

**AEROSPACE
STANDARD**

SAE AS8009

**REV.
B**

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Revised 2005-09

Superseding AS8009A

(R) Pressure Altimeter Systems

RATIONALE

A general update of AS8009 was requested. areas that were investigated included making the testing requirement of as8009 compatible with those of appendix E(6)(1) of Far 43, providing cold weather correction, referencing both feet and meters and updating the environmental section to call out DO-160D.

TABLE OF CONTENTS

1.	SCOPE	4
2.	APPLICABLE DOCUMENTS	4
2.1	SAE Publications.....	4
2.2	Other Documents	5
3.	GENERAL STANDARDS.....	5
3.1	Compatibility.....	5
3.2	Accessibility of Controls	5
3.3	Interchangeability.....	6
3.4	Altitude Range.....	6
3.5	Barometric Setting System.....	6
3.6	Multiple Mode Indications.....	6
3.7	Visibility.....	6
3.8	Instrument Cover Glass Reflectance	6
3.9	Static Source Error Correction	7
3.10	Cold Temperature Corrections.....	7
3.11	Graduations.....	7
3.12	Display Markings.....	7
3.13	Maximum Altitude.....	7

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SAE AS8009 Revision B

3.14	Nameplate.....	8
3.15	Fire Resistance	8
4.	MINIMUM PERFORMANCE UNDER STANDARD CONDITIONS	8
4.1	Case Pressure	8
4.2	Leakage	8
4.3	Scale and Hysteresis Error	9
4.3.1	Static Source Correction	9
4.4	Balance Error	9
4.5	Barometric Setting Scale.....	10
4.6	Friction	10
4.7	Hysteresis	11
4.8	Minimum Operating Rate	11
4.9	Threshold	12
4.10	Monitoring Functions.....	12
4.11	Vibrator.....	12
5.	MINIMUM PERFORMANCE STANDARDS UNDER ENVIRONMENTAL CONDITIONS..	13
5.1	Environmental Conditions	13
5.2	High and Low Temperature.....	13
5.3	Drift and After Effect.....	13
5.4	Fogging (Hermetically Sealed Instruments Only).....	13
5.5	Thermal Shock (Hermetically Sealed Instruments Only)	14
5.6	Electrical Insulation	14
5.7	Other Conditions	14
6.	TEST PROCEDURES.....	15
6.1	Case Pressure	15
6.2	Leakage	15
6.2.1	Static Pressure.....	15
6.2.2	Total Pressure (If Applicable).....	15
6.2.3	Hermetically Sealed Components (If Applicable).....	15
6.3	Scale Error, Including Hysteresis	16
6.3.1	Scale Error at Room Temperature Operation (25 °C) (For Altimeters Without Automatic Static Pressure Error Correction Mechanism).....	16
6.3.2	Scale Error at Room Temperature Operation (25 °C) (For Altimeters With Automatic Static Pressure Error Correction Mechanism).....	16
6.4	Balance Error	17
6.5	Barometric Setting Scale.....	18
6.6	Stop-and-Jump.....	18
6.6.1	Counterpointer Display.....	18
6.6.2	Other Displays.....	18

SAE AS8009 Revision B

6.7	Static Friction	19
6.7.1	Instrument Without Integral Vibrator	19
6.7.2	Instrument With Integral Vibrator	19
6.8	Minimum Operating (Slew) Rate	19
6.9	Threshold	19
6.10	Drift and After Effect	20
6.11	Low Temperature Operation	20
6.12	High Temperature Operation	20
6.13	Extreme Temperature Exposure	20
6.14	Vibration	21
6.15	Humidity	21
6.16	Fogging (Hermetically Sealed Instruments Only).....	21
6.17	Thermal Shock (Hermetically Sealed Instruments Only)	21
7.	TEST CONDITIONS	22
7.1	Atmospheric Conditions	22
7.2	Power Conditions	22
7.3	Attitude	22
7.4	Standard Pressures	22
7.5	Barometric Setting Scale.....	23
8.	INDIVIDUAL TESTS	23
9.	QUALIFICATION TESTS	24
10.	NOTES.....	25

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SAE AS8009 Revision B

1. SCOPE:

This SAE Aerospace Standard (AS) specifies minimum performance requirements for primary pressure altimeter systems other than air data computers.

