

TACHOMETER INSTRUMENTS (INDICATOR AND GENERATOR)

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1. PURPOSE: This Aerospace Standard establishes the essential minimum safe performance standards for Tachometer Instruments primarily for use on turbine-powered subsonic transport aircraft, the operation of which may subject the instruments to the environmental conditions specified in Section 3.3.
2. SCOPE: This Aerospace Standard covers tachometer instruments (RPM indicator, 0-110 percent RPM and 0-120 percent RPM indicators and generator) for remote indication of engine speed.
3. GENERAL REQUIREMENTS:
 - 3.1 Materials and Workmanship:
 - 3.1.1 Materials: Materials shall be of a quality which experience and/or tests have demonstrated to be suitable and dependable for use in aircraft instruments.
 - 3.1.2 Workmanship: Workmanship shall be consistent with high-grade aircraft instrument manufacturing practice.
 - 3.2 Identification: The following information shall be legibly and permanently marked on the instrument or nameplate attached thereto:
 - (a) Name of instrument
 - (b) SAE, AS432A
 - (c) Manufacturer's part number
 - (d) Manufacturer's serial number or date of manufacture
 - (e) Manufacturer's name and/or trademark
 - (f) Range
 - (g) Explosion category
 - 3.3 Environmental Conditions: The following conditions have been established as minimum design requirements. Tests shall be conducted as specified in Sections 5, 6, and 7.
 - 3.3.1 Temperature: When installed in accordance with the instrument manufacturer's instructions, the instrument shall function over the range of ambient temperature shown in Column A below and shall not be adversely affected by exposure to the range of temperature shown in Column B below:

<u>Instrument Location</u>	<u>A</u>	<u>B</u>
Power Plant Accessory Compartment	-30 to 150C	-65 to 150C
Pressurized Areas	-30 to 70C	-65 to 70C
Non-pressurized or External Areas	-55 to 70C	-65 to 70C

Section 8.3 of the SAE Technical Board rules provides that: "All technical reports, if use by anyone engaged in industry or trade, is entirely voluntary. There is no agreement to conform to or be guided by any technical report. In formulating and approving technical reports, the Board and its Committees will not investigate or consider patents which may apply to the subject matter. Prospective users of the report are responsible for protecting themselves against liability for infringement of patents."

- 3.3.2 Altitude: When installed in accordance with the instrument manufacturer's instructions, the instrument shall function from sea level up to the altitudes and temperatures listed below. Altitude pressure values are per NACA Report 1235. The instrument shall not be adversely affected following exposure to extremes in ambient pressure of 50 and 3 inches of mercury absolute respectively.

<u>Instrument Location</u>	<u>Alt. Ft.</u>	<u>Temp.</u>
Power Plant Accessory Compartment	60,000	80C
Pressurized Areas	15,000	50C
Non-pressurized or External Areas	60,000	40C

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

<u>Instrument Location</u>	<u>Cycles per sec.</u>	<u>Max. Double Amplitude</u>	<u>Max. Peak Accel.</u>
<u>On Airframe</u>			
Nacelle & Nacelle Mounts, Wings, Empennage and Wheel Wells	5-1000	0.036"	10g
Fuselage			
Forward of Spar Area	5-500	0.036"	2g
Center or Spar Area	5-1000	"	4g
Aft of Spar Area	(5-500 500-1000)	" --	7g 5g
Vibration Isolated Rack	5-1000	0.030"	1.0g
Flight Deck Area	(5-30 30-1000)	0.020" --	-- 0.25g

- 3.3.4 Humidity: The instrument shall function and shall not be adversely affected following exposure to any relative humidity in the range from 0 to 95% at any temperature up to 70C.

