80	10
700	30.76	104.17	10

For differential pressure equivalent to the test points, but given in pounds per square inch (psi) or inches of water (in H_2O) see NASA Technical Note D822.

TABLE II

SCALE ERROR TOLERANCE

MILES PER HOUR (mph)

Indicated Airspeed	Differential Pressure		Tolerance ±
mph	in Hg	kPa	mph
20	.0145	.05	5
30	.0325	.11	5
40	.0579	.20	5
50	.0905	.31	5
60	.130	.44	5
70	.178	.60	4
80	.232	.79	4
90	.294	1.00	4
100	.363	1.23	3
120	.524	1.77	3
140	.715	2.42	3
160	.936	3.17	3
180	1.19	4.03	3
200	1.47	4.98	6
220	1.79	6.06	6
250	2.32	7.86	6
300	3.38	11.45	6
350	4.67	15.81	6
400	6.20	21.00	6
450	7.98	27.02	9
500	10.05	34.03	9
550	12.44	42.13	9
600	15.16	51.34	9
650	18.26	61.84	9
700	21.78	73.76	12

For differential pressure equivalent to the test points, but given in pounds per square inch (psi) or inches of water (in H_2O) see NASA Technical Note D822.

TABLE III

KILOMETRES PER HOUR (Km/Hr.)

Indicated Airspeed	Differential Pressure		Tolerance ±
Km/Hr.	Inches of Hg.	kPa	Km/Hr.
40	.022	.074	8
60	.047	.159	8
80	.089	.301	8
100	.140	.474	8
120	.202	.684	6
140	.277	.938	6
160	.356	1.205	5
180	.453	1.534	5
200	.562	1.903	5
250	.881	2.983	5
300	1.275	4.317	5
350	1.745	5.909	10
400	2.293	7.765	10
450	2.923	9.898	10
500	3.637	12.316	10
600	5.333	18.059	10
700	7.416	25.113	15
800	9.927	33.616	15
900	12.915	43.735	15
1000	16.441	55.675	15
1100	20.574	69.671	20
1200	25.396	86.001	20
1300	30.984	104.924	20

TABLE IV

FRICTION AND POSITION ERROR TOLERANCE

AIR SPEED			TOLERANCE ±		
knots	mph	km/h	knots	mph	km/h
40-180			3		
190-700			5		
	40-200			4	
	210-800			6	
		64-320			6
		336-1280			10

4.4 Leak: With both the pitot pressure and static pressure connections simultaneously evacuated to 15 in. Hg (50.7 kPa) and properly sealed off, the leakage shall not cause more than 0.05 in Hg (0.17 kPa) 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 and properly sealed off, the leakage shall not cause more than 1 mph (1.6 km/h) or 1 knot decrease in indication during a one-minute period. This test shall be made with test apparatus having a total volume of 100 ±10 in^3 (1.6L ±.16L), including the instrument and the test equipment. For types A and B only.

4.5 Insulation Resistance: The insulation resistance between all electrical circuits connected together and the metallic case, measured at 200 VDC for five seconds, 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 insure adequacy of insulation.

5. MINIMUM PERFORMANCE STANDARDS UNDER ENVIRONMENTAL CONDITIONS: Unless otherwise specified herein, the measurement procedures applicable to a determination of performance of airspeed instruments under environmental conditions are set forth in Radio Technical Commission for Aeronautics (RTCA) Document No. DO-160 entitled "Environmental Conditions and Test Procedures for Airborne Electronic/Electrical Equipment and Instruments," dated 28 February 1975. Performance tests which must be made after subjection to test environments may be made after exposure to several environmental conditions. The order of tests must be in accordance with paragraph 3.2 of DO-160. The test procedures specified or referenced are satisfactory for use in determining the performance of airspeed instruments under normal and extreme environmental conditions; equipment category is to be as specified by the manufacturer. Alternate approved test procedures that provide equivalent results may be used.

5.1 Magnetic Effect: When subjected to the test of DO-160, paragraph 15.0, the instrument must meet the requirements of Class A or Z.

5.2 Temperature:

(a) Low Temperature: When subjected to the tests of DO-160, paragraph 4.4, the instrument must operate electrically and mechanically, and the requirements of paragraph 4.1 of this standard must be met, except that the tolerance for all points shall be increased by 3 knots (3.5 mph - 6 km/h). After subjection to this test, the requirements of paragraphs 4.1 and 4.2 of this standard shall be met.