This document covers altimeter systems that measure and display altitude as a function of atmospheric pressure. The pressure transducer may be contained within the instrument display case or located remotely. Requirements for air data computers are specified in AS8002. Some requirements for nontransducing servoed altitude indicators are included in AS791.

The instrument system specified herein does not include aircraft pressure lines. Unless otherwise specified, whenever the term "instrument" is used, it is to be understood to be the complete system of pressure transducer components, any auxiliary equipment, and display components.

The test procedures specified herein apply specifically to analog type instruments. Digital instruments or automatic test instrumentation may require other test procedures. Such differing procedures shall be justified prior to use.

2. APPLICABLE DOCUMENTS:

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

2.1 SAE Publications:

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001,
Web address: <http://www.sae.org>.

AS791	Remote Servoed Air Data Instruments for Subsonic Aircraft
AIR1075	Recommendation on Barometry for Altimeter Calibration
AS8002	Air Data Computer - Minimum Performance Standard

SAE AS8009 Revision B

2.2 Other Documents:

- 2.2.1 Available from: Superintendent of Documents, Government Printing Office, Washington, DC 20402, Web address: www.gpoaccess.gov.

U.S. Standard Atmosphere, 1976 (Altitude Reference)

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

- 2.2.2 Available from: Radio Technical Commission for Aeronautics, 1140 Connecticut Avenue, Suite 1020, Washington, DC 20036, Web address: www.rtca.org.

Environmental Conditions and Test Procedures for Airborne Equipment, RTCA Document DO-160D, July 1997

- 2.2.3 Available from: Department of Transportation, Federal Aviation Administration, Washington, DC 20591, Web address: www.faa.gov.

Federal Aviation Regulations, Part 25 Airworthiness Standards; Transport Category Airplanes

- 2.2.4 Available from: International Civil Aviation Organization, P.O. Box 400, Place de l'Aviation, 1000 Sherbrooke Street West, Montreal, Quebec, Canada, H3A 2R2, Web address: www.icao.int.

Manual of the ICAO Standard Atmosphere - ICAO Document 7488, 1993.

3. GENERAL STANDARDS:

3.1 Compatibility:

If components are individually acceptable but require matching for proper operation, they shall be identified in a manner that will insure performance to the requirements of this document.

3.2 Accessibility of Controls:

Controls that are not normally adjustable in flight shall not be readily accessible to flight personnel when the instrument is installed in accordance with the manufacturer's instructions.

SAE AS8009 Revision B

3.3 Interchangeability:

Instruments that are identified with the same manufacturer's part or model number shall be completely interchangeable.

3.4 Altitude Range:

The minimum calibrated altitude (at a 29.92 in Hg/1013.2 mb barometric setting) shall be -1000 ft (-300 m). The maximum shall be as specified by the manufacturer and marked on the nameplate and dial.

3.5 Barometric Setting System:

The barometric setting system shall permit the altimeter to be set to any ambient barometric pressure throughout a minimum range of 27.50 to 31.50 in Hg (931.3 to 1066.7 mb). A safety feature shall be provided that will prevent either incorrect indication or damage to the mechanism should attempts be made to operate the barometric setting adjustment beyond the design range specified for the instrument. The barometric setting number shall increase with a clockwise motion of the knob.

3.6 Multiple Mode Indications:

An instrument intended for operation in more than one mode shall meet the requirements of this document in each mode. The "normal" mode shall be as specified by the manufacturer. Means shall be provided to indicate when in other than the "normal" mode. If the instrument is provided with an automatic static source correction function, positive indication shall be given when it is not in use.

3.7 Visibility:

Pointers and dial markings shall be visible from any point within the frustrum of a cone; the side of which makes an angle of 45° with the perpendicular to the dial and the small diameter of which is the aperture of the instrument case. The distance between the dial and the cover glass shall be a practical minimum.

