

TEMPERATURE INSTRUMENTS
(TURBINE POWERED SUBSONIC AIRCRAFT)

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Revised

1. **PURPOSE:** This Aeronautical Standard establishes the essential minimum safe performance standards for Electrical Type Temperature Instruments primarily for use with 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 Aeronautical Standard covers two basic types of temperature instruments as follows:

Type I: Ratiometer type, actuated by changes of electrical resistance of a temperature sensing electrical resistance element: The resistance changes being obtained by temperature changes of the temperature sensing resistance element.

Type II: Millivoltmeter type, operated and actuated by varying e.m.f. output of a thermocouple, the varying e.m.f. input to the instrument being obtained by temperature changes of the temperature sensing thermocouple.

3. **GENERAL REQUIREMENTS:**

3.1 **Materials and Workmanship:**

3.1.1 **Materials:** Materials shall be of a quality which experience and/or tests have demonstrated to be suitable and dependable for use in aircraft instruments.

3.1.2 **Workmanship:** Workmanship shall be consistent with high-grade aircraft instrument manufacturing practice.

3.2 **Identification:** The following information shall be legibly and permanently marked on the instrument or attached thereto:

- (a) Name of instrument (Temperature Instruments)
- (b) SAE AS 414
- (c) Manufacturer's part number
- (d) Manufacturer's serial number or date of manufacture
- (e) Manufacturer's name and/or trademark
- (f) Range
- (g) Rating (electrical)

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 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:

Instrument Location:

	<u>A</u>	<u>B</u>
Pressurized Areas	-30 to 50C	-65 to 70C

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- 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>Altitude</u>	<u>Temp.</u>
Pressurized Areas	15,000 ft.	50C

- 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>Frequency Cycles per sec.</u>	<u>Max. Double Amplitude inches</u>	<u>Maximum accel.</u>
Instrument Panel	5-30	0.020	1 g
	30-1000	-----	0.25 g

- 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 a temperature of approximately 70C.

- 3.4 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.

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

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

4. DETAIL REQUIREMENTS:

4.1 Display Markings:

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

- 4.1.3 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.

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- 4.1.4 Instrument Title: The instrument title 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 ($^{\circ}\text{C}$ or $^{\circ}\text{F} \times 100$, as applicable) shall appear on the dial in lettering noticeably smaller than either the numerals or title.
- 4.1.5 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 deg. 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.
- 4.2 Case Markings: Type II instrument terminal posts shall be of different sizes and shall be distinctly marked to indicate plus for either iron wire, copper wire, or chromel wire connections, and minus for either the constantan or alumel wire connections. External resistance of the lead and thermocouple shall be plainly marked.
- 4.3 Resistance vs Temperature Equivalents: Unless otherwise specified, Type I instruments shall be calibrated to indicate temperature in accordance with the temperature versus resistance values listed in Table I.
- 4.4 E.M.F. versus Temperature Equivalents: Unless otherwise specified, Type II instruments shall be calibrated to indicate temperature in accordance with the E.M.F. versus temperature values as established by the National Bureau of Standards. (Research Paper RP767 dated 19 December 1934, and Research Paper RP 1080 dated July 1937.)
- 4.5 Indicating Method: Type I and Type II instruments shall indicate temperature by means of a pointer moving over a fixed dial. Clockwise and upward motion of single pointers or upward motion of dial pointers shall indicate rising temperature.
- 4.6 Adjustment: When provided, the zero adjustment shall have sufficient friction so that it will not change its adjustment due to vibration encountered in service within the tolerances specified herein for scale error tests.
- 4.7 Limitation of Pointer Travel: The pointer shall be free to move a minimum of two angular degrees beyond the ends of the scale travel and may be limited by stops.
- 4.8 Power Variation: Type I instruments shall properly function with plus or minus 15 percent variation in DC voltage and/or plus or minus 10 percent variation in A.C. voltage and plus or minus 5 percent variation in frequency.
- 4.9 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 and fogging tests of this Aeronautical Standard.

