



AEROSPACE STANDARD

AS5562™

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Ice and Rain Minimum Qualification Standards for Pitot and Pitot-static Probes

RATIONALE

This standard provides a consistent means to evaluate electrically heated pitot and pitot-static probes for in-flight ice and rain conditions that may be experienced in service. This standard does not address other functions that are sometimes combined with pitot and static pressure measurements, such as aircraft AOA.

1. SCOPE

This SAE Aerospace Standard (AS) establishes minimum ice and rain performance criteria for electrically-heated pitot and pitot-static probes intended for use on the following classes of fixed-wing aircraft and rotorcraft. The classes of fixed-wing aircraft are defined by aircraft flight envelopes and are shown in Figure 1. The flight envelopes generally fall into the classes as shown below:

- Class 1: Cruise altitude $\leq$ 23 000 feet
- Class 2: Cruise altitude $\leq$ 31 000 feet
- Class 3: Cruise altitude $\leq$ 42 000 feet
- Class 4: Cruise altitude $>$ 42 000 feet
- Class R: Rotorcraft

The user of this standard must evaluate the aircraft level installation requirements for the probe against the class definition criteria to ensure adequate coverage for the application. It may be necessary to step up in class or modify the test conditions in order to meet the applicable installation requirements.

NOTE: Class 2 is divided into two subgroups identified as either Class 2a or Class 2b. Class 2a probe applications typically include aircraft that operate within the mid to lower end of the Class 2 altitude range and that only use probe output to display basic airspeed and/or altitude. As such, Class 2a probes do not have to test ice crystals at an altitude-capable icing tunnel. Class 2b applications are for probe installations intended to serve a critical function and should be tested at an altitude-capable icing tunnel. Probes qualified to Class 2 of this standard shall be identified as either Class 2a or Class 2b.

In addition this performance standard applies only to the probe types listed below and is limited to only the performance of the probe itself as defined from the aerodynamic sensing aperture on the probe to the aircraft pneumatic interface connection.

- Type I – Pitot Pressure, Straight and L-Shaped
- Type II – Pitot and Static Pressures, Straight and L-Shaped

NOTE: This specification, when used in conjunction with AS8006, provides a comprehensive design and test standard for the devices that fall within the scope of this document.

NOTE: This document is technically equivalent to EUROCAE ED-225, dated TBD.

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2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this document 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.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

ARP5624	Aircraft Inflight Icing Terminology
ARP5905	Calibration and Acceptance of Icing Wind Tunnels
AS8006	Minimum Performance Standard for Pitot and Pitot-Static Tubes

2.1.2 EUROCAE Publications

Available from EUROCAE Secretariat, 102 rue Etienne Dolet, 92240 Malakoff, France, Tel: +33 1 40 92 79 30, www.eurocae.net.

ED-225	MOPS Icing Conditions Test Requirements for Pitot and Pitot-static Probes
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2.1.3 U.S. Government Publications

Copies of these documents are available online at <http://quicksearch.dla.mil>.

MIL-HDBK-310	Global Climatic Data for Developing Military Products
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2.1.4 Code of Federal Regulations

Available from the United States Government Printing Office, 732 North Capitol Street, NW, Washington, DC 20401, Tel: 202-512-1800, www.gpo.gov.

Title 14 Code of Federal Regulations

2.2 Abbreviations

AOA	Angle of Attack
CAS	Calibrated Airspeed
CM	Continuous Maximum
DP	Delta Pressure
g	Grams
K	Kilo
IC	Ice Crystals

IM	Intermittent Maximum
ISA	International Standard Atmosphere
IWC	Ice Water Content
KTAS	Knots True Airspeed
kt	Knots
LWC	Liquid Water Content
m	Meters
microns	Micrometers (common usage)
MMD	Median Mass Diameter (Ice Crystals)
MP	Mixed Phase
MVD	Median Volumetric Diameter (Liquid)
PST	Piston
Ref	Freestream Reference Test Condition
SAT	Static Air Temperature
SL	Sea Level
SLD	Supercooled Large Drops
SLW	Supercooled Liquid Water
TAS	True Airspeed
TAT	Total Air Temperature
TBP	Turboprop
UUT	Unit Under Test
μ	Micro
Σ	Standard Deviation

NOTE: Reference ARP5624 for a definition of each icing term.

3. GENERAL CONDITIONS

3.1 Environment

This specification addresses the following environmental in-flight icing conditions: supercooled liquid water, ice crystals, and mixed phase. Additionally, the effects of heavy rain environments and the subsequent susceptibility to probe freezing after exposure to rain are also evaluated.