(b) High Temperature: When subjected to the tests of DO-160, paragraph 4.5, the instrument must operate electrically and mechanically, and the requirements of paragraph 4.1 of this standard must be met except that the tolerance for all points shall be increased by 3 knots (3.5 mph - 6 km/h). After subjection to this test, the requirements of paragraphs 4.1 and 4.2 of this standard shall be met.

(c) Temperature Variation: When subjected to the tests of DO-160, paragraph 5.0, Category C, the instrument must operate electrically and mechanically and the requirements of paragraph 4.1 of this standard must be met. The scale error tolerance at the intermediate temperature test points shall be calculated as a linear percentage of the 3 knots (3.5 mph or 6 km/h) additional temperature tolerance allowed at the low and high operating temperatures. Standard test temperature is as given in Appendix A.

After subjection to this test the requirements of paragraphs 4.1 and 4.2 of this standard must be met.

5.3 Altitude: When subjected to the tests of DO-160, paragraph 4.6, the instrument must operate electrically and mechanically, and the requirements of paragraphs 4.1 and 4.2 of this standard must be met.

5.4 Humidity: Immediately following subjection to the tests of DO-160, paragraph 6.3.1, standard humidity environment, the requirements of paragraphs 4.1 and 4.2 of this standard must be met.

5.5 Vibration: When subjected to the tests of DO-160, paragraph 8.0, the instrument must operate electrically and mechanically, and the requirements of paragraph 4.1 of this standard must be met. Vibration test requirements by aircraft type and equipment location shall be specified by the manufacturer.

5.6 Shock: After subjection to the tests of DO-160, paragraph 7.0, the instrument must operate electrically and mechanically, and the requirements of paragraphs 4.1 and 4.2 of this standard must be met.

5.7 Power Input (Type B and C):

5.7.1 Normal Electrical Input Variation Test: When subjected to the tests of DO-160, paragraphs 16.3.1.1 or 16.3.2.1, the instrument must operate electrically and mechanically and meet the requirements of paragraph 4.1 of this standard.

5.7.2 Abnormal Electrical Input Variation Test: When subjected to the tests of DO-160, paragraph 16.3.3.1 or 16.3.4.1, the instrument must operate electrically and mechanically and degradation of performance is permissible. After returning to normal electrical input, the instrument must meet the requirements of paragraph 4.1 of this standard.

5.8 Voltage Spike Conducted Test (Type B and C): The instrument shall be subjected to the tests of DO-160, paragraph 17.0. After completion of the test, the instrument must operate electrically and mechanically and shall meet the requirements of paragraph 4.1 of this standard.

5.9 Audio Frequency Conducted Susceptibility Test (Type B and C): The instrument shall be subjected to the tests of DO-160, paragraph 18.0. During the test, the instrument must operate electrically and mechanically and shall meet the requirements of paragraph 4.1 of this standard.

5.10 Induced Signal Susceptibility Test (Type B and C): The instrument shall be subjected to the tests of DO-160, paragraph 19.0. During the tests, the instrument must operate electrically and mechanically, and must meet the requirements of paragraph 4.1 of this standard.

5.11 Radio Frequency Susceptibility Test, and Radiated and Conducted (Types B and C): The instrument shall be subjected to the tests of DO-160, paragraph 20.0. During the tests, the instrument must operate electrically and mechanically and must meet the requirements of paragraph 4.1 of this standard.

5.12 Emission of Radio Frequency Energy Test (Type B and C): The instrument shall be subjected to the tests of DO-160, paragraph 21.0. During the test, the instrument shall operate electrically and mechanically. After completion of the tests, the instrument shall meet the requirements of paragraph 4.1 of this standard.

5.13 Explosion: Instruments which are to be marked Explosion Category E must be tested in accordance with DO-160, paragraph 9.0.

5.14 Waterproofness: Instruments which are to be marked Waterproofness Category W must be tested in accordance with DO-160, paragraph 10.0. Following this test, the instrument must meet the requirements of paragraphs 4.1 and 4.2 of this standard.

5.15 Hydraulic Fluid: Instruments which are to be marked Hydraulic Fluid Category H must be tested in accordance with DO-160, paragraph 11.0. Following this test, the instrument must meet the requirements of paragraphs 4.1 and 4.2 of this standard.

