



The European Organisation for Civil Aviation Equipment
L'Organisation Européenne pour l'Équipement de l'Aviation Civile

ICE AND RAIN MINIMUM QUALIFICATION STANDARDS FOR PITOT AND PITOT-STATIC PROBES

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FOREWORD

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CHAPTER 1

INTRODUCTION

1.1 PURPOSE

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.

1.2 SCOPE

This aerospace standard 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 $\leq 23,000$ ft.

Class 2: Cruise Altitude $\leq 31,000$ ft.

Class 3: Cruise Altitude $\leq 42,000$ ft.

Class 4: Cruise Altitude $> 42,000$ ft.

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 SAE AS5562, dated TBD.*

1.3 RELATIONSHIP WITH OTHER DOCUMENTS

This standard is technically equivalent to AS5562, dated August 2015 and is intended to be referenced in the update of ETSO C16a.

1.4 DESCRIPTION OF THIS DOCUMENT

1.4.1 Document Organisation

Chapter 1 describes the purpose and scope of this standard.

Chapter 2 describes the general conditions that must be taken into account when evaluating pitot probes. It covers the environmental conditions of Supercooled Liquid Water, Ice Crystals, Mixed Phase, Supercooled Large Droplets and heavy rain, as well as the data sources for these conditions. Acceptable Test point scaling is described, to address situations where there are test facility limitations. There is a description of the qualification test records that users of this standard shall maintain for each probe that is identified as qualified to this standard.

Chapter 3 covers the test requirements for all test conditions, addressing concentration factors, probe mounting location, probe mount heating, installation heat sink effects, probe power, tunnel blockage, angle of attack, data collection sample rate and pressure reading processing, test unit selection and trapped water.

Chapter 4 describes the qualification tests in detail, covering test set up, test procedure and pass/fail criteria.

1.4.2 Acronyms and glossary of terms

AOA	Angle of Attack
CAS	Calibrated Airspeed
CM	Continuous Maximum
DP	Delta Pressure
ft	Feet
g	Grams
K	Kilo
IC	Ice Crystals
IM	Intermittent Maximum
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
°	Degrees
μ	Micro
σ	Standard Deviation

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

1.5 REFERENCES

1.5.1 European Airworthiness Requirements

CS-23 Certification Specification and Acceptable Means of Compliance for Normal, Utility, Aerobatic and Commuter Category Aeroplanes

CS-25 Certification Specifications and Acceptable Means of Compliance for Large Aeroplanes

Available from the European Aviation Safety Agency, Ottoplatz 1 D-50679 Cologne, Germany. Tel: +49 221 8999 000. www.easa.europa.eu

1.5.2 SAE Publications

AS8006A Minimum Performance Standard for Pitot and Pitot-static Probes

AS5562 Ice and Rain Minimum Qualification Standards for Pitot and Pitot-static Probes

ARP5905 Calibration and Acceptance of Icing Wind Tunnels

ARP5624 Aircraft In-flight Icing Terminology

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

1.5.3 US Government Publications

MIL-HDBK-310 Global Climatic Data for Developing Military Products

TSO-C16b Electrically heated Pitot and Pitot static tubes

Available from the Document Automation and Production Service (DAPS), Building 4/D, 700 Robbins Avenue, Philadelphia, PA 19111-5094, Tel: 215-697-6257, <http://assist.daps.dla.mil/quicksearch/>.

1.5.4 Code of Federal Regulations

Title 14 Code of Federal Regulations

Available from the United States Government Printing Office, 732 North Capitol Street, NW, Washington, DC20401, Tel: 202-512-0000, www.gpoaccess.gov.

CHAPTER 2

GENERAL CONDITIONS

2.1 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.

2.1.1 Data Sources and Criteria for Environmental Conditions

Supercooled Liquid Water: Consists of water droplets derived from CS-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 – 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 ft. 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 CS 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 CS-25 Appendix P. 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 ft. 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 – 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

2.2

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 1.0. 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.

2.3

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.

2.3.1

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.