Supercooled large drops, such as freezing rain and freezing drizzle, are not directly evaluated in this specification. The conditions specified for SLW adequately address the effects of SLD and therefore, no direct SLD tests are required. This is based on the following: The characterizing parameters of liquid water content and static air temperature associated with SLD conditions are covered by the SLW conditions. Analysis of the collection efficiency for liquid water associated with pitot and pitot-static probes indicates a value typically exceeding 90%. This implies the sensitivity of these devices to variations in drop size is low and will be adequately addressed by the SLW conditions. Also, the LWC associated with the SLW test conditions substantially exceed SLD LWC levels found in service.

3.1.1 Data Sources and Criteria for Environmental Conditions

Supercooled Liquid Water: Consists of water droplets derived from 14 CFR Part 25 Appendix C for both continuous maximum and intermittent maximum icing conditions. LWC is conservatively established by utilizing water contents associated with 15 micron droplets for the respective temperatures. A single droplet MVD of 20 microns is selected for evaluation based on the high probability of encountering droplets of this size in nature, and the ability of icing wind tunnels to generate droplets of this size. The low LWC and higher altitude associated with the -40 °C IM condition produces a less severe condition than the test conditions specified by this standard.

The altitudes and airspeeds for the liquid water conditions were determined by performing a critical point thermal analysis for the respective test condition temperature.

Ice Crystals: Consists of ice water content derived from the application of the theoretical adiabatic total water content applied over an altitude range from sea level to 51 000 feet, and temperature range from -10 to -70 °C. A median mass diameter range of 150 to 250 microns shall be acceptable and is based on the current knowledge of atmospheric ice crystal particle size.

The altitudes associated with ice crystal conditions presented in this document consider in-service pitot and pitot-static probe events. The altitudes defined in this specification for ice crystal conditions are determined by the lower of the aircraft cruise altitude defined for that class or the ISA+30 °C curve or the linear extension of the ISA+30 °C lapse rate beyond 36 089 feet for the respective test condition temperature. The altitude-temperature envelope is shown in Figure 2. The airspeeds associated with ice crystal conditions are typical cruise speeds per the class definition, or those typical cruise speeds reduced to maintain a TAT below freezing.

Mixed Phase: Consists of the combination of SLW and IC icing conditions. The liquid phase is taken from the application of 14 CFR Part 25 Appendix C intermittent maximum icing conditions at the standard 2.6 nautical mile horizontal extent. The solid phase is derived by applying a distance scale factor for 2.6 nautical miles to the theoretical adiabatic maximum total water content as defined in 14 CFR Part 25 Appendix D. This is done over an altitude range of sea level to that consistent with a static air temperature above -40 °C, as -40 °C constitutes the theoretical minimum temperature for the existence of supercooled liquid water. The temperature range considered shall be -10 to -40 °C. The MVD and MMD shall be consistent with those used for SLW and IC icing conditions.

The altitudes associated with the mixed phase test conditions are also based on in-service event history, and are determined by the lower of the aircraft cruise altitude defined for that class or the ISA+20 °C curve or the linear extension of the ISA+20 °C lapse rate beyond 36 089 feet for the respective test condition temperature. The altitude-temperature envelope is shown in Figure 2. The airspeeds associated with ice crystal conditions are typical cruise speeds per the class definition, or those typical cruise speeds reduced to maintain a TAT below freezing.

Rain: The values utilized are based on MIL-HDBK-310 for extreme precipitation rates. The temperature range evaluated is static air temperatures below 10 °C, and drop sizes having an MVD in the range of 500 to 2000 microns. The broad range of allowable drop MVD acknowledges the difficulty of introducing large drops into some icing wind tunnels. Only one value within the specified range of temperature and MVD need be tested. Again, due to the insensitivity of these devices to drop size the significant parameters for rain testing are SAT, TAS, and LWC.

Specific altitudes for the rain test conditions are not presented for these tests as they are primarily a test of the probe water management features. The altitudes are representative of an all liquid water distribution for the extreme precipitation rates. The airspeeds are chosen to evaluate the probes at a high and low speed condition consistent with the test condition altitude requirements.

