AEROSPACE STANDARD

SOCIETY OF AUTOMOTIVE ENGINEERS, Inc 485 Lexington Ave., New York, N.Y.

AS 793

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Revised

TOTAL TEMPERATURE MEASURING INSTRUMENTS (TURBINE POWERED SUBSONIC AIRCRAFT)

1. PURPOSE - This standard establishes essential minimum safe performance requirements for total temperature measuring instruments, primarily for use with turbine-powered subsonic transport aircraft, the operation of which may subject the instruments to the environmental conditions specified in paragraph 3.4 et seq.

2. SCOPE - This standard covers three basic types of total-temperature-measuring instruments used as a means of determining the total temperature developed by adiabatic heating of the air due to motion of the aircraft through the air.

Type I - Flush-type total-temperature sensor
Type II - Probe-type total-temperature sensor (electrically heated)
Type III - Probe-type total-temperature sensor (unheated)

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 AS 793
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, etc.)
h. Explosion category
i. Aircraft identification

3.3 Compatibility of Components - If components are individually acceptable, but require matching for proper operation, they shall be specified accordingly.

3.4 Environmental Conditions - The following conditions have been established as minimum design requirements. Tests shall be conducted as specified in Sections 5,6,7 and 8 to insure compliance with this standard.

3.4.1 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 following exposure to the range of temperature shown in column B below.

3.4.2 Instrument Location	A	B
Nonpressurized or external areas	-70 to +150 C	-70 to +150 C

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 2 in. Hg abs, respectively.

Instrument Location	Altitude	Temp
External areas	50,000 ft	-2C

3.4.3 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:

Instrument Location	Frequency (CPS)	Maximum Double Amplitude (In.)	Maximum Acceleration (g)
Nacelle, nacelle mounts, wings, empennage and wheel wells	5 - 1000	0.036	10
Fuselage			
Forward of spar area	5 - 500	0.036	2
Center of spar area	5 - 1000	0.036	4
Aft of spar area	5 - 500	0.036	7
	500 - 1000	-	5

3.4.4 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 70 C.

3.5 Explosion Category - The instrument component, when intended for installation either in uninhabited areas of nonpressurized aircraft or in nonpressurized 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.

Category	Definition	Requirement
I	Explosion proofed: case not designed to preclude flame or explosion propogation	Paragraph 7.10.1
II	Explosion proofed: case designed to preclude flame or explosion propogation	Paragraph 7.10.2
III	Hermetically sealed	Paragraph 6.2
IV	Instrument not capable of causing an explosion	Shall not be capable of producing a spark of more than 1.0 millijoule of energy and shall not have a short circuit current of more than 100 milliamperes

3.6 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 200 C due to self-heating.

All material should be noncombustible and shall not liberate gases or fumes which will result in such corrosion as to cause malfunction of equipment or discoloration of dials or indicia, nor shall toxic gases or fumes that are detrimental to performance of the aircraft or health of personnel be liberated under the operating conditions specified herein.

3.7 Radio Interference - The instruments shall not be a source of objectionable interference wider operating conditions at any frequencies used on the aircraft, either by radiation conduction, or feedback in any electronic equipment installed in the same aircraft as the instruments in accordance with Specification MIL-I-6181, latest revision.

4. DETAIL REQUIREMENTS

4.1 Submersion - The instrument shall function and shall not be adversely affected following submersion in water maintained at 18 C (65 F) for a period of 8 hr.

4.2 Thermal Response - The thermal time constant shall not exceed 1.5 sec when subjected to an airflow of Mach 0.3 at sea level. The thermal time constant is defined as the time required to reach 63% of a step function change in temperature.

4.3 Static Loading - The instrument shall withstand static impact pressures the equivalent of Mach 1.5 at 10,000 ft or 3512 psf.

4.4 Reactance - The resistance shall not vary more than 0.04 ohm when tested for inductive or capacitive effect over a frequency range of 0 to 2000 cps.