3.8 Instrument Cover Glass Reflectance:

The total reflectance of the instrument cover glass including the integral lighting wedge, if applicable, shall not exceed 3% of the incident light. This reflectance applies over the visible light spectrum from 450 to 600 nm (4500 to 6000 Å) and over an incident solid angle of 30° perpendicular to the viewing plane.

SAE AS8009 Revision B

3.9 Static Source Error Correction:

When an instrument employs a correction mechanism that is unique to a particular aircraft, the aircraft type and model number for which the altimeter has been manufactured and performs its intended function shall be clearly and permanently marked on the instrument.

3.10 Cold Temperature Corrections:

When an instrument employs automatic cold temperature corrections, it shall use corrections given in Table 9. The instrument shall provide a clear indication to the pilot the cold temperature corrections are being automatically applied. If the instrument that normally provides automatic cold temperature correction cannot compute the correction, positive indication shall be given that corrections are not being performed.

3.11 Graduations:

Dial markings shall be provided at intervals not exceeding 20 ft of altitude with major increment markings at 100 ft intervals. Metric Scales shall not exceed 20 m with major increment markings at 100 m intervals. Digital displays not supplemented by an analog display shall provide 10 ft (2 m) increments and shall have a non-ambiguous means of displaying altitudes below 0 ft (0 m).

3.12 Display Markings:

Altitude shall be indicated in feet or meters as required, by means of one or more pointers, dials, tapes, drums, digital readouts, or any combination thereof. Relative motion of the index with respect to the scale (either the index or the scale may be the moving element) shall be clockwise, up, or to the right for increasing altitude. In the case of counters, drums, or tapes, the higher number shall be above the lower. The word ALTITUDE or ALT shall be marked on the dial and may be in the same finish as the numerals. The altitude range shall be shown on the dial. The maker's name or trademark shall not appear unless in black-on-black.

3.13 Maximum Altitude:

Tests at altitudes beyond the range marked on the nameplate and dial are not required.

3.14 Nameplate:

The instrument shall carry a nameplate that shall be permanently marked with the following:

- a. Name of instrument
- b. Altitude range
- c. Barometric range
- d. Manufacturer
- e. Part number
- f. Serial number
- g. AS8009A or TSO __ (when issued)
- h. Type of aircraft (if limited)

3.15 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 25.1359 (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.

4. MINIMUM PERFORMANCE UNDER STANDARD CONDITIONS:

4.1 Case Pressure:

The instrument case shall withstand a positive external differential pressure of 26 in (660 mm) Hg (88 kPa).

4.2 Leakage:

The static pressure system shall not exceed the allowable leak in 1 min as specified in Table 1. The total pressure system (where applicable) shall exhibit no more than a 1 knot change during 1 min when subjected to full scale pressure.

SAE AS8009 Revision B

TABLE 1 - Leakage
Static Pressure

Altitude Range		Test Altitude		Leak Tolerance	
Feet	Meters	Feet	Meters	Feet/Min	Meters/Min
20,000	6,100	10,000	3,000	±50	±15
35,000	10,500	17,000	5,200	±50	±15
50,000	15,000	23,000	7,000	±50	±15

4.3 Scale and Hysteresis Error:

The instrument shall meet the tolerance specified in Table 2, which includes the following conditions: (1) Decreasing and increasing pressure for the test pressure ranges specified in Table 2, or (2) these pressures plus the static defect correction pressures (if specified) for the applicable aircraft as supplied by the airframe manufacturer.

- 4.3.1 Static Source Correction: Where a static source correction means is in operation, the scale error tolerance shall be that shown in Table 2, increased by an amount of 10% of the static source error plus 10 ft (3 m).

TABLE 2 - Scale and Hysteresis Errors
for Increasing and Decreasing Altitude
(AMBIENT ROOM TEMPERATURE)

Test Pressure Altitude		Tolerance	
Feet	Meters	Feet	Meters
-1,000	-300	±20	±9
0	0	±20	±9
2,000	300	±20	±9
2,000	600	±30	±9
3,000	900	±30	±9
4,000	1,200	±35	±9
5,000	1,500	±35	±9
10,000	3,000	±80	±15
20,000	6,000	±130	±20
30,000	9,000	±180	±35
40,000	12,000	±230	±45
50,000	15,000	±280	±55

4.4 Balance Error:

Balance errors due to orientation of the instrument from the normal operating positions shall not exceed those specified in Table 3.

