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Minimum Operational Performance Specification for Inflight Icing Detection Systems

FOREWORD

1. The development of these guidelines was jointly accomplished by EUROCAE Working Group 54 and the Society of Automotive Engineers (SAE) AC-9C through a consensus process. It was accepted by the Council of EUROCAE on June 2001 and SAE on September 2001.

2. SAE, Inc. and EUROCAE are, respectively, US and international not-for-profit making organizations, formed to advance the art and science of aviation and aviation electronic systems for the benefit of the public.

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CHAPTER 1

1. SCOPE:

1.1 Purpose and Scope:

The objective of this Minimum Operational Performance Specification is to specify the minimum performance of onboard inflight icing detection systems. Throughout the document, these devices are referred to as Flight Icing Detection Systems (FIDS). These systems are intended to either provide information which indicates the presence of ice accreted in flight on monitored surfaces or indicate the presence of icing conditions in the atmosphere. They may operate the airplane anti-ice/ deice systems. Detection of ice accreted on the ground is not considered in this document but can be found in ED-104. This MOPS was written for the use of FIDS on airplanes only, as defined in paragraph 1.5. Use on other aircraft may require additional considerations.

Chapter 1 of this document 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 Chapter 2 to Chapter 4. Definitions essential to proper understanding of this document are also provided in Chapter 1.

Chapter 2 contains general design requirements for an onboard FIDS.

Chapter 3 contains the Minimum Operational Performance Specification for the equipment, defining performance under icing conditions likely to be encountered in flight.

Chapter 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.

Chapter 5 describes recommended test procedures for demonstrating compliance with Chapter 3.

Chapter 6 specifies the performance required of the installed equipment. Ground and flight tests for the installed equipment are included when performance cannot be adequately determined through testing under standard test conditions.

1.2 Applications:

Compliance with this Minimum Operational Performance Specification is recommended as a means of assuring that the equipment will satisfactorily perform its intended functions under all icing conditions likely to be encountered in flight.

Any regulatory application of this document in whole or in part is the sole responsibility of appropriate government agencies.

1.2 (Continued):

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 this document.

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 Functionality and Description of System:

Icing instrumentation systems provide information to the flight crew and/or airplane systems concerning inflight icing. Components of the system may be intrusive or non-intrusive to the airflow. The system may be directly or indirectly sensitive to the physical phenomena of inflight icing. Some possible icing instrumentation technologies include: latent heat of fusion, changes in the natural frequency of vibrating components, visual cues, ultrasonic waves, optical methods such as IR cameras, the friction between a rotating cylinder and scraper, etc. Icing instrumentation systems are divided into two types: FIDS and Aerodynamic Performance Monitoring Systems (APMS). FIDS are further divided into those that detect ice accretion and those that detect icing conditions.

A FIDS that detects ice accretion informs the flight crew and/or systems about the presence of ice accretions on reference airplane surfaces. FIDS that detect ice accretion may also inform the crew or a system about ice thickness, ice accretion rate, liquid water content, cloud droplet size, and/or accretion location. This MOPS only defines testing for ice detection, ice thickness, ice accretion rate, and liquid water content. FIDS that detect ice accretion may be located on or remote from the monitored airplane surfaces.

A FIDS that detects icing conditions provides information to the flight crew and/or airplane systems concerning atmospheric icing conditions. The output of a FIDS that detects icing conditions informs the flight crew and/or airplane systems about the presence of atmospheric conditions that are conducive to the accretion of ice on airplane surfaces. A FIDS that detects icing conditions is not necessarily sensitive to the presence of ice accretions.

A FIDS may include a processing unit to perform signal processing, sensor monitoring, data communication or other functions. The processing unit may either be integrated with or separate from the sensor(s). A FIDS may be connected to a device to provide information to the cockpit crew. The FIDS may communicate with other onboard equipment or systems.

1.3 (Continued):

An Aerodynamic Performance Monitoring System (APMS) informs the flight crew and/or airplane systems about aerodynamic performance degradation, which may be due to ice accretions, over monitored surfaces. This aerodynamic performance degradation may result in degraded airplane performance and handling qualities. An APMS is not directly sensitive to ice accretions. These systems are not considered in this specification.

1.4 System Classification:

1.4.1 Classification By Use: This MOPS will consider two classes of Flight Icing Detection Systems (FIDS) that detect ice accretion or icing conditions: ADVISORY systems and PRIMARY systems.