4.5 Self-Heating

4.5.1 Temperature Sensing Element - Self-heating shall not change the resistance more than the equivalent of 3 C when tested at 0.3 Mach at standard sea level pressure and temperature.

4.5.2 Heater Element (Type II only) - The resistance of the temperature sensing element shall not change by more than the equivalent of 1 C when the deicing heater element is operated at rated volt age and the probe is in an ambient airflow of Mach 0.3 at sea level conditions.

4.6 Power Variation - The instrument shall properly function with ± 15% variation in d-c voltage, and/or ± 10% variation in a-c voltage, and ± 5% variation in frequency.

4.7 Hermetic Sealing - When hermetically sealed, the instrument shall be filled with an inert gas, free of dust particles, and sufficiently dry so that condensation does not occur during the low temperature tests of this standard.

4.8 Electrical Characteristics

4.8.1 Temperature Sensing Element - The resistance versus temperature relationship of the sensing element shall follow the Callendar-Van Dusen equation:

$$\frac{R_T}{R_O} = 1 + \alpha\left[T - \delta\left(\frac{T}{100} - 1\right)\left(\frac{T}{100}\right) - B\left(\frac{T}{100} - 1\right)\left(\frac{T}{100}\right)^3\right]$$

where R_T = resistance at temperature in C, R_o = resistance at O C, $\alpha = 0.03925$, $\delta = 1.45$, B = O (for temperatures above O C) and B = 0.10 (for temperatures below O C) and T = temperature in C. Deviations from the Callendar-Van Dusen equation over the temperature range of the instrument shall not be greater than allowed by the following equation:

$$\Delta T \leq 0.25 + 0.005T$$

Where Δ T is allowable deviation in C. (the negative sign, when T is below O, shall not be used in this equation.)
R_o shall be specified by the airframe manufacturer.

4.8.2 Heater Element (Type II Only) - The nominal heater power consumption shall not be greater than 350 w when the probe is operating under in-flight icing conditions with a static temperature ranging from -10 to -35 C and an indicated airspeed of from 200 to 350 knots.

4.9 Mounting - The mounting method shall be keyed to prevent installation with the wrong orientation.

5. TEST CONDITIONS

5.1 Atmospheric Conditions - Unless otherwise specified herein, all tests required by this standard shall be made at an atmospheric pressure of approximately 29.92 in. Hg, an ambient temperature of approximately 25 C and 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 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 3.4.3.

5.3 Power Conditions - Unless otherwise specified herein, all tests should be conducted at the power rating recommended by the manufacturer.

5.4 Position - Unless otherwise specified herein, all tests shall be conducted with the instrument in its normal operating position.

6. INDIVIDUAL PERFORMANCE REQUIREMENTS - All instruments shall be subjected to tests by the instrument manufacturer to demonstrate specific compliance with this standard, including the following requirements where applicable.

6.1 Dielectric - The instrument shall be completely submerged in water maintained at 18 C (65 F) for a period of 8 hr. Upon completion of the 8-hr period, the instrument shall be removed from the water and dried for a period of one hour. At the end of this time each instrument shall be tested by the method of inspection listed in paragraphs 6.1.1 and 6.1.2.

6.1.1 Insulation Resistance - The insulation resistance measured at 200 v d-c for 5 sec between all electrical circuits and the metallic case shall not be less than 5 megohms.

Insulation 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.

6.1.2 Overpotential Tests - The instruments 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 6.1.2.1 or 6.1.2.2, 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 5 sec, 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.

6.1.2.1 Hermetically sealed instruments shall be tested at five times the maximum circuit voltage up to a maximum of 200 RMS.

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

6.2 Sealing - Hermetically scaled 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 0.0434 mu cu ft/hr*/cu in of filling gas at a pressure differential of one atmosphere.

*A micron cubic foot per hour leak rate is defined as that gas leakage which would change the pressure of a one cubic foot volume by the amount of one micron (one millionth of a meter of mercury) in one hour.

6.3 Calibration - The resistance of the instrument shall be measured at 0 and at 100 C. The resistance shall meet the temperature resistance calibration equation of paragraph 4.8.1, within the accuracy specified therein.