- 3.4 Explosion Category: The instrument component, when intended for installation either in uninhabited areas of non-pressurized aircraft or in non-pressurized areas of pressurized aircraft, shall not cause an explosion when operated in an explosive atmosphere. The component shall meet the requirements applicable to the explosion category below. Specifically, any instrument component which can be an ignition source and is intended for installation in an area in which combustible fluid or vapor may result from abnormal conditions, e.g., fuel line leakage, shall meet the requirements of Category I. If the intended location is an area where combustible fluid or vapor can occur during normal operation, e.g., fuel tank, the instrument component shall meet the requirements of Category II, listed below:

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<u>Category</u>	<u>Definition</u>	<u>Requirement</u>
I	Explosion-proofed; case not designed to preclude flame or explosion propagation.	Paragraph 7.3.1
II	Explosion-proofed; case designed to preclude flame or explosion propagation.	Paragraph 7.3.2
III	Hermetically sealed.	Paragraph 6.5
IV	Instrument not capable of causing an explosion.	Shall not be capable of producing a capacitive or inductive spark of more than 0.2 millijoules of energy or a contact spark of more than 4.0 millijoules of energy.

3.5 Fire Hazard: The instrument shall be so designed to safeguard against hazards to the aircraft in the event of malfunction or failure, and the maximum operating temperature of surfaces of any instrument component contacted by combustible fuel or vapor shall not exceed 200C due to self-heating.

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

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

3.8 Decompression: When installed in accordance with the instrument manufacturer's instructions, the indicator shall function and not be adversely affected following exposure to a pressure decrease from 22 to 2 inches of mercury in 2 seconds.

4. DETAIL REQUIREMENTS:

4.1 Indicator:

4.1.1 Indicating Method: Engine speed shall be indicated in RPM or in percent RPM by means of one or more pointers, dials, tapes, drums, or other types of moving elements. Relative motion of the index with respect to the scale (either the index or the scale may be the moving element) shall be clockwise or "up" or to the right for increasing RPM or percent RPM.

4.1.2 Display Markings:

4.1.2.1 Finish: Unless otherwise specified by the user, matte white material shall be applied to all graduations, numerals and indication means.

Non-functional surfaces and markings shall be durable dull black.

4.1.2.2 Graduations: The graduations shall be arranged to provide a maximum of readability consistent with the accuracy of the instrument.

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

Numerals shall distinctly indicate the graduation to which each applies.

4.1.2.4 Instrument Title: The instrument title, when used, shall be of the same approximate size, but no larger than the numerals. The title may be of the same finish as the numerals. The units of measure (RPM or percent RPM) shall appear on the dial in lettering noticeably smaller than either the numerals or title.

4.1.2.5 Visibility: The indicating means and all markings shall be visible from any point within the frustum of a cone the side of which makes an angle of at least 30 degrees 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.

4.1.3 Hermetic Sealing: When hermetically sealed, the case shall be filled with an inert gas, free of dust particles, and sufficiently dry so that fogging of the indicator glass does not occur during the low temperature or fogging tests of this Aerospace Standard.

4.1.4 Integral Lighting: Integral lighting, if provided, shall be in accordance with ARP-582 "Lighting, Integral for Aircraft Instruments, Criteria for Design".

4.2 Generator: The generator shall be designed to operate in either direction of rotation and in any position.

5. TEST CONDITIONS:

5.1 Atmospheric Conditions: Unless otherwise specified herein, all tests required by this Aerospace Standard shall be made at an atmospheric pressure of approximately 29.92 inches of Mercury, an ambient temperature of approximately 25C and relative humidity of not greater than 85%. When tests are conducted with the atmospheric pressure or the temperature substantially different from these values, allowance shall be made for the variation from the specified conditions.