5. TEST CONDITIONS:

- 5.1 Atmospheric Conditions: Unless otherwise specified herein, all tests required by this Aeronautical Standard shall be made at an atmospheric pressure of approximately 29.92 inches of mercury and at an ambient temperature of 25C, and at a relative humidity of not greater than 85%. 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 conditions.
- 5.2 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 inch double amplitude 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 Power Conditions: Unless otherwise specified, all tests shall be conducted at the power rating recommended by the manufacturer.
- 5.5 Position: Unless otherwise specified, all tests shall be conducted with the instrument in its normal operating position.
6. INDIVIDUAL PERFORMANCE REQUIREMENTS: All instruments shall be subjected to whatever tests the manufacturer deems necessary to demonstrate specific compliance with this Aeronautical Standard, including the following requirements where applicable.

6.1 Type I Position Error:

- 6.1.1 No Voltage: With no voltage applied to type I instruments, and when the instrument is tipped from the normal operating position to a position with the plane of the dial horizontal or 90 degrees to the right or left, the pointer shall remain slightly off scale at the low temperature end.
- 6.1.2 Voltage: The test specified for "No Voltage" shall be repeated on Type I instruments with the test voltage applied. This test may be performed at any indication. The change in pointer indication shall not exceed 2% of the total scale span in temperature degrees. When the power to the instrument is cut off, the pointer shall return to the no voltage position.

- 6.2 Type II Position Error: Type II instruments shall be tested on open circuit, and the reading of the instrument observed in the normal operating position with the dial in the vertical plane. The instrument shall then be rotated through angles of 90 degrees to the right and left, and also tipped to a position with the dial horizontal. The readings shall be noted in all positions. The maximum change in reading shall not exceed 2.5 percent of the total scale span in temperature degrees.

6.3 Friction:

6.3.1 Type I Instruments: The difference in readings of type I instruments shall be noted after a slow change in indication before and after tapping or vibrating. This test may be performed at any point on the scale. The change in pointer indication shall not exceed 2 percent of total scale span in temperature degrees.

6.3.2 Type II Instruments: The friction test on type II instruments may be conducted in conjunction with the scale error test. The voltage shall be slowly increased up to each test point. The instrument reading shall be noted before and after the instrument is lightly tapped or vibrated and the friction shall not exceed 4 percent of the total scale span in temperature degrees. The procedure shall be repeated for decreasing voltage values. The movement of the pointer shall be smooth when the applied voltage is varied uniformly.

6.4 Scale Error at Room Temperature:

6.4.1 Type I instruments shall have connected to the resistance bulb terminals the appropriate resistance of the temperature versus resistance curve. When the test voltage is applied, the scale errors shall be determined at a minimum of five test points for the instrument under test except that instruments having less than five major graduations shall be tested at each major graduation. The scale errors shall not exceed 2 percent of the total scale span in temperature degrees, or 2C, whichever is the greater error.

6.4.1.1 Bulb Lead Resistance Effect: When the negative voltage is connected at the bulb, there shall not be over 1.5 percent of the full scale span change in indication at any point of the scale, when the total balanced lead resistance is changed from 0 to 4 ohms (2 ohms in each lead).

6.4.2 Type II Instruments: Type II instruments shall be subjected to a constant room temperature for a period of not less than one hour. Then, by means of the zero adjuster, the pointer is set to the critical temperature. The instrument is to read in its particular application, when the millivoltage for this temperature, corrected for ambient, is applied to the terminals of the instrument through the specified external resistance in series with the instrument.

Readings shall be taken at a minimum of five (5) test points. The errors shall not exceed two (2) percent of the total scale span in temperature degrees.

Accuracies greater than two (2) percent can be accomplished in the critical temperature portions of the scale on type II instruments at the sacrifice of accuracy at test points further removed from the critical temperature point of the instruments.

6.5 Dielectric: Each instrument shall be tested by the method of inspection listed in paragraphs 6.5.1 and 6.5.2.

6.5.1 Insulation Resistance: The insulation resistance measured at 200 volts D.C. 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.

6.5.2 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 paragraph 6.5.2.1 or 6.5.2.2 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.