SAE AS8009 Revision B

TABLE 3 - Different Instrument Orientations

Test Pressure Altitude		Tolerance	
Feet	Meters	Feet	Meters
2,500	750	±20	±6
25,500	7,500	±30	±9

4.5 Barometric Setting Scale:

The pressure-to-altitude coordination and backlash shall meet the requirements of 6.5 and Table 4.

TABLE 4 - Barometric Setting Mechanism

Barometric Pressure Scale		Correct Difference		Baro-Setting Tolerance	
in Hg	mb	Feet	Meters	Feet	Meters
22.0	745	-8,266	-2,520	±40	±12
23.27	788	-6,794	-2,071	±35	±11
23.92	810	-6,065	-1,830	±35	±11
24.98	846	-4,907	-1,496	±30	±9.0
25.98	880	-3,850	-1,173	±30	±9.0
26.99	914	-2,825	-861	±25	±7.5
27.55	933	-2,265	-691	±25	±7.5
28.20	955	-1,630	-497	±25	±7.5
28.58	968	-1,264	-385	±25	±7.5
28.94	980	-920	-280	±25	±7.5
29.91	1013	-10	-3	±25	±7.5
30.15	1021	211	64	±25	±7.5
30.77	1042	776	237	±25	±7.5
30.98	1049	965	294	±25	±7.5

4.6 Friction:

Friction errors shall not exceed those specified for stop-and-jump friction in Table 5 and static friction in Table 6.

SAE AS8009 Revision B

TABLE 5 - Stop and Jump Friction Error

Test Pressure Altitude		Ascent and Descent		Tolerance					
				Column A		Column B		Column C	
Feet	Meters	Feet/Min	Meters/Min	Feet	Meters	Feet	Meters	Feet	Meters
1,000	300	500	150	25	8	200	60	70	20
3,000	900	500	150	25	8	200	60	70	20
5,000	1,500	500	150	25	8	200	60	70	20
10,000	3,000	500	150	25	8	350	105	70	20
20,000	6,000	3,000	900	25	8	350	105	100	30
30,000	9,000	3,000	900	25	8	450	140	140	40
40,000	12,000	3,000	900	50	15	600	180	180	55
500,000	15,000	3,000	900	50	15	750	230	250	75

Column A - Vibrator "On" - all types
 Column B - Vibrator "Off" - counter - pointer type
 Column C - Vibrator "Off" - all other types, or non-vibrator types

TABLE 6 - Static Friction

Column A		Tolerance			
Test Pressure Altitude		Column B		Column C	
Feet	Meters	Feet	Meters	Feet	Meters
1,500	457	70	21	25	8
2,500	762	70	21	25	8
5,500	1,676	70	21	25	8
15,500	4,724	90	27	25	8
25,500	7,772	120	37	25	8
35,500	10,820	120	37	50	15
45,500	13,868	150	46	50	15

Column A - Friction in the instrument not containing an integral vibrator or with the integral vibrator off.
 Column B - Residual friction not removed by an integral vibrator.

4.7 Hysteresis:

The tolerances of Table 2 include and limit errors resulting from hysteresis.

4.8 Minimum Operating Rate:

The instrument shall be capable of a minimum operating rate of 20,000 ft/min (6,100 m/min).

SAE AS8009 Revision B

4.9 Threshold:

The instrument shall be capable of indicating a change in display when subjected to a sinusoidal static pressure change within the tolerance values shown in Table 7.

