SAE INTERNATIONAL

AEROSPACE STANDARD

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Superseding AS5498A	

Minimum Operational Performance Specification for Inflight Icing Detection Systems

RATIONALE

The document has been updated to address editorial and technical errors and add some clarifications in A.1.1:

- Technical: Corrected the value of the thermal diffusivity.
- Technical: Corrected an error in the discrimination time calculation formula used in the spreadsheet to generate data of the requirements tables.
- Technical: Added a reference to the calculation tool spreadsheet which will now be included with the document.
- Clarifications: Clarified the default value of the surface temperature (T_{surf}) and indicated the default value of the barometric pressure to be used. Addressed and resolved the impacts of the corrections on the document (e.g., updated requirements in the test matrix tables).

PLEASE NOTE: Some discrimination time values given in revision A of the document either for AIRCRAFT or ROTORCRAFT are too long and do not correspond to the requirements of the equation stated. However, since AS5498A was considered to provide guidance material rather than certification requirements, and it requires confirmation of the acceptable discrimination time with the AIRCRAFT manufacturer prior to certification, this was not considered to be a safety issue.

FOREWORD

1. This document was prepared jointly by Committee AC-9C "Aircraft Icing Technology" and EUROCAE Working Group 95 "Inflight Ice Detection System."
2. EUROCAE is an international non-profit organization in Europe. Membership is open to manufacturers and users of equipment for aeronautics, trade associations, national civil aviation administrations, and, under certain conditions, non-European organizations. Its work program is principally directed to the preparation of performance specifications and guidance documents for civil aviation equipment, for adoption and use at European and world-wide levels.
3. The findings of EUROCAE are resolved after discussion amongst members of EUROCAE and in collaboration the SAE International (SAE), Warrendale, PA, U.S.A., through appropriate committees.
4. This document is technically identical to ED-103 Rev B.

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For more information on this standard, visit
https://www.sae.org/standards/content/AS5498B/

5. EUROCAE performance specifications and other documents are recommendations only. EUROCAE is not an official body of the European governments. Its recommendations are valid as statements of official policy only when adopted by a particular government or conference of governments.

TABLE OF CONTENTS

1. SCOPE AND REFERENCES

1.1 Purpose and Scope

This document contains minimum operational performance specification (MOPS) of active on-board INFLIGHT ICING DETECTION SYSTEMS (FIDS).

This MOPS specifies FIDS operational performance which is the minimum necessary to satisfy regulatory requirements for the design and manufacture of the equipment to a minimum standard and guidance towards acceptable means of compliance when installed on an AIRCRAFT.

Detection of ICE accreted on the AIRCRAFT during ground operations is not considered in this document. This MOPS was written for the use of FIDS on AIRCRAFT as defined in 1.3 and 2.3.

Expected minimum performance specifications for FIDS and their functions are provided in Section 3.

The minimum performance requirements as defined in Section 3 do not consider SYSTEM performance as installed on the AIRCRAFT. Performance in excess of the minimum performance may be required by the SYSTEM installed on an AIRCRAFT in order to meet regulatory or operational requirements. This topic is considered in Section 6.

This MOPS document is structured as follows:

Section 1 Provides information required to understand the need for the equipment characteristics and tests defined in the remaining chapters. It describes typical equipment applications and operational objectives and is the basis for the performance criteria stated in Sections 2 to 4. Definitions essential to proper understanding of this document are also provided in Section 1.

Section 2 Contains FIDS intended functions, general design requirements and general reporting and test requirements.

Section 3 Contains the minimum operational performance specification for the equipment, defining performance requirements under ENVIRONMENTAL INFLIGHT ICING CONDITIONS likely to be encountered in flight.

Section 4 Describes the environmental test conditions which provide a laboratory means of determining the overall performance characteristics of the equipment under conditions representative of those which may be encountered in actual operations.

Section 5 Describes recommended test procedures for demonstrating compliance with Section 3 requirements.

Section 6 Provides guidance on the installed SYSTEM. Installation effects may require FIDS performance in excess of the minimum requirements provided in this MOPS.

Operational performance specifications for functions or COMPONENTS that refer to equipment capabilities that exceed the stated minimum requirements are identified as optional features.

The word “equipment” as used in this document includes all COMPONENTS and units necessary for the SYSTEM to properly perform its intended function(s). For example, the “equipment” may include all of the COMPONENTS listed in 1.4. It should not be inferred that each FIDS design will necessarily include all of the COMPONENTS or units listed in that Section. This will depend on the specific design chosen by the FIDS manufacturer.

1.2 Applications

Compliance with this MOPS by FIDS manufacturers, installers and users is recommended as a means of assuring that the equipment will satisfactorily perform its intended functions under the ENVIRONMENTAL INFLIGHT ICING CONDITIONS established by the regulatory authorities in the reference documents listed in 1.6.

This MOPS is considered as guidance material and application of this document, and associated compliance demonstration, in whole or in part is the sole responsibility of the applicant and shall be agreed by the appropriate airworthiness authority. Mechanical and electrical interface standardizations were outside of the objectives of this SAE Aerospace Standard and are therefore not addressed by this MOPS.

As the measured values of equipment performance characteristics may be a function of the method of measurement, standard test conditions and methods of test are recommended in Section 5.

The members of AC-9C and WG-95 recognize that no FIDS is likely to be capable of performing all of the functions described in this document and it will be difficult to test each requirement exactly as written. Furthermore, each specific application may desire thresholds different than those specified. Therefore, it is not intended for a FIDS manufacturer to state their device complies with this entire MOPS. It is required that the FIDS manufacturer provide a compliance matrix against this MOPS as part of the qualification report to assist the AIRCRAFT manufacturer in understanding the FIDS performance. When used by an AIRCRAFT manufacturer to define FIDS requirements, the paragraphs required must be specified along with any modifications to the functions, thresholds, and/or test conditions.

1.2.1 Mandating and Recommendation Phrases

a. “Shall”: The use of the word “shall” indicates a mandated criterion; i.e., compliance with the particular procedure or specification is mandatory and no alternative may be applied.

b. “Should”: The use of the word “should” (and phrases such as “It is recommended that...,” etc.) indicates that although the procedure or criterion is regarded as the preferred option, alternative procedures, specifications, or criteria may be applied, provided that the manufacturer, installer, or tester can provide information or data to adequately support and justify the alternative.

1.3 System Description

For INFLIGHT icing operations, airworthiness and operations regulations require that a method of icing detection be provided and that, following AIRCRAFT icing detection, actions required for safe flight be implemented. Methods of ICE detection may be active or passive, primary, or advisory, and may or may not require flight crew intervention to initiate activation of AIRCRAFT SYSTEMs required for safe INFLIGHT icing operations. If not automatic, flight crew intervention is required to activate the appropriate AIRCRAFT SYSTEMs. Flight crews are required to use one or a combination of active and/or passive ICE detection methods/cues to detect icing. MOPS provided by this document apply to active icing detection methods, primary or advisory, defined herein as FIDS.

FIDS is a device/SYSTEM that senses, detects or discriminates and annunciates ICING CHARACTERISTICS to the flight crew and/or to AIRCRAFT SYSTEMS.

For the remainder of the document:

- Detect or detection means: “sense, detect, and annunciate.”

- Discriminate or discrimination means: “sense, discriminate, and annunciate.”

These devices/SYSTEMs detect the presence of ICE accreted on the SURFACE OF INTEREST and/or atmospheric ENVIRONMENTAL INFLIGHT ICING CONDITIONS, and possibly provide icing characterization information.

A FIDS ensures at least one of the intended functions defined in 2.3.

A FIDS includes at least one sensor that is directly or indirectly sensitive to the physical phenomenon of icing (such as atmospheric liquid water droplets and/or ICE crystals, atmospheric water vapor, temperature, or ICE accretion).

Passive ICE detection methods and AERODYNAMIC PERFORMANCE MONITORING SYSTEMs (APMS) are not addressed by this document.

1.4 Equipment Components

FIDS COMPONENTS include: sensor(s) required to perform FIDS FUNCTIONS, signal processor(s), and control unit(s) providing the output signal. A FIDS processing unit performs signal processing, sensor monitoring, data communication, or other functions. The processing unit may either be integrated with or separate from the sensor(s). Equipment COMPONENTS may be contained within a single unit or in multiple units and the sensor(s) may be intrusive or non-intrusive to the airflow.

The FIDS may be connected to a device to provide information to the cockpit crew. The FIDS may also communicate with other on-board equipment or SYSTEMs. However, cockpit displays or any other consumers of ICE detection information are not addressed in this MOPS.

1.5 Definitions and Abbreviations

1.5.1 Definitions

Refer to ARP5624 for more details or more definitions of icing-related terms.

ACTIVE* ICE DETECTION: Any process used for determining the presence of ENVIRONMENTAL INFLIGHT ICING CONDITIONS or ICE accretion which makes physical measurements and interprets/processes information to provide an indication to the flight crew and/or to AIRCRAFT SYSTEMs requiring no interpretation that ENVIRONMENTAL INFLIGHT ICING CONDITIONS or ICE accretion is present.

*NOTE: Both passive and active methods can be used either as a primary or advisory means.

ADVISORY FIDS (AFIDS): The AFIDS, in conjunction with visual cues, such as visible ICE accretion on the SURFACE OF INTEREST, should advise the flight crew to initiate operation of the IPS using airplane flight manual (AFM) procedures. An AFIDS is not the prime means used to determine if the IPS should be activated. When there is an AFIDS installed on an AIRCRAFT, the flight crew has primary responsibility for determining when the IPS must be activated.

AERODYNAMIC PERFORMANCE MONITORING SYSTEM (APMS): An AERODYNAMIC PERFORMANCE MONITORING SYSTEM monitors aerodynamic performance of AIRCRAFT surfaces that are amenable to ICE accretion and informs the cockpit crew or another SYSTEM about degradation of aerodynamic performance (these SYSTEMs are not considered in this MOPS).

AIRCRAFT: Any machine capable of flying by means of buoyancy or aerodynamic forces, such as an airship, ROTORCRAFT, or AIRPLANE.

AIRCRAFT SURFACES: Any surfaces exposed to external ENVIRONMENTAL INFLIGHT ICING CONDITIONS, whether internal or external to the AIRCRAFT and/or engine, subject to ICE accretion.

AIRPLANE (AEROPLANE): A fixed-wing vehicle that travels through air supported by the dynamic action of air against its lifting surfaces.

ANTI-ICING/ANTI-ICE: The prevention of ICE formation on a surface.

COMPONENT: A part of a SYSTEM (e.g., sensor, processor, or display).

CRITICAL SURFACE: A surface whose integrity affects safe AIRCRAFT take off, flight, and landing. A surface that accretes ICE and affects safe AIRCRAFT take off, flight, and landing is a CRITICAL SURFACE for INFLIGHT icing.

DEICING/DEICE: The periodic shedding of ICE accretion by destroying the bond between the ICE and the protected surface.

ENVIRONMENTAL INFLIGHT ICING CONDITIONS: Conditions encompassing either ICING CONDITIONS, GLACIATED CONDITIONS, or MIXED PHASE CONDITIONS.

FAILURE: Loss of function or malfunction of a SYSTEM or a part thereof.

FIDS FUNCTION(S): One of the FIDS functionalities defined in 2.3.

FREESTREAM: The air surrounding an AIRCRAFT in flight that is not disturbed by the AIRCRAFT's passage. Relative to aircraft icing, the undisturbed air is assumed sufficiently free from local airflow variations such that the icing drop trajectories (relative to the AIRCRAFT) are not altered.

FROST: ICE CRYSTALS formed on a surface by water vapor deposition from the atmosphere.

GLACIATED CONDITIONS: Conditions consisting entirely of ICE CRYSTALS; to be distinguished in this sense from ICING CONDITIONS containing exclusively SUPERCOOLED liquid water drops and MIXED CONDITIONS.

GLAZE ICE: Transparent or translucent ICE formed by liquid water drops which do not freeze immediately on impact.

HOVER: Flight at zero groundspeed. Operation in winds up to 35 knots from any azimuth is typically assumed.

ICE: Any form of frozen water found on an AIRCRAFT including clear ICE, GLAZE ICE, mixed ICE, RIME ICE, RUNBACK ICE, FROST, snow, ICE CRYSTALS, etc.

ICE CRYSTALS: Any one of a number of macroscopic, crystalline forms in which ICE appears, including hexagonal columns, hexagonal platelets, dendritic crystals, ice needles, and combinations of these forms.

ICING CHARACTERISTICS: A group of parameters that characterize an Icing event. Such parameters include, but are not limited to: atmospheric condition of encountered ENVIRONMENTAL INFLIGHT ICING CONDITIONS as defined in 1.8, temperature, presence of ICE, ICE thickness, ICE accretion rate, visible moisture, presence of water, LIQUID WATER CONTENT, the presence of ICE CRYSTALS, ice particle size, ice water content, water drops size, and exceedance of predefined values.

ICING CONDITIONS: The presence of SUPERCOOLED liquid water drops and temperature conducive to AIRCRAFT icing.

INFLIGHT: Flight phases from AIRCRAFT take off to AIRCRAFT landing.

INFLIGHT ICING DETECTION SYSTEM (FIDS): A FIDS includes at least one sensor which is directly or indirectly sensitive to the physical phenomenon of icing.

LATENT FAILURE: FAILURE which is not detected and/or annunciated. Per CS-25/14 CFR 25.1309-1A, a LATENT FAILURE is one that is inherently undetected when it occurs. LATENT FAILUREs result from the inability of the built-in test function to identify equipment FAILUREs.

LIQUID WATER CONTENT (LWC): LIQUID WATER CONTENT is the total mass of water contained in liquid drops within a unit volume or mass of cloud or precipitation, usually given in units of grams of water per cubic meter or per kilogram of dry air (g/m^3, g/kg).

MIXED PHASE CONDITIONS: A mixture of liquid SUPERCOOLED water drops and ICE CRYSTALS existing within the same cloud environment. Also called a mixed condition.

NUISANCE ALARM: Annunciation of the presence of ICE or ENVIRONMENTAL INFLIGHT ICING CONDITIONS when no ICE or no ENVIRONMENTAL INFLIGHT ICING CONDITIONS are present.

OPERATE (THE) IPS: Activation or deactivation of the AIRCRAFT ice protection SYSTEM (IPS) and/or control of the AIRCRAFT ANTI-ICING or DEICING functions.

PASSIVE* ICE DETECTION: Any process/technique used for determining the presence of ENVIRONMENTAL INFLIGHT ICING CONDITIONS or ICE accretion which requires flight crew intervention to interpret and make the final decision that ENVIRONMENTAL INFLIGHT ICING CONDITIONS or ICE accretion are/is present. examples include using information/cues derived from flight crew visual observation from the following sources: ICE accretion on reference surfaces, wipers post ICE accretion, lighted ICE accretion probe, ICE accretion information from an infrared imaging SYSTEM (non-enhanced), etc.

*NOTE: Both passive and active methods can be used either as a primary or advisory means.

PRIMARY FIDS (PFIDS): A PFIDS must either alert the flight crew who is then obligated to OPERATE THE IPS using AFM procedures or automatically activate the IPS before an unsafe accumulation of ice on the airframe, engine COMPONENTs, or engine air inlets occurs.

RESPONSE TIME: The elapsed time from the beginning of the icing event of interest to the annunciation of this icing event by the specific function of the FIDS to the flight crew and/or AIRCRAFT SYSTEMs.

RIME ICE: Milky and opaque ICE formed by liquid cloud drops that freeze immediately on impact.

ROTORCRAFT: ROTORCRAFT includes conventional helicopters of various configurations, compound helicopters, and tiltrotors.

RUNBACK ICE: Ice formed from the freezing or refreezing of water leaving an area on an AIRCRAFT surface that is above freezing and flowing downwind to an area that is sufficiently cooled for freezing to take place. This ICE type is frequently associated as an unwanted product of thermal ANTI-ICING or DEICING SYSTEMs.

SENSING SURFACE: The surface where a FIDS sensor makes its measurement.

SUPERCOOLED: Liquid cooled below the freezing point without solidification or crystallization.

SURFACE OF INTEREST: The AIRCRAFT surface of concern regarding ICE hazard (e.g., the leading edge of the wing).

SYSTEM: A combination of COMPONENTs/devices which are inter-connected to perform one or more functions.

UN-ANNUNCIATED: Lack of indication of (a parameter of interest).

V_{MINI}: ROTORCRAFT instrument flight minimum speed, utilized in complying with minimum limit speed requirements for instrument flight.

1.5.2 Abbreviation

AC	Alternating current, also advisory circular
AFIDS	ADVISORY INFLIGHT ICING DETECTION SYSTEM
AFM	Airplane flight manual
AIA	Aerospace Industries Association
AIR	Aerospace Information Report
Amdt	Amendment
AOA/AOS	Angle of attack/angle of sideslip
APFIDS	AUTOMATIC PRIMARY INFLIGHT ICING DETECTION SYSTEM
APMS	AERODYNAMIC PERFORMANCE MONITORING SYSTEM
ARP	Aerospace Recommended Practices
AS	Aerospace Standard
ATP	Acceptance test procedure
CFR	Code of Federal Regulations
C_p	Pressure coefficient
CPA	Critical point analysis
CS	Certification specification
DAL	Design assurance level

DC	Direct current
Dmax	Maximum liquid water drop size
Dvxx = yyy	Drops distribution such that xx% of the water in an icing cloud is contained in droplets with a diameter smaller than yyy micrometers (µm); e.g., Dv90=100 means 90% of the LIQUID WATER CONTENT is contained by drops with a diameter smaller than 100 µm Note: Dvxx < yyy means that you can have any distribution where the DVxx is below the specified value, e.g., Dv99 < 100
EASA	European Aviation Safety Agency
ED	EUROCAE document
EMI	Electromagnetic Interference
EUROCAE	European Organization for Civil Aviation Equipment
FAA	Federal Aviation Administration
FIDS	INFLIGHT ICING DETECTION SYSTEM
FMECA	FAILURE modes effects and criticality analysis
FOD	Foreign object damage
FZDZ	Freezing drizzle
FZRA	Freezing rain
GL	Glaciated
HIRF	High-intensity radiated fields
ICC	Ice Crystal Consortium
IGE/OGE	In ground effect/out of ground effect
I/O	Input/output
IPS	Ice protection SYSTEM
IWC	Ice water content; expressed in mass of ice water (from ICE CRYSTALS) per unit volume of air
IWT	Icing wind tunnel
KTAS	Knots true air speed
LRU	Line replaceable unit
LW	Liquid water drops atmospheric conditions (Appendices C and O)
LWC	LIQUID WATER CONTENT; expressed in mass of water per unit volume of air
LW-C	Liquid water drops atmospheric conditions Appendix C
LW-FZDZ	Liquid water drops atmospheric conditions Appendix O FZDZ

LW-FZRA	Liquid water drops atmospheric conditions Appendix O FZRA
LW-100+	Subset of liquid water drops having drop diameters above 100 µm
LW-500+	Subset of liquid water drops having drop diameters above 500 µm
MMD	Median mass diameter (of an ice crystal or ICE CRYSTALS population)
MOPS	Minimum operational performance specification
MP	MIXED PHASE CONDITIONS; a mixture of liquid SUPERCOOLED water drops and ICE CRYSTALS existing within the same cloud environment
MPFIDS	Manual PRIMARY INFLIGHT ICING DETECTION SYSTEM
MVD	Median volumetric diameter; defined in DOT/FAA/CT-88/8-1
N/A	Not applicable
OEM	Original equipment manufacturer
PFIDS	PRIMARY INFLIGHT ICING DETECTION SYSTEM
SLD	SUPERCOOLED large drops
SSA	SYSTEM safety assessment
TWC	Total water content (TWC = LWC + IWC)
WG-95	EUROCAE Working Group 95 tasked with developing ED103, MOPS for INFLIGHT ICE DETECTION SYSTEMS
WT	Wind tunnel

1.6 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.