An ADVISORY FIDS annunciates the presence of ice accretion or icing conditions. The cockpit crew is responsible for monitoring the icing as defined in the Airplane Flight Manual (AFM). Typical methods include monitoring:

- total air temperature
- visible moisture criteria
- visible ice accretion
- specific airframe ice accretion thickness
- FIDS

Activation by the cockpit crew of the anti-icing or deicing system(s) remains a requirement. The ADVISORY FIDS provides information to advise the cockpit crew of the presence of ice accretion or icing conditions, but it can only be used in conjunction with other means to determine the need or timing of anti-icing or deicing system activation.

A PRIMARY FIDS annunciates the presence of ice accretion or icing conditions and may also provide information to other airplane systems. The PRIMARY FIDS can further be classified as PRIMARY automatic or PRIMARY manual. In a PRIMARY automatic system, the FIDS automatically activates anti-icing or deicing systems. In a PRIMARY manual system, the cockpit crew activates the ice protection systems based on the FIDS annunciation.

1.4.2 Classification By Sensing Method: Flight Icing Detection Systems that detect ice accretion and are covered by this document include the following classes:

- FIDS that make a measurement on a reference surface correlated to ice accumulation on a monitored surface (i.e., probe type sensors)
- FIDS that make a direct measurement on a reference surface which is part of a monitored surface (i.e., flush mounted sensors)
- FIDS that make a remote measurement on a reference surface which is part of a monitored surface (i.e., optical camera methods)

In addition, this document includes FIDS that detect icing conditions. This document considers all FIDS that detect icing conditions as a single class.

1.5 Definitions and Abbreviations:

TABLE 1 - Definitions

ADVISORY FIDS	A FIDS that provides the cockpit crew with an additional indication of ice or icing, but the cockpit crew still activates ice protection systems based on Aeroplane Flight Manual (AFM) criteria (typically when the total air temperature is below a threshold level and visible moisture is present) and not solely based on the FIDS.
Aeroplane	A fixed-wing vehicle that travels through air supported by the dynamic action of air against its lifting surfaces.
Anti-icing	The prevention of ice formation on a surface.
APMS	An Aerodynamic Performance Monitoring System informs the cockpit crew or another system about degradation of aerodynamic performance (these systems are not considered in this MOPS).
Component	A part of a system (e.g., sensor, processor, or display).
Deicing	The removal of ice accumulation from a surface.
Failure	An occurrence which affects the operation of a component such that it can no longer function as intended.
FIDS	Flight Icing Detection System. A FIDS includes at least one sensor which is directly or indirectly sensitive to the physical phenomena of icing.
Frost	Frozen moisture condensed from the atmosphere.
Glaze Ice	Transparent or translucent ice formed by liquid water droplets which do not freeze immediately on impact.
Ice	Any form of frozen water including glaze ice, rime ice, frost, runback ice, snow, and ice crystals.
Ice Detector	Informs the cockpit crew or a system about ice accretion on monitored aeroplane surfaces.
Icing Conditions	The presence of atmospheric moisture and temperature conducive to aeroplane icing.
Inflight	From weight off wheels to weight on wheels.
Intrusive	A FIDS in which the sensing component is located outside the boundary layer.
LWC	Liquid water content. Expressed in mass of water per unit volume of air.
Monitored Surface	The surface of concern regarding ice hazard (e.g., the leading edge of the wing).

TABLE 1 - Definitions (Continued)

Nuisance Alarm	An undesired indication of ice or icing.
PRIMARY Automatic FIDS	A FIDS that automatically activates anti-icing or deicing systems.
PRIMARY Manual FIDS	A FIDS that provides the cockpit crew with an indication of ice or icing and the cockpit crew is required to activate the ice protection systems based on the FIDS.
Reference Surface	The surface where a FIDS sensor makes it measurement (e.g., the intrusive part of a probe system).
Rime Ice	A milky, opaque ice formed by the rapid freezing of supercooled droplets.
Runback Ice	Ice formed from the freezing or re-freezing of water leaving thermally protected surfaces onto unprotected surfaces.
Supercooled	Liquid cooled below the freezing point without solidification or crystallization.
System	A combination of components which are inter-connected to perform one or more functions