5.16 Sand and Dust: Instruments which are to be marked Sand and Dust Category D must be tested in accordance with DO-160, paragraph 12.0. Following this test, the instrument must meet the requirements of paragraphs 4.1 and 4.2 of this standard.

5.17 Fungus Resistance: Instruments which are to be marked Fungus Resistance Category F must be tested in accordance with DO-160, paragraph 13.0. Following this test, the instrument must meet the requirement of paragraphs 4.1 and 4.2 of this standard.

5.18 Salt Spray: Instruments which are to be marked Salt Spray Category S must be tested in accordance with DO-160, paragraph 14.0. Following this test, the instrument must meet the requirements of paragraphs 4.1 and 4.2 of this standard.

PREPARED BY

SAE COMMITTEE A-4
AIRCRAFT INSTRUMENTS

APPENDIX A

I. STANDARD TEST CONDITIONS:

The following conditions of test are applicable to the instrument tests specified herein:

Atmospheric Conditions: Unless otherwise specified, all tests required by this standard must be conducted at an atmospheric pressure of approximately 29.921 in Hg (101.325 kPa), an ambient temperature of approximately +20°C and a relative humidity of not greater than 85 percent. When tests are conducted with the atmospheric pressure or temperature substantially different from these values, allowance shall be made for the variation from the specified conditons.

Vibration to Minimize Friction: Unless otherwise specified, all tests for performance may be conducted with the instrument subjected to a maximum vibration of 0.001 inches (0.025 mm) double amplitude at a frequency of 10 to 60 Hz. The term double amplitude as used herein indicates the total displacement from positive maximum to negative maximum.

Power Conditions: Unless otherwise specified, all tests must be conducted at the power rating recommended by the manufacturer, measured at the input terminal to the instrument.

Mounting Position: Unless otherwise specified, all tests must be made with the instrument mounted in its normal operating position.

Supersedes but does not void AS 391C

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3. GENERAL REQUIREMENTS:

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3.2 Display:

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

a. The first graduation shall be at the lowest usable airspeed of the instrument, as specified by the manufacturer.

b. From the 10 knot, 10 mph, or 20 km/h graduation nearest to the first graduation and continuing to 250 knots, 250 mph, or 400 km/h major graduations shall be at least every 10 knots, 10 mph, or 20 km/h, with minor graduations at least every 5 knots, 5 mph, or 10 km/h.

c. Over 250 knots, 250 mph, or 400 km/h, graduations shall be at least every 50 knots, 50 mph, or 100 km/h.

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3.2.2 Numerals: The display shall include sufficient numerals positioned to permit quick and positive identification of each graduation.

3.2.3 Instrument Identification: The instrument face shall be marked with "Airspeed" or "IAS" and also with the units of measure applicable to the instrument.

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3.2.5 Visibility: The indicating means must be visible from all points within a space defined by a surface generated by lines making an angle of at least 30 degrees with the perpendicular to the display surface and diverging from the perimeter of the instrument window aperture. If integral lighting is provided, it must make all markings within the instrument easily readable, and not allow objectionable stray light to come from the instrument.

3.2.6 Range: The range of operation of the instrument shall be marked on the nameplate.

3.3 Fire Resistance: Except for small parts (such as knobs, fasteners, seals, grommets, and small electrical parts) that would not contribute significantly to the propagation of a fire, all materials used must be self-extinguishing when tested in accordance with the requirements of Federal Aviation Regulation 25.139(d) and Appendix F thereto, with the exception that materials tested may be configured in accordance with paragraph (b) of Appendix F or may be configured as used.

3.4 Self-Test Capability: If the equipment contains integral arrangements to permit pre-flight and/or in-flight self-test checks on the operation of the equipment in combination with other aircraft subsystems, a means shall be provided to deactivate any subsystem which might be adversely affected during the self-test cycle. In flight, self-test activating controls must provide a means to warn the pilot of this mode of operation. Self-test provisions shall automatically return to the normal operation mode following self testing.

3.5 Compatibility of Components: If instrument system components are individually acceptable but require matching for proper operation, they shall be identified on the equipment nameplate in a manner that will ensure proper matching.

3.6 Reflectance, Cover Glass: The total reflectance of the instrument cover glass including the integral lighting wedge, if applicable, shall not exceed 10 percent of the incident light. This reflectance applies over the visible light spectrum from 450 milli-microns to 600 milli-microns, and over an incident solid angle of 60° perpendicular to the viewing plane.

