



AEROSPACE STANDARD

AS8016™**REV. A**

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Reaffirmed 2023-06

Superseding AS8016

Vertical Velocity Instrument (Rate-of-Climb)

RATIONALE

AS8016A has been reaffirmed to comply with the SAE Five-Year Review policy.

1. SCOPE:

1.1 Types:

This AS covers Vertical Velocity Instruments which display the rate of change of pressure altitude of an aircraft, as follows:

Type A - Direct reading, self-contained, pressure actuated

Type B - Electrically or electronically operated, self-contained, pressure actuated

Type C - Electrically or electronically operated, input from a remote pressure sensor

1.2 Range:

The range of operation of the instrument and the altitude range when applicable shall be as marked on the instrument face or nameplate.

1.3 Purpose:

This SAE Aerospace Standard (AS) establishes the minimum performance standards for vertical velocity instruments for aircraft use.

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2. APPLICABLE DOCUMENTS:

The following documents shall form a part of this AS to the extent specified herein:

- 2.1 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, DC 20006.
- 2.2 U.S. Standard Atmosphere, 1962. Copies may be obtained from the RTCA Secretariat, at the address given in 2.1.
- 2.3 "Rules for SAE Use of SI (metric) Units - SAE document J916b," dated July 1976. Copies may be obtained from SAE, 400 Commonwealth Drive, Warrendale, PA 15096.

3. GENERAL STANDARDS:

3.1 Indicating Means:

The vertical velocity shall be indicated by means of a pointer, dial tape, drum, or other type of moving element, or by a digital display with appropriate direction indication. Relative motion of the index with respect to the scale, or of the direction indicator (either the index or the scale may be the moving element) must be clockwise, up, or to the right for ascending vertical velocity.

3.2 Display:

- 3.2.1 Graduation (If Applicable): The graduations shall be arranged to provide the maximum readability consistent with the accuracy of the instrument, with at least 100 ft/minute (30 m/minute), graduations to 1000 ft/minute (300 m/minute). Major graduations shall be at 1000 ft/minute (300 m/minute), intervals and the minor graduations shall be at 500 ft/minute (150 m/minute) intervals.
- 3.2.2 Numerals (If Applicable): The display shall include sufficient numerals to permit quick and positive identification of each graduation.
- 3.2.3 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 inch (.6 mm) for linear displays beyond the greatest graduation in both ascending and descending directions. When the instrument is pegged at its maximum rate indication, the direction of that indication, whether ascending or descending, shall be clear and unambiguous. If a digital display is used, a positive indication shall be provided on the display when the vertical velocity of the aircraft exceeds the instrument readout capability.

- 3.2.4 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 indicia within the instrument easily readable and not allow any objectionable stray light to come from the instrument.
- 3.2.5 Zero Setting: Means for manually zeroing the instrument shall be provided for Type A, and shall be optional for Types B and C. The zero adjust range shall be not less than 400 ft/minute up and down movement. These methods shall meet the requirements of 3.5.

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 25.1359(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.

3.4 Reflectance, Cover Glass:

The total reflectance of the instrument cover glass including the integral lighting wedge, if applicable, shall not exceed 10% of the incident light. This reflectance applies over the visible light spectrum from 450 millimicrons to 600 millimicrons, and over an incident solid angle of 60° perpendicular to the viewing plane.

3.5 Accessibility of Controls:

Controls not normally adjusted in flight must not be readily accessible to flight personnel.

3.6 Acceleration Sensitive Device:

Any device used in the instrument to superimpose an acceleration-sensitive indication of vertical velocity on the pressure-actuated indication of vertical velocity shall be fail safe and shall not degrade the normal operation of the instrument.

3.7 Interchangeability:

Instruments which are identified with the same manufacturer's part number shall be interchangeable.

3.8 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.

3.9 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. Instruments incorporating acceleration-sensitive devices must have these attitude limitations stated.

3.10 Accuracy:

Accuracy requirements for this standard are related to the instrument display or electrical output for a specified sensor input. For Type A and B instruments, the accuracy relates output to pressure input to the instrument, 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.

3.11 Power Malfunction Indication:

For Type B and C instruments, means must be incorporated in the instrument to indicate the loss of signal to the instrument and/or the loss of electrical power to the instrument. The indicating means must indicate a failure or malfunction in a positive manner.

4. PERFORMANCE STANDARDS UNDER STANDARD CONDITIONS:

The test conditions applicable to a determination of the performance of vertical velocity instruments are set forth in Appendix A of this AS. 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. Test equipment used to demonstrate the required performance shall be described and its accuracy specified.

4.1 Zero Setting:

The pointer zero setting mechanism, where applicable, shall operate smoothly throughout its range, which shall not be less than 400 fpm (120 m/minute) up and down movement.

4.2 Scale Error:

4.2.1 When subjected to the rates of change of pressure specified in Table 1 for the instrument range, Types A and B instruments shall meet the tolerances specified in that table.

4.2.2 Type C indicators must be tested in a manner equivalent to the testing of Type A and B. Input signals equivalent to the pressure input to the sensor for the instrument range must be used, and the error from the sensor input to the indicator output must be in accordance with Table 1.