TABLE 2 - Abbreviations

AIR	Aerospace Information Report
APMS	Aerodynamic Performance Monitoring System
ARP	Aerospace Recommended Practices
AS	Aerospace Standard
CFR	Code of Federal Regulations
ED	EUROCAE Document
EUROCAE	European Organization for Civil Aviation Equipment
FAR	Federal Aviation Regulation
FIDS	Flight Icing Detection System
FMECA	Failure Modes Effects and Criticality Analysis
FOD	Foreign Object Damage
JAR	Joint Aviation Requirement
KCAS	Knots Calibrated Air Speed
KTAS	Knots True Air Speed
LWC	Liquid water content. Expressed in mass of water per unit volume of air.
MOPS	Minimum Operational Performance Specification
MVD	Median volumetric diameter. Defined in the FAA Aircraft Icing Handbook.
RTCA	Radio Technical Commission for Aeronautics
SAE	Society of Automotive Engineers

1.6 References:

NOTE: Title 14 of the US Code of Federal Regulations (14 CFR), Federal Aviation Regulation (FAR) Part XX documents are referred to as “FAR XX” in the body of this document.

1.6.1 Reference Documents: The following documents are incorporated by reference:

EUROCAE ED-14D - Environmental Conditions and Test Procedures for Airborne Equipment

RTCA DO-160D - Environmental Conditions and Test Procedures for Airborne Equipment

EUROCAE ED-12B - Software Considerations in Airborne Systems and Equipment Certification

RTCA DO-178B - Software Considerations in Airborne Systems and Equipment Certification

JAR 23 First Issue - Normal, Utility, Aerobatic and Commuter Category Aeroplanes

JAR 25 Change 14 - Large Aeroplanes

14 CFR Part 23 Amendment 23-53 (FAR 23) - Airworthiness Standards: Normal, Utility, Acrobatic, and Commuter Category Airplanes

14 CFR Part 25 Amendment 25-98 (FAR 25) - Airworthiness Standards: Transport Category Airplanes

14 CFR Part 21 Amendment 21-76 (FAR 21) - Certification Procedures for Products and Parts

1.6.2 Applicable Documents:

EUROCAE ED-79/SAE ARP4754 - Certification Considerations for Highly-Integrated or Complex Aircraft Systems - November 1996

EUROCAE ED-104 - Minimum Operational Performance Specification for Ground Ice Detection Systems

SAE ARP4761 - Guidelines and Methods for Conducting the Safety Assessment Process on Civil Airborne Systems and Equipment - December 1996

JSSG-2010-5 Joint Service Specification Guide - Crew Systems Aircraft Lighting Handbook - October 30, 1998

SAE AIR4367 - Aircraft Ice Detectors and Icing Rate Measuring Instruments

1.6.2 (Continued):

SAE ARP4256 - Design Objectives for Liquid Crystal Displays for Part 25 (Transport) - December 1996

MIL-STD-1472E - Human Engineering

SAE AS8034 - Minimum Performance Standard for Airborne Multipurpose Electronic Displays - Reaffirmed May 1993

FAA Aircraft Icing Handbook DOT/FAA/CT-88/8-1 - Updated Sept 93

FAA AC 20.73 - Advisory Circular - Aircraft Ice Protection - April 21, 1971

FAA AC 23.1419-2A - Certification of Part 23 Airplanes for Flight in Icing Conditions - August 19, 1998

FAA AC 25.1419-1 - Certification of Transport Category Airplanes for Flight in Icing Conditions

JAR-E - Engines

14 CFR Part 33 Amendment 33-19 (FAR 33) - Airworthiness Standards: Aircraft Engines

14 CFR Part 91 Amendment 91-258 (FAR 91) - General Operating and Flight Rules

14 CFR Part 121 Amendment 121-271 (FAR 121) - Certification and Operations: Domestic, Flag, and Supplemental Air Carriers and Commercial Operators of Large Aircraft

14 CFR Part 135 Amendment 135-75 (FAR 135) - Air Taxi Operators and Commercial Operators

JAR/OPS 1 - Commercial Air Transportation (Aeroplanes)

CHAPTER 2

2. GENERAL DESIGN REQUIREMENTS:

2.1 Design Requirements:

2.1.1 Airworthiness And Certification:

The FIDS shall comply with any applicable airworthiness requirements, the scope of which should be defined in the airplane specification. The system may also be regulated by the airplane specification. In the event of conflict, airworthiness requirements shall prevail. Regulatory bodies include the United States Federal Aviation Administration (FAA) and the European Joint Aviation Authorities (JAA). The FAA and the JAA regulate the design of airplanes with the following airworthiness standards:

- FAR/JAR 23 for normal, utility, acrobatic, and commuter category airplanes
- FAR/JAR 25 for transport category airplanes

Consideration should also be given to operational regulations.