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4.1 Scale Error: The airspeed instruments shall be tested for scale error at the proper pressure to produce all the differential pressure test points shown on Table I, Table II, or Table III (knots, mph, or km/h), within the instrument range, first with pressure differential increasing, and then with pressure differential decreasing. With the differential pressure increasing it shall be brought up to, but shall not exceed, the specified differential pressure; with the differential pressure decreasing, it shall be brought down to, but shall not go below, the specified differential pressure. The errors at the test points shall not exceed the tolerances specified in Table I, Table II, or Table III as applicable.

4.2 Friction: Type A. The instrument shall be tested for friction at four approximately equal scale intervals appropriate to the total range. The differential pressure shall be brought up to the desired test point and be held constant while two instrument readings are taken: the first reading shall be taken before the instrument is vibrated, and the second reading after the instrument is vibrated. The difference between any pair of readings shall not exceed the tolerance shown in Table IV. The vibration applied shall be sufficient to remove all the friction from the instrument, and may be more than that given in Appendix A.

Types B & C. The instrument operation and indication shall be smooth and free from irregular motion as the differential pressure or its electrical equivalent is increased and decreased smoothly. Irregular motion shall be defined to be compatible with the type of display used.

4.3 Balance Error: A pressure equivalent to one quarter, one half, and three quarters of full scale deflection shall be applied to the instrument successively as test points. The difference in readings at each test point between that with the instrument in its normal operating position and that with the instrument in any other position, while being vibrated, shall not exceed the tolerance of Table IV.

TABLE I

SCALE ERROR

KNOTS

Indicated Airspeed	Differential Pressure		Tolerance ±
knots	in Hg	kPa	knots
20	.0192	.065	5
30	.0431	.15	5
40	.0767	.26	5
50	.120	.41	5
60	.173	.59	5
70	.235	.76	4
80	.308	1.04	4
90	.390	1.32	4
100	.481	1.63	3
120	.695	2.35	3
140	.949	3.21	3
160	1.24	4.20	3
180	1.58	5.35	5
200	1.96	6.64	5
220	2.38	8.06	5
250	3.10	10.50	5
300	4.53	15.34	5
350	6.29	21.30	5
400	8.39	28.41	8
450	10.87	36.81	8
500	13.78	46.66	8
550	17.16	58.11	8
600	21.08	71.39	10
650	25.63	86.80	10
700	30.76	104.17	10

For differential pressure equivalent to the test points, but given in pounds per square inch (psi) or inches of water (in H_2O) see NASA Technical Note D822.

TABLE II

SCALE ERROR TOLERANCE

MILES PER HOUR (mph)

Indicated Airspeed	Differential Pressure		Tolerance ±
mph	in Hg	kPa	mph
20	.0145	.05	5
30	.0325	.11	5
40	.0579	.20	5
50	.0905	.31	5
60	.130	.44	5
70	.178	.60	4
80	.232	.79	4
90	.294	1.00	4
100	.363	1.23	3
120	.524	1.77	3
140	.715	2.42	3
160	.936	3.17	3
180	1.19	4.03	3
200	1.47	4.98	6
220	1.79	6.06	6
250	2.32	7.86	6
300	3.38	11.45	6
350	4.67	15.81	6
400	6.20	21.00	6
450	7.98	27.02	9
500	10.05	34.03	9
550	12.44	42.13	9
600	15.16	51.34	9
650	18.26	61.84	9
700	21.78	73.76	12

For differential pressure equivalent to the test points, but given in pounds per square inch (psi) or inches of water (in H_2O) see NASA Technical Note D822.

TABLE III

KILOMETRES PER HOUR (Km/Hr.)