3.2 Aircraft Class/Flight Parameter Discussion

This standard defines five aircraft classes with the intent to specify the minimum icing test conditions appropriate to the flight envelope addressed by each class. In this fashion, test requirements can be better matched to the particular application. As with any minimum performance standard, application specific requirements may exceed those defined in this specification; the user of this standard is cautioned to closely examine application specific requirements to verify the appropriateness of the test conditions presented in this standard. If necessary, the test conditions may be modified. However, parts identified as having met this standard must meet or exceed the requirements specified in this document.

The fixed wing aircraft classes were determined by examining aircraft performance parameters (cruise altitude and airspeed) associated with fixed wing aircraft representing the spectrum of aircraft covered by this specification. The grouping of these aircraft by cruise altitude and Mach number is shown in Figure 1. As seen in Figure 1, the aircraft tend to group by the flight envelope defined by the aircraft classes presented in Section 1. Rotorcraft all generally fall in the same area in terms of cruise altitude and airspeed and therefore did not require further class breakdown.

Representative icing exposure flight and icing parameters (altitude, airspeed, IWC) were determined for each class of aircraft by assuming a flight profile that consists of a leg from takeoff and climb to cruise altitude, a leg at cruise altitude, and a leg from cruise altitude to a descent and landing.

3.3 Test Point Scaling

When a particular freestream (reference) test condition cannot be achieved due to a test facility limitation, the following scaling methods shall be used to arrive at an achievable test condition. Other scaling methods may be acceptable so long as they are shown to be conservative for the respective test condition.

3.3.1 Altitude Limitation

Due to the potential safety exposure and in-service history, the ice crystal conditions specified for Class 2b, 3, and 4 must be tested at the specified altitude. This is because as of the time of publication there is no acceptable method to scale the conditions for a non-altitude capable test facility. All other test conditions, including mixed phase, can be performed at a non-altitude capable facility when appropriately scaled as described below. Experience has shown this to be conservative.

NOTE: Ice crystal scaling methods continue to evolve. Suitable methods for scaling altitude may be developed in the future. These methods must be thoroughly validated.

Thus, when testing at a non-altitude capable test facility the test shall be run matching each parameter, except altitude, to the greatest extent possible.

3.3.2 Airspeed Limitation

If the airspeed is limited, the SAT shall be varied to maintain TAT identical to the reference condition:

$$TAT_{\text{test}} = TAT_{\text{ref}}$$

LWC and/or IWC shall be varied to maintain the mass flux identical to the reference condition:

$$LWC_{\text{test}} = LWC_{\text{ref}} * TAS_{\text{ref}} / TAS_{\text{test}}$$
$$IWC_{\text{test}} = IWC_{\text{ref}} * TAS_{\text{ref}} / TAS_{\text{test}}$$

3.3.3 Static Air Temperature Limitation

If the static air temperature is limited, the TAS shall be varied to maintain TAT identical to the reference condition:

$$TAT_{\text{test}} = TAT_{\text{ref}}$$

LWC and/or IWC shall be varied to maintain the mass flux identical to the reference condition:

$$LWC_{\text{test}} = LWC_{\text{ref}} * TAS_{\text{ref}} / TAS_{\text{test}}$$

$$IWC_{\text{test}} = IWC_{\text{ref}} * TAS_{\text{ref}} / TAS_{\text{test}}$$

3.3.4 Test Point Scaling Limitations

The scaling methods presented in 3.3.2 and 3.3.3 shall be re-evaluated if either of the following limitations is exceeded:

- If $Mach_{\text{ref}} \leq 0.47$ and $(TAS_{\text{test}} / TAS_{\text{ref}}) \leq 0.75$, or
- If $Mach_{\text{ref}} > 0.47$ and $(Mach_{\text{ref}} - Mach_{\text{test}}) \geq 0.12$

3.4 Qualification Test Records

Users of this standard shall maintain the records described in the following sections for each probe that is identified as qualified to this standard.

3.4.1 Icing Wind Tunnel Calibration Record

A valid calibration of the icing parameters of interest (LWC, MVD, SAT, TAT, airspeed) across the test section must exist prior to testing. Reference ARP5905 for appropriate methods of calibration and approval of icing wind tunnels.

NOTE: The icing wind tunnel calibration record(s) must be maintained by the test facility and made available upon request. They need not be contained in the test report.

3.4.2 Test Report

A test report documenting the following shall be prepared:

- Probe part number and/or model number
- Probe serial number
- Probe acceptance test procedure and results
- Probe class
- Concentration factors used for icing tests
- Probe installation details
- Justification of minimum thermal performance (4.9)
- Voltage applied to the heater and heater current for each test condition
- Test matrix which indicates reference and actual test conditions