2.1.2 Controls: The operation of FIDS controls intended for use during flight, in all possible positions, combinations and sequences, shall not result in a condition, the presence or continuation of which would be detrimental to the continued performance of the system.

2.1.3 Effects Of Tests: Unless otherwise stated, the design of the system shall be such that, during and after the application of operational tests, no condition exists which would be detrimental to the subsequent performance of the equipment.

2.1.4 Software Management: Software design shall follow the guidelines specified in document EUROCAE ED-12/RTCA DO-178 “Software Considerations in Airborne Systems and Equipment Certification.” The software criticality level will depend on the particular equipment function and application as defined by the airplane specification.

2.1.5 Operational Minimum Requirements:

2.1.5.1 Built-in Test Equipment (BITE): Any FIDS certificated as primary shall incorporate built-in test equipment (BITE) and annunciate detected ice detector failures to the cockpit crew. The undetected failure rate for latent loss of ice detection capability for primary certificated equipment shall be in accordance with the failure classification resulting from a failure modes effects and criticality analysis/fault hazard analysis for the system installation. BITE should be incorporated in non-primary certificated FIDS as well.

2.1.5.2 Safety Objectives: All aspects of the FIDS design should be considered in terms of safety. When installed, the system should be designed so that:

1. FIDS and associated components, considered separately and in relation to other systems, should be designed so that failure conditions classification and effects shall be in compliance with FAR/JAR 23.1301, 23.1309, 25.1301, and 25.1309. Information concerning unsafe FIDS operating conditions shall be provided to the cockpit crew.

2. In order to assist the designer, manufacturer, installer and certification authorities with the safety aspects associated with FIDS design, the following two SAE documents are referenced:

   EUROCAE ED-79/SAE ARP4754 - Certification Considerations for Highly-Integrated or Complex Aircraft Systems.

   SAE ARP4761 - Guidelines and Methods for Conducting the Safety Assessment Process on Civil Airborne Systems and Equipment.

2.1.6 Minimum Structural Considerations:

2.1.6.1 Normal Operations: The sensor should be designed to withstand impact from ice particles shed from the airplane during operations and continue to operate.

2.1.6.2 Foreign Object Damage (FOD): The sensor should be constructed so that parts do not become loose in service. It should withstand strains, impacts, vibrations, and damage from foreign objects. The FIDS is not required to remain functional in order to satisfy this requirement. However, FIDS certificated as primary shall indicate an unsafe system operating condition as required in paragraph 3.3.1.

2.1.7 Additional Design Criteria: Design of any FIDS shall take into account the applicable human factors as enumerated in MIL-STD-1472. As a minimum, each design shall consider the following factors.

2.1.7.1 Functional Criteria:

2.1.7.1.1 Atmospheric Conditions Associated With Icing: The effect on the FIDS of conditions associated with icing conditions, such as ice crystals, freezing fog, and snow shall be taken into account if any of these conditions may result in a hazard to the airplane.

2.1.7.1.2 Effect Of Contamination: The FIDS design shall take into account the effects of contaminants likely to be encountered in service (e.g., fuel, hydraulic fluid, deicing fluids, insects, sand). If operation of the FIDS has been found through analysis to be sensitive to contaminants likely to be encountered in service, the manufacturer shall define, perform, and document substantiating tests.

2.1.7.1.3 Thermal Compatibility: Temperature differences between the reference surface and the surrounding surface shall be minimized to account for self-heating of electronic components.

2.1.7.1.4 Airplane Effects: The FIDS manufacturer shall take into account the possibility that icing conditions at the installed FIDS location may differ from free stream conditions. This subject is addressed in more detail in paragraph 6.2.9.

2.1.7.2 Operational Criteria:

2.1.7.2.1 Installation: It shall not be possible to complete installation of the FIDS on the airplane if such installation prevents proper operation in flight.