Indicated Airspeed Km/Hr.	Differential Pressure		Tolerance ± Km/Hr.
	Inches of Hg.	kPa	
40	.022	.074	8
60	.047	.159	8
80	.089	.301	8
100	.140	.474	8
120	.202	.684	6
140	.277	.938	6
160	.356	1.205	5
180	.453	1.534	5
200	.562	1.903	5
250	.881	2.983	5
300	1.275	4.317	5
350	1.745	5.909	10
400	2.293	7.765	10
450	2.923	9.898	10
500	3.637	12.316	10
600	5.333	18.059	10
700	7.416	25.113	15
800	9.927	33.616	15
900	12.915	43.735	15
1000	16.441	55.675	15
1100	20.574	69.671	20
1200	25.396	86.001	20
1300	30.984	104.924	20

TABLE IV

FRICTION AND POSITION ERROR TOLERANCE

AIR SPEED			TOLERANCE ±		
knots	mph	km/h	knots	mph	km/h
40-180			3		
190-700			5		
	40-200			4	
	210-800			6	
		64-320			6
		336-1280			10

4.4 Leak: With both the pitot pressure and static pressure connections simultaneously evacuated to 15 in. Hg (50.7 kPa) and properly sealed off, the leakage shall not cause more than 0.05 in Hg (0.17 kPa) 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 and properly sealed off, the leakage shall not cause more than 1 mph (1.6 km/h) or 1 knot decrease in indication during a one-minute period. This test shall be made with test apparatus having a total volume of 100 ±10 in^3 (1.6L ±.16L), including the instrument and the test equipment. For types A and B only.

4.5 Insulation Resistance: The insulation resistance between all electrical circuits connected together and the metallic case, measured at 200 VDC for five seconds, 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 insure adequacy of insulation.

5. MINIMUM PERFORMANCE STANDARDS UNDER ENVIRONMENTAL CONDITIONS: Unless otherwise specified herein, the measurement procedures applicable to a determination of performance of airspeed instruments under environmental conditions are set forth in Radio Technical Commission for Aeronautics (RTCA) Document No. DO-160 entitled "Environmental Conditions and Test Procedures for Airborne Electronic/Electrical Equipment and Instruments," dated 28 February 1975. Performance tests which must be made after subjection to test environments may be made after exposure to several environmental conditions. The order of tests must be in accordance with paragraph 3.2 of DO-160. The test procedures specified or referenced are satisfactory for use in determining the performance of airspeed instruments under normal and extreme environmental conditions; equipment category is to be as specified by the manufacturer. Alternate approved test procedures that provide equivalent results may be used.

5.1 Magnetic Effect: When subjected to the test of DO-160, paragraph 15.0, the instrument must meet the requirements of Class A or Z.

5.2 Temperature:

(a) Low Temperature: When subjected to the tests of DO-160, paragraph 4.4, the instrument must operate electrically and mechanically, and the requirements of paragraph 4.1 of this standard must be met, except that the tolerance for all points shall be increased by 3 knots (3.5 mph - 6 km/h). After subjection to this test, the requirements of paragraphs 4.1 and 4.2 of this standard shall be met.

(b) High Temperature: When subjected to the tests of DO-160, paragraph 4.5, the instrument must operate electrically and mechanically, and the requirements of paragraph 4.1 of this standard must be met except that the tolerance for all points shall be increased by 3 knots (3.5 mph - 6 km/h). After subjection to this test, the requirements of paragraphs 4.1 and 4.2 of this standard shall be met.

(c) Temperature Variation: When subjected to the tests of DO-160, paragraph 5.0, Category C, the instrument must operate electrically and mechanically and the requirements of paragraph 4.1 of this standard must be met. The scale error tolerance at the intermediate temperature test points shall be calculated as a linear percentage of the 3 knots (3.5 mph or 6 km/h) additional temperature tolerance allowed at the low and high operating temperatures. Standard test temperature is as given in Appendix A.

After subjection to this test the requirements of paragraphs 4.1 and 4.2 of this standard must be met.

5.3 Altitude: When subjected to the tests of DO-160, paragraph 4.6, the instrument must operate electrically and mechanically, and the requirements of paragraphs 4.1 and 4.2 of this standard must be met.

5.4 Humidity: Immediately following subjection to the tests of DO-160, paragraph 6.3.1, standard humidity environment, the requirements of paragraphs 4.1 and 4.2 of this standard must be met.

5.5 Vibration: When subjected to the tests of DO-160, paragraph 8.0, the instrument must operate electrically and mechanically, and the requirements of paragraph 4.1 of this standard must be met. Vibration test requirements by aircraft type and equipment location shall be specified by the manufacturer.

5.6 Shock: After subjection to the tests of DO-160, paragraph 7.0, the instrument must operate electrically and mechanically, and the requirements of paragraphs 4.1 and 4.2 of this standard must be met.

5.7 Power Input (Type B and C):

5.7.1 Normal Electrical Input Variation Test: When subjected to the tests of DO-160, paragraphs 16.3.1.1 or 16.3.2.1, the instrument must operate electrically and mechanically and meet the requirements of paragraph 4.1 of this standard.