TABLE 7 - Threshold

Test Pressure Altitude		Tolerance	
Feet	Meters	Feet	Meters
0	0	10	3
10,000	3,000	15	4.5
20,000	6,000	20	6
30,000	9,000	25	7.5
40,000	12,000	30	9
50,000	15,000	40	12

4.10 Monitoring Functions:

Means shall be incorporated in the instrument to indicate when it is not receiving an adequate level of power (voltage and/or current). An indicator or display of the repeating or remote indicating type shall be provided with means to monitor and indicate the presence of the following failures:

- a. Primary power loss to the indicator or display
- b. Loss of synchro excitation
- c. Servoamplifier failure or power loss
- d. Mechanical obstruction within the indicator
- e. Electrical failure in the servomotor drive phases
- f. Loss of a "valid" signal provided by a remote sensor or computer

The failure indicating means shall display the failure or malfunction in a positive and conspicuous manner.

4.11 Vibrator:

If an integral vibrator is required for instrument operation within the stated tolerances, power to the vibrator shall be monitored at the input terminals of the electromechanical device that produces the vibration, and a failure of the power shall be indicated in a positive and conspicuous manner.

5. MINIMUM PERFORMANCE STANDARDS UNDER ENVIRONMENTAL CONDITIONS:

Unless otherwise specified, the measurement procedures applicable to a determination of the performance under environmental conditions are set forth in RTCA Document DO-160D. Performance tests, which must be made after subjection to test environments, may be conducted after exposure to several environmental conditions. The order of tests must be in accordance with section 3.2 of DO-160D.

5.1 Environmental Conditions:

The instrument shall perform as in Section 4 throughout the environmental conditions set forth, and the conditions selected by the equipment manufacturer shall be declared as operating conditions.

5.2 High and Low Temperature:

A change in the ambient room (test) temperature (25 °C) shall not cause the scale error to exceed the sum of the ambient room temperature tolerance (Table 2) and 1% of the tolerance for each degree Centigrade change in the range 0 to 71 °C, nor 2% of the tolerance for each degree below 0° or above 71 °C. The high and low temperatures to be applied shall be determined by the manufacturer and shall be consistent with the environmental conditions specified in the applicable category of RTCA DO-160D.

5.3 Drift and After Effect:

The instrument when subjected to 80% of the operating pressure range for 6 hours shall meet the tolerances specified in Table 8 for drift and after effect.

TABLE 8 - Drift and After Effect

Altitude Range		Tolerance			
		Drift		After Effect	
Feet	Meters	Feet	Meters	Feet	Meters
-1,000 to 80% of Full Scale	-300 to 80% of Full Scale	40	12	30	9

5.4 Fogging (Hermetically Sealed Instruments Only):

The instrument cover glass shall exhibit no fogging due to vapors or other materials when the instrument is subjected to extreme changes in temperature.

5.5 Thermal Shock (Hermetically Sealed Instruments Only):

The instrument shall be subjected to four cycles of immersion in water at $85\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$ and $4\text{ }^{\circ}\text{C} \pm 3\text{ }^{\circ}\text{C}$ without evidence of moisture penetration or damage to enclosure.

5.6 Electrical Insulation:

The insulation resistance measured at a minimum of 500 V DC for 5 s between all electrical circuits and the metallic case shall not be less than 40 M Ω . 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.

5.7 Other Conditions:

The instrument shall be tested to the compliance category specified by the manufacturer in the following additional environmental disciplines per the procedures in RTCA DO-160D:

- a. Vibration
- b. Humidity
- c. Shock
- d. Power input variation
- e. Conducted voltage spike
- f. Audio - frequency susceptibility
- g. Radio - frequency susceptibility
- h. Radio - frequency emission
- i. Magnetic effect

6. TEST PROCEDURES:

6.1 Case Pressure:

The instrument shall be placed in a pressure chamber with the pressure port(s) connected to outside ambient pressure during this test. The chamber pressure shall be increased to 26 in (660 mm) Hg (88 kPa) differential (gage) and maintained at approximately 25 °C for a period of 1 hour. At the conclusion of the test period, the instrument shall be examined and any evidence of deformation, damage, or unsatisfactory operation shall be cause for rejection.

6.2 Leakage:

6.2.1 Static Pressure: The static pressure connection and the Pitot or total pressure connection, if applicable, shall be "Y" connected to the master test equipment and to a source of vacuum. The total volume of equipment and plumbing including the instrument under test shall be $100 \text{ in}^3 \pm 10 \text{ in}^3$ ($1650 \text{ cm}^3 \pm 165 \text{ cm}^3$). A pressure shall be applied to the pressure connections in accordance with Table 1. After the instrument indication has stabilized, the source shall then be sealed off for a period of 1 min during which time the readings of the master test equipment shall not exceed the tolerance specified in Table 1.