1.6.1 SAE Publications and SAE/EUROCAE 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.

AIR1168/4	SAE Aerospace Applied Thermodynamics Manual Ice, Rain, Fog, and Frost Protection
ARP4256	Design Objectives for Liquid Crystal Displays for Part 25 (Transport) Aircraft
ARP4754/EUROCAE ED-79	Guidelines for Development of Civil Aircraft and Systems
ARP4761	Guidelines and Methods for Conducting the Safety Assessment Process on Civil Airborne Systems and Equipment
ARP5624	Aircraft Inflight Icing Terminology

ARP5905	Calibration and Acceptance of Icing Wind Tunnels
AS8034	Minimum Performance Standard for Airborne Multipurpose Electronic Displays

Jackson, D., “Primary Ice Detection Certification Under the New FAA and EASA Regulations,” SAE Technical Paper 2015-01-2105, 2015, https://doi.org/10.4271/2015-01-2105.

1.6.2 EUROCAE/RTCA Publications

Available from EUROCAE Secretariat, 9-23 Rue Paul Lafargue, 93200 Saint-Denis, France, Tel: +33 1 40 92 79 30, https://www.eurocae.net/.

ED-14/RTCA DO-160	Environmental Conditions and Test Procedures for Airborne Equipment
ED-12/RTCA DO-178	Software Considerations for Airborne Systems and Equipment Certification
ED-80/RTCA DO-254	Design Assurance Guidance for Airborne Electric Hardware

1.6.3 EASA Publications

Available from European Aviation Safety Agency, Konrad-Adenauer-Ufer 3, D-50668 Cologne, Germany (for visitors and for mail over 1 kg) and Postfach 10 12 53, D-50452 Cologne, Germany (for mail 1 kg or less); Tel: +49 221 8999 000, www.easa.europa.eu.

CS-23, Amdt. 5	(Normal, Utility, Aerobatic and Commuter Aeroplanes): §§ 23.1301, 23.1309 and 23.1322
CS-25, Amdt.26	(Large Aeroplanes) §§ 25.1419, 25.1420, 25.1302, 25.1309, and 25.1322, Appendix C, Appendix O, Appendix P. AMC 25-21(g) (Performance and Handling Characteristics in Icing Conditions), (AMC 25.1093 (Powerplant icing), AMC 25.1302 (Installed Systems and Equipment for Use by the Flight Crew), AMC 25.1324 (Flight Instruments External Probes), AMC 25.1419 (Ice Protection), AMC 25.1420 (SLD Icing Conditions)
CS-27, at Amdt. 7	(Small Rotorcraft) §§ 27.1301, 27.1309, 27.1322, and 27.1419
CS-29, at Amdt. 8	(Large Rotorcraft) §§ 29.1301, 29.1302, 29.1309, 29.1322, 29.1419; Appendix C
CS-E, at Amdt. 6	(Engines) § CS-E 230

EASA Commission Regulation No 748/2012

PART 21	Certification of Aircraft and Related Products, Parts and Appliances, and of Design and Production Organisation
	21.A.33 Inspection and Tests
	21.A.609 Obligations of Holders of ETSO Authorisations
	21.A.807 Identification of ETSO

1.6.4 FAA Publications

Available from Federal Aviation Administration, 800 Independence Avenue, SW, Washington, DC 20591, Tel: 866-835-5322, www.faa.gov.

1.6.4.1 Code of Federal Regulations (CFR)

Title 14 CFR Part 23	at Amdt. No. 23-64 (Airworthiness Standards: Normal, Utility, Acrobatic, and Commuter Category Airplanes), §§ 23.1309, 23.1322 and 23-1419
Title 14 CFR Part 25	at Amdt. No. 25-146 (Airworthiness Standards: Transport Category Airplanes): §§ 25.21(g), 25.1093, 25.1302, 25.1309, 25.1322, 25.1419, 25.1403, 25.1420; Appendix C; Appendix O
Title 14 CFR Part 27	at Amdt. No. 27-50 (Airworthiness Standards: Normal Category Rotorcraft), §§ 27.1301, 27.1309, 27.1322, and 27.1419
Title 14 CFR Part 29	at Amdt. No. 29-57 (Airworthiness Standards: Transport Category Rotorcraft): §§ 29.1301, 29.1302, 29.1309, 29.1322, and 29.1419; Appendix C
Title 14 CFR Part 33	at Amdt. No. 33-34 (Airworthiness Standards: Aircraft Engines); Appendix D
Title 14 CFR Part 45	at Amdt. 45-26 Identification and Registration Marking: § 45.15
Title 14 CFR Part 91	at Amdt. No. 91 (General Operating and Flight Rules)
Title 14 CFR Part 121	at Amdt. 121-370 (Operating Requirements: Domestic, Flag, and Supplemental Air Operations), § 121.321
Title 14 CFR Part 135	at Amdt. 135-130 (Operating Requirements: Commuter and On-Demand Operations and Rules Covering Persons Onboard Such Aircraft)

1.6.4.2 FAA Advisory Circulars (AC)

AC 20-73A	Aircraft Ice Protection
AC 20-147A	Turbojet, Turboprop, Turboshaft, and Turbofan Engine Induction System Icing and Ice Ingestion
AC 20-158A	The Certification of Aircraft Electrical and Electronic Systems for Operation in the High-intensity Radiated Fields (HIRF) Environment.
AC 20-175	Controls for Flight Deck Systems
AC 23.1309-1E	System Safety Analysis and Assessment for Part 23 Airplanes
AC 23.1311-1C	Installation of Electronic Displays in Part 23 Airplanes
AC 25-11B	Electronic Flight Displays
AC 25-25A	Performance and Handling Characteristics in Icing Conditions
AC 25-28	Compliance of Transport Category Airplanes with Certification Requirements for Flight in Icing Conditions
AC 25.1302-1	Installed Systems and Equipment for Use by the Flight Crew
AC 25.1309-1A	Systems Design and Analysis
AC 25.1322-1	Flight Crew Alerting
AC 91-74B	Pilot Guide: Flight In Icing Conditions
AC 121.321-1	Compliance with Requirements of 121.321 Operations in Icing

AC 27-1B Certification of Normal Category Rotorcraft

AC 29-2C Certification of Transport Category Rotorcraft

1.6.4.3 Aviation Rulemaking Committee Reports

Part 23 SLD ARC REPORT Part 23 Icing Aviation Rulemaking Committee Report Rev B, Feb 2012

1.6.4.4 FAA Orders

FAA ORDER 8110.4C Type Certification

1.6.5 U.S. Military Specifications

Copies of these documents are available online at https://quicksearch.dla.mil.

JSSG 2010-5 Crew Systems Aircraft Lighting Handbook

MIL-HDBK-217 Reliability Prediction of Electronic Equipment

MIL-STD-130 Identification Marking of U.S. Military Property

MIL-STD-1472 Human Engineering

1.6.6 U.S. Government Publications

Copies of these documents are available at https://ntrl.ntis.gov/NTRL/.

DOT/FAA/AR-09/10 Data and Analysis for the Development of an Engineering Standard for Supercooled Large Drop Conditions

DOT/FAA/CT-88/8-1 Aircraft Icing Handbook Volume 1 of 3

DOT/FAA/TC-18 An Assessment of Cloud Total Water Content and Particle Size from Flight Test Campaign Measurements in High Ice Water Content, Mixed Phase/Ice Crystal Icing Conditions: Primary In-Situ Measurement

1.6.7 Arnold Engineering and Development Center

Copies of this document is available from Defense Technical Information Center at https://discover.dtic.mil.

AEDC-TR-85-30, Vol 1 Analysis and Verification of the Icing Scaling Equations, Gary Ruff, March 1986

1.6.8 NASA Publications

Available from NASA Technical Services, NASA STI Program STI Support Services, Mail Stop 148, NASA Langley Research Center, Hampton, VA 23681-2199, 757-864-9658, Fax: 757-864-6500, http://ntrs.nasa.gov/

CR-2004-212875 Manual of Scaling Methods, David Anderson, March 2004

CR-2006-214127 Latest Developments in SLD scaling, Jen Ching Tsao and David N. Anderson Ohio Aerospace Institute Cleveland Ohio

CR-2008-215302 Ice Shape Scaling for Aircraft in SLD Conditions, Dave Anderson and Jen-Ching Tsao, September 2008 (Appendix C and SLD)

CR-2016-219131 Additional results of glaze icing scaling in SLD conditions, Jen Ching Tsao, Ohio Aerospace Institute Brook Park Ohio

TM-107140	Further Evaluation of Traditional Icing Scaling Methods, Anderson, David N., January 1996

1.6.9 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org.

ASTM F3120	Standard Specification for Ice Protection for General Aviation Aircraft

1.6.10 American Institute of Aeronautics and Astronautics (AIAA) Publications

Available from American Institute of Aeronautics and Astronautics, 1801 Alexander Bell Drive, Suite 500, Reston, VA 20191-4344, Tel: 703-264-7500, www.aiaa.org.

AIAA-88-0203	"Proposed Modifications to Ice Accretion/Icing Scaling Theory,," Bilanin, Alan J., January 1988
AIAA-95-0540	"Methods for Scaling Icing Test Conditions," Anderson, David N., January 1995
AIAA-2001-0679	"Ludlam Limit Considerations on cylinder ice accretion," Jackson, Cronin, Severson, Owens, 2001

1.6.11 Airlines for America (A4A) Publications

Available from Airlines for America (A4A), 1301 Pennsylvania Avenue, NW, Suite 1100, Washington, DC 20004, Tel: 202-626-4000, www.airlines.org.

Spec 2000 Chapter 9	Automated Identification and Data Capture

1.6.12 Other Applicable Publications

Canadian National Research Council (CNRC) Report No. LTR - LT – 92, An Appraisal of the Single Rotating Cylinder Method of Liquid Water Content Measurement, Stallabrass J. R., 1978.

Incropera F., DeWitt D., Bergman, T., Lavine, A., Fundamentals of Heat and Mass Transfer, 6th Edition, 2007.

1.7 Related Publications

The following publications are provided for information purposes only and are not a required part of this SAE Technical Report.

1.7.1 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.

AIR4367	Aircraft Inflight Ice Detectors and Icing Rate Measuring Instruments

1.7.2 ARINC Publications

Available from ARINC, 2551 Riva Road, Annapolis, MD 21401-7435, Tel: 410-266-4000, www.arinc.com.

ARINC 604	Guidance for Design and Use of Built-in Test Equipment (BITE)
ARINC 607	Design Guidance for Avionics Equipment

1.8 Atmospheric Conditions Operating Envelope

For this MOPS, ENVIRONMENTAL INFLIGHT ICING CONDITIONS include the following atmospheric conditions as defined in 1.8.1 and 1.8.2.

1.8.1 Liquid Water Drops Icing Conditions (LW)

- LW: Atmospheric ICING CONDITIONS containing only liquid water drops at temperatures conducive to AIRCRAFT icing.

- LW atmospheric ICING CONDITIONS include:

  - LW-C: Atmospheric ICING CONDITIONS defined by 14 CFR Part 25/CS-25 Appendix C and 14 CFR PART 29/CS-29 Appendix C for AIRPLANES.

  - LW-FZDZ: Freezing drizzle atmospheric ICING CONDITIONS defined by 14 CFR Part 25/CS-25 Appendix O FZDZ for AIRPLANES.

  - LW-FZRA: Freezing rain atmospheric ICING CONDITIONS defined by 14 CFR Part 25/CS-25 Appendix O FZRA Conditions for AIRPLANES.

- For this MOPS, droplet size subsets of LW-FZDZ and LW-FZRA include:

  - LW-100+: Subset of liquid water drops having drop diameters above 100 μm.

  - LW-500+: Subset of liquid water drops having drop diameters above 500 μm.

NOTE: For LW-FZDZ, LW-FZRA, LW-100+, and LW-500+ drops populations, see A.2 for the cumulative mass of the different drop size distributions.

1.8.2 Ice Crystals in Mixed Phase or Glaciated Conditions

- Atmospheric ICING CONDITIONS containing ICE CRYSTALS or particles in static air temperature colder than 0 °C (see note) and within specific altitudes affecting the AIRCRAFT and engine surfaces icing. These atmospheric ICING CONDITIONS include:

  - GL: GLACIATED CONDITIONS as defined CS-25 Appendix P/14 CFR Part 33 Appendix D for AIRPLANES.

  - MP: Mixed phase, liquid water drops and ICE CRYSTALS conditions as defined by CS-25 Appendix P/14 CFR Part 33 Appendix D for AIRPLANES.

If the FIDS is used as part of the flight instruments external probes ice protection logic, the extension of the 14 CFR Part 33 Appendix D/CS 25 Appendix P conditions shall be considered. Refer to EASA AMC 25.1324, § 12.1.

NOTE: It is recognized that there is a conflict between the upper temperature limit for EASA Figures 1 and 2 of Appendix P and FAA Figures D1 and D2 of Appendix D and it has been agreed with the authorities that this will be harmonized in the future.

NOTE: The results of recent convective weather high altitude ice crystal atmospheric characterization flight research provide new data regarding ice crystal cloud properties (e.g., ice crystal size, morphology, ice water content). The FAA report DOT/FAA/TC-18/1 provides updated information that is different than the current Appendix D/P regulatory envelopes. These differences will be evaluated in a future rulemaking process and may alter the current values identified in the regulations.

1.9 Assumptions

Long range icing awareness equipment (weather radars, lidar, radiometer, etc.) are not considered in this MOPS.

1.10 Compliance Demonstration

The test procedures specified in this document are intended to be used as one means of demonstrating compliance with minimum performance requirements defined in Section 3 and environmental requirements defined in Section 4.

Compliance of the FIDS to the requirements of this MOPS may be performed by one of the three following methods: test, analysis, or similarity. When analysis or similarity are used, appropriate rationale and evidence must be provided to satisfy regulatory requirements in the relevant qualification report(s). Only similarity to the original configuration tested is allowed.

Although specific test procedures are cited, it is recognized that other methods may be preferred. When showing compliance by tests, alternate procedures may be used if they provide at least equivalent information. In such cases, the procedures cited herein should be used as one criterion in evaluating the acceptability of the alternate procedures. Users of this document should not infer performance requirements based on test procedures.

Sections 2.9 and 2.10 establish the test setup and reporting requirements applicable to Sections 4 and 5. Additional test set-up requirements and guidelines are given in 5.2.3 for the conduct of tests in an icing wind tunnel.

a. Environmental Tests

Environmental test requirements are specified in Section 4. The procedures and their associated limits are intended to provide a laboratory means of determining the electrical and mechanical performance of the equipment under environmental conditions expected to be encountered in actual operations.

Unless otherwise specified, the environmental conditions and test procedures contained in EUROCAE ED-14/RTCA DO-160 will be used to demonstrate equipment compliance.

b. Performance Tests

Performance test procedures are specified in Section 5. These tests provide a laboratory means of demonstrating compliance with the requirements of Section 3. Test results may be used by equipment manufacturers as design guidance, for monitoring manufacturing compliance and, in certain cases, for obtaining formal approval of equipment design.

c. Installed Equipment Considerations

Additional tests and/or analysis for the installed equipment are required when performance cannot be adequately determined through Sections 4 and 5 test procedures or when FIDS performance parameters might be affected by its installation on the AIRCRAFT and can only be verified after installation. Section 6 provides guidance with regard to the analysis that might be required.

Installed equipment test may be used in lieu of test simulation of such factors as power supply characteristics, interference from or to other equipment installed on the AIRCRAFT, etc. Installed tests are normally performed under two conditions:

1. With the AIRCRAFT on the ground and using simulated or operational SYSTEM inputs.

2. With the AIRCRAFT in flight using dedicated Icing instrumentation and/or operational SYSTEM inputs appropriate to the equipment under test.

Test results may be used to demonstrate functional performance in the intended operational environment.

2. GENERAL DESIGN REQUIREMENTS

2.1 Introduction

This section establishes the design considerations and general requirements for FIDS equipment.

In addition to the general design requirements, 2.9 and 2.10 establish the reporting requirements and the test requirements applicable to Sections 4 and 5.

2.2 Airworthiness and Certification

When installed on an AIRCRAFT, the FIDS shall comply with any applicable airworthiness requirements, the scope of which is defined in the AIRCRAFT certification plan or type certification data sheet. See Section 6 for guidance.

2.3 Intended Functions

Minimum FIDS FUNCTIONs performance requirements are provided in Section 3.

A FIDS shall provide one or more of the following numbered functions:

- Indicate atmospheric ENVIRONMENTAL INFLIGHT ICING CONDITIONS:

  1. Detect liquid water drops ICING CONDITIONS (LW) above the specified threshold. See 3.3.1.1 (Appendix C, O, D/P mixed phase, only for the liquid part of it).

  2. Detect ICE CRYSTALS in mixed phase or GLACIATED CONDITIONS above the specified threshold. See 3.3.1.2 (Appendix D/P mixed phase or GLACIATED CONDITIONS).

- Discriminate specific liquid water drops ICING CONDITIONS:

  3. Discriminate Appendix O conditions above the specified threshold. See 3.3.1.3.1 (Appendix O).

  4. Discriminate Appendix O FZRA conditions above the specified threshold. See 3.3.1.3.1 (Appendix O).

- Discriminate specific GLACIATED or MIXED PHASE CONDITIONS:

  5. Discriminate GLACIATED (GL) CONDITIONS above the specified threshold. See 3.3.1.4 (Appendix D/P mixed phase or ICE CRYSTALS conditions).

  6. Discriminate MIXED PHASE (MP) CONDITIONS above the specified threshold. See 3.3.1.4 (Appendix D/P mixed phase or GLACIATED CONDITIONS).

- Indicate ICING CHARACTERISTICS:

  7. ICE accreted on the SURFACE OF INTEREST. See 3.3.2.1.

  8. Specific ICING CONDITIONS that exceed AIRCRAFT design parameters. See 3.3.2.2.

  9. Provide other information on ICING CHARACTERISTICS. Indicate: ICE thickness, ICE accretion rate, LIQUID WATER CONTENT, ICE water content, total water content, max drops size, MVD, other parameters. See 3.3.2.3 and following subsections.

2.4 Sensing Techniques

FIDS may use one or a combination of the following sensing techniques:

2.4.1 Ice Accretion Detection

- Makes a measurement on a SENSING SURFACE separated from the SURFACE OF INTEREST (e.g., probe type sensors).

- Makes a measurement on a SENSING SURFACE which is part of the SURFACE OF INTEREST (e.g., flush mounted sensors).

- Makes a remote measurement on a SENSING SURFACE which is part of the SURFACE OF INTEREST (e.g., observation of the wing from the fuselage.

2.4.2 Atmospheric Conditions Detection

- Directly sensitive to ENVIRONMENTAL INFLIGHT ICING CONDITIONS:

Methods that measure directly the characteristics of the atmospheric conditions that might be conducive to ice accretion on the AIRCRAFT SURFACES. For example, techniques may remotely measure LW drops size, LW drop concentration and/or ICE CRYSTALS in the airflow (e.g., drops or ICE CRYSTALS imaging, optical sensors, lidar, radar, radiometer, etc.).

- Indirectly sensitive to ENVIRONMENTAL INFLIGHT ICING CONDITIONS:

Methods that indirectly measure the characteristics of the ENVIRONMENTAL INFLIGHT ICING CONDITIONS by measuring the induced effect of the conditions on a sensing element. Such techniques may be sensitive to the presence of ice and/or water and/or heat exchange and/or aerodynamic degradation, excluding APMS.

2.5 Controls Accessibility and Effects

Controls which are not to be adjusted in flight shall not be readily accessible to flight personnel.

The operation of FIDS controls (e.g., test or reset inputs) available for use during flight, shall not result in a condition, the presence or continuation of which would be detrimental to the continued safe flight of the AIRCRAFT.

2.6 Maintainability

A FIDS design shall provide evidence to the AIRCRAFT (and other SYSTEMs as required) concerning any need for unscheduled maintenance action linked with loss of FIDS functionalities. Troubleshooting of the failed COMPONENTs shall be as detailed as necessary to fault isolate to the line replaceable unit (LRU) and/or function.