5.7.2 Abnormal Electrical Input Variation Test: When subjected to the tests of DO-160, paragraph 16.3.3.1 or 16.3.4.1, the instrument must operate electrically and mechanically and degradation of performance is permissible. After returning to normal electrical input, the instrument must meet the requirements of paragraph 4.1 of this standard.

5.8 Voltage Spike Conducted Test (Type B and C): The instrument shall be subjected to the tests of DO-160, paragraph 17.0. After completion of the test, the instrument must operate electrically and mechanically and shall meet the requirements of paragraph 4.1 of this standard.

5.9 Audio Frequency Conducted Susceptibility Test (Type B and C): The instrument shall be subjected to the tests of DO-160, paragraph 18.0. During the test, the instrument must operate electrically and mechanically and shall meet the requirements of paragraph 4.1 of this standard.

5.10 Induced Signal Susceptibility Test (Type B and C): The instrument shall be subjected to the tests of DO-160, paragraph 19.0. During the tests, the instrument must operate electrically and mechanically, and must meet the requirements of paragraph 4.1 of this standard.

5.11 Radio Frequency Susceptibility Test, and Radiated and Conducted (Types B and C): The instrument shall be subjected to the tests of DO-160, paragraph 20.0. During the tests, the instrument must operate electrically and mechanically and must meet the requirements of paragraph 4.1 of this standard.

5.12 Emission of Radio Frequency Energy Test (Type B and C): The instrument shall be subjected to the tests of DO-160, paragraph 21.0. During the test, the instrument shall operate electrically and mechanically. After completion of the tests, the instrument shall meet the requirements of paragraph 4.1 of this standard.

5.13 Explosion: Instruments which are to be marked Explosion Category E must be tested in accordance with DO-160, paragraph 9.0.

5.14 Waterproofness: Instruments which are to be marked Waterproofness Category W must be tested in accordance with DO-160, paragraph 10.0. Following this test, the instrument must meet the requirements of paragraphs 4.1 and 4.2 of this standard.

5.15 Hydraulic Fluid: Instruments which are to be marked Hydraulic Fluid Category H must be tested in accordance with DO-160, paragraph 11.0. Following this test, the instrument must meet the requirements of paragraphs 4.1 and 4.2 of this standard.

5.16 Sand and Dust: Instruments which are to be marked Sand and Dust Category D must be tested in accordance with DO-160, paragraph 12.0. Following this test, the instrument must meet the requirements of paragraphs 4.1 and 4.2 of this standard.

5.17 Fungus Resistance: Instruments which are to be marked Fungus Resistance Category F must be tested in accordance with DO-160, paragraph 13.0. Following this test, the instrument must meet the requirement of paragraphs 4.1 and 4.2 of this standard.

5.18 Salt Spray: Instruments which are to be marked Salt Spray Category S must be tested in accordance with DO-160, paragraph 14.0. Following this test, the instrument must meet the requirements of paragraphs 4.1 and 4.2 of this standard.

PREPARED BY

SAE COMMITTEE A-4
AIRCRAFT INSTRUMENTS

APPENDIX A

I. STANDARD TEST CONDITIONS:

The following conditions of test are applicable to the instrument tests specified herein:

Atmospheric Conditions: Unless otherwise specified, all tests required by this standard must be conducted at an atmospheric pressure of approximately 29.921 in Hg (101.325 kPa), an ambient temperature of approximately +20°C and a relative humidity of not greater than 85 percent. When tests are conducted with the atmospheric pressure or temperature substantially different from these values, allowance shall be made for the variation from the specified conditons.

Vibration to Minimize Friction: Unless otherwise specified, all tests for performance may be conducted with the instrument subjected to a maximum vibration of 0.001 inches (0.025 mm) double amplitude at a frequency of 10 to 60 Hz. The term double amplitude as used herein indicates the total displacement from positive maximum to negative maximum.

Power Conditions: Unless otherwise specified, all tests must be conducted at the power rating recommended by the manufacturer, measured at the input terminal to the instrument.

Mounting Position: Unless otherwise specified, all tests must be made with the instrument mounted in its normal operating position.