NOTE: Electrical power should be applied as required and thermal equilibrium shall be maintained and the instrument tapped or vibrated while performing this test.

6.2.2 Total Pressure (If Applicable): The Pitot pressure port shall be connected to the master test equipment and to a source of pressure, and the static port vented to atmospheric pressure. The total volume including the instrument under test shall be $100 \text{ in}^3 \pm 10 \text{ in}^3$ ($1650 \text{ cm}^3 \pm 165 \text{ cm}^3$). A pressure equivalent to the maximum airspeed for which the equipment was designed shall be applied to the total pressure connection. After the instrument indication has stabilized, the pressure source shall then be sealed off for a period of 1 min during which the master test equipment pressure indication shall change no more than 1 knot.

6.2.3 Hermetically Sealed Components (If Applicable): Hermetically sealed components shall be tested for leaks by a mass spectrometer leak detector of the helium type, or equivalent. The leak rate shall not exceed $0.0434 \mu\text{m ft}^3/\text{h}/\text{in}^3$ in filling gas, at a pressure differential of 1 atmosphere.

NOTE: A micrometer cubic foot per hour leak rate is defined as the gas leakage that would change the pressure of a 1 ft^3 volume by the amount of $1 \mu\text{m Hg}$ in 1 hour, at a pressure differential of 1 atmosphere at 25 °C.

6.3 Scale Error, Including Hysteresis:

- 6.3.1 Scale Error at Room Temperature Operation (25 °C) (For Altimeters Without Automatic Static Pressure Error Correction Mechanism): A period of not less than 6 hours shall be allowed to elapse before testing, during which time the instrument shall not have been subjected to other than ambient pressures, and no adjustments shall have been made. The barometric pressure scale shall be set at 29.921 in Hg (1,013.25 mb). The instrument shall be subjected successively to decreasing and increasing pressures specified in Table 2 (within the maximum pressure altitude range).

A change in pressure shall be made at a rate not in excess of 20,000 ft/min until within approximately 500 ft of the test point, then the test point shall be approached at a rate compatible with the test equipment, being careful not to overshoot the test point. Static pressure shall be stabilized at each test point for at least 20 s, but not more than 1 min before the scale error value is recorded. With tapping or vibration, the scale error in feet of altitude at any test pressure within the altitude range of the instrument shall not exceed the tolerance specified in Table 2. The movement of the indicating means shall be free from erratic motion when the pressure is changed uniformly.

- 6.3.2 Scale Error at Room Temperature Operation (25 °C) (For Altimeters with Automatic Static Pressure Error Correction Mechanism): A period of not less than 6 hours shall be allowed to elapse before testing during which time the instrument shall not have been subjected to other than ambient pressures, and no adjustments shall have been made. The barometric pressure scale shall be set at 29.921 in Hg (1,013.25 mb). The instrument shall be subjected successively to decreasing and increasing pressures specified in Table 2 or these pressures plus the equivalent of the static pressure error (within the maximum pressure altitude range), while the static pressure error correction functions are varied over the ranges specified for the applicable aircraft. Change in pressures shall be made at a rate not in excess of 20,000 ft/min until within approximately 500 ft of the test point, then the test point shall be approached at a rate compatible with the test equipment. Static pressure shall be stabilized at each test point for at least 20 s, but not more than 1 min before the scale error value is recorded.

- a. For aircraft requiring a static source correction system as a function of Mach (and/or other parameters), the altimeter should be calibrated by providing inputs to the system, which apply all the variables to be accounted for in the correction system at 40 or more points distributed over the useful range of each variable. With tapping or vibration readings shall be taken at each test point in Table 2.

The scale error at each test point shall not exceed that shown in Table 2 increased by 15% of the static source error, up to a maximum increase of 80 ft (25 m).