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- 5.2 Vibration: (to minimize friction) Unless otherwise specified herein, all tests for performance may be conducted with the instrument subjected to a vibration of 0.001 inch double amplitude maximum at a frequency of 10 to 60 cycles per second. The term double amplitude, as used herein, indicates the total displacement from positive maximum to negative maximum.
- 5.3 Vibration Equipment: Vibration equipment shall be such as to allow vibration to be applied along each of three mutually perpendicular axes of the instrument at frequencies and amplitudes consistent with the requirements of Paragraph 3.3.3.
- 5.4 Position: Unless otherwise specified herein, all tests shall be conducted with the instrument in its normal operating position.
- 5.5 RPM vs. Percent RPM requirements: For instruments with markings in RPM instead of percent RPM, all references herein to percent RPM or % RPM shall apply and shall be interpreted to mean the RPM value equivalent to the stated percent of the indicated RPM corresponding to 4200 RPM generator drive shaft speed.
6. INDIVIDUAL PERFORMANCE REQUIREMENTS: All instruments shall be subjected to tests by the instrument manufacturer to demonstrate specific compliance with this Aerospace Standard, including the following requirements where applicable.
- 6.1 Scale Error at Room Temperature: The tachometer indicator shall be connected to a generator that meets the requirements of Paragraph 6.6 and the generator operated at the shaft speeds listed in either Table I or Table II. The test shall be made either by driving the generator at a speed to produce the specified indicator readings and reading the speed of the generator, or by driving the generator at the specified speeds and reading the indicator. The test shall be made with speeds increasing and the speed shall be brought up to, but shall not exceed the speed specified to give the desired reading. The scale error at any speed shall not exceed the values specified in the Table.
- When the speed is held constant at any point on the scale, the pointer shall not oscillate over a range greater than 0.5% from 5-20% RPM and 0.3% from 20% RPM to full scale.
- 6.2 Friction Error: The indicator shall be set at the 5, 20, 40, 70, 85 and 100 percent graduations, or at generator speeds of 200, 800, 1600, 3200, 3600 and 4200 RPM, whichever is more convenient. After each setting, the indicator shall be tapped and the change in indications noted. The change shall not exceed 2% at the 5% graduation, 1% at the 20% graduation, and .75% at the 40, 70, 85, and 100% graduations.
- 6.3 Position Error: The indicator shall be operated at 100% with the instrument in its normal operating position. Readings obtained with the indicator tilted 45 degrees in any direction (back, forward, left and right) shall not vary from the reading taken in the normal position by an amount in excess of 0.3 percent.
- 6.4 Dielectric: Each instrument shall be tested by the method of inspection listed in Paragraphs 6.4.1 and 6.4.2.

- 6.4.1 Insulation Resistance: The insulation resistance measured at 200 volts DC for five seconds between all electrical circuits connected together and the metallic case shall not be less than 5 megohms. Insulation resistance measurements shall not be made to circuits where the potential will appear across elements such as windings, resistors, capacitors, etc., since this measurement is intended only to determine adequacy of insulation.
- 6.4.2 Overpotential Tests: The instrument shall not be damaged by the application of a test potential between electrical circuits, and between electrical circuits and the metallic case. The test potential shall be a sinusoidal voltage of a commercial frequency with an RMS value of five times the maximum circuit voltage or per paragraphs 6.4.2.1 or 6.4.2.2 whichever applies. The potential shall start from zero and be increased at a uniform rate to its test value. It shall be maintained at this value for five seconds and then reduced at a uniform rate to zero. Since these tests are intended to insure proper electrical isolation of the circuit components in question, these tests shall not be applied to circuits where the potential will appear across elements such as windings, resistors, capacitors, etc.
- 6.4.2.1 Hermetically sealed instruments shall be tested at 200 volts RMS.
- 6.4.2.2 Circuits that operate at potentials below 15 volts are not to be subjected to overpotential tests.
- 6.5 Sealing: Hermetically sealed components shall be tested for leaks by means of a mass spectrometer type of helium leak detector or equivalent. The leak rate shall not exceed 76 microns per hour per cubic foot of filling gas at a pressure differential of one atmosphere.
- Note: A micron cubic foot per hour leak rate is defined as that gas leakage which would change the pressure of one cubic foot volume by the amount of one micron (one millionth of a meter of mercury) in one hour.
- 6.6 Generator Voltage Output: The generator shall be operated at a drive shaft speed of 4200 RPM with a load consisting of three 40-ohm Y-connected resistances, and the three terminal voltages shall be 21 ± 0.5 volts, when measured at the generator terminals. When the generator is similarly operated at a shaft speed of 1000 RPM with a load of three 20-ohm Y-connected resistances, none of the 3 terminal voltages shall be less than 3.5 volts.
7. QUALIFICATION TESTS: As many instruments or components as deemed necessary by the manufacturer to demonstrate that all instruments will comply with the requirements of this section shall be tested in accordance with his recommendations.