Supersedes but does not void AS 391C

Society of Automotive Engineers, Inc.
400 COMMONWEALTH DRIVE, WARRENDALE, PA. 15096

AEROSPACE STANDARD

AS 8019

Issued 3-30-81
Revised

AIRSPEED INSTRUMENTS

1. PURPOSE: This standard establishes minimum performance standards for total and static pressure actuated airspeed instruments.

2. SCOPE:

2.1 Types: This standard covers Airspeed Instruments which display airspeed of an aircraft, as follows:

Type A - Air Driven, direct reading, self contained
Type B - Electrically operated, self contained
Tyep C - Electrically operated, input from a remote sensor

2.2 Applicable Documents: The following documents shall form a part of this specification to the extent specified herein:

a. Radio Technical Commission for Aeronautics (RTCA) Document DO-160 "Environmental Conditions and Test Procedures for Airborne Electronic/ Electrical Equipment and Instruments," dated 28 February 1975. (Copies may be obtained from the RTCA Secretariat, 1717 H Street N.W., Washington, D.C. 20006).

b. NASA Technical Note D-822, Tables of Airspeed, Altitude, and Mach Number Based on International Values for Atmospheric Properties and Physical Constants, by Livingston and Gracey August 1961.

3. GENERAL REQUIREMENTS:

3.1 Indicating Means: The airspeed shall be indicated by means of a pointer, dial, tape, drum, or other type of moving element, or by a digital display. Unless otherwise specified, relative motion of the index with respect to the scale (either the index or the scale may be the moving element) must be clockwise, up, or to the right for increasing airspeed.

3.2 Display:

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

a. The first graduation shall be at the lowest usable airspeed of the instrument, as specified by the manufacturer.

b. From the 10 knot, 10 mph, or 20 km/h graduation nearest to the first graduation and continuing to 250 knots, 250 mph, or 400 km/h major graduations shall be at least every 10 knots, 10 mph, or 20 km/h, with minor graduations at least every 5 knots, 5 mph, or 10 km/h.

c. Over 250 knots, 250 mph, or 400 km/h, graduations shall be at least every 50 knots, 50 mph, or 100 km/h.

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3.2.2 Numerals: The display shall include sufficient numerals positioned to permit quick and positive identification of each graduation.

3.2.3 Instrument Identification: The instrument face shall be marked with "Airspeed" or "IAS" and also with the units of measure applicable to the instrument.

3.2.4 Limits: The indicating means shall be limited in such a way that the moving element will not move more than (a) 10 degrees for circular display or (b) 0.25 in (6 mm) for linear displays beyond the greatest or least graduation in both increasing and decreasing directions.

For circular displays, positive means must be taken so that no ambiguity will exist when the indicator is at the maximum or minimum position, including the maximum overtravel of 10°. If a digital display is used a positive indication shall be provided on the display when the airspeed exceeds the instrument's calibrated range.

3.2.5 Visibility: The indicating means must be visible from all points within a space defined by a surface generated by lines making an angle of at least 30 degrees with the perpendicular to the display surface and diverging from the perimeter of the instrument window aperture. If integral lighting is provided, it must make all markings within the instrument easily readable, and not allow objectionable stray light to come from the instrument.

3.2.6 Range: The range of operation of the instrument shall be marked on the nameplate.

3.3 Fire Resistance: Except for small parts (such as knobs, fasteners, seals, grommets, and small electrical parts) that would not contribute significantly to the propagation of a fire, all materials used must be self-extinguishing when tested in accordance with the requirements of Federal Aviation Regulation 25.139(d) and Appendix F thereto, with the exception that materials tested may be configured in accordance with paragraph (b) of Appendix F or may be configured as used.

3.4 Self-Test Capability: If the equipment contains integral arrangements to permit pre-flight and/or in-flight self-test checks on the operation of the equipment in combination with other aircraft subsystems, a means shall be provided to deactivate any subsystem which might be adversely affected during the self-test cycle. In flight, self-test activating controls must provide a means to warn the pilot of this mode of operation. Self-test provisions shall automatically return to the normal operation mode following self testing.

3.5 Compatibility of Components: If instrument system components are individually acceptable but require matching for proper operation, they shall be identified on the equipment nameplate in a manner that will ensure proper matching.

3.6 Reflectance, Cover Glass: The total reflectance of the instrument cover glass including the integral lighting wedge, if applicable, shall not exceed 10 percent of the incident light. This reflectance applies over the visible light spectrum from 450 milli-microns to 600 milli-microns, and over an incident solid angle of 60° perpendicular to the viewing plane.