2.1.7.2.2 Marking: Labels installed on the FIDS shall follow the guidelines of FAR 21.607(d) and/or JAR 21.609 (e) and 21.807 (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, including modification status.

2.1.7.2.3 Fasteners: If the FIDS fasteners could fall into an inaccessible airplane space when the unit is installed or removed, then they shall be made captive to the unit.

2.1.7.2.4 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. The installed unit shall not produce toxic fumes under any single fault conditions.

2.1.7.2.5 Displays: If a display is to operate in conjunction with a FIDS, then the requirements of SAE ARP4256 and SAE AS8034 regarding displays shall be considered. It may be useful to also consider the Joint Service Specification Guide JSSG-2010-5 “Crew Systems, Aircraft Lighting Handbook” paragraph 3.5.2.1.8.5 Visual Displays.

2.1.7.2.6 Nuisance Alarms: Nuisance alarms should be minimized.

2.2 Reporting Requirements:

2.2.1 Summary Report: The equipment manufacturer or type certificate holder shall prepare a report which includes as a minimum:

a. A test procedure that includes a detailed description of the functional test(s) that is (are) performed to determine compliance with the applicable equipment performance specification.

b. A test procedure that includes a description of the laboratory setups for each EUROCAE ED-14/RTCA DO-160 section that is tested.

c. For all tests that are not included in b) above, a test procedure that includes a detailed description of each test performed.

d. A Completed Environmental Qualification Form in accordance with Appendix A of EUROCAE ED-14/RTCA DO-160.

e. A listing of FIDS performance limitations, if any. This shall include types of ice accretion (frost, glaze, rime, runback) not detected.

2.2.2 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 performance before, during and after the various tests detailed in EUROCAE ED-14/RTCA DO-160 sections or the other tests performed.

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

c. As applicable, analysis to show the effectiveness of Built-in-test capability.

d. As applicable, analysis to calculate the probability of functional failure or the probability of an undetected functional failure.

e. As applicable, Failure Modes Effects and Criticality Analysis (FMECA).

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

g. As applicable, design tolerance/sensitivity and interface analysis.

The preceding information is also referenced in paragraphs 5.2 and 6.2 of this MOPS.

2.3 Other Requirements:

2.3.1 Qualification Testing Responsibility: Except for the requirements in Chapter 6, the manufacturer of the product shall be responsible for performing all required tests specified herein to demonstrate compliance with this MOPS.

2.3.2 Test Samples: The tests shall be conducted on a sample of the equipment that is in full conformity with production specifications. If the tested item incorporates features that are still experimental or in the development stage, any tests involving the non-production features shall be repeated later on a production item, or evidence presented to substantiate that the test results are valid for the production instrument.

CHAPTER 3

3. MINIMUM OPERATIONAL PERFORMANCE SPECIFICATION UNDER STANDARD CONDITIONS:

3.1 Overview:

Ice accretion on the airplane may result in a degradation of the airplane's handling characteristics, and a loss in airplane performance and flight safety margins.

Inflight icing can be attributed to a combination of factors such as atmospheric conditions (e.g., temperature, humidity, liquid water, and cloud structure), airplane airspeed, and configuration. The frequency of encountering icing conditions is at a maximum between +10 °C and -10 °C static air temperature, then decreases rapidly with decreasing temperature below -20 °C. The chance of encountering icing conditions below static temperatures of -40 °C is rare. For general use, a FIDS should be designed to operate in all types of icing conditions throughout an ambient temperature range of -54 to +10 °C.

This chapter defines the minimum performance criteria under standard operating conditions for the system described in paragraph 1.3.

3.2 Functional Minimum Requirements:

The values given in paragraph 3.2 are for guidance only and may be modified to satisfy airplane manufacturer specifications and/or to comply with regulatory requirements. Refer to Chapter 6 for installed system considerations.

3.2.1 FIDS That Detect Ice Accretion:

3.2.1.1 Conditions to Detect/Measure: A FIDS shall detect ice accretion that can occur in flight (frost, glaze, rime, runback) on defined airplane surfaces and shall annunciate the status to another airplane system and/or directly to the cockpit crew. A FIDS should be capable of detecting the presence of ice accretion under all atmospheric conditions.