7.1 Temperature Characteristics:

- 7.1.1 Low Temperature Operation: The instrument shall be subjected to the applicable low ambient temperature listed in Column A of paragraph 3.3.1 for a period of five hours without operating. While still at the low temperature the instrument shall meet the scale error requirement of Table I or II. It is permissible to operate the instrument at approximately half scale for a period of 10 minutes before starting the scale error test.

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The force required to turn the generator shaft while, and after it has been subjected to the low temperature of Column A, Paragraph 3.3.1 shall not exceed 8 pound inches. No damage to the generator shall result from this test.

- 7.1.2 High Temperature Operation: The instrument shall be subjected to the applicable high ambient temperature listed in Column A of Paragraph 3.3.1 for a period of five hours without operating. While still at the high temperature, the instrument shall meet the scale error requirements of Table I or II.
- 7.1.3 Extreme Temperature Exposure: The instrument shall be exposed to the applicable low and high temperatures listed in Column B of Paragraph 3.3.1 for a period of 24 hours at each extreme temperature without operating. After a delay of 3 hours at room temperature, the instrument shall meet the requirements of Paragraphs 6.1 "Scale Error at Room Temperature", 6.2 "Friction Error", and 6.3 "Position Error." There shall be no evidence of damage as a result of exposure to the extreme temperatures specified.
- 7.1.4 Altitude: The indicator shall be subjected to the ambient temperature and pressure listed in paragraph 3.3.2 for a period of three hours while operating. The indicator shall then meet at the conditions specified, the requirements of Table I or II.

The indicator shall be exposed alternately to 50 inches Hg absolute and three inches Hg absolute, non-operating. The indicator shall meet the requirements of Paragraph 6.1 "Scale Error at Room Temperature" at atmospheric pressure following this test.

- 7.2 Vibration: After completion of the following vibration tests, no damage shall be evident and the Scale Error at Room Temperature Test, Paragraph 6.1 shall be repeated. The change in indication as a result of this test shall not exceed 1% RPM.
- 7.2.1 Resonance: The instrument, while operating at approximately one half scale shall be subjected to a resonant frequency survey of the appropriate range specified in paragraph 3.3.3 in order to determine if there exists any resonant frequency of the parts. The amplitude used may be any convenient value that does not exceed the maximum double amplitude and the maximum acceleration specified in paragraph 3.3.3.

The instrument shall then be subjected to vibration at the appropriate double amplitude or maximum acceleration specified in paragraph 3.3.3 at the resonant frequency for a period of one hour in each axis. When more than one resonant frequency is encountered with vibration applied along any one axis, a test period may be accomplished at the most severe resonance, or the period may be divided among the resonant frequencies, whichever shall be considered most likely to produce failure. The test period shall not be less than one-half hour at any resonant mode. When resonant frequencies are not apparent within the specified frequency range, the instrument shall be vibrated for two hours in each axis in accordance with the vibration requirements schedule, paragraph 3.3.3, at the maximum double amplitude and the frequency to provide the maximum acceleration. The pointer position may be changed every twenty to thirty minutes during this test.

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While the instrument is being vibrated, the pointer oscillation shall not exceed 1% RPM and the average pointer variation shall not exceed 1% RPM.

7.2.2 Cycling: The instrument, while operating shall be tested with the frequency cycled between the limits specified in paragraph 3.3.3 in 15-minute cycles for a period of one hour in each axis at an applied double amplitude specified in 3.3.3, or an acceleration specified in 3.3.3, whichever is the limiting value. The pointer position may be changed every twenty to thirty minutes during this test.

7.3 Explosionproof: The instrument component shall be subjected to whatever requirements are applicable for the specific category listed in paragraph 3.4. The following requirements cover only two categories.

7.3.1 Category I: The instrument component shall be subjected, while in the test chamber, to an ambient temperature in the range of 20C to 50C. The test shall be conducted while the component is operating, and if applicable, it shall be connected electrically to related system components located externally to the test chamber. It shall be possible to operate the electrical and/or the mechanical controls, and to apply electrical and/or mechanical loads, as appropriate to the component. All making and breaking electrical contacts shall be operated at least 10 times while the component is being tested.