3.7 Accessibility of Controls: Controls not normally adjusted in flight must not be readily accessible to flight personnel.

3.8 Case Markings (Types A & B): The back of the case, adjacent to the connections shall be permanently marked as follows:

P - for pitot pressure connection.
S - for static pressure connection

3.9 Interchangeability: Instruments which are identified with the same manufacturer's part number shall be interchangeable. When an instrument is characterized for a particular type aircraft it shall be so marked on the instrument nameplate.

3.10 Effects of Tests: Unless otherwise stated, the application of the specified tests shall not produce a condition which would be detrimental to the continued performance of the instrument.

3.11 Mounting Attitude: Should the capability of an instrument to meet its stated performance be limited to a specific relationship of its axes to the axes of the aircraft, this limitation must be stated.

3.12 Accuracy: Accuracy requirements for this standard are related to the instrument output for a specified sensor input. For Type A & B instruments, the accuracy relates output to pressure input to the instruments, since they are self contained. For Type C instruments, the accuracy relates output to the input at the remote sensor; if matching of the instrument to the remote sensor is necessary to maintain the required overall accuracy, this must be so stated on the instrument nameplate.

3.13 Power Malfunction Indication: For Type B & C instruments, means must be incorporated in the instrument to indicate the loss of adequate electrical power or loss of signal to the instrument. The indicating means must indicate a failure or malfunction in a positive manner.

4. MINIMUM PERFORMANCE REQUIREMENTS UNDER STANDARD TEST CONDITIONS: The test conditions applicable to a determination of the performance of airspeed instruments are set forth in Appendix A of this Standard. All instruments shall be tested in accordance with the manufacturer's recommendations. The manufacturer shall conduct sufficient tests to prove compliance with these Minimum Performance Standards.

4.1 Scale Error: The airspeed instruments shall be tested for scale error at the proper pressure to produce all the differential pressure test points shown on Table I, Table II, or Table III (knots, mph, or km/h), within the instrument range, first with pressure differential increasing, and then with pressure differential decreasing. With the differential pressure increasing it shall be brought up to, but shall not exceed, the specified differential pressure; with the differential pressure decreasing, it shall be brought down to, but shall not go below, the specified differential pressure. The errors at the test points shall not exceed the tolerances specified in Table I, Table II, or Table III as applicable.

4.2 Friction: Type A. The instrument shall be tested for friction at four approximately equal scale intervals appropriate to the total range. The differential pressure shall be brought up to the desired test point and be held constant while two instrument readings are taken: the first reading shall be taken before the instrument is vibrated, and the second reading after the instrument is vibrated. The difference between any pair of readings shall not exceed the tolerance shown in Table IV. The vibration applied shall be sufficient to remove all the friction from the instrument, and may be more than that given in Appendix A.

Types B & C. The instrument operation and indication shall be smooth and free from irregular motion as the differential pressure or its electrical equivalent is increased and decreased smoothly. Irregular motion shall be defined to be compatible with the type of display used.

4.3 Balance Error: A pressure equivalent to one quarter, one half, and three quarters of full scale deflection shall be applied to the instrument successively as test points. The difference in readings at each test point between that with the instrument in its normal operating position and that with the instrument in any other position, while being vibrated, shall not exceed the tolerance of Table IV.

TABLE I

SCALE ERROR

KNOTS

Indicated Airspeed	Differential Pressure		Tolerance ±
knots	in Hg	kPa	knots
20	.0192	.065	5
30	.0431	.15	5
40	.0767	.26	5
50	.120	.41	5
60	.173	.59	5
70	.235	.76	4
80	.308	1.04	4
90	.390	1.32	4
100	.481	1.63	3
120	.695	2.35	3
140	.949	3.21	3
160	1.24	4.20	3
180	1.58	5.35	5
200	1.96	6.64	5
220	2.38	8.06	5
250	3.10	10.50	5
300	4.53	15.34	5
350	6.29	21.30	5
400	8.39	28.41	8
450	10.87	36.81	8
500	13.78	46.66	8
550	17.16	58.11	8
600	21.08	71.39	10
650	25.63	86.80	10
700	30.76	104.17	10

For differential pressure equivalent to the test points, but given in pounds per square inch (psi) or inches of water (in H_2O) see NASA Technical Note D822.