3.2.1.2 Minimum Performance:

3.2.1.2.1 Detection of the Ice Accretion: The FIDS shall be capable of detecting ice accretion on reference surfaces. It shall be capable of determining the presence of ice with a maximum detection threshold of 0.5 mm thickness. The duration to recover the capability of performing detection after annunciation of ice should be minimized. The FIDS shall not indicate the presence of ice when no ice is present on the reference surface. If the thickness of accreted ice on the reference surface is in excess of the threshold thickness, the FIDS shall continue to indicate the presence of ice.

NOTE: The detection threshold of 0.5 mm is chosen for the purpose of testing these devices independently of a specific airplane application. This detection threshold is not a statement of the acceptable level of ice accretion on a particular airplane.

3.2.1.2.2 FIDS that Measure Ice Thickness: A FIDS may provide information on ice thickness. A FIDS with an ice thickness measuring capability shall measure thickness with a minimum accuracy of ±0.5 mm or ±20% of the actual value, whichever is greater. The FIDS shall be capable of measuring thickness increments of 1 mm or smaller. The FIDS manufacturer shall specify the maximum thickness for which this accuracy applies.

3.2.1.2.3 FIDS that Measure Ice Accretion Rate: A FIDS may provide information on ice accretion rate. A FIDS with an ice accretion rate capability shall be capable of measuring ice accretion rates ≥0.5 mm/minute and shall measure with a minimum accuracy of ±30% or ±0.2 mm/minute, whichever is greater. The FIDS shall update the measurement at a maximum interval of 1 minute.

3.2.1.2.4 FIDS that Measure Liquid Water Content: A FIDS may provide information on supercooled liquid water content (LWC). A FIDS capable of detecting LWC shall measure LWC with an accuracy of ±0.1 g/m^3 or ±30% whichever is greater. The FIDS manufacturer shall specify the range of liquid water content for which this accuracy applies.

3.2.2 FIDS That Detect Icing Conditions:

3.2.2.1 Conditions to Detect/Measure: A FIDS shall detect atmospheric icing conditions and shall annunciate the status to another airplane system and/or directly to the cockpit crew.

3.2.2.2 Minimum Performance:

3.2.2.2.1 Detection of Icing Conditions: A FIDS that detects icing conditions shall detect the presence of liquid water and shall measure temperature and shall annunciate the status to another airplane system and/or directly to the cockpit crew. A FIDS should be capable of detecting the presence of icing conditions under all atmospheric conditions.

3.2.2.2.2 Temperature Measurement: A FIDS shall provide information on air or water droplet temperature. It shall measure temperature with an accuracy of ±3 °C.

3.2.2.2.3 FIDS That Measure Liquid Water Content: A FIDS may provide information on liquid water content (LWC). It shall measure LWC with an accuracy of ±0.1g/m^3 or ±30% whichever is greater. The FIDS manufacturer shall specify the range of liquid water content for which this accuracy applies.

3.2.2.2.4 FIDS That Measure Other Parameters: A FIDS may provide information on other parameters (such as MVD). In this case, the FIDS manufacturer shall specify the accuracy of these parameters in their range of measurement.

CHAPTER 4

4. MINIMUM PERFORMANCE SPECIFICATION UNDER ENVIRONMENTAL CONDITIONS:

4.1 Introduction:

The environmental test conditions and performance criteria described in this section provide a laboratory means of determining the overall performance characteristics of the equipment under conditions representative of those which may be encountered in actual operation.

Unless otherwise specified, the test procedures applicable to the determination of equipment performance under environmental test conditions are contained in document EUROCAE ED-14/RTCA DO-160 “Environmental Conditions and Test Procedures for Airborne Equipment.” Reference to issue D of EUROCAE ED-14/RTCA DO-160 in paragraph 4.2 is for the purpose of maintaining continuity with issue D. If a FIDS is tested to other issues of these documents, the comments listed in Table 3 shall still apply to the test with similar intent. For each test, the manufacturer shall choose an appropriate category based on the expected application of the FIDS.

4.2 Testing:

The following tests determine whether the FIDS can withstand the effects of the following environmental test conditions and applicable test procedures described in document EUROCAE ED-14D/RTCA DO-160D.

The functional tests shall be performed in relationship to the identified FIDS categories, defined in EUROCAE ED-14D/RTCA DO-160D. Compliance shall be also verified with the performance and accuracy found in FIDS design requirements defined in Chapter 3 before, during, and after each environmental test, as applicable. The FIDS manufacturer shall provide sufficient functional test data