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 Calibration - The resistance of the instrument shall be measured at -40, 0, 100, and 150 C. The resistance shall meet the temperature resistance calibration equation of Paragraph 4.8.1, within the accuracy specified therein.

7.2 Thermal Response - The thermal time constant shall not exceed 1.5 sec when measured at an airflow of Mach 0.3 at sea level. The thermal time constant is defined as the time required to reach 63% of a step function change in temperature.

7.3 Aerodynamic Calibration - The conduction and radiation errors of the instrument shall be determined under dynamic conditions. The instrument shall be subjected to the aerodynamic conditions necessary to produce the conditions specified In Table I. The errors of the instrument in determination of the stagnation temperature shall not exceed the values specified in Table I.

Table I

Aerodynamic Conditions

Total Pressure (mm Hg)	Stagnation Temperature (C)	Allowable Error in Measured Stagnation Temperature + %
1000	150	0.5
100	150	0.5
30	150	0.7

7.4 Reactance - The instrument shall be tested for inductive and/or capacitive reactance effect. The resistance, of the instrument shall not vary more than 0.04 ohm at any frequency of the measurement from 0 to 2000 cps.

7.5 Self-Heating

7.5.1 Temperature Sensing Element - The instrument shall be tested with room pressure and temperature air for self-heating effect. Sufficient voltage shall be applied to produce a current of 50 ma. This test shall be conducted with an ambient flow velocity of 0.3 Mach. The change in resistance shall not exceed the equivalent of 3 C after 5 minutes.

7.5.2 Heater Element (Type II Only) - The probe shall be subjected to an internal airflow of Mach 0.3 at room pressure and temperature with the deicing heater element de-energized. When the temperature-sensing element has reached stabilized condition, the deicing heater element shall be energized. After a period of 3 minutes, the temperature indicated shall be not more than 1 C above the temperature indicated with the heater de-energized. If temperature fluctuations exist in the air stream, an average of several test runs may be used.

7.6 Deicing and Anti-icing (Type II Only) - The probe shall be tested in an icing wind tunnel at an indicated tunnel speed of 400 ± 25 knots. The tunnel static temperature for the tests shall be between -25 and - 35 C. The liquid water content shall be between 1.00 and 1.50 gr/cu m of air. The procedure for the tests shall be as follows: Ice should be allowed to form on the air inlet of the probe until the ice cap has extended 1/2 inch from the inlet tip. Power shall then be applied at rated voltage and the total time to remove all accumulated ice from the inlet shall be less than 2 minutes. At the end of this time, the indicated temperature of the temperature-sensing element shall return to within 1 C of the reading before the ice was allowed to accumulate. If temperature fluctuations exist in the icing wind tunnel, an average of several test runs may be used. After the ability of the probe to deice properly has been demonstrated rated power should be continually applied for an additional 15 minutes. There shall be no re-accumulation of ice on the probe which would affect the temperature indication.

7.7 Extreme Temperature Exposure - The instrument shall be exposed to the applicable low and high temperatures listed in column B of paragraph 3.4.1 for a period of 24 hr at each extreme temperature, without operating. After a delay of 3 hr at room temperature, the instrument shall meet the applicable individual performance tests (Section 6, except 6.1) at room temperature. There shall be no evidence of damage as a result of exposure to the extreme temperatures specified.

7.8 Altitude - The instrument shall be subjected to the ambient temperature and pressure listed in paragraph 3.4.2 for a period of 3 hr while operating. The instrument shall then meet, at the conditions specified, the applicable individual performance tests (Section 6 except 6.1).

The instrument shall be exposed alternately to 50 in Hg abs and 3 in Hg abs, non-operating. he instrument shall meet the applicable individual performance tests (Section 6 except 6.1) at atmospheric pressure following this test. The time required to change from one pressure extreme to the other shall not exceed 4 minutes.

7.9 Vibration - After the completion of the following vibration tests, no damage shall be evident and the instrument shall meet the applicable individual performance tests (Section 6, except 6.1).