6.5.2.1 Hermetically Sealed Instruments shall be tested at 200 volts A.C. RMS.

6.5.2.2 Circuits that operate at potentials below 15 volts are not to be subjected to overpotential tests.

7. QUALIFICATION TESTS:

As many instruments or components 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 Reduced Voltage Operation: The type I instrument shall be tested with 85 percent of test voltage. The indications at the reduced voltage shall not differ from the indications at normal test voltage by more than 2.5 percent of full scale span in temperature degrees or 3.5 degree centigrade (6.3 deg. Farh.) whichever is the greater error.

7.2 Temperature Characteristics:

7.2.1 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. At the end of this time and while the instrument is still at the low temperature, resistance and/or voltage shall be applied as specified for scale error at room temperature (6.4). The scale errors shall not exceed plus or minus five (5) percent of the total scale span in temperature degrees or 3C, whichever is the greater error.

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7.2.2 High Temperature Operation: The instrument shall be subjected to the applicable high temperature listed in Column A of paragraph 3.3.1 for a period of five hours without operating. (Electrical equipment shall be energized). At the end of this time and while the instrument is still at the high temperature, resistance and/or voltage shall be applied as specified for scale error at room temperature (6.4). The scale errors shall not exceed plus or minus five (5) percent of the total scale span in temperature degrees, or 3C, whichever is the greater error.

7.2.3 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 three (3) hours at room temperature the instrument shall be subjected to the scale error at room temperature test (6.4) the scale errors shall not exceed plus or minus three (3) percent of the total scale span in temperature degrees or 3C whichever is the greater error.

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

7.2.4 Altitude: The instrument shall be subjected to the ambient temperature and pressure listed in paragraph 3.3.2 for a period of three hours while operating. At the end of this time and while the instrument is still at this temperature and pressure resistance and/or voltage shall be applied as specified for scale error at room temperature (6.4). The scale errors shall not exceed plus or minus five (5) percent of the total scale span in temperature degrees or 3C, whichever is the greater error.

The instrument shall be exposed alternately to 50 inches HG. absolute and three inches HG absolute, non-operating. Following this exposure, resistance and/or voltage shall be applied as specified for scale error at room temperature, at atmospheric pressure. The scale errors shall not exceed two (2) percent of the total scale span in temperature degrees or 2C, whichever is the greater error.

7.3 Vibration:

7.3.1 Resonance: The instrument while operating shall be subjected to a resonant frequency survey of the appropriate range specified in para. 3.3.3 in order to determine if there exists any resonant frequencies 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 para. 3.3.3.

The instrument shall then be subjected to vibration at the appropriate maximum double amplitude or maximum acceleration specified in para. 3.3.3 at the resonant frequency for a period of one hour along each axis. If more than one resonant frequency is encountered with the 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 along each axis in accordance with the vibration requirements schedule (Para. 3.3.3) at the maximum double amplitude and the frequency to provide the maximum acceleration.

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- 7.3.2 Cycling: The instrument, while operating, shall be tested with the frequency cycled between limits specified in para. 3.3.3 in 15 minute cycles for a period of one hour along each axis at an applied double amplitude specified in para. 3.3.3, or an acceleration specified in para. 3.3.3, whichever is the limiting value.

While the instrument is being vibrated, the pointer oscillation shall not exceed 3 percent of total scale span in temperature degrees. The pointer variation during vibration shall not exceed 3 percent of the total scale span in temperature degrees.

After the completion of this vibration test, no damage shall be evident and the instrument shall be subjected to the scale error at room temperature test (para. 6.4). (Without resetting the zero corrector on type II instruments). The change in indications between this test and the initial room temperature scale error test shall not exceed 1.5 percent of the total scale span.

- 7.4 Endurance: This paragraph will be added when available.

- 7.5 Humidity: The instrument, unless hermetically sealed, shall be mounted in a chamber maintained at a temperature of 70 plus, or minus 2C and a relative humidity of 95 plus or minus 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 18 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 one time for components 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 be subjected to the scale error at room temperature test of para. 6.4. The change in reading between this test and the original scale error at room temperature test shall not exceed 2% of total scale range in temperature degrees, or 2C, whichever is the greater error.

- 7.6 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 (plus or minus 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.

- 7.7 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 micron cubic feet per hour per cubic foot of filling gas at a pressure differential of one atmosphere.