The test chamber pressure shall be reduced to a pressure approximately 10,000 feet above the altitude pressure test point at which the test is to be conducted to compensate for increase in pressure when fuel is introduced. Tests shall be conducted at pressure altitudes in feet at approximately sea level; 10,000, 20,000, 30,000, 40,000, 50,000, and at 60,000 feet for turbine aircraft application only. The introduction of the explosive mixture into the test chamber shall be made at each test altitude, and the amount of fuel used shall be appropriate for the test chamber, the test altitude pressure, and the prevailing atmospheric conditions. The test shall be conducted utilizing an explosive mixture in the lean sector of the explosive range, and capable of producing an instantaneous explosion when ignited by a spark plug. The fuel used for conducting the tests shall be aviation grade 100/130 gasoline or commercial butane.

The above tests shall be repeated utilizing explosive mixtures in the intermediate and rich sectors respectively of the explosive range, and also at approximately sea level and at 40,000 feet pressure altitude with the instrument component at the lowest applicable ambient temperature listed in Column A of Paragraph 3.3.1.

Operation of the instrument component during the above conditions without an explosion resulting in the test chamber shall be considered as evidence that the instrument component fulfills the requirements of this explosion category.

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- 7.3.2 Category II: The instrument component shall be installed in the test chamber, and both the case of the instrument component and the test chamber shall be subjected to an explosive mixture circulated in a positive manner. The instrument component need not be operating during this test. Upon energizing the ignition means within the case, the explosion must be contained within the case to satisfy the requirements of this explosion category.

This test shall be repeated at least five times using any pressure altitude between sea level and 5,000 feet. It shall be repeated utilizing explosive mixtures in the "intermediate" and "rich" sectors respectively of the explosive range. Any burned gases shall be cleared from the test chamber after completing each test.

- 7.4 Humidity: The instrument unless hermetically sealed, shall be mounted in a chamber maintained at a temperature of $70 \pm 2C$ and a relative humidity of $95 \pm 5\%$ for a period of six hours. After this period, the heat shall be shut off and the instrument allowed to cool for a period of eighteen hours in this atmosphere in which the humidity rises to 100% as the temperature decreases to not more than $38C$. This complete cycle shall be conducted:
- (a) Five times for instruments located in uncontrolled temperature areas.
 - (b) Once for instruments located in controlled temperature areas.

Immediately after cycling, there shall be no evidence of damage or corrosion which affects performance. Following this test, the instrument shall meet the requirements of Paragraph 6.1, Scale Error at Room Temperature Test.

- 7.5 Magnetic Effect: The magnetic effect of the indicator shall be determined in terms of the deflection of a free magnet approximately 1-1/2 inches long, in a magnetic field with a horizontal intensity of 0.18 ± 0.01 gauss when the indicator is held in various positions on an east-west line with its nearest part 12 inches from the center of the magnet. With the instrument operating, the maximum deflection of the free magnet shall not exceed 5 degrees from any indicating or reference position.
- 7.6 Decompression: The indicator while operating shall be exposed to a pressure decrease from 22 to 2 inches of Mercury in 2 seconds. There shall be no evidence of damage as a result of exposure to the specified pressure change. The indicator shall meet the Scale Error at Room Temperature Test, Paragraph 6.1 following this test.
- 7.7 Thermal Shock: This test shall apply to hermetically sealed instruments only. The indicator shall be subjected to four cycles of exposure to water at $85C \pm 2C$ and $5 \pm 2C$ without evidence of moisture penetration or damage to enclosure. Each cycle of the test shall consist of immersing the indicator in water at $85 \pm 2C$ for a period of 30 minutes, and then within 5 seconds of removal from the bath, immersing the indicator for a period of 30 minutes in the other bath maintained at $5C$. This cycle shall be repeated continuously, one cycle following the other until four cycles have been completed.

Following this test, the indicator shall be subjected to the Sealing Test specified in paragraph 6.5.