SAE AS8009 Revision B

TABLE 9 - Cold Temperature Correction
Altitude Correction Chart

A/D Temp °C	Height Above the Elevation of the Altimeter Source (feet)													
	200	300	400	500	600	700	800	900	1000	1500	2000	3000	4000	5000
0°	0	20	20	20	20	20	40	40	40	60	80	120	160	200
-10°	20	20	40	40	40	60	60	80	80	120	160	240	320	400
-20°	20	40	40	60	80	80	100	100	120	180	240	360	500	620
-30°	40	40	60	80	100	120	140	160	160	260	340	500	680	860
-40°	40	60	80	100	120	160	180	200	220	320	440	660	880	1100
-50°	60	80	100	140	160	200	220	240	280	400	540	820	1100	1380

NOTE: Values are to be added to published altitudes.

6.4 Balance Error:

The instrument shall be subjected to the test pressures (within the maximum pressure altitude range) specified in Table 3. With tapping or vibration readings shall be taken while the instrument is in each of the following attitudes:

- a. Normal operating position
- b. Instrument rotated clockwise around its X (longitudinal) axis, 90° from its normal position
- c. Instrument rotated clockwise around its X (longitudinal) axis, 180° from its normal position
- d. Instrument rotated counterclockwise around its X (longitudinal) axis, 90° from its normal position
- e. Instrument rotated about its Y (lateral) axis, 30° from its normal operating position so that its dial is up
- f. Instrument rotated about its Y (lateral) axis, 30° from its normal operating position so that its dial is down

A change in indication from that obtained when tested in the normal position (item a. above) shall be considered a "balance error" and shall not exceed the tolerance specified in Table 3.

6.5 Barometric Setting Scale:

The instrument shall be vented to atmospheric pressure and the pressure recorded at the beginning and end of the test. Alternatively, the instrument may be connected to a controlled constant pressure. The pressure scale shall be set successively to the values specified in Table 4 for both the clockwise and counterclockwise directions of rotation of the baroset knob. If both inches of mercury and millibar scales are provided, settings of both shall be made.

After the series of altitude readings (with tapping or vibration) has been recorded, the difference between the reading at the reference setting of 29.921/1,013.25 and each other setting shall be found. The reading obtained at the reference setting for the clockwise direction of rotation of the baroset knob shall be used to compute the differences for both the clockwise and counterclockwise directions of rotation. The differences shall be recorded and compared with the values in the "Correct Differences" column of Table 4 and shall be within the stated tolerances. If the instrument was vented to atmospheric pressure, proper allowance shall be made for any variation of that pressure during the test. Differences between the values recorded for the clockwise and counterclockwise rotations of the baroset knob shall not exceed 20 ft.

The design of the instrument shall be such that the test requirements are met under any atmospheric pressure within the range -1000 to 6000 ft, and such that no damage nor shift of calibration shall result from turning the barometric setting to its low limit while the instrument is exposed to an absolute pressure of 31.50 in Hg (1066.7 mb).

6.6 Stop-and-Jump:

6.6.1 Counterpointer Display: With the integral vibrator in operation, the instrument shall be subjected to a constant rate of decreasing and increasing pressure equivalent to the rate indicated at the test points specified in Table 5. The change in reading of the pointer at the test points, due to its stopping and jumping, shall be recorded as friction and shall not exceed the tolerance specified in Table 5, Column A. This test shall be repeated with the integral vibrator inoperative. The friction shall not exceed the tolerances specified in Table 5, Column B.

6.6.2 Other Displays: With the integral vibrator in operation, the instrument shall be subjected to a constant rate of decreasing and increasing pressure equivalent to the rate indicated at the test point specified in Table 5. The change in reading of the indication at the test points, due to its hesitation, shall be recorded as friction and shall not exceed the tolerance specified in Table 5, Column A. This test shall be repeated with the integral vibrator inoperative. The friction shall not exceed the tolerances specified in Table 5, Column C.

6.7 Static Friction:

6.7.1 Instrument Without Integral Vibrator: While connected as in the scale error test, the instrument shall be tested for friction at each of the test pressures specified in Table 6. Pressure shall be decreased at a rate compatible with the test equipment, but not to exceed 5000 ft/min until within approximately 500 ft of a test point when the rate shall be gradually reduced until the test pressure is approximated. The pressure shall then be held constant while two readings are taken. The first with no external vibration applied to the instrument and the second with external vibration applied to the instrument. Sufficient external vibration shall be applied to assure removal of all friction. The difference between the two readings shall be considered "friction" and shall not exceed the tolerance specified in Table 6, Column A.

6.7.2 Instrument With Integral Vibrator: While connected as in the scale error test, the instrument shall be tested for friction at each of the test pressures specified in Table 6. Pressure shall be decreased at a rate compatible with the test equipment, but not to exceed 5000 ft/min until within approximately 500 ft of a test point when the rate shall be gradually reduced until the test pressure is approximated. The pressure shall then be held constant while three readings are taken. The first with no internal vibration applied (integral vibrator inoperative) nor external vibration applied to the instrument. The second with only internal vibration applied (integral vibrator operating), and the third with both internal and external vibration applied to the instrument. The difference between the first and third reading shall not exceed the tolerance specified in Table 6, Column B, and the difference between the second and third reading shall not exceed the tolerance specified in Table 6, Column C.

6.8 Minimum Operating (Slew) Rate:

Pressure and/or electrical signals shall be applied to the instrument to cause it to indicate above 30,000 ft. At a rate greater than 18,000 ft/min, the pressure and/or signals shall be changed to cause the instrument to indicate below 12,000 ft. The instrument indication shall travel from 30,000 to 12,000 ft in 60 s or less.

6.9 Threshold:

The pressure altitude shall be set at each of the altitude test points in Table 7. With the instrument tapped or vibrated the static pressure shall be slowly increased and decreased around each test point (sinusoidal rates are desired) until a change in indication or output is noticed. The total change in increasing and decreasing pressure shall not exceed the values in Table 7.

6.10 Drift and After Effect:

Electrical power shall be applied as required, and the instrument shall be tapped or vibrated when reading. The reading at the 0 ft test point shall be recorded. The pressure shall then be reduced, at a rate corresponding to an increase in altitude of approximately 6000 ft/min (1800 m/min), to a pressure equal to 80% of the maximum pressure altitude range, and a reading taken within 2 min after reaching altitude. The instrument shall be held at 80% of the full altitude range for a period of 6 hours, and the pressure shall be maintained within ± 2000 ft (600 m). At the completion of the 6 hours exposure period, the pressures shall be readjusted to the previous pressure and a reading taken. The pressure shall then be increased at a rate corresponding to a decrease in altitude not in excess of 20,000 ft/min (6000 m/min) until within approximately 500 ft (150 m) of the 0 ft test point, then the test pressure shall be approached and reached at a rate compatible with the test equipment. Within 3 min after passing through the 500 ft (150 m) approach point, a reading shall be taken at the 0 ft test point. The allowable change in indication between the first and second reading (drift) taken at the 80% test point shall not exceed the tolerance specified in Table 8. The allowable change in indication between the first and second reading (after effect) taken at the 0 ft test point shall not exceed the tolerance specified in Table 8.

6.11 Low Temperature Operation:

The instrument shall be subjected to the low temperature environmental conditions as specified in the applicable category of RTCA DO-160D. Scale error tests as specified in 4.3 shall be conducted at the low temperature environment. With tapping or vibration the altitude scale error shall not exceed that specified in 5.2.

6.12 High Temperature Operation:

The instrument shall be subjected to the high temperature environmental conditions as specified in the applicable category of RTCA DO-160D. Scale error tests as specified in 4.3 shall be conducted at the high temperature environment. With tapping or vibration the altitude scale error shall not exceed that specified in 5.2.

6.13 Extreme Temperature Exposure:

The instrument shall be exposed to low and high temperature for the environmental conditions specified in the applicable category of RTCA DO-160D for a period of 24 hours at each extreme temperature, without operating. After the instrument has attained the normal operating temperature for 3 hours, the instrument shall meet the applicable individual performance tests specified in 4.1 through 4.10. There shall be no evidence of damage as a result of exposure to the extreme temperatures specified.