TABLE 1

	Standard Altitude Test Interval Feet	Standard Altitude Test Interval Meters	Test Rate Ascent and Descent Feet Per Minute (ft/minute)	Test Rate Ascent and Descent Meters Per Minute (m/minute)	Tolerance Feet Per Minute (ft/minute)	Tolerance Meters Per Minute (m/minute)
Between	2,000 to 2,500	600 to 750	500	150	100	30
	2,000 to 3,000	600 to 900	1,000	305	200	61
	2,000 to 4,000	600 to 1200	2,000	610	300	91
	2,000 to 5,000	600 to 1500	3,000	915	300	91
	2,000 to 6,000	600 to 1800	4,000	1220	400	122
	2,000 to 7,000	600 to 2400	5,000	1525	500	152
Between	15,000 to 17,000	4500 to 5200	2,000	610	300	91
	15,000 to 19,000	4500 to 5800	4,000	1220	400	122
Between	28,000 to 30,000	8550 to 9150	2,000	610	300	91
	28,000 to 32,000	8550 to 9800	4,000	1220	400	122

4.3 Pointer Damping, Types A and B:

The pointer damping of the instrument on ascent and descent, when timed over the following test interval, shall be between 3 and 12 seconds:

TABLE 2

Instrument Range ft/minute	Instrument Range m/minute	Test Interval ft/minute	Test Interval m/minute
0-2000	610	1800-180	549-61
All greater ranges	All greater ranges	2000-200	610-61

This test may be conducted by applying slight vacuum or pressure to the static pressure connection of the instrument, instantaneously releasing this vacuum or pressure, and measuring the time for the pointer to cover the test interval as it approaches zero. Vibration shall be applied during this test. (See Appendix A.)

Where other than exponential type damping is used, the pointer shall not lag by more than the equivalent of 12 seconds in the above test, and the pointer oscillation shall be damped to an amplitude no greater than exists with the 3 second exponential damping as specified above.

4.4 Friction, Types A and B:

With no vibration applied, the instrument shall be tested in a manner similar to that used in the pointer lag test, as in 4.3. The pointer shall move smoothly toward zero and shall stop within 200 ft/minute (61 m/minute) of zero.

4.5 Leakage Type A and B; Type C, as Applicable:

With a suction of 15 inches of mercury (50.7 kPa) applied to the static pressure connection, the leakage shall not cause more than 0.05 inch of mercury (0.17 kPa) pressure drop during a 1-minute period. With a pressure of 10 inches of mercury (33.8 kPa) applied to the static pressure connection, the leakage shall not cause more than 0.05 inch of mercury (0.71 kPa) pressure drop during a 1-minute period. The total volume of the static pressure system during these tests shall be 100 ± 10 inches³ ($1.6 \text{ L} \pm .16 \text{ L}$).

4.6 Attitude Error:

With the instrument vented to ambient pressure and the pointer approximately zeroed, the difference between the pointer indication in its normal operating position and when it is in any other position shall not exceed 50 ft/minute (15 m/minute). Instruments incorporating acceleration-sensitive devices shall be allowed to stabilize at each reading attitude before compliance with this requirement is tested.

4.7 Acceleration-Sensitive Device Testing:

It shall be the responsibility of the instrument manufacturer to specify the method of test in order to show compliance with 3.6.

4.8 Overpressure (Type A):

Within 5 minutes following a rate of descent of 30,000 ft/minute (9150 m/minute) the instrument must return to plus or minus 100 ft/minute (30 m/minute) of the initial reading. The test altitude shall be within the altitude range specified for the instrument.

5. MINIMUM PERFORMANCE STANDARDS UNDER ENVIRONMENTAL CONDITIONS:

Unless otherwise specified herein, the measurement procedures applicable to a determination of the performance 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 vertical velocity 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:

- 5.2.1 Low Temperature: When subjected to the tests of DO-160, paragraph 4.4, the instrument must operate electrically and mechanically, and the requirements of 4.2 of this AS must be met. After subsection to this test, the requirements of 4.2 and 4.4 of this AS shall be met.
- 5.2.2 High Temperature: When subjected to the tests of DO-160, paragraph 4.5, the instrument must operate electrically and mechanically, and the requirements of 4.2 of this AS must be met. After subsection to this test, the requirements of 4.2 and 4.4 of this AS shall be met.
- 5.2.3 Temperature Variation: When subjected to the tests of DO-160, paragraph 5.0, the instrument must operate electrically and mechanically and the requirements of 4.2 of this AS must be met. After subsection to this test, the requirements of 4.2 and 4.4 of this AS 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 4.2 of this AS must be met.

5.4 Vibration:

When subjected to the tests of DO-160, paragraph 8.0, the instrument must operate electrically and mechanically, and the requirements of 4.2 of this AS must be met. After subsection to this test, the requirements of 4.2 and 4.4 of this AS must be met. Vibration test requirements by aircraft type and equipment location shall be as specified by the manufacturer.

5.5 Shock Test:

After subsection to the tests of DO-160, paragraph 7.0, the instrument must operate electrically and mechanically, and the requirements of 4.2 and 4.4 of this AS must be met.

5.6 Humidity:

Immediately following subsection to the tests of DO-160, paragraph 6.3.1, standard humidity environment, the requirements of 4.2 and 4.4 of this AS 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 4.2 of this AS.
- 5.7.2 Abnormal Electrical Input Variation Test: When subjected to the tests of DO-160, paragraphs 16.3.3.1 or 16.3.4.1, the instruments must operate electrically and mechanically and degradation of performance is permissible. After returning to normal electrical input, the instrument must meet the requirements of 4.2 of this AS.

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 shall meet the requirements of 4.2 of this AS.

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 4.2 of this AS.

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 4.2 of this AS.

5.11 Radio Frequency Susceptibility Test, Radiated and Conducted (Type 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 4.2 of this AS.

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 4.2 of this AS.

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 4.2 and 4.4 of this AS.

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 4.2 and 4.4 of this AS.