For any maintenance action, needs for non-standard tooling or specific labor skill should be avoided unless accepted by the OEM.

FIDS design should ensure no life limitation due to any COMPONENT, and thus no scheduled maintenance unless accepted by the OEM.

FIDS COMPONENTs with the same part number shall be fully interchangeable.

FIDS design shall include mechanical and electrical features ensuring proper installation.

FIDS manufacturers shall provide information to support AIRCRAFT maintenance and repair documentation (procedures, actions, etc.).

2.7 Software and Hardware Management Design

Software design shall follow EUROCAE ED-12/RTCA DO-178. The software design assurance level (DAL) will depend on the particular equipment function and application.

Electronic Hardware design shall follow EUROCAE ED-80/RTCA DO-254. The hardware DAL will depend on the particular equipment function and application.

Reference should be made to ARP4754/EUROCAE ED-79 as an additional source of guidance in these areas.

2.8 Additional Performance Criteria

2.8.1 Built-in Test (BIT)

Built-in test for the FIDS shall be designed taking into account reliability, maintainability, and safety considerations consistent with the requirements of the AIRCRAFT manufacturers. See 6.5.2.2 for additional guidance.

2.8.2 FIDS Temperature Measurement

For FIDS that rely on temperature measurement (internal or external to the FIDS), accuracy must be assessed when establishing the temperature threshold to avoid potential UN-ANNUNCIATED ENVIRONMENTAL INFLIGHT ICING CONDITIONS that are part of the intended FIDS FUNCTIONs.

The temperature thresholds used shall be specified by the FIDS manufacturer or the AIRCRAFT manufacturer.

If the temperature is used in combination with water content measurement, a SAT ≤5 °C or TAT ≤10 °C is commonly used to detect the presence of ENVIRONMENTAL INFLIGHT ICING CONDITIONS.

2.8.3 FIDS Design Robustness

External conditions likely to be encountered in service, such as air flow conditions, sun, rain, fuel, hydraulic fluid, deicing fluids, insects, sand, etc., need to be considered in the design robustness analysis.

FIDS manufacturers shall identify external conditions that could foreseeably lead to erroneous annunciation and demonstrate FIDS meets its intended functions under these conditions or clearly establish FIDS limitations.

Limitations resulting from external conditions shall be documented.

2.8.4 Nuisance Alarms

The FIDS should not annunciate the presence of ice or ENVIRONMENTAL INFLIGHT ICING CONDITIONS when no ice or no ENVIRONMENTAL INFLIGHT ICING CONDITIONS are present. NUISANCE ALARMs should be minimized.

2.8.5 Other Considerations

2.8.5.1 Hazards

If any COMPONENT of the FIDS can produce a hazard to personnel or property, then a warning label shall be prominently provided on the unit.

2.8.5.2 Foreign Object Damage (FOD)

The FIDS shall be constructed so that parts do not detach during normal operations.

FIDS FAILURE due to FOD shall be annunciated.

The FIDS should withstand strains, impacts, vibrations, and damage from foreign objects expected in normal operation. With the exception of FAILURE indication, the FIDS is not required to remain functional in order to satisfy this requirement.

2.9 General Reporting Requirements

It is recognized that it can be difficult to achieve and to demonstrate the stated performance requirements. Not only are those requirements difficult, but the state of the art in test/analysis capability will present challenges demonstrating the requirements of Section 3 particularly given uncertainties in test conditions and FIDS measurements. Requirements that are not met must be stated in the test report.

Additional test reporting requirements are listed in 2.10.

2.9.1 Summary Report

The equipment manufacturer or type certificate holder shall document as a minimum:

a. Qualification plan that follows the recommendations of 2.10.1.

b. Compliance matrix to the requirements of Sections 2, 3, and 4 as included in the qualification plan.

c. A completed environmental qualification form in accordance with Appendix A of EUROCAE ED-14/RTCA DO-160.

d. A description of the FIDS performance envelope. This shall include, but not be limited to, possible FIDS FUNCTION deviation, accuracy, and threshold for each of the applicable requirements of Section 3 over the ENVIRONMENTAL INFLIGHT ICING CONDITIONS and the intended flight envelope (e.g., altitude, airspeed, angle of attack/angle of sideslip (AOA/AOS), etc.).

e. Installation information for the end-user in accordance with 6.3.

2.9.2 Substantiating Test Data/Analysis

The equipment manufacturer shall compile and make available for review all the following:

a. Data to support the compliance of the equipment with all demonstrated requirements as required by the qualification plan. This includes data to show compliance with the design requirements of Section 2, the qualification test report of 4.2.3 and the performance test report of 5.1.1.

b. For FIDS incorporating software, data to show compliance with the appropriate level EUROCAE ED-12/RTCA DO-178.

c. For FIDS incorporating complex hardware, data to show compliance with the appropriate level EUROCAE ED-80/RTCA DO-254.

d. As applicable, analysis to show the effectiveness of built-in test capability.

e. As applicable, analysis to calculate the probability of functional FAILURE or the probability of an undetected functional FAILURE.

f. As applicable, FAILURE modes effects and criticality analysis (FMECA).

g. Verification test results that detail any human factor or design limitations.

h. As applicable, design tolerance/sensitivity and testing error analysis.

The preceding information is also referenced in 5.2 of this MOPS.

2.10 Test Requirements

2.10.1 Qualification Plan

The equipment manufacturer shall prepare a qualification plan that include the means of compliance (tests, analysis, similarity, etc.) used to demonstrate:

- All design requirements of Section 2.
- All functional requirements of Section 3.
- All environmental requirements of Section 4 and EUROCAE ED-14/RTCA DO-160.

The qualification plan shall include detailed test procedures and test setup when tests are used to determine compliance with this MOPS and the FIDS equipment performance specification. In particular, test procedures such as the ones given in Section 5 should be used to demonstrate the requirements of Section 3. These procedures shall include the ICING CONDITIONS from the test matrices (Tables 1 and 2) and any supplemental conditions required by the critical point analysis (see recommendations of 5.2.1 and 5.2.1.2).

The qualification plan shall also identify deviations such as:

- FIDS requirement deviations by design.
- Test facility limitations requiring alternative means of demonstrating compliance and description of the alternate method or test conditions.

2.10.2 Test Setup

The test setup used for qualification testing shall be representative of the AIRCRAFT installation. Depending on the DAL of the ICE detection function (e.g., Level A, B, etc.), an AIRCRAFT SYSTEM-level qualification test may be required. Alternatively, the exact wiring harness used on the AIRCRAFT may be required for certain qualification tests including an accurate representation of the impedance, loads, etc., of interfacing equipment outside of the FIDS (refer to FAA AC 20-158A or latest revision and EASA CS-25 Appendix R). Details of the qualification test setup(s), including photographs, shall be provided in the qualification test report(s).

2.10.3 Test Facilities

Each test facility used to perform testing shall demonstrate compliance with industry recommended practices (e.g., calibration, traceability with standards, etc.). Each test facility used shall be recorded in the test report(s).

2.10.4 Test Equipment

All test equipment used to perform testing shall be properly calibrated prior to the start of testing. The complete listing of equipment used in the testing shall be provided in the test report(s). The test equipment listing shall include the equipment description, manufacturer, model, asset identification number, and calibration due date at a minimum.

2.10.5 Conformity and Witnessing

Depending on regulatory requirements, a regulatory authority (not just company) conformity Inspection of the test article(s) and/or test setup(s) may be required prior to the start of testing (refer to FAA Order 8110.4; EASA Commission Regulation No 748/2012, paragraph 21.A.33 inspection and test). Since multiple test setups may be used for a particular test, consideration must be given whether the setup change is significant enough to warrant a new conformity inspection. In addition to the Conformity Inspection requirements, it may be required by the regulatory authority that each test is witnessed by a delegated engineering representative and/or representative from the AIRCRAFT manufacturer. A copy of all conformity inspection paperwork (if applicable) shall be included in the test report(s).

2.10.6 Test Article

Each ice detector test article shall be built to a released, documented configuration which is equivalent to the production standard. The test article(s) shall successfully pass an acceptance test procedure (ATP) prior to the start of Sections 4, 5, and 6 testing. The exact serial number of the test article(s) used in each qualification test and its associated ATP report (data sheet) shall be documented in the test report(s).

2.10.7 Power Input Voltage

Unless otherwise specified or agreed with the AIRCRAFT manufacturer, all tests shall be conducted with the power input voltage adjusted to design voltage ±2%. The input voltage shall be measured at the equipment input terminals.

Table 1 - Aircraft and rotorcraft test matrices for liquid water (LW) conditions: LW-C conditions

B	C	D	E	F	G	H	I	J	L	M	O	P
									Maximum RESPONSE TIME requirements according to Section 3.4			
Test Case #	Atmospheric Conditions	Aircraft True Air Speed	Static Temp	Static Temp	Liquid Drop MVD	Drops Distribution	LWC	IWC	Detection Time (LWC)	Discrimination Time App O Drops >100µm	Discrimination Time App O Drops >500µm	Detection Time (IWC)
	(- - -)	(knots)	(deg C)	(deg F)	(µm)	(µm)	(g/m^3)	(g/m^3)	(seconds)	(seconds)	(seconds)	(seconds)
1	LW-C	200	-40	-40,0	15	Dv99 <100	0,25	0	14	No Detection	No Detection	No Detection
2	LW-C	200	-10	14,0	15	Dv99 <100	0,6	0	7	No Detection	No Detection	No Detection
3	LW-C	150	-20	-4,0	25	Dv99 <100	0,15	0	28	No Detection	No Detection	No Detection
4	LW-C	200	-30	-22,0	30	Dv99 <100	0,5	0	6	No Detection	No Detection	No Detection
5	LW-C	250	-20	-4,0	15	Dv99 <100	1,9	0	2	No Detection	No Detection	No Detection
6	LW-C	200	-10	14,0	25	Dv99 <100	1,45	0	6	No Detection	No Detection	No Detection
7	LW-C	120	-30	-22,0	40	Dv99 <100	0,05	0	99	No Detection	No Detection	No Detection
8	LW-C	200	-3	26,6	40	Dv99 <100	0,14	0	46	No Detection	No Detection	No Detection
9	LW-C	150	-2,5	27,5	30	Dv99 <100	1,3	0	34	No Detection	No Detection	No Detection
10	LW-C	200	-3,5	25,7	15	Dv99 <100	2,9	0	18	No Detection	No Detection	No Detection
11	LW-FZDZ	450	-25	-13,0	20	MVD <40 Dmax <500	0,295	0	5	56	No Detection	No Detection
12	LW-FZDZ	200	-4	24,8	20	MVD <40 Dmax <500	0,43	0	23	87	No Detection	No Detection
13	LW-FZDZ	200	-25	-13,0	110	MVD >40 Dmax <500	0,05	0	55	103	No Detection	No Detection
14	LW-FZDZ	200	-4	24,8	110	MVD >40 Dmax <500	0,43	0	24	26	No Detection	No Detection
15	LW-FZDZ	300	-13	8,6	110	MVD >40 Dmax <500	0,24	0	8	14	No Detection	No Detection
16	LW-FZRA	200	-4	24,8	19	MVD <40	0,29	0	24	33	49	No Detection
17	LW-FZRA	150	-2,5	27,5	526	MVD >40	0,05	0	72	96	137	No Detection
18	LW-FZRA	200	-13	8,6	526	MVD >40	0,05	0	54	72	103	No Detection

Appendix C	Appendix O	
CM	FZDZ < 40	FZRA < 40
IM	FZDZ > 40	FZRA > 40

AIRCRAFT Test Matrix

NOTE: Test case LW-C #1 at -40 °C is an extremely low temperature condition belonging to the Appendix C IM envelope of the current regulations. Figure 4 of Appendix C is representing this -40 °C temperature limit by a dotted line and as a possible extent of the temperature limits. Indeed, at such low temperature there is a high risk of spontaneous drops freezing with a possible partial or total drops freeze-out, reducing the number of (or avoiding any) liquid water drops to reach the FIDS under test. The applicant should identify the occurrence of this phenomenon and alternate methods should be considered to demonstrate the capability to detect these conditions.

B	C	D	E	F	G	H	I	J	L	M	O	P
									Maximum RESPONSE TIME requirements according to Section 3.4			
Test Case #	Atmospheric Conditions	Rotorcraft True Air Speed	Static Temp	Static Temp	Liquid Drop MVD	Drops Distribution	LWC	IWC	Detection Time (LWC)	Discrimination Time App O Drops >100µm	Discrimination Time App O Drops >500µm	Detection Time (IWC)
	(- - -)	(knots)	(deg C)	(deg F)	(µm)	(µm)	(g/m^3)	(g/m^3)	(seconds)	(seconds)	(seconds)	(seconds)
1R	LW-C	120	-30	-22,0	15	Dv99 <100	0,25	0	26	No Detection	No Detection	No Detection
2R	LW-C	120	-15	5,0	15	Dv99 <100	0,6	0	11	No Detection	No Detection	No Detection
3R	LW-C	80	-10	14,0	20	Dv99 <100	0,15	0	61	No Detection	No Detection	No Detection
4R	LW-C	120	-20	-4,0	30	Dv99 <100	0,5	0	10	No Detection	No Detection	No Detection
5R	LW-C	140	-10	14,0	15	Dv99 <100	1,9	0	6	No Detection	No Detection	No Detection
6R	LW-C	120	-5	23,0	20	Dv99 <100	1,45	0	14	No Detection	No Detection	No Detection
7R	LW-C	40	-20	-4,0	40	Dv99 <100	0,05	0	321	No Detection	No Detection	No Detection
8R	LW-C	150	-2,5	27,5	40	Dv99 <100	0,16	0	45	No Detection	No Detection	No Detection
9R	LW-C	80	-2,5	27,5	30	Dv99 <100	1,3	0	37	No Detection	No Detection	No Detection
10R	LW-C	120	-3,5	25,7	15	Dv99 <100	2,9	0	17	No Detection	No Detection	No Detection
11R	LW-FZDZ (*)	150	-25	-13,0	20	MVD <40 Dmax <500	0,295	0	15	170	No Detection	No Detection
12R	LW-FZDZ (*)	80	-4	24,8	20	MVD <40 Dmax <500	0,43	0	24	219	No Detection	No Detection
13R	LW-FZDZ (*)	80	-25	-13,0	110	MVD >40 Dmax <500	0,05	0	138	260	No Detection	No Detection
13R	LW-FZDZ (*)	120	-2,5	27,5	110	MVD >40 Dmax <500	0,43	0	40	42	No Detection	No Detection
15R	LW-FZDZ (*)	150	-13	8,6	110	MVD >40 Dmax <500	0,24	0	15	29	No Detection	No Detection
16R	LW-FZRA (*)	150	-4	24,8	19	MVD <40	0,29	0	21	44	65	No Detection
17R	LW-FZRA (*)	80	-2,5	27,5	526	MVD >40	0,05	0	134	180	257	No Detection
18R	LW-FZRA (*)	150	-13	8,6	526	MVD >40	0,05	0	72	96	137	No Detection

Appendix C	Appendix O	
CM	FZDZ < 40	FZRA < 40
IM	FZDZ > 40	FZRA > 40

ROTORCRAFT Test Matrix

(*) FZDZ & FZRA test conditions are given in this document in case of ROTORCRAFT Regulations change but were not applicable at the time of the approval of this document.

Table 2 - Aircraft and rotorcraft test matrices for mixed phase or glaciated conditions: GL, MP conditions

B	C	D	E	F	G	H	I	J	K	L	O	P	R	S
											Maximum RESPONSE TIME requirements according to Section 3.4			
Test Case #	Atmospheric Conditions	Aircraft True Air Speed	Static Temp	Static Temp	Liquid Drop MVD	Drops Distribution	LWC	Ice Crystal MMD	IWC	TWC	Detection Time (LWC)	Discrimination Time App O Drops >100µm	Discrimination Time App O Drops >500µm	Detection Time (IWC)
	(- - -)	(knots)	(deg C)	(deg F)	(µm)	(µm)	(g/m³)	(µm)	(g/m³)	(g/m³)	(seconds)	(seconds)	(seconds)	(seconds)
1	GL	450	-60	-76,0	n/a	n/a	0	50-200	3,3	3,3	No Detection	No Detection	No Detection	6
2	GL	300	-40	-40,0	n/a	n/a	0	1000	3,5	3,5	No Detection	No Detection	No Detection	8
3	GL	250	-40	-40,0	n/a	n/a	0	50-200	2	2	No Detection	No Detection	No Detection	19
4	GL	250	-20	-4,0	n/a	n/a	0	50-200	4,8	4,8	No Detection	No Detection	No Detection	7
5	GL	150	-20	-4,0	n/a	n/a	0	50-200	1,3	1,3	No Detection	No Detection	No Detection	79
6	GL	200	0	32,0	n/a	n/a	0	50-200	3	3	No Detection	No Detection	No Detection	15
7	MP	200	-20	-4,0	15	Dv99 <100	0,7	50-200	0,5	1,2	5	No Detection	No Detection	500
8	MP	300	-10	14,0	15	Dv99 <100	1	50-200	2	3	7	No Detection	No Detection	15
9	MP	450	-20	-4,0	15	Dv99 <100	0,29	50-200	4,3	4,59	5	No Detection	No Detection	4
10	MP	150	-2,5	27,5	15	Dv99 <100	0,5	50-200	0,5	1	38	No Detection	No Detection	500
11	MP	250	-5	23,0	15	Dv99 <100	1	50-200	4	5	18	No Detection	No Detection	9
12	MP	200	-20	-4,0	110	MVD >40 Dmax <500	0,2	50-200	1	1,2	14	26	No Detection	76
13	MP	200	-4	24,8	110	MVD >40 Dmax <500	0,43	50-200	0,6	1,03	24	26	No Detection	341
14	MP	300	-10	14,0	110	MVD >40 Dmax <500	0,2	50-200	2,8	3	9	17	No Detection	10
15	MP	450	-20	-4,0	110	MVD >40 Dmax <500	0,2	50-200	3,8	4	6	11	No Detection	5
16	MP	150	-2,5	27,5	526	MVD >40	0,2	50-200	0,8	1	45	45	46	341
17	MP	250	-5,5	22,1	526	MVD >40	0,2	1000	4,8	5	19	20	21	7

Ice Crystals + App C	Ice Crystals + App O		Fully Claciated App D/P
CM	FZDZ < 40	FZRA < 40	
IM	FZDZ > 40	FZRA > 40	

AIRCRAFT Test Matrix

B	C	D	E	F	G	H	I	J	K	L	O	P	R	S
											Maximum RESPONSE TIME requirements according to Section 3.4			
Test Case #	**Atmospheric Conditions**	**Rotorcraft True Air Speed**	**Static Temp**	**Static Temp**	**Liquid Drop MVD**	**Drops Distribution**	**LWC**	**Ice Crystal MMD**	**IWC**	**TWC**	**Maximum Detection Time (LWC)**	**Discrimination Time App O Drops >100µm**	**Discrimination Time App O Drops >500µm**	**Detection Time (IWC)**
	(- - -)	**(knots)**	**(deg C)**	**(deg F)**	**(µm)**	**(µm)**	**(g/m^3)**	**(µm)**	**(g/m^3)**	**(g/m^3)**	**(seconds)**	**(seconds)**	**(seconds)**	**(seconds)**
1R	GL (*)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
2R	GL (*)	150	-30	-22,0	n/a	n/a	0	1000	3,5	3,5	No Detection	No Detection	No Detection	18
3R	GL (*)	120	-30	-22,0	n/a	n/a	0	50-200	2	2,0	No Detection	No Detection	No Detection	54
4R	GL (*)	120	-20	-4,0	n/a	n/a	0	50-200	4,8	4,8	No Detection	No Detection	No Detection	16
5R	GL (*)	80	-20	-4,0	n/a	n/a	0	50-200	1,3	1,3	No Detection	No Detection	No Detection	500
6R	GL (*)	120	0	32,0	n/a	n/a	0	50-200	3	3,0	No Detection	No Detection	No Detection	30
7R	MP (*)	120	-20	-4,0	15	Dv99 <100	0,7	50-200	0,5	1,2	9	No Detection	No Detection	500
8R	MP (*)	140	-5	23,0	15	Dv99 <100	1	50-200	2	3,0	14	No Detection	No Detection	43
9R	MP (*)	150	-20	-4,0	15	Dv99 <100	0,29	50-200	4,3	4,6	17	No Detection	No Detection	14
10R	MP (*)	80	-2,5	27,5	15	Dv99 <100	0,5	50-200	0,5	1,0	36	No Detection	No Detection	500
11R	MP (*)	120	-5	23,0	15	Dv99 <100	1	50-200	4	5,0	15	No Detection	No Detection	20
12R	MP (*)	80	-20	-4,0	110	MVD >40 Dmax <500	0,2	50-200	1	1,2	35	65	No Detection	500
13R	MP (*)	120	-2,5	27,5	110	MVD >40 Dmax <500	0,43	50-200	1	1,4	40	42	No Detection	341
14R	MP (*)	120	-10	14,0	110	MVD >40 Dmax <500	0,2	50-200	2,8	3,0	23	43	No Detection	33
15R	MP (*)	150	-20	-4,0	110	MVD >40 Dmax <500	0,2	50-200	3,8	4,0	18	35	No Detection	16
16R	MP (*)	80	-2,5	27,5	526	MVD >40	0,2	50-200	0,8	1,0	46	46	64	500
17R	MP (*)	150	-5,5	22,1	526	MVD >40	0,2	1000	4,8	5,0	18	24	34	12

Ice Crystals + App C	Ice Crystals + App O		Fully Glaciated App D/P
CM	FZDZ < 40	FZRA < 40	
IM	FZDZ > 40	FZRA > 40	

ROTORCRAFT Test Matrix

(*) GL & MP test conditions are given in this document in case of ROTORCRAFT Regulations change but were not applicable at the time of the approval of this document.

NOTE: For the AIRCRAFT and ROTORCRAFT Table 2, the maximum detection time of Column O and the discrimination time of Column P and R under the mixed phase (MP) conditions are calculated considering only the relevant LWC part contained in the MP conditions. In some MIXED PHASE CONDITIONS with low LWC and high IWC, erosion may occur, preventing this requrement to be met. If this occurs, the FIDS manufacturer must characterize this behavior and provide the information in the report provided to the end user (see 6.3).

2.10.8 Power Input Frequency

In the case of equipment designed for operation from an AC power source of essentially constant frequency (e.g., 400 Hz), the input frequency shall be adjusted to design frequency ±2%.

In the case of equipment designed for operation from an AC power source of variable frequency (e.g., 300 to 1000 Hz), unless otherwise specified, tests shall be conducted with the input frequency adjusted to within 5% of a selected frequency within the range for which the equipment is designed.

3. MINIMUM PERFORMANCE SPECIFICATION UNDER ENVIRONMENTAL INFLIGHT ICING CONDITIONS

3.1 Introduction

This section defines the minimum performance specification under ENVIRONMENTAL INFLIGHT ICING CONDITIONS and the performance requirements for FIDS FUNCTION, including RESPONSE TIME requirements. Deviations from these requirements may be needed to satisfy specific AIRCRAFT manufacturer's requirements and/or to comply with regulatory requirements. Deviations shall be documented.

The FIDS manufacturer shall take into account the possibility that ENVIRONMENTAL INFLIGHT ICING CONDITIONS at the installed location may differ from FREESTREAM conditions. See Section 6 for installed SYSTEM considerations and possible impacts on FIDS performance when exposed to different values and ranges of ICING CHARACTERISTICS (e.g., extended temperature range, LWC and IWC concentration factor, MVD distribution, airspeed, etc.).

See 5.2.1.2 for guidance on installation factors when showing compliance with the following requirements.

3.2 Flight Envelopes

Unless otherwise specified the following airspeed and altitude apply to all requirements of the following paragraphs depending on the AIRCRAFT type:

- ROTORCRAFT: 40 KTAS < TAS < 200 KTAS and -2000 feet < Alt < 20000 feet.
- AIRPLANE: 60 KTAS < TAS < 520 KTAS and -2000 feet < Alt < 51000 feet.

NOTE: Both ROTORCRAFT and AIRPLANE requirements may apply to tilt-rotors and other compound ROTORCRAFT.

3.3 FIDS Functions and Minimum Operating Performance Specification

3.3.1 Atmospheric Environmental Inflight Icing Conditions

A FIDS that detects ENVIRONMENTAL INFLIGHT ICING CONDITIONS shall communicate the information to the flight crew or to another AIRCRAFT SYSTEM complying with one or more of the following FIDS FUNCTIONS.

3.3.1.1 Detect Liquid Water Drops Icing Conditions (LW)

LW FIDS FUNCTION shall be sensitive to LWC conditions equal to or greater than 0.05 g/m^3.

The maximum RESPONSE TIME of this LW FIDS FUNCTION to detect the presence of liquid water drops when exposed to LW atmospheric conditions as defined by 1.8.1 shall be calculated using Equation 1, given in 3.4.1.1, where the LWC distribution considered is defined in Table 3.

Table 3 - LWC distribution requirements for LW FIDS functions

LW FIDS FUNCTIONs	LWC distribution used in Equation 1
LW-C	Appendix C only **(LW-C)**
LW-FZDZ	Freezing drizzle portion of Appendix O **(LW-FZDZ)**
LW-FZRA	All of Appendix O **(LW-FZRA)**

3.3.1.2 Detect Ice Crystals in Mixed Phase or Glaciated Conditions

Whether in glaciated or MIXED PHASE CONDITIONS, this FIDS FUNCTION shall be sensitive to IWC conditions equal to or greater than 0.5g/m^3 regardless of the TWC.

The maximum RESPONSE TIME of this FIDS FUNCTION to detect the presence of MIXED PHASE OR GLACIATED CONDITIONS shall be calculated using Equation 2 and the resulting curve (curve fit) as described in 3.4.1.2, where the IWC considered is defined in 1.8.2.

3.3.1.3 Discriminate Specific Liquid Water Drops Icing Conditions

This FIDS FUNCTION shall be sensitive to LWC conditions equal to or greater than 0.05 g/m^3 for the drops belonging to the relevant drop population as defined by 1.8.1.

3.3.1.3.1 Discriminate Appendix O Conditions

The FIDS may provide an Appendix O and Appendix O FZRA function which discriminates the presence of liquid water drop conditions having drop diameters exceeding a particular value as defined in Table 4 and in 1.8.1.

The maximum RESPONSE TIME for this FIDS FUNCTION to discriminate Appendix O and Appendix O FZRA conditions from other ICING CONDITIONS shall be calculated using Equation 1 given in 3.4.1.1, where the LWC considered is only for drops belonging to the desired drop population as defined in Table 4 and in 1.8.1.

See A.2 for assumptions and discrimination time calculations.

Table 4 - LWC requirements for Appendix O FIDS functions

Appendix O FIDS FUNCTIONS	Environment	Drops Population for LWC
Appendix O	LW-FZDZ or LW-FZRA	>100 µm(LW-100+)
Appendix O FZRA	LW-FZRA	>500 µm(LW-500+)

NOTE: When Appendix O conditions are identified without the identification of Appendix O FZRA, then Appendix O FZDZ conditions are inferred.

3.3.1.4 Discriminate Specific GLACIATED or MIXED PHASE CONDITIONS

This FIDS FUNCTION discriminates GLACIATED (GL) from MIXED PHASE (MP) CONDITIONS from liquid water (LW) conditions as defined by 1.8.2.

The maximum response time for this function to discriminate GL or MP conditions from other ICING CONDITIONS is given in Table 5.

Whether in fully glaciated or mixed phase, this FIDS FUNCTION shall be sensitive to IWC conditions equal to or greater than 0.5 g/m^3 regardless of the TWC.

Table 5 - GL and MP response time requirements

FIDS Function	Discrimination Time
GL	Calculated using IWC in Equation 2 and the resulting curve (curve fit) of Figure 2 as described in 3.4.1.2
MP	The longer of the two values calculated from LWC using Equation 1 given in 3.4.1.1 and using IWC in Equation 2 and the resulting curve (curve fit) of Figure 2 as described in 3.4.1.2.

3.3.2 Icing Characteristics

A FIDS that provides information on ICING CHARACTERISTICS when flying in the ENVIRONMENTAL INFLIGHT ICING CONDITIONS shall communicate the information to the flight crew or to another AIRCRAFT SYSTEM complying with one or more of the following FIDS FUNCTIONS.

3.3.2.1 Ice Accreted on the Surface of Interest

This FIDS FUNCTION detects the presence of ICE with a maximum thickness detection threshold of 0.3 mm on the SURFACE OF INTEREST using ice accretion based sensing methods; see 2.4.1 for more details.

If the FIDS has the capability to remove accumulated ice, the annunciation of ICE should be maintained at least for the duration to recover the capability of performing detection. If the thickness of accreted ICE on the FIDS SENSING SURFACE is in excess of the threshold thickness, the FIDS shall continue to annunciate the presence of ICE.

3.3.2.2 Specific Conditions that Exceed Aircraft Design Parameters

This FIDS FUNCTION detects when the ENVIRONMENTAL INFLIGHT ICING CONDITIONS and/or resulting ICE accretion exceed thresholds determined by the AIRCRAFT manufacturer within the accuracy specified in the relevant sub-paragraph of 3.3.2. AIRCRAFT manufacturers may identify design limitations of the AIRCRAFT ice protection. These limitations are typically based on drop size (e.g., Dmax, MVD, etc.), LWC, ICE accretion rate, etc.

The FIDS FUNCTION shall continue to annunciate that exceedance conditions exist as long as the measurement exceeds the specified threshold.

NOTE: The design parameters are specified by the AIRCRAFT manufacturer.

3.3.2.3 Provide Other Information on ICING CHARACTERISTICS

Unless specified in the following sections, the RESPONSE TIME and sampling rate for each of the following functions shall be specified in the FIDS manufacturer's specification.

3.3.2.3.1 Ice Thickness Measurement and Indication

ICE thickness measuring capability shall indicate the ICE thickness value above 0.3 mm with a measurement accuracy of ±0.2 mm or ±20% of the thickness, whichever is greater.

The FIDS manufacturer shall specify the maximum thickness the device can measure and the range for which this accuracy applies.

It is expected that the sampling rate the FIDS uses to measure the function above should take into account the ICE accretion rates that can be encountered.

3.3.2.3.2 Ice Accretion Rate Measurement and Indication

The ice accretion rate measuring function shall provide a measurement of ICE accretion rates as low as 0.1 mm/min, and as high as 18 mm/min. The ICE accretion rate measurement shall have a minimum accuracy of ±30% or ±0.1 mm/min, whichever is greater. For ICE accretion rates greater than 18 mm/min, the FIDS may saturate, but shall still indicate at least 18 mm/min.

The FIDS shall indicate the ICE accretion rate value within two times the RESPONSE TIME τ as defined by Equation 1, given in 3.4.1.1, as long as an initial ICE detection signal is provided within one times τ. Once provided, the FIDS shall update the measurement at a maximum interval of one times τ.

It is expected that the sampling rate the FIDS uses to measure the function above should take into account the ICE accretion rates that can be encountered.

3.3.2.3.3 Liquid Water Content (LWC) Measurement and Indication

LWC shall be measured having a minimum threshold of 0.05 g/m^3 and with a measurement accuracy of ±0.03 g/m^3 or ±30%, whichever is greater. The maximum measurable LWC and the LWC range that the required accuracy applies to shall be defined.

3.3.2.3.4 Max Drops Size (Dmax) Measurement and Indication

Liquid water Dmax capability shall measure with an accuracy of ±100 µm or ±20%, whichever is smaller. The minimum and maximum measurable Dmax that the required accuracy applies to shall be defined.

This FIDS function shall be sensitive to LWC conditions equal or greater than 0.05 g/m^3.

3.3.2.3.5 Drops MVD Measurement and Indication

MVD shall be measured with a measurement accuracy of ±20%. The minimum and maximum measurable MVD that the required accuracy applies to shall be defined.

This FIDS FUNCTION shall be sensitive to LWC conditions equal to or greater than 0.05 g/m^3.

3.3.2.3.6 Ice Water Content Measurement and Indication

IWC shall be measured having a minimum threshold of 0.5 g/m^3 and with a measurement accuracy of ±30%. The maximum measurable IWC and the IWC range that the required accuracy applies to shall be defined.

3.3.2.3.7 Total Water Content Measurement and Indication

Total water content measurement under MIXED PHASE CONDITIONS shall comply with requirements given in 3.3.2.3.3 for LWC for the liquid water part and shall comply with requirements given in 3.3.2.3.6 for the IWC for ICE CRYSTAL part.

3.3.2.3.8 Measurement and Indication of Other Parameters

Some FIDS FUNCTIONs may provide information on other parameters (ICE CRYSTAL size, MMD, temperature, etc.). In this case, the FIDS manufacturer shall specify the accuracy of these parameters in their range of measurement.

3.4 FIDS Response Time Requirement

3.4.1 Entering Environmental Inflight Icing Conditions

3.4.1.1 When Exposed to Liquid Water Drops Icing Conditions

Equation 1 shall be used to calculate the maximum FIDS RESPONSE TIME, τ, to detect the presence of ICING CONDITIONS liquid water (LW) icing.

See Appendix A for FIDS RESPONSE TIME requirements and rationale, A.1 for RESPONSE TIME when exposed to liquid water drops conditions, and A.2 for rationale for discrimination time when exposed to Appendix O conditions.

$$\tau = t\rho/(\beta_s\, LWC_s\, V_s\, \eta_s) \quad \text{(Eq. 1)}$$

where each of these terms is evaluated at (or on) the AIRCRAFT CRITICAL SURFACE OF INTEREST, local conditions as represented by Figure 1 and defined as follows:

τ = maximum FIDS RESPONSE TIME (seconds)

β_s = local collection efficiency (non-dimensional value)

LWC_s = local LIQUID WATER CONTENT calculated from liquid water mass of interest (g/m^3) (see A.2, 3.3.1.1, and 3.3.1.3)

V_s = local true airspeed (m/s)

η_s = local freezing fraction (non-dimensional value)

t = maximum allowable ice thickness (m)

ρ = ice density (g/m^3); ρ = 0.917 x 10^6 g/m^3

The equipment manufacturer should work with the AIRCRAFT manufacturer to determine the appropriate values of β_S, η_S, and t to use in Equation 1. However, if no information is directly available from the AIRCRAFT manufacturer; for the purpose of this MOPS and in order to provide a practical way to calculate a RESPONSE TIME, a maximum allowable ice thickness (t) of 0.3 mm can be recommended, and the parameters β_S and η_S can be calculated using the method given in A.1.1.

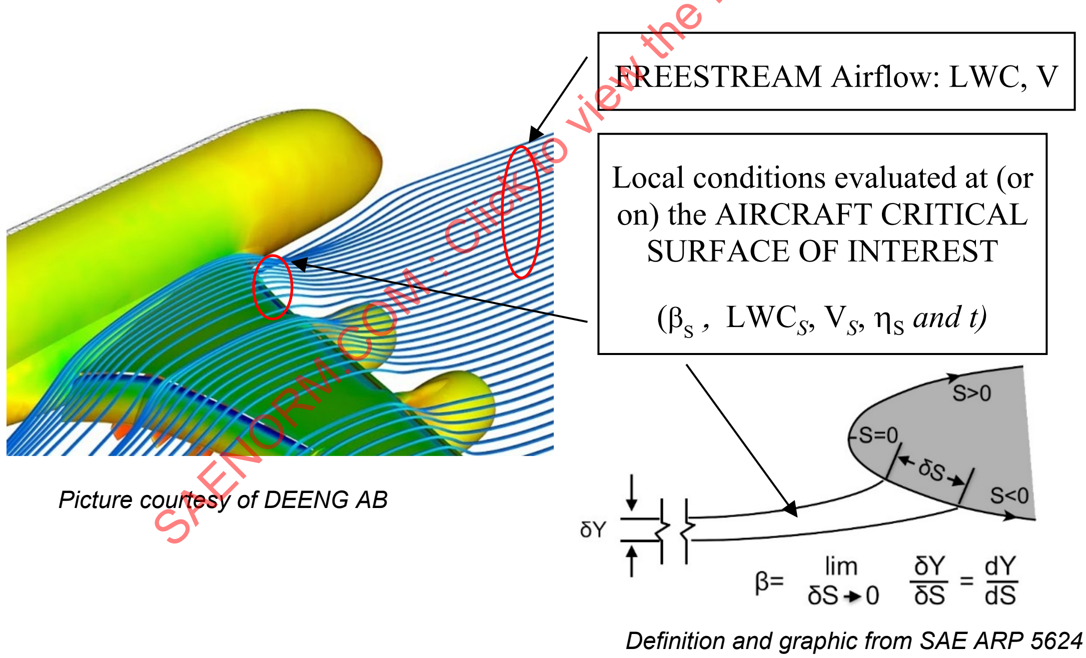


Figure 1 - Local air flow conditions evaluated at the surface of interest

3.4.1.2 When Exposed to ICE CRYSTALS in MIXED PHASE or GLACIATED CONDITIONS

The requirements for MIXED PHASE or GLACIATED CONDITIONS do not apply to ROTORCRAFT.

Sections 3.3.1.2 and 3.3.1.4 provide FIDS FUNCTIONs requirements when exposed to MIXED PHASE or GLACIATED CONDITIONS and shall take into account the following maximum RESPONSE TIME determination method.

The maximum RESPONSE TIME to detect the presence of ICE CRYSTALS contained in MIXED PHASE or GLACIATED CONDITIONS as defined by 1.8.2, is provided by Equation 2 and the resulting curve (curve fit) of Figure 2.

See A.3 for rationale on the RESPONSE TIME when exposed to ICE CRYSTAL conditions.

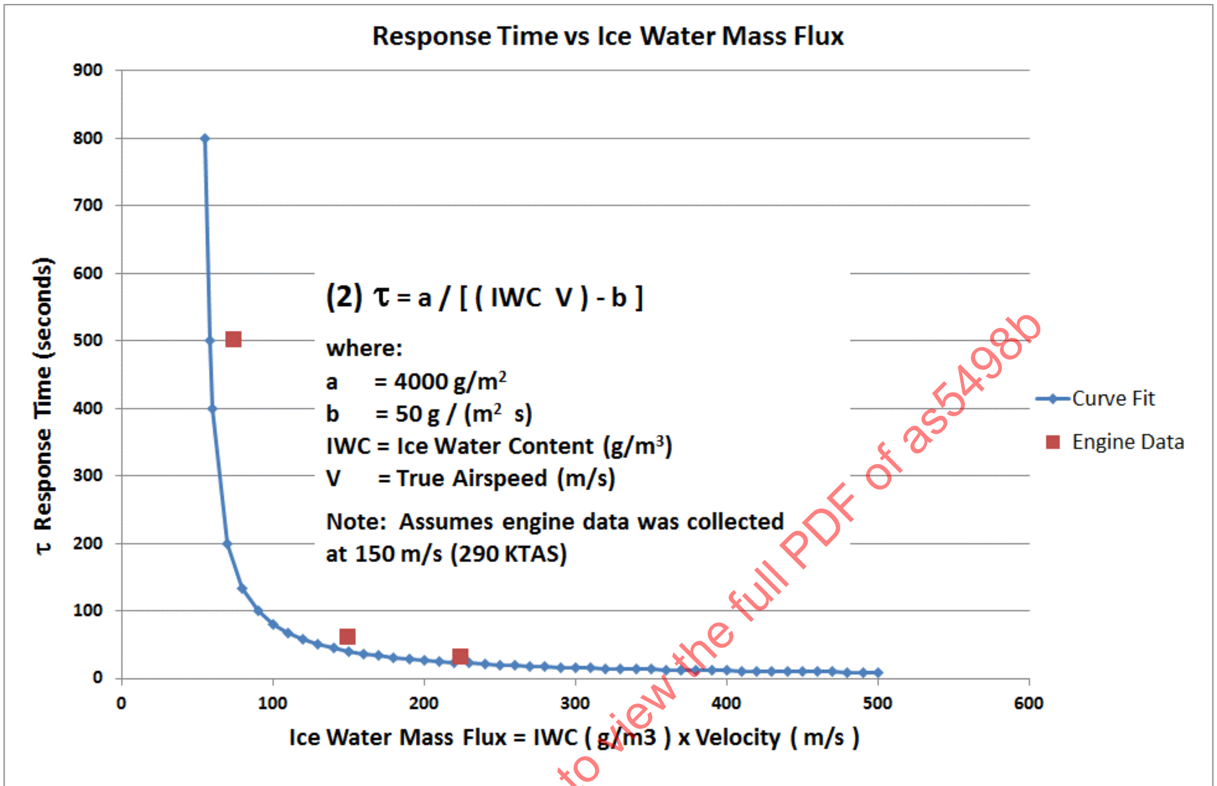


Figure 2 - Response time under mixed phase or glaciated conditions

Equation 2 provides maximum FIDS RESPONSE TIME when exposed to IWC conditions:

$$\tau = a/[(IWC\ V) - b] \qquad \text{(Eq. 2)}$$

where IWC and V are FREESTREAM conditions and it is assumed engine data was collected at 150 m/s (290 KTAS); therefore the terms are defined as follows:

τ = maximum FIDS RESPONSE TIME (seconds)

IWC = FREESTREAM ice water content (g/m^3)

V = FREESTREAM true airspeed (m/s)

a = 4000 g/m^2

b = 50 g/(m^{2}s)

3.4.2 Exiting Environmental Inflight Icing Conditions

At a minimum, FIDS should identify the exit of the icing encounter within 180 seconds of exiting the icing encounter. In any case, the annunciation should be maintained for a minimum of 60 seconds hold time to avoid frequent on/off activation of the signal to the flight crew and/or other AIRCRAFT SYSTEMs.

These values are given for information, but are specific for each AIRCRAFT manufacturer application. The equipment manufacturer should work with the AIRCRAFT manufacturer to determine the appropriate values.

3.4.3 Environmental Inflight Icing Conditions Discrimination Time

The maximum RESPONSE TIME to discriminate a specific ICING CONDITION corresponds to the time after entering the ENVIRONMENTAL INFLIGHT ICING CONDITIONS and the abilities of the FIDS FUNCTIONS described in 3.3.1.3 or 3.3.1.4 to identify and annunciate presence of one specific icing condition from the others. For rationale, see A.2 (Appendix O conditions) and A.3 (MIXED PHASE or GLACIATED CONDITIONS).

4. MINIMUM PERFORMANCE SPECIFICATION UNDER ENVIRONMENTAL TEST CONDITIONS

4.1 Introduction

The intent of this chapter is to provide required test protocols applicable to FIDS under all environmental conditions. General guidelines are also given for test procedures. However, the reference for test procedures for determining equipment performance under environmental test conditions is EUROCAE ED-14/RTCA DO-160.

The test categories provided in 4.2 are based on Issue G of EUROCAE ED-14/RTCA DO-160. The applicant shall use the latest revision of the EUROCAE ED-14/RTCA DO-160 and ensure the categories used are equivalent to those specified in 4.2.

4.2 General Acceptable Means for Qualification Testing

4.2.1 Operational Modes

The equipment manufacturer shall consider the different operational modes of the ice detector and consider the impact that each mode may have for the various qualification tests described in Table 6. For example, if DEICING or ANTI-ICING heaters are activated in some operational modes, the additional current draw may contribute to increased (or reduced) sensitivity/susceptibility. Similarly, it may be necessary to evaluate and/or test the I/O in each operational state in order to ensure that undetected loss may not occur as a result of exposure to the particular qualification test. DC and/or AC power switching may also be factors to consider along with operating frequencies of electrical COMPONENTs such as crystals, microcontrollers, etc.

Table 6 - List of ED-14/DO-160 test conditions and requirements

Item #	EUROCAE ED-14D/RTCA DO-160G Section	Title	Applicable Category or Guideline	Comments
4.5	4.5	Temperature	Category D2	
4.6	4.6	Altitude, Decompression, Overpressure	Category D2	
5	5.0	Temperature Variation	Category A	
6	6.0	Humidity	Category C	Presence of humidity could impact RESPONSE TIME and could cause false ice detection.
7.2	7.2	Operational Shock	Category B	For this item, performance should be checked after exposure to the gust only (other sources for operational shock are for ground phases).
7.3	7.3	Crash Safety	Category B	The application of this test may result in damage to the equipment.
8	8.0	Vibration	Category S, curves C and C1	
9	9.0	Explosion	NA or Category E (depending on location)	The application of this test may result in damage to the equipment.
10	10.0	Water Proofness	Category S outside of AIRCRAFT; category R inside of AIRCRAFT	FIDS may be affected by vapors (optics, electric conductivity, etc.)
11	11.0	Fluid Susceptibility	Category F	Contamination can only be applied prior to installation in WT, not during. For verification of performance during contamination, other means shall be used.
12	12.0	Sand and Dust	Category S	Contamination can only be applied prior to installation in WT, not during. For verification of performance during contamination, other means shall be used.
13	13.0	Fungus	Category F	Demonstration is usually that fungus cannot develop on the device so it will not affect performance.
14	14.0	Salt Spray	Category S	Contamination can only be applied prior to installation in WT, not during. For verification of performance during contamination, other means shall be used.
15	15.0	Magnetic Effect	Category A	Device needs to be tested in all modes of operations (in dry conditions/ICING CONDITIONS, heater/cooling SYSTEM active or not active or with transition if applicable).
16	16.0	Power Input	Category Z for DC Category A(WF) for AC	
17	17.0	Voltage Spike	Category A	For this item, performance should be checked after exposure only (very short exposure time).
18	18.0	Audio Frequency Susceptibility	Category Z for DC Category R(WF) for AC	

Item #	EUROCAE ED-14D/RTCA DO-160G Section	Title	Applicable Category or Guideline	Comments
19	19.0	Induced Signal Susceptibility	Category ZC for DC Category ZW for AC	
20	20.0	Radio Frequency Susceptibility	Category R for conducted, category W for radiated	
21	21.0	Radio Frequency Emission	Category H	Device needs to be tested in all modes of operation (heater/cooling SYSTEM active or not active or with transition if applicable).
22	22.0	Lightning Induced Transient Susceptibility	Category A3G3L3 (unshielded) Category B3K3L3 (shielded)	For this item, performance should be checked after exposure only (very short exposure time).
23	23.0	Lightning Direct Effects	Category XX1A or XX2B depending on location	Depends if device is supposed to be functioning after exposure. If yes, then performance needs to be demonstrated after exposure. If no, N/A.
24	24.0	Icing	Category A	
25	25.0	Electrostatic Discharge	Category A	For this item, performance should be checked after exposure only (very short exposure time).
26	26.0	Fire/Flammability	Category C	

4.2.2 Qualification Test Procedures

The qualification test procedures shall address the requirements planned to be satisfied by test and shall specify the detailed steps required to accomplish each agreed to test, diagram the test setup and list the test equipment to be used. All necessary information required to perform the test shall be provided in the qualification test procedure (references to procedures in other documents are not sufficient). The operational modes of the equipment shall be carefully considered and reflected in the applicable qualification test procedure(s). Each procedure shall define if conformity and/or witnessing requirements is required and which paragraphs (including figures) are subject to these requirements. The qualification test procedure shall clearly identify the pass/fail criteria for each test performed along with any performance test procedure (e.g., a full or abbreviated acceptance test) that may be used to confirm proper operation of the equipment.

4.2.3 Qualification Test Reports

Qualification test reports shall be generated following the completion of qualification tests. The reports shall contain a summary of all tests including the following:

a. The actual qualification test procedures as performed or a reference to the relevant procedure highlighting any changes, deviations or details missing from the procedure defined in the qualification plan (see 2.10.1).

b. A record of all tests, test results and test data, including the recorded results of pre-qualification and post-qualification performance tests. All recorded test results will be quantitative in that actual test results will be recorded. Graphic, tabular, and photographic entries will be made as required for clarity and completeness. Supporting test data will include a narrative history or log of the test.

c. A description of and the disposition of any equipment FAILUREs or defects occurring during the tests.

d. All relevant pre/post qualification ATP reports (data sheets) (see 2.10.6).

e. Details of the test set-up, test facility and test equipment used (see 2.10.2, 2.10.3, and 2.10.4).

f. Relevant conformity and witnessing documentation (see 2.10.5).

4.3 Qualification Requirements

4.3.1 Minimum FIDS Qualification Requirements

For this section, icing detection performance shall be understood as the capability of FIDS to perform intended function with applicable requirements as defined in Section 3, and to not detect the presence of icing when no icing is present.

Exposure to the environmental tests shall not impact FIDS icing detection performance. However, it is recognized that it may not be possible to expose the device simultaneously to environmental testing and ENVIRONMENTAL INFLIGHT ICING CONDITIONS.

When trying to demonstrate compliance to the requirements in all environmental conditions, the FIDS manufacturer should use the “comments” provided in Table 6 and provide sufficient evidence that this environmental condition does not impact icing detection performance. The FIDS manufacturer should also demonstrate the robustness of FIDS icing performance to this condition and identify potential limitations; see 2.8.3.

Modified minimum FIDS qualification requirements may be used if there is agreement with the AIRCRAFT manufacturer.

See 6.5.2.1 for additional qualification requirements specific to AIRCRAFT installation.

5. TEST PROCEDURES

5.1 General

This section defines the laboratory test procedures used to verify the minimum operational performance requirements specified in Section 3.

5.1.1 Performance Test Reports

Performance test reports shall be generated following the completion of the performance tests. The reports shall contain a summary of all tests including the following:

a. The actual performance test procedures as performed or a reference to the relevant procedure highlighting any changes, deviations, need for scaling, or details missing from the procedure defined in the qualification plan (see 2.10.1).

b. Data from the critical point analysis (CPA) as required in 5.2.1 and/or detailed data on the scaling methods used shall be provided to substantiate the additional/modified ICING CONDITIONS selected in the qualification plan.

c. Compliance of the equipment with the applicable requirements of Section 3 including the intended FIDS FUNCTIONS and flight envelope (e.g., altitude, airspeed, AOA/AOS, etc.). The accuracy and threshold of the applicable requirements of Section 3 need to be demonstrated and documented. This includes the accuracy and uncertainties of the test facilities, (e.g., lab, IWT, etc.). In addition, the FIDS design accuracy shall be evaluated including, but not limited to, mechanical, electrical, aerodynamic, thermodynamic, software, etc.

d. A description of and the disposition of any applicable FIDS FUNCTION non-compliance, FAILURES, or unexpected behavior (e.g., nuisance indication) occurring during the tests.

e. A record of all tests, test results and test data, including the record of key information as requested by each test procedure of 5.2.4 and 5.2.5. In addition, the considered installation factors, test duration and the pass/fail criteria shall be documented. All recorded test results will be quantitative in that actual test results will be recorded. Graphic, tabular, and photographic entries will be made as required for clarity and completeness. Supporting test data will include a narrative history or log of the test.

f. All relevant pre/post qualification ATP reports (data sheets) (see 2.10.6).

g. Details of the test set-up, test facility, and test equipment used (see 5.2.3, 2.10.2, 2.10.3, and 2.10.4).

h. Relevant conformity and witnessing documentation (see 2.10.5).

5.2 Detailed Test Procedures

5.2.1 Test Matrix

Tables 1 and 2 define matrices of test points which represent a minimum set of flight conditions to be used to demonstrate compliance to the requirements of Section 3. Each table contains one matrix for AIRCRAFT application (test points #1 through 18) and one matrix for ROTORCRAFT application (test points #1R through 18R). In the following sections, when test conditions are indicated with a number (e.g., test point #7 or #1 through 17) it shall be understood that for ROTORCRAFT application the test conditions to be used are the one from the ROTORCRAFT matrix (e.g., test point #7R or #1R through 17R). Additional test points may be required by the OEM. The equipment manufacturer should consider testing beyond this minimum data set in order to fully characterize dependency of the equipment on certain parameters, such as maximum drop size and distribution, altitude, airspeed, angle of attack, etc.

A critical point analysis (CPA) must be performed by the manufacturer to determine if these additional test points are required depending on the sensitivity of the sensing technology to these parameters. Some of these parameters may also be affected by the installation location.

When establishing the minimum number of test points, the corners of each icing appendix were considered (e.g., minimum MVD at maximum temperature and maximum LWC within Appendix C). To ensure an adequate distribution between the corner conditions, points were selected to represent different MVD, drop size and temperature criterion within each icing envelope (Appendices C, O, or D/P, as applicable). Once the atmospheric conditions were selected, they were paired with varying airspeeds. Typically, lower airspeeds were paired with lower LIQUID WATER CONTENTs, and higher airspeeds with higher LIQUID WATER CONTENTs. The intent of the pairing is to bound the detector's RESPONSE TIME. The lowest water content at the lowest airspeed will represent the maximum RESPONSE TIME expected from the device. In contrast, the highest water content at the highest airspeed will represent the quickest RESPONSE TIME, not including the effect of freezing fraction.

The values identified for freezing fraction and collection efficiency may be used for testing purposes only. The values do not indicate acceptable values for a particular AIRCRAFT. These shall be revisited with the OEM.

5.2.1.1 Maximum response time requirements and altitude conditions:

The "Maximum RESPONSE TIME requirements" indicated for liquid water conditions or MIXED PHASE CONDITIONS (columns L to O Table 1 and columns O to R Table 2) were established according to the method described in Appendix A. The freezing fraction and collection efficiency values were determined using the Equations A-3 and A-5 of A.1.1 with a barometric pressure of 42797 Pa corresponding to an altitude of 22000 feet. The choice of the 22000 foot value for all the liquid water or mixed phase test conditions of Table 1 and Table 2 ensures the highest freezing fraction value and the shortest RESPONSE TIME requirement giving an additional safety margin on the time to detect or discriminate the ICING CONDITIONS. This safety margin is substantially higher for slower and/or lower flying AIRCRAFT than for higher performance jet AIRCRAFT. It is recognized that for particular applications (e.g., AIRCRAFT or ROTORCRAFT with altitude limitations) or specific environmental conditions (e.g., warm temperatures, FZRA) the 22000 foot value and the associated minimum temperature might not be appropriate and one should be selected based on the application AIRCRAFT's performance envelope. The relevant alternative test conditions can be proposed but need to be agreed on by the OEM and the appropriate authorities.

It shall be also recognized that some testing facilities are unable to set a specific barometric pressure value in the test section of the tunnel (e.g., the 22000 foot conditions), the following paragraph gives recommendations on how to manage such situations.

5.2.1.2 Test Conditions

If the recommended test conditions are not deemed suitable for the application or testing facility, alternate test conditions need to be investigated by either of the following:

- Tests with modified test conditions, using justified and state of the art scaling laws for determination of scaled tests conditions.
- Analysis (i.e., maximum, minimum speed, maximum drop size, drops distribution spectrum, maximum, minimum LWC or IWC, etc.) to verify compliance with the applicable requirement.

The alternate conditions need to get the approval of the appropriate authorities to verify the same intent is achieved.

The number of times the test points indicated in Tables 1 and 2 are repeated for each test condition shall be agreed by the relevant stakeholders.

5.2.1.3 Test Point Scaling

When a particular FREESTREAM (reference) test condition cannot be achieved due to a test facility limitation, scaling methods may be used to arrive at an achievable test condition. Refer to scaling documents AEDC-TR-85-30, Vol 1, NASA/CR-2004-212875, NASA/CR-2008-215302, AIAA-88-0203, AIAA-95-0540, and NASA TM-107140, which are provided as guidance. State-of-the-art scaling laws shall be considered.

The particular parameters that are scaled shall not affect the characteristic being evaluated by the test (e.g., detection threshold, DEICING or ANTI-ICING capability, LWC characterization, freezing fraction, etc.).

In particular, effects of altitude have to be evaluated and considered in the scaling laws, to be representative of INFLIGHT heat transfer coefficients.

Ice crystal scaling methods continue to evolve. Suitable methods for scaling altitude test of ICE CRYSTALS may be developed in the future. These methods must be thoroughly validated.

5.2.1.4 Installation Factors

In order to cover most of the AIRCRAFT FIDS applications, the user of this MOPS shall consider relevant installation factors for the test conditions indicated in Tables 1 and 2; see 6.2.3 for rationale. At a minimum, FIDS performance shall be demonstrated over a range of local LWC and IWC installation factors, also known as the concentration factor.

A critical point analysis (CPA) may be conducted by FIDS manufacturer to determine the concentration factor(s) that should be applied to each test point.

The factors utilized for each test point shall be recorded in the test results and form part of the test record.

5.2.1.5 Test Duration

Two COMPONENTs of testing, ICE detection performance and risk of adverse ice accretion, are considered here in term of test duration.

- ICE detection performance:

  The matrix will be run for a minimum of 3 minutes or three ice detection RESPONSE TIME cycles whichever is the greater.

  - Risk of adverse ice accretion:

  The purpose of this testing is to determine if accretions occur that would adversely affect the performance of the FIDS.

  A critical point analysis will be performed to determine the critical points from the run matrix for assessing this aspect. Note that the highest thermal load may not be the only critical point, e.g., warm case at low LWC for a deicing SYSTEM. These runs will be conducted to show that either:

  - No ICE accretes, or

  - Stabilized ice accretions form that do not adversely affect the performance of the FIDS.

The duration of the test is the greater of:

- 10 minutes, or
- Time for thermal stabilization (ANTI-ICE SYSTEM) once no ice remains, or
- Time to establish stabilized ice accretions (a minimum of three build and shed cycles where the ice accretions have reached their maximum size).

5.2.1.6 Correct Functionality Over an Extended Time Period

Over the duration of each test point as defined in the above section, observed ice accretion formed on FIDS surface shall not demonstrate potential risk of FIDS performance degradations and the annunciation of the conditions shall remain stable until the end of the FIDS indication after the water drops/ICE CRYSTAL injection has stopped.

5.2.1.7 FIDS Functions Pass/Fail Criteria

Instrumentation used for calibration of the IWT or during the conduct of the test have their own tolerances and icing wind tunnel facilities have performance limitations in term of Icing cloud uniformity, temperature accuracy, MVD accuracy, FZDZ and FZRA drop distributions, drops/particles injection transient and regularity during the conduct of the test, drops/particles recirculation, drops freezing at low temperature, etc.

Therefore, when assessing FIDS FUNCTIONS compliance with the expected requirements, the impact of the above uncertainties and possible side effects of IWT operations shall be analyzed before determining compliance with the pass/fail criteria. Special attention should be drawn to test conditions exhibiting long maximum detection/ discrimination time or test conditions with low freezing fraction values where small changes in one IWT parameter may have large impact on the RESPONSE TIME, see the example in A.1.2. Also, care must be taken when the stabilization time of water drops/particles injection is longer than the FIDS RESPONSE TIME requirement.

The RESPONSE TIME requirement from the test matrix assumes certain values of the terms given in A.1. It should be understood that each of these terms should be more carefully evaluated for each test condition taking into account specific test parameters which may be used in these equations.

5.2.2 Input Power

To demonstrate that the FIDS can function correctly over the AIRCRAFT supply voltage range, perform step (b) of the following test procedures at the upper and lower limits of the supply voltage range, unless a critical point analysis can demonstrate that a limited number of critical points chosen in the test matrix are sufficient.

For all tests defined under this chapter (see Tables 1 and 2), it shall be demonstrated via analysis or test that the FIDS operates within specification over the entire EUROCAE ED-14/RTCA DO-160 “normal” operating voltage and frequency (AC only) ranges and shall survive any “abnormal” voltages and frequencies within the EUROCAE ED-14/RTCA DO-160 specification, resuming normal operation without external intervention.

If the FIDS is required to operate under emergency power, then the FIDS supplier and the AIRCRAFT manufacturer shall agree on what level of functionality is required from the FIDS and what are the minimum and maximum power supply voltages that shall be considered for the FIDS performance demonstration.

5.2.3 Icing Wind Tunnel Test Set-Up

Before starting the test, the icing wind tunnel (IWT) shall be calibrated for the test conditions. The calibration process might require the removal of the FIDS; refer to ARP5905.

The FIDS shall be tested in an IWT. The FIDS shall be mounted in the IWT such that the IWT test section boundary layer will not adversely affect the airflow over the FIDS SENSING SURFACE.

If the operation of the FIDS may be affected by its interface to the AIRCRAFT then, for an IWT test, the FIDS shall be mounted in a manner representative of its intended operating environment.

For example, for FIDS that can be flush mounted into an AIRCRAFT structure (for example in a wing) it might be necessary to provide evidence that its performance is not impacted by and does not impact the operation of other AIRCRAFT equipment. In such a case, the FIDS should be mounted in either a section of the actual AIRCRAFT structure (which might have to be modified to ensure that the IPS (if fitted) or other important sub-SYSTEMs still function) or, if the IWT working section is small, a scaled model of the AIRCRAFT structure.

If a scaled section is used, both scaling for thermal and aerodynamic scaling for proper flow field need to be evaluated. Guidance on how to address aerodynamic scaling can be found in FAA Advisory Circular 20-73A; Appendix R. Any test section used shall be constructed to the same manufacturing tolerances as a production part.

5.2.3.1 IWT and FIDS Stabilized Conditions

Refer to ARP5905 for definition of IWT temporal stability.

The FIDS Manufacturer shall define internal FIDS parameter and conditions to declare FIDS temporal stability.

5.2.4 Atmospheric Environmental Inflight Icing Conditions

5.2.4.1 Detect Liquid Water (LW) Icing Conditions

This section provides guidance on verifying that this FIDS FUNCTION meets the requirements of 3.3.1.1 when exposed to LW-C, LW-FZDZ, or LW-FZRA liquid water drop conditions as defined in 1.8.1 and MIXED PHASE CONDITIONS as defined in 1.8.2.

Test Conditions:

At a minimum, the FIDS shall be tested for LW-C, LW-FZDZ and LW-FZRA test cases #1 through 18 as referenced in Table 1.

FIDS shall be also tested for glaciated and MIXED PHASE CONDITIONS, test cases #1 through 17 as referenced in Table 2.

Test Procedure:

The FIDS manufacturer shall demonstrate through steps (a) and (b) that:

- LW-C FIDS FUNCTION complies with Table 3 LW-C requirements when exposed to LW-C or MP atmospheric conditions.

- LW-FZDZ FIDS FUNCTION complies with Table 3 LW-FZDZ requirements when exposed to LW-FZDZ or MP atmospheric conditions.

- LW-FZRA FIDS FUNCTION complies with Table 3 LW-FZRA requirements when exposed to LW-FZRA or MP atmospheric conditions.

FIDS shall continue to comply with the above requirements over an extended period of time.

a. Demonstration of minimum detection threshold.

   The IWT and FIDS shall be allowed to stabilize at the specified velocity and temperature. After this, record the output of the FIDS before the activation of the liquid water drops injection at 0.05 g/m^3 into the IWT to ensure the FIDS is stabilized for the tests. This should be performed for each of the test conditions #7, 13, 17, and 18 as referenced in Table 1. Confirm that the FIDS detects the conditions within the RESPONSE TIME requirement given in 3.3.1.1.

b. Demonstration of correct functionality over an extended time period.

The IWT and FIDS shall be allowed to stabilize at the specified velocity and temperature. After this, record the output of the FIDS before FIDS is exposed to test cases #1 through 18 as referenced in Table 1 and test cases #1 through 17 as referenced in Table 2. Confirm that the FIDS detects the condition within the RESPONSE TIME requirements given in 3.3.1.1. After the FIDS starts detecting the conditions, maintain this condition for a minimum time as indicated in 5.2.1.5. The FIDS shall operate in accordance with its intended function during this period. After this time, the liquid water drops injection/ICE CRYSTAL introduction shall be stopped while maintaining the other wind tunnel parameters.

The following information shall be recorded during the test:

- The IWC and LWC values shall be known and recorded during the conduct of the test.
- RESPONSE TIME: This is the time from initial exposure of the ice sensor to the liquid water drops until the first detection of the condition. Verify that the FIDS does not provide a NUISANCE ALARM when exposed to GLACIATED CONDITIONS as defined in Table 2 test cases #1 through #6.
- Record the minimum LWC detection threshold.
- Record the time required for the FIDS to annunciate no ICING CONDITIONS after the liquid water drops injection has stopped.

Function Pass/Fail Criteria:

LW FIDS FUNCTIONS:

To show compliance with 3.3.1.1, the relevant FIDS FUNCTION shall meet the RESPONSE TIME requirements for each of the LW and MP test cases as defined by Table 7. The RESPONSE TIME may be corrected taking into account the real LWC value recorded during the test. The LWC used shall be reported.

Table 7 - LW and MP test requirements

FIDS FUNCTIONS	LW Conditions		GL and MP Conditions	
	Maximum RESPONSE TIME	Test Cases	Maximum RESPONSE TIME	Test Cases
LW-C	Table 1 Column L	Table 1 #1-10	Table 2 Column O	Table 2 #7-11
LW-FZDZ	Table 1 Column L	Table 1 #11-15	Table 2 Column O	Table 2 #12-15
LW-FZRA	Table 1 Column L	Table 1 #16-18	Table 2 Column O	Table 2 #16-17

In addition to the above requirements, when exposed to GLACIATED CONDITIONS as defined in Table 2 test cases #1 through 6, it shall be demonstrated by test or analysis that the FIDS does not provide a NUISANCE ALARM in accordance with 2.8.3 and 2.8.4.

5.2.4.2 Detect Ice-Crystals in Mixed Phase or Glaciated Conditions

This section provides guidance on verifying that this FIDS FUNCTION meets the requirements of 3.3.1.2 when exposed to GLACIATED (GL) and/or MIXED PHASE (MP) CONDITIONS as defined by 1.8.2.

Test Conditions:

At a minimum, the FIDS shall be tested for GLACIATED and MIXED PHASE CONDITIONS, test cases #1 through 17 as referenced in Table 2 and liquid water condition test cases #1 through 18 as referenced in Table 1.

Test Procedure:

The FIDS manufacturer shall demonstrate through steps a) and b) that:

- This FIDS FUNCTION complies with 3.3.1.2 requirements when exposed to MIXED PHASE or GLACIATED CONDITIONS as defined by 1.8.2.

FIDS shall continue to comply with the above requirements over an extended period of time.

a. Demonstration of minimum detection threshold.

The IWT and FIDS shall be allowed to stabilize at the specified velocity and temperature. After this, record the output of the FIDS before activation of the ice crystal introduction at 0.5 g/m^3 into the IWT to ensure the FIDS is stabilized for the test. This should be performed for each of the test conditions #7 and #10 as referenced in Table 2. Confirm that the FIDS detects the condition within the RESPONSE TIME indicated in Column S.

b. Demonstration of correct functionality over an extended time period.

The IWT and FIDS shall be allowed to stabilize at the specified velocity and temperature. After this, record the output of the FIDS before FIDS is exposed to test cases #1 through 17 as referenced in Table 2 and test cases # 1 through 18 as referenced in Table 1. Confirm that the FIDS detects the condition within the RESPONSE TIME requirements given in 3.3.1.2. After the FIDS starts detecting the conditions, maintain this condition for a minimum time as indicated in 5.2.1.5. The FIDS shall operate in accordance with its intended function during this period. After this time, the liquid water drop injection /ICE CRYSTAL introduction shall be stopped while maintaining the other wind tunnel parameters.

The following information shall be recorded during the test:

- The IWC and LWC values shall be known and recorded during the conduct of the test.

- RESPONSE TIME: This is the time from initial exposure of the ice sensor to the ICE CRYSTALS and the first detection of the condition. Verify that the FIDS does not provide a NUISANCE ALARM when exposed to liquid water conditions (test cases # 1 through 18 as referenced in Table 1).

- Record the minimum IWC detection threshold.

- Record the time required for the FIDS to detect that the ICE CRYSTAL injection has stopped.

Function Pass/Fail Criteria:

ICE CRYSTAL FIDS FUNCTION:

To show compliance of 3.3.1.2, the RESPONSE TIME of this function as identified in Column C shall not exceed those identified in Column S of Table 2. The RESPONSE TIME can be corrected taking into account the real IWC value recorded during the test. The IWC used shall be reported.

In addition to the above requirements, when exposed to liquid water conditions as defined in Table 1, it shall be demonstrated by test or analysis that the FIDS does not annunciate a NUISANCE ALARM in accordance with 2.8.3 and 2.8.4.

5.2.4.3 Discriminate Specific Liquid Water Drops Icing Conditions

5.2.4.3.1 Discriminate Appendix O Based on Drop Size Conditions

This Section provides guidance on verifying that this FIDS FUNCTION meets the requirements of 3.3.1.3.1, when exposed to Appendix O liquid water drops conditions and discriminate Appendix O, Appendix O FZRA, atmospheric conditions within the RESPONSE TIME requirements given in 3.3.1.3.1.

Test Conditions:

See 5.2.4.1 for the test conditions.

LWC Measurement Considerations:

The requirement to verify that this FIDS FUNCTION can discriminate specific atmospheric conditions means that the drops size distribution and the associated LWC values achieved in the IWT shall be known and recorded during the conduct of the test for the two following populations of drops:

- LWC measured from liquid water mass of drops above 100 µm (LW-100+).
- LWC measured from liquid water mass of drops above 500 µm (LW-500+).

Test Procedure:

See 5.2.4.1 for test procedures and guidelines.

The RESPONSE TIME to discriminate Appendix O or Appendix O FZRA conditions from other ICING CONDITIONS is the time from initial exposure of the ICE sensor to the liquid water drops until the FIDS FUNCTION discriminates the condition.

Function Pass/Fail Criteria:

Appendix O FIDS FUNCTIONs:

To show compliance with 3.3.1.3.1 the relevant FIDS FUNCTION shall meet the maximum RESPONSE TIME requirements for each of the LW, GL, and MP test cases as defined by Table 8. The RESPONSE TIME can be corrected taking into account the real LWC value due to the contribution of drops above 100 µm for the Appendix O function and 500 µm for the Appendix O FZRA function recorded during the test. The LWC used shall be reported.

Table 8 - Appendix O test requirements

FIDS FUNCTIONS	LW		GL and MP Conditions	
	Maximum RESPONSE TIME	Test Cases	Maximum RESPONSE TIME	Test Cases
Appendix O	Table 1 Column M	Table 1 #1-18	Table 2 Column P	Table 2 #1-17
Appendix O FZRA	Table 1 Column O	Table 1 #1-18	Table 2 Column R	Table 2 #1-17

5.2.4.4 Discriminate Specific Glaciated or Mixed Phase Conditions

This Section provides guidance on verifying that this FIDS FUNCTION meets the requirements of 3.3.1.4 when exposed to GLACIATED and/or MIXED PHASE CONDITIONS and discriminate as such the GL and/or MP atmospheric conditions within the RESPONSE TIME requirements given in the 3.3.1.4.

Test Conditions:

See 5.2.4.2 for the test conditions.

Test Procedure:

See 5.2.4.2 for the test procedures and guidelines.

The RESPONSE TIME to discriminate GL and/or MP conditions from other ICING CONDITIONS is the time from initial exposure of the ice sensor to the GL or MP conditions until the FIDS FUNCTION discriminates the condition.

Function Pass/Fail Criteria:

GL and MP FIDS FUNCTIONS:

To show compliance to 3.3.1.4 requirements, the relevant FIDS FUNCTION shall meet the maximum RESPONSE TIME requirements for each LW, GL, and MP test case as defined by Table 9. The RESPONSE TIME can be corrected taking into account the real LWC/IWC value recorded during the test.

Table 9 - Ice crystals and mixed phase test requirements

FIDS FUNCTION	LW Conditions		GL and MP Conditions	
	RESPONSE TIME	Test Cases	RESPONSE TIME	Test Cases
GL	Table 1 Column P	Table 1 #1-18	Table 2 Column S	Table 2 #1-17
MP	Table 1 Column P	Table 1 #1-18	Table 2 Column O or S (See Note in 5.2.4.4)	Table 2 #1-17

NOTE: When testing in MIXED PHASE CONDITIONS, the RESPONSE TIME should be the longer of the two detection times from Columns O or S.

The LWC/IWC used shall be reported.

5.2.5 Icing Characteristics

5.2.5.1 Ice Accreted on the Surface of Interest

This Section provides guidance on verifying that this FIDS FUNCTION meets the requirements of 3.3.2.1 when exposed to LW-C, LW-FZDZ or LW-FZRA liquid water drops conditions as defined in 1.8.1 and MIXED PHASE CONDITIONS as defined in 1.8.2. The FIDS shall demonstrate detection of ice accretion that can occur in flight (FROST, GLAZE, RIME, RUNBACK) on the SURFACE OF INTEREST using ICE accretion based sensing methods; see 2.4.1 for more details. The RUNBACK icing condition is considered to be covered by the GLAZE ICE test condition. Due to the wide variety of ICE accretion sensing techniques technology, this section will not specify the exact test method, but will provide guidance on the best practice that shall be used during the verification testing.

Test Conditions:

At a minimum, the FIDS shall be tested for LW-C, LW-FZDZ, LW-FZRA, test cases #1 through 18 as referenced in Table 1.

FIDS shall be also tested for GLACIATED and MIXED PHASE CONDITIONS, test cases #1 through 17 as referenced in Table 2.

Test Procedure:

The FIDS manufacturer shall demonstrate through steps (a) and (b) that this FIDS FUNCTION detects the presence of ice accreted within the detection threshold and that the FIDS will operate correctly over an extended period of time.

Ice Thickness Measurement Considerations:

The requirement to verify that a FIDS is able to sense the onset of ICE accretion before 0.3 mm of ICE has accreted on the SENSING SURFACE, means that the equipment used to verify this thickness shall need accuracy within a range of 0.03 mm.

Before testing commences, the chosen method of verifying ICE thickness shall be agreed by the relevant stakeholders. Possible methods are:

- Real time remote measurement. For example, using a high definition video camera (30+ MP with a macro lens where the width of a pixel can be equal to a given fraction of a millimeter).

- Interruptive measurement where the IWT is stopped and the ice is measured in-situ on the FIDS.

- ICE removal where the IWT is stopped and the ICE is removed from the FIDS and measured. For the later method, the FIDS manufacturer shall be required to demonstrate/calculate how much ICE is lost during the removal process.

If the purpose of the test is to verify that the FIDS is able to sense the onset of ICE accretion before 0.3 mm of ICE has accreted, the surface roughness of the ICE at this thickness is not sufficient to warrant using an average thickness of the ICE. However, if the purpose of the test is to determine the accuracy of the FIDS ICE thickness measurement (which may mean measuring many millimeters of accreted ICE), an average of the ICE thickness that takes account of the surface roughness will be required. A statistical methodology for determining average ICE thickness shall be agreed by the relevant stakeholders.

a. Demonstration of minimum detection performance.

The IWT and FIDS shall be allowed to stabilize at the specified velocity and temperature. After this, record the output of the FIDS before the activation of the liquid water drops injection/ICE CRYSTALS introduction into the IWT to ensure the FIDS is stabilized for the test. This should be performed for each of the test cases #1 through 18 as referenced in Table 1 and test cases #1 through 17 as referenced in Table 2. After the FIDS detects the presence of ICE, verify the thickness of accreted ICE.

If a FIDS technology does not make a direct ICE thickness measurement on the SURFACE OF INTEREST but infers the thickness of accreted ice using a different method, a 25 mm diameter cylinder can be used in place of the SURFACE OF INTEREST to assess the performance of this FIDS FUNCTION.

b. Demonstration of correct functionality over an extended time period.

After the FIDS annunciates the presence of ICE as defined in step (a), keep the liquid water drop injection/ICE CRYSTAL introduction for a minimum time as indicated in 5.2.1.5. The FIDS shall operate in accordance with its intended function during this period. After this time, the liquid water drop injection/ICE CRYSTAL introduction shall be stopped while maintaining the other wind tunnel parameters.

If a real time ICE thickness verification method is being used, then tests (a) and (b) can be performed back-to-back without stopping the IWT.

The following information shall be recorded during the test:

- RESPONSE TIME: This is the time from initial exposure of the ice sensor to water and the first annunciation of ICE accretion.

- Record the time required for the FIDS to annunciate no ICE or that ICE accretion has ceased after the water injection has stopped.

- Unavailability of active detection signal: The time period when an active signal is not available (for example, if the FIDS is fitted with a DEICING heater and detection capability is lost during a DEICING cycle).

- That if the thickness of accreted ICE on the specific surface is in excess of the threshold thickness, the FIDS shall continue to annunciate the presence of ICE.

- That during a DEICING cycle, the FIDS shall continue to annunciate the presence of ICE until a new detection cycle is started.

Additional information that shall be recorded if the FIDS has these functions:

- That the location of the FIDS in the AIRCRAFT structure does not adversely affect the ICE detection performance of the FIDS, nor the performance of any AIRCRAFT equipment in this area.

Functions Pass/Fail Criteria:

To show compliance with the requirements specified in 3.3.2.1, this FIDS FUNCTION shall annunciate the presence of ICE accreted on the SURFACE OF INTEREST when exposed to LW-C, LW-FZDZ, LW-FZRA, and MP mixed phase atmospheric conditions as soon as the ice thickness has reached the 0.3 mm thickness threshold.

Correct functionality over an extended time period.

Over the test duration, observed ICE accretion formed on the FIDS SENSING SURFACE shall not demonstrate potential risk of FIDS performance degradations and the annunciation of the conditions shall remain stable as long as the ICE remains on the SENSING SURFACE.

5.2.5.2 Ice Accreted on Specific Aircraft Surfaces that Exceeds the Design Parameters

This cannot be specified in this MOPS as it is AIRCRAFT specific, but the test procedure given in the 5.2.5.1 can be followed and adapted to cover the specific AIRCRAFT requirements.

5.2.5.3 Specific Environmental Inflight Icing Conditions that Exceed the Design Parameters

This cannot be specified in this MOPS as it is AIRCRAFT specific, but the test procedure given in the following 5.2.5.4 and subsections can be followed and adapted to cover the specific AIRCRAFT requirements.

5.2.5.4 Provide other information on Icing Characteristics

5.2.5.4.1 Ice Thickness Measurement and Indication

This section provides guidance on verifying that this FIDS FUNCTION meets the requirements of 3.3.2.3.1 when exposed to LW-C, LW-FZDZ, or LW-FZRA liquid water drops conditions as defined in 1.8.1 and MIXED PHASE CONDITIONS as defined in 1.8.2. The FIDS shall demonstrate its capability to measure ICE thickness formed over the SURFACE OF INTEREST (either FROST, GLAZE, RIME, RUNBACK) using ICE accretion based sensing methods; see 2.4.1 for more details. The runback icing condition is considered to be covered by the GLAZE ICE test condition. Due to the wide variety of ICE accretion sensing techniques, this section will not specify the exact test method, but will provide guidance on the best practice that shall be used during the verification testing.

Test Conditions:

Use test conditions described in 5.2.5.1.

Test Procedure:

The FIDS manufacturer shall demonstrate through steps (a) and (b) as defined in 5.2.5.1 and step (c) described here that this FIDS FUNCTION is capable to measure ICE thickness with the required accuracy over the range specified by the FIDS manufacturer and that the FIDS will operate correctly over an extended period of time.

To show compliance with these requirements conduct steps (a) and (b) as defined in 5.2.5.1 and step (c) described here.

c. Demonstration of correct measurement ICE thickness.

After the FIDS annunciates the presence of ICE as defined in procedure 5.2.5.1 step (a), keep the liquid water drops injection/ICE CRYSTALS introduction for a minimum time as indicated in 5.2.1.5 for the particular test point together with the equipment being used to verify the thickness of accreted ICE on the FIDS SENSING SURFACE. Record the ICE thickness measurements of the FIDS and compare to the ice thickness verification equipment measurements. After this time, the liquid water drops injection/ICE CRYSTALS introduction shall be stopped while maintaining the other wind tunnel parameters.

If a real time ice thickness verification method is being used, then tests 5.2.5.1 steps (a) and (b) and tests 5.2.5.4.1 step (c) can be performed back-to-back without stopping the IWT.

If a FIDS technology does not make a direct ICE thickness measurement on the SURFACE OF INTEREST but infers the thickness of accreted ICE using a different method, a 25 mm diameter cylinder can be used in place of the SURFACE OF INTEREST to assess the performance of this FIDS FUNCTION.

In addition to the information recorded according to test procedure 5.2.5.1, the following information shall also be recorded during the test:

- The maximum thickness of accreted ice that can be measured by this FIDS function together with the accuracy of measured ice thickness.

Functions Pass/Fail Criteria:

To show compliance with the requirements specified in 3.3.2.3.1, this FIDS FUNCTION shall indicate the thickness that is accreted on the SURFACE OF INTEREST with the required accuracy when exposed to LW-C, LW-FZDZ, or LW-FZRA and MP mixed phase atmospheric conditions.

Correct functionality over an extended time period.

Over the test duration, observed ICE accretion formed on the FIDS surface shall not demonstrate potential risk of FIDS performance degradations and the annunciation of the conditions shall remain stable as long as the ice remains on the sensor.

5.2.5.4.2 Ice Accretion Rate Measurement and Indication

This section provides guidance on verifying that this FIDS FUNCTION meets the requirements of 3.3.2.3.2 when exposed to LW-C, LW-FZDZ, or LW-FZRA liquid water drops conditions as defined in 1.8.1 and MIXED PHASE CONDITIONS as defined in 1.8.2. The FIDS shall demonstrate its capability to indicate the ice accretion rate over the SURFACE OF INTEREST (either FROST, GLAZE, RIME, RUNBACK) using ICE accretion based sensing methods; see 2.4.1 for more details. The runback icing condition is considered to be covered by the GLAZE ICE test condition. Due to the wide variety of ice accretion sensing techniques, this section will not specify the exact test method, but will provide guidance on the best practice that shall be used during the verification testing.

Test Conditions:

Use test conditions described in 5.2.5.1.

Test Procedure:

The FIDS manufacturer shall demonstrate through steps (a) and (b) as defined in 5.2.5.1 and step (c) described here that this FIDS FUNCTION is capable to indicate the ice accretion rate with the required accuracy over the range specified by the FIDS manufacturer and that the FIDS will operate correctly over an extended period of time.

To show compliance with these requirements, conduct steps (a) and (b) as defined in 5.2.5.1 and step (c) described here.

c. Demonstration of correct measurement ice accretion rate.

After the FIDS annunciates the presence of ice as defined in procedure 5.2.5.1 step (a), keep the liquid water drops injection/ICE CRYSTALS introduction for a minimum time as indicated in 5.2.1.5for the particular test point together with the equipment being used to verify the ICE accretion rate on the SURFACE OF INTEREST. Record the ICE accretion rate indication given by the FIDS and compare to the ice accretion rate verification equipment measurements. After this time, the liquid water drops injection/ICE CRYSTALS introduction shall be stopped while maintaining the other wind tunnel parameters.

If a real time ice thickness verification method is being used, then tests 5.2.5.1 steps (a) and (b) and tests 5.2.5.4.1 step (c) can be performed back-to-back without stopping the IWT.

If a FIDS technology does not make a direct ice thickness measurement on the SURFACE OF INTEREST but infers the ICE accretion rate using a different method, a 25 mm diameter cylinder can be used in place of the SURFACE OF INTEREST to assess the ICE accretion rate performance.

In addition to the information recorded according to 5.2.5.1 test procedure, the following information shall also be recorded during the test:

- The accuracy of measurement of the rate of ICE accretion on the SURFACE OF INTEREST.

Functions Pass/Fail Criteria:

To show compliance with the requirements specified in 3.3.2.3.2, this FIDS FUNCTION shall indicate the ICE accretion rate on the SURFACE OF INTEREST with the required accuracy when exposed to LW-C, LW-FZDZ, or LW-FZRA and MP mixed phase atmospheric conditions.

Correct functionality over an extended time period.

Over the test duration, observed ICE accretion formed on FIDS surface shall not demonstrate potential risk of FIDS performance degradations and the annunciation of the conditions shall remain stable as long as the ice remains on the sensor.

5.2.5.4.3 Liquid Water Content Measurement and Indication

This section provides guidance on verifying that this FIDS FUNCTION meets the requirements of 3.3.2.3.3 when exposed to LW-C, LW-FZDZ, or LW-FZRA liquid water drops atmospheric conditions as defined in 1.8.1.

Test Conditions:

At a minimum, the FIDS shall be tested for LW-C, LW-FZDZ, or LW-FZRA, test cases #1 through 18 as referenced in Table 1.

Additional points shall be considered for testing the maximum LWC value this FIDS FUNCTION can measure as mentioned in 3.3.2.3.3.

LWC Measurement Considerations:

The requirement to verify that this FIDS FUNCTION has a measurement accuracy of ±0.03 g/m^3 or 30% means that the equipment used to calibrate the IWT shall meet a similar accuracy requirement or better.

Test Procedure:

The FIDS manufacturer shall demonstrate through steps (a), (b), and (c) that this FIDS FUNCTION has the capability to measure the LWC value with the minimum detection threshold and accuracy requirements specified in 3.3.2.3.3 and can continue to do so over an extended period of time over the range specified by the FIDS manufacturer.

a. Demonstration of minimum detection threshold.

The IWT and FIDS shall be allowed to stabilize at the specified velocity and temperature. After this record, the output of the FIDS before the activation of the liquid water drops injection at 0.05 g/m^3 into the IWT to ensure the FIDS is stabilized for the test. This should be performed for each of the test conditions #7, 13, 17, and 18 as referenced in Table 1. Record the FIDS RESPONSE TIME to indicate the first LWC value.

b. Demonstration of correct functionality over an extended time period.

After the FIDS indicates the first LWC value as defined in step (a), maintain this condition for a minimum time as indicated in 5.2.1.5. The FIDS shall operate in accordance with its intended function during this period. After this time, the liquid water drops introduction shall be stopped while maintaining the other wind tunnel parameters.

c. Demonstration of LWC accuracy.

During the test condition of step (b), record the LWC measurements of the FIDS. Compare the FIDS measurement of LWC against the calibrated LWC for the IWT to evaluate the accuracy against the requirements of 3.3.2.3.3 are achieved.

The following information shall be recorded during the test:

- The LWC value shall be known and recorded during the conduct of the test.
- RESPONSE TIME: This is the time from initial exposure of the ice sensor to the liquid water drops and the first LWC measurement.
- Record the time required for the FIDS to indicate no LWC after the liquid water drops injection has stopped.
- That if the LWC is present in excess of the maximum LWC measurement, the FIDS shall continue to indicate the maximum LWC value for the device.

Additional Information that shall be recorded if the FIDS has these functions:

- The maximum LWC that can be measured by the FIDS together with the accuracy.
- The accuracy of LWC measurement for the FIDS FUNCTION.

Function Pass/Fail Criteria:

To show compliance to 3.3.2.3.3 requirements, this FIDS FUNCTION shall indicate the LIQUID WATER CONTENT value with the minimum LWC threshold value and the accuracy specified in 3.3.2.3.3 when exposed to conditions described in this above test procedure.

During the tests, it shall be verified that the RESPONSE TIME to indicate the LWC value and the maximum LWC value the FIDS can measure comply with the FIDS manufacturer specification.

5.2.5.4.4 Max Drops Size (Dmax) Measurement and Indication

This Section provides guidance on verifying that this FIDS FUNCTION meets the requirements of 3.3.2.3.4 when exposed to LW-C, LW-FZDZ, or LW-FZRA liquid water drops atmospheric conditions as defined in 1.8.1.

Test Conditions:

See 5.2.4.1 for the test conditions.

Liquid Water Drops Characteristics Considerations:

The requirement to verify that this FIDS FUNCTION has a measurement accuracy of ±100 µm or ±20% means that the equipment used to calibrate the IWT shall meet a similar accuracy requirement or better. In order to ease the verification of the FIDS FUNCTION, the drops spectrum distribution of the proposed test conditions can be modified using monomodal drops distribution.

Test Procedure:

See 5.2.4.1 for test procedures and guidelines.

Function Pass/Fail Criteria:

To show compliance to 3.3.2.3.4 requirements, this FIDS FUNCTION shall indicate the Dmax values with the accuracy specified in 3.3.2.3.4 when exposed to conditions described in this above test procedure.

It shall be verified that when FIDS is exposed to glaciated and MIXED PHASE CONDITIONS (test cases #1 through 17 as referenced in Table 2), this FIDS FUNCTION, which is sensitive to liquid water drops, continues to indicate Dmax with the expected accuracy in the presence of ice crystals.

5.2.5.4.5 Drops MVD Measurement and Indication

This section provides guidance on verifying that this FIDS FUNCTION meets the requirements of 3.3.2.3.5 when exposed to LW-C, LW-FZDZ, or LW-FZRA liquid water drops atmospheric conditions as defined in 1.8.1.

Test Conditions:

See 5.2.4.1 for the test conditions.

Liquid Water Drops Characteristics Considerations:

The requirement to verify that this FIDS FUNCTION has a measurement accuracy of ±20% means that the equipment used to calibrate the IWT shall meet a similar accuracy requirement or better. In order to ease the verification of the FIDS FUNCTION, the drops spectrum distribution of the proposed test conditions can be modified using a specific drops distribution.

Test Procedure:

See 5.2.4.1 for test procedures and guidelines.

Function Pass/Fail Criteria:

To show compliance to 3.3.2.3.5 requirements, this FIDS FUNCTION shall indicate the MVD values with the accuracy specified in 3.3.2.3.5 when exposed to conditions described in this above test procedure.

It shall be verified that when FIDS is exposed to GLACIATED and MIXED PHASE CONDITIONS (test cases #1 through 17 as referenced in Table 2) this FIDS FUNCTION which is sensitive to liquid water drops continues to indicate drops MVD with the expected accuracy in the presence of ICE CRYSTALS.

5.2.5.4.6 Ice Water Content Measurement and Indication

This Section provides guidance on verifying that this FIDS FUNCTION meets the requirements of 3.3.2.3.6 when exposed to glaciated and/or mixed phase atmospheric conditions as defined in 1.8.2.

Test Conditions:

At a minimum, the FIDS shall be tested for glaciated and/or mixed phase atmospheric conditions test cases #1 through 17 as referenced in Table 2.

Additional points shall be considered for testing the maximum IWC value this FIDS FUNCTION can measure as mentioned in 3.3.2.3.6.

IWC Measurement Considerations:

The requirement to verify that this FIDS FUNCTION has a measurement accuracy of ±0.1 g/m^3 or 30% means that the equipment used to calibrate the IWT shall meet a similar accuracy requirement or better.

Test Procedure:

The FIDS manufacturer shall demonstrate through steps (a), (b), and (c) that this FIDS FUNCTION has the capability to measure the IWC value with the minimum detection threshold and accuracy requirements specified in 3.3.2.3.6 and can continue to do so over an extended period of time over the range specified by the FIDS manufacturer.

a. Demonstration of minimum detection threshold.

The IWT and FIDS shall be allowed to stabilize at the specified velocity and temperature. After this, record the output of the FIDS before the activation of the ICE CRYSTALS injection at 0.5 g/m^3 into the IWT to ensure the FIDS is stabilized for the test. This should be performed for each of the test conditions #7 and 10 as referenced in Table 2). Record the FIDS RESPONSE TIME to indicate the first IWC value.

b. Demonstration of correct functionality over an extended time period.

After the FIDS indicates the first IWC value as defined in step (a), maintain this condition for a minimum time as indicated in 5.2.1.5. The FIDS shall operate in accordance with its intended function during this period. After this time, the ICE CRYSTAL introduction shall be stopped while maintaining the other wind tunnel parameters.

c. Demonstration of IWC accuracy.

During the test condition of step b) above, record the IWC measurements of the FIDS. Compare the FIDS measurement of IWC against the calibrated IWC for the IWT to evaluate the accuracy against the requirements of 3.3.2.3.6.

The following information shall be recorded during the test:

- The IWC value shall be known and recorded during the conduct of the test.
- RESPONSE TIME: This is the time from initial exposure of the ICE sensor to the ICE CRYSTALS and the first IWC measurement.
- Record the time required for the FIDS to indicate no IWC after the ICE CRYSTALS injection has stopped.
- That if the IWC is present in excess of the maximum IWC measurement, the FIDS shall continue to indicate the maximum IWC value for the device.

Additional information that shall be recorded if the FIDS has these functions:

- The maximum IWC that can be measured by the FIDS together with the accuracy.
- The accuracy of IWC measurement for the FIDS FUNCTION.

Function Pass/Fail Criteria:

To show compliance to 3.3.2.3.6 requirements, this FIDS FUNCTION shall indicate the ICE water content value with the minimum IWC threshold value and the accuracy specified in 3.3.2.3.6 when exposed to conditions described in this test procedure.

During the tests, it shall be verified that the RESPONSE TIME to indicate the IWC value and the maximum IWC value the FIDS can measure comply with the FIDS manufacturer specification.

5.2.5.4.7 Total Water Content Measurement and Indication

This section provides guidance on verifying that this FIDS FUNCTION meets the requirements of 3.3.2.3.7 when exposed to glaciated and/or mixed phase atmospheric conditions as defined in 1.8.2 and/or to LW-C, LW-FZDZ, or LW-FZRA liquid water drops atmospheric conditions as defined in 1.8.1.

Test Conditions:

Use the test conditions described in 5.2.5.4.3 and in 5.2.5.4.6.

Test Procedure:

Use the test procedure described in 5.2.5.4.3 and in 5.2.5.4.6.

Function Pass/Fail Criteria:

To show compliance to 3.3.2.3.7 requirements, this FIDS FUNCTION shall indicate the total water content value with the minimum IWC and LWC threshold value.

The FIDS TWC measurement accuracy shall comply with 3.3.2.3.6 requirement for the IWC part and with 3.3.2.3.3 requirement for the LWC part.

During the tests, it shall be verified that the RESPONSE TIME to indicate the IWC value and the maximum IWC value the FIDS can measure comply with the FIDS manufacturer specification.

5.2.5.4.8 Measurement and Indication of Other Parameters

This cannot be specified in this MOPS as the procedure will be specific to the type of parameter that needs to be measured and indicated. Nevertheless, the various test procedures given in this chapter can be used as guidelines and adapted to cover this specific need.

6. AIRCRAFT INSTALLATION GUIDANCE

6.1 Introduction

This section provides guidance for installing FIDS on an AIRCRAFT. Detailed knowledge of both the FIDS design and the AIRCRAFT design are required for installation. Generally, for a FIDS supplier, this means a working relationship with the AIRCRAFT OEM or other party knowledgeable of the specific AIRCRAFT.

This section provides guidance in four areas:

1. Impacts of AIRCRAFT specific installation on the functional performance of FIDS.

2. Installation considerations specific to ROTORCRAFT.

3. Airworthiness certification.

4. Implications of the two modes of operation (advisory and primary).

6.2 Functional Performance Considerations

General design requirements of Section 2 are applicable and installed performance criteria are the same as those contained in Section 3. Certain FIDS performance parameters may be affected by its installation on the AIRCRAFT and can only be verified after installation. Sections 6.2.1, 6.2.2, 6.2.3, and 6.2.4 provide guidance on possible impacts of AIRCRAFT specific installation on the functional performance of FIDS. Section 6.2.5 specifies the FIDS RESPONSE TIME requirement that should be met when installed on AIRCRAFT.

6.2.1 Aircraft Atmospheric Environment

A FIDS should be able to operate within the operating limitations of the AIRCRAFT, including airspeed, flight loads and types of operation.

The installed FIDS should be compatible and reliably perform its intended function within the atmospheric environmental conditions present at the location on the AIRCRAFT where the equipment is installed.

AIRCRAFT manufacturers may require different levels or additional tests beyond or different than those specified in Sections 4 and 5. This may also include sensing at temperatures above freezing and specific to the AIRCRAFT's or engine's design.

6.2.2 Installation Location

To help guide the FIDS and AIRCRAFT manufacturer in determining the proper location and design of the FIDS, the following factors should be considered:

- AIRCRAFT configuration including dynamic disturbances in all attitudes encountered in flight operations, e.g., all throttle settings, slat/flap, landing gear position, AOA/AOS, gust, etc.

- Installation location that could affect the local ICING CONDITIONS, e.g.:

    - Local flow angularity and airspeed.

    - Local airspeed affecting temperature and pressure coefficient.

    - Local freezing fraction.

    - Local collection efficiency.

    - Surface boundary layer characteristics and impinging droplet distributions.

    - Influences of forward AIRCRAFT equipment on FIDS droplet impingement and water collection.

    - LWC/IWC concentration factor over the range of possible drop/crystal size and the associated drop/crystal spectra between FREESTREAM and local conditions.

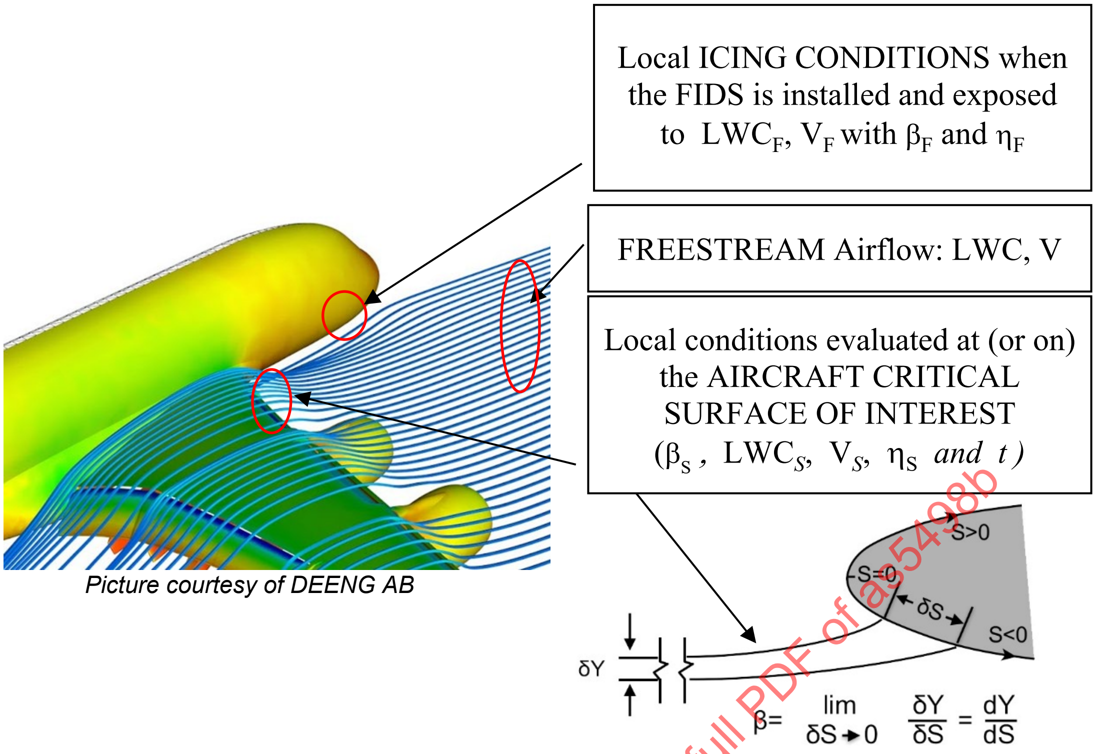
    - Disturbance induced by other AIRCRAFT upstream/downstream objects (probes, possible ICE build-up on some AIRCRAFT SURFACES, etc.).

The above considerations are applicable whether or not the SENSING SURFACE and the SURFACE OF INTEREST are the same.

6.2.3 Installation Factors

As a consequence of the above considerations, ICING CHARACTERISTICS and airflow conditions sensed by the FIDS can be different from the FREESTREAM value. The ratio of these values, also known as the "installation factor," can range from below one to greater than one, depending on the FIDS location and the flight conditions.

Figure 3 illustrates the local conditions seen by the FIDS SENSING SURFACE when installed on the AIRCRAFT and the FREESTREAM conditions.



Picture courtesy of DEENG AB

Definition and graphic from SAE ARP5624

Figure 3 - FIDS local conditions versus airframe local conditions

The installation factor can be defined by the ratio of each individual local parameter (e.g., LWC_F, V_F, local C_p, local temperature, and the resulting freezing fraction η_F) on the FIDS SENSING SURFACE compared with the FREESTREAM conditions parameters (e.g., LWC, V, and C_p and SAT).

The ratio of LWC_F/LWC is also referred to as the LWC concentration factor (CFLWC).

The installation factor in ICE CRYSTALS conditions can be mainly defined by the ratio of IWC_F and V_F sensed by the FIDS SENSING SURFACE compared with the FREESTREAM conditions IWC and V.

The ratio of IWC_F/IWC is also referred to as the IWC concentration factor (CFIWC).

When assessing the IWC and LWC values at/on the FIDS SENSING SURFACE, the differences in the drop/crystals spectra between FREESTREAM and local conditions should also be assessed. Differences in drop spectra might affect the FIDS RESPONSE TIME, but can also impair the performance of the FIDS Appendix O and/or Appendix D/P discrimination functions.

For a particular application, the installation factors may vary within a certain range depending on the different AIRCRAFT configuration and flight phases.

When the FIDS is installed at a particular location of the AIRCRAFT, the influence of these installation factors on the FIDS performance should be analyzed taking into account the FIDS installation factors already specified by the FIDS manufacturers in 5.2.1.4. The results of this analysis could require additional testing demonstrating full coverage of the ICING CHARACTERISTICS and airflow conditions at the installed location.

6.2.4 Structural Thermal Transfer, Structural Damage, Electrical and Aerodynamics

In addition to the generic installation standards applicable to AIRCRAFT equipment, the following factors should be considered:

- Thermal compatibility such as:
  - Heat exchange from the AIRCRAFT structure to the FIDS.
  - Heat exchange from the FIDS to the AIRCRAFT structure.
  - Material thermal expansion.
- AIRCRAFT interaction such as:
  - ICE shedding from the FIDS impacting the AIRCRAFT SURFACES.
  - Flow disturbance affecting the AIRCRAFT SURFACES and other instruments.
  - Environmental contamination (e.g., fluids, bugs, slush, mud, etc.) during taxiing, landing, and take-off.
- Maintainability such as:
  - Protective devices and maintenance procedures may be needed if damage to FIDS can occur during ground operations.
- Electrical such as:
  - Appropriate bonding to the AIRCRAFT structure for Electromagnetic Interference (EMI) and lightning protection.
  - Appropriate grounding between the case of FIDS and the AIRCRAFT structure to minimize the voltage between the two parts.

6.2.5 FIDS Response Time When Installed on Aircraft

Based on the above analysis the following RESPONSE TIME requirement should be met when operating within the full AIRCRAFT flight envelope:

$$\tau \text{ FIDS\_installed} < \tau \text{ AIRCRAFT ICE buildup} \qquad \text{(Eq. 3)}$$

where:

τ FIDS_installed = the maximum RESPONSE TIME to sense and annunciate the ICING CONDITIONS when the FIDS is installed and exposed to local LWC concentration (LWC_F, β_F), local airspeed (V_F), local C_p, local temperature, and the resulting freezing fraction (η_F) on the FIDS SENSING SURFACE

τ AIRCRAFT ICE-buildup = the time to accumulate the maximum allowable amount of ICE on the AIRCRAFT CRITICAL SURFACE OF INTEREST, this time can be calculated using Equation 1 and local parameters t, ρ, LWC_S, V_S, β_S, and η_S as defined in 3.4.1.1

The aerothermal and aerodynamic analysis conducted on the SURFACE OF INTEREST should provide the appropriate values of β, η and the maximum allowable ICE thickness, t, to use in Equation 1. This is a reflection of how the airframe moving through the environment affects these parameters in the immediate region of the SURFACE OF INTEREST. These locally varying parameters are important when assessing airframe ICE accumulations and FIDS performance.

The freezing fraction term is a function of many different variables and must be evaluated independently for both the AIRCRAFT SURFACE OF INTEREST and FIDS SENSING SURFACE taking into account the local LWC, V, surface temperature, etc., seen by each. See A.1.1.

Figure 3 illustrates the local conditions seen by the FIDS SENSING SURFACE when installed on the AIRCRAFT and the local conditions seen by the AIRCRAFT CRITICAL SURFACES OF INTEREST.

Figure 4 represents an example of resulting freezing fraction on the FIDS SENSING SURFACE when installed on the AIRCRAFT and the freezing fraction on the airframe surface (AIRCRAFT CRITICAL SURFACE OF INTEREST) showing possible miss-alignment of the two critical temperatures.

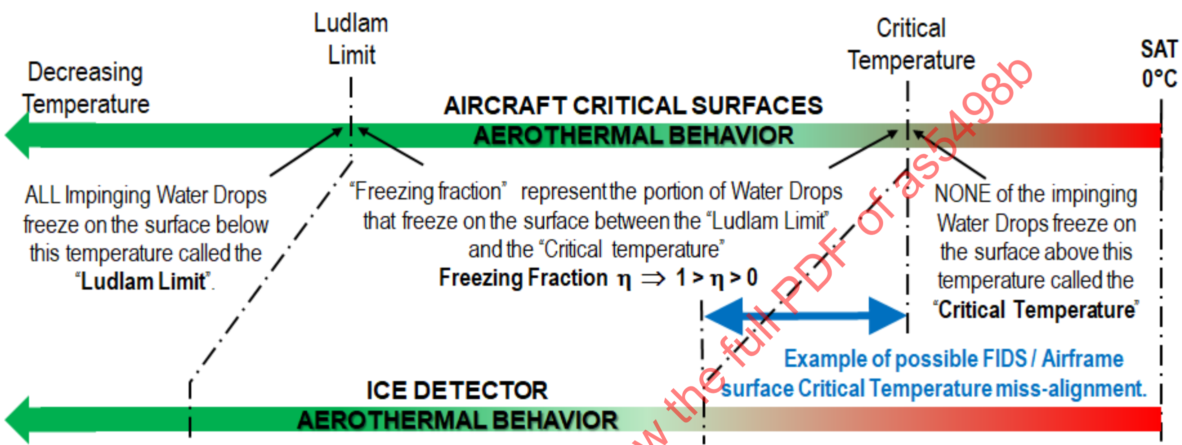


Figure adapted with permission from SAE Technical Paper (*) 2015-01-2105. © SAE International

Figure 4 - Freezing fraction at FIDS location and on aircraft surfaces

Refer to SAE Technical Paper 2015-01-2105, Figures 11, 12, and 15.

6.2.5.1 Effect of FIDS Detection and Detectability Threshold

AIRCRAFT airframe exposure to ICING CONDITIONS below the FIDS detection or detectability thresholds should be assessed by the AIRCRAFT manufacturer for safe operation during the maximum exposure time.

6.2.6 Primary FIDS Function Integrating Multiple Sensors

Safety assessment: When showing installation level compliance to the SYSTEM safety requirements for a PRIMARY FIDS FUNCTION integrating multiple ICE detectors, it should be assumed that the loss of one ICE detector leads to the loss of the PRIMARY FIDS FUNCTION, unless it can be demonstrated that the remaining ICE detector(s) can still ensure detection performance in the whole approved ICING CONDITIONS and flight envelope that meets the safety objectives. Otherwise, the FIDS FUNCTION should revert to an ADVISORY FIDS FUNCTION.

6.3 Installation Information for the End-User

The FIDS equipment manufacturer shall prepare information for the end user (e.g., installation instructions and user's manual) containing at a minimum the following:

1. Operating instructions and limitations sufficient to describe the equipment's operational capability and the specific intended ICE detection function(s) per 2.3 of this specification.

2. Any required operating safety precautions (e.g., probe is hot when the heaters are active and can result in burn injury).

3. Installation procedures and limitations sufficient to ensure that the INFLIGHT ICE detection SYSTEM meets the requirements of this specification when installed (e.g., power availability limits, concentration factor limits, etc.). Specific installation guidance may be incorporated by reference to Section 6 of this specification.

4. Equipment installation limitations, exceptions or test deviations resulting from the 4.3 qualification testing requirements of this specification.

5. Instructions for maintainability per 2.6 of the specification to ensure equipment continues to meet the standards of this specification in service.

6. Certification documentation as required to support installation approval (software and electronic hardware supporting documents, DAL, qualification test results, FAILURE rate information, etc.).

6.4 Rotorcraft Specific Guidance

6.4.1 Icing Environment Considerations

While sharing a number of design characteristics with AIRPLANES, ROTORCRAFT are often flown in adverse operating conditions, often at low speeds (including HOVER) and close to the ground. In addition, ROTORCRAFT may operate in ICING CONDITIONS for the duration of the flight and not simply pass through an icing cloud.

It should be noted that:

- Appendix O, as defined in CS-25/14 CFR Part 25, is not part of CS-29/14 CFR Part 29 or CS-27/14 CFR Part 27 and thus it is not currently applicable to ROTORCRAFT.

- Appendix D/P as defined in CS-25 /14 CFR Part 33, is not part of CS-29/14 CFR Part 29 or CS-27/14 CFR Part 27 and is only applicable to AIRCRAFT engines and therefore is not currently applicable to ROTORCRAFT.

- SLD (Appendix O), glaciated and mixed phase (Appendix D/P) ICING CONDITIONS are beyond the range of the current CS-29/14 CFR Part 29 Appendix C icing envelope; thus ROTORCRAFT, with no criteria for certification in freezing drizzle or freezing rain, are currently prohibited from flying in such conditions. Accordingly, 3.3.1.3, 3.3.1.3.1 and 3.3.1.4 may not be applicable to a rotorcraft installation.

- The ROTORCRAFT manufacturer may provide or identify cues to crew such that they may recognize if the ROTORCRAFT has entered such conditions, and that adequate exit or avoidance procedures exist. If the FIDS is not capable of detecting such conditions, any applicable limitations pertaining to the FIDS should be included in the ROTORCRAFT flight manual.

6.4.2 Hover Considerations

ROTORCRAFT, including conventional helicopters, compound helicopters, and tilt-rotors/tilt-wings, have the ability to operate at low airspeed, including HOVER, sideward, and rearward flight. The FIDS should be able to consistently detect the presence of ICING CONDITIONS such that the necessary AIRCRAFT ICE protection SYSTEMs can be activated.

While current commercial operating rules prevent flight in ICING CONDITIONS below V_{MINI}, other applications require that the FIDS must be able to detect ICE continuously from take-off to landing. In HOVER, the blades and engine intakes can accrete ICE, but large sections of the fuselage may not. As a result, there may be no visual cues to prompt the crew to manually activate the AIRCRAFT ICE protection SYSTEM. The requirement for measuring ICE accretion or ICE accretion rate at low speed (<40 knots) should be closely coordinated with the ROTORCRAFT manufacturer.

Care must be taken while selecting and placing the FIDS, as rotor downwash may affect the flow-field around the AIRCRAFT.

NOTE: Rotor wash is highly variable and may not be suitable for inducing sufficient flow over the FIDS to provide an accurate reading as it varies with AIRCRAFT gross weight, height above ground (IGE/OGE) and cross winds.

An aspirated FIDS may be used to provide ICE detection/rate of accretion in the low-speed range. Consideration, however, should be made of the likely operating environment at low speed near the ground, where snow, ICE, and dirt particulates are often present when the ROTORCRAFT operates over unimproved surfaces.

Environmental Considerations

As noted in 6.4.1, ROTORCRAFT may operate in non-ideal environments. The FIDS will need to maintain full operational capability while not generating NUISANCE ALARMS.

Due to the dynamic characteristics of rotor SYSTEMs, the rotorcraft vibratory environment may be higher than that of fixed wing AIRCRAFT.

ROTORCRAFT are operated in closer vicinity to crew, passengers and cargo than fixed wing AIRCRAFT. Due to their runway independence and often critical mission requirements, personnel unfamiliar with the AIRCRAFT have the potential to damage any exposed sensors. The FIDS needs to be sufficiently robust, while complying with the appropriate bird strike design requirements, and be capable of performing self-diagnosed pre-take-off performance checks.

6.4.3 Performance Criteria

Traditional FIDS performance criteria, detailed in 6.2.1, 6.2.3, and 6.2.5 may not be applicable to ROTORCRAFT. The critical ICE accretion time cannot be calculated simply based upon a FREESTREAM velocity, especially in low speed conditions. There are significant differences in collection efficiency and velocity at any blade section and there may be little correlation between ICE accretion rates on the rotor and the fuselage (in particular the engine inlet) and any fixed lifting or stabilizing surfaces. This disparity between the fuselage and rotor is design and flight condition specific.

The critical rotor blade ICE accretion time will need to be determined by the AIRCRAFT manufacturer. On some ROTORCRAFT, a specific ICE thickness is required prior to the triggering of rotor DEICE SYSTEM to prevent the SYSTEM from generating runback refreeze while preventing self-shedding of oversize pieces of ICE.

6.5 Airworthiness Certification

6.5.1 Applicable Regulations

A FIDS shall comply with applicable airworthiness requirements defined in the AIRCRAFT’s type certification data sheet. FIDS equipment may also be defined by AIRCRAFT manufacturer specifications. For this MOPS, regulatory authorities include the United States Federal Aviation Administration (FAA) and the European Aviation Safety Agency (EASA). EASA and the FAA regulate the design of AIRPLANES with the following airworthiness regulations:

- CS-23/14 CFR Part 23 for normal, utility, acrobatic, and commuter category AIRPLANES.
- CS-25/14 CFR Part 25 for transport category AIRPLANES.
- CS-27/14 CFR Part 27 for small ROTORCRAFT.
- CS-29/14 CFR Part 29 for large ROTORCRAFT.
- CS-E for engines.
- 14 CFR Part 33 for engines.

Safety assessment processes provided by ARP4761 should be followed.

Consideration should also be given to operational regulations:

- 14 CFR Part 91 for general operating and flight rules.
- 14 CFR Part 121 for domestic, flag, and supplemental air operations.

- 14 CFR Part 135 for commuter and on-demand operations.

Certification requirements may vary depending on the FIDS's function, mode of operation, and design. Specific certification requirements and means of compliance for the FIDS may be provided by certification authorities in the form of a certification review item, issue paper, acceptable means of compliance, or in an advisory circular.

6.5.2 Certification Guidance

Beyond unique certification requirements issued for specific FIDS applications, the following general certification guidance is applicable.

6.5.2.1 FIDS Qualification Requirements to be Considered when Installed on AIRCRAFT

FIDS may be located on virtually any part of the AIRCRAFT. While mounting to the fuselage is the most common, installations on the wing, tail, and engine could be envisaged. These different mounting locations can have an impact on vibration levels, EMI/lightning energy exposure, min/max temperatures, local pressures, exposure to contaminants, etc. The type of power supply used by the FIDS needs to also be considered. If the FIDS is mounted to a metallic versus composite AIRCRAFT structure, this can also have a significant impact on the qualification requirements. Similarly, the use of a shielded versus non-shielded wiring harness will affect the test levels used for HIRF and lightning tests.

Depending on the above considerations the categories provided in 4.3.1, Table 6 shall be reviewed and adapted.

6.5.2.2 Reliability, Availability, and Integrity

The integrity (i.e., how good the data is) and availability (i.e., SYSTEM is working normally) of the data are driven by requested mode of operation and the AIRCRAFT SYSTEM safety assessment (SSA). The design assurance level (DAL) for the "item" (LRU) and functions is derived from the SSA and associated analyses from ARP4754/EUROCAE ED-79. The DAL associated with each function or LRU largely determines the integrity required as per AMC/AC 25.1309. The reliability and availability (roughly 1/reliability) is driven by AIRCRAFT dispatch and other operational requirements and must be coordinated with the AIRCRAFT manufacturer.

6.5.2.3 Human Factors

Design and installation of any FIDS shall take into account the applicable human factors as required by CS-23/14 CFR Part 23.1309, 23.1322, 25.1302, 25.1309, 25.1322, 27.1309, 29.1302, 29.1309 and 29.1322, and MIL-STD-1472). Regulatory compliance guidance is provided by AMC 25.1302, FAA AC 20-175, 23.1311-1C, 25-11B, 25.1302-1, and 25.1322-1.

Even though the pilots retain responsibility to monitor external conditions when an ADVISORY FIDS is installed, it shall be recognized the natural tendency of flight crews to become reliant on the ADVISORY FIDS as they would on a PFIDS. Therefore, undetected FAILURE should be considered as at least a Major FAILURE unless substantiated as meriting a lower FAILURE condition classification.

6.5.2.4 Displays

If a display is to operate in conjunction with a FIDS, then compliance to CS-25/14 CFR Part 25.1302 is required and recommended procedures/specifications of ARP4256 and AS8034 regarding displays shall be considered. It may be useful to also consider JSSG-2010-5 paragraph 3.5.2.1.8.5 Visual Displays.

6.5.2.5 Marking

Marking on the FIDS shall follow the guidelines of 14 CFR Part 45.15 and/or CS Part 21A.609(e) and CS Part 21A.807(b), unless otherwise specified. If the COMPONENT includes software, the part number shall include hardware and software identification, or separate part numbers may be utilized for hardware and software. The part number shall uniquely identify the hardware and software design (unless the unit has Field loadable software), including modification status.

If radio frequency identification (RFID) and/or machine-readable information (MRI) is to be used for part marking, A4A Spec 2000 Chapter 9 or MIL-STD-130 may be used for guidance.

6.6 System Functions

6.6.1 Modes of Operation

For guidance for both ADVISORY and PRIMARY FIDS, refer to the latest revision of the following regulatory documents: AC 20.73A, 25-28, 121.321-1, 27-1B, 29-2C, AMC 25.1419. Also refer to ASTM F3120.

6.6.1.1 Advisory

An ADVISORY FIDS (AFIDS) provides advisory ICE accretion or ENVIRONMENTAL INFLIGHT ICING CONDITIONS information used by the flight crew in the decisions that AIRCRAFT and/or engine icing is present and that implementation of AFM procedures for INFLIGHT icing operations is required. This advisory information cannot be the only available ICE detecting cue, but is used with other AFM identified icing detecting cues to confirm AIRCRAFT and engine icing.

6.6.1.2 Primary

A PRIMARY FIDS (PFIDS) is the only required means of providing its function and may automatically implement actions required for safe INFLIGHT icing operations without flight crew intervention (APFIDS). (An APFIDS may or may not provide ICE accretion or ENVIRONMENTAL INFLIGHT ICING CONDITIONS information to the flight crew.) A PFIDS may also provide ICE ACCRETION OR ENVIRONMENTAL INFLIGHT ICING CONDITIONS information to the flight crew and the flight crew is required to manually implement AFM procedures to ensure safe INFLIGHT icing operations (MPFIDS). A PFIDS may provide icing environment characteristics information.

7. NOTES

7.1 Revision Indicator

A change bar (l) located in the left margin is for the convenience of the user in locating areas where technical revisions, not editorial changes, have been made to the previous issue of this document. An (R) symbol to the left of the document title indicates a complete revision of the document, including technical revisions. Change bars and (R) are not used in original publications, nor in documents that contain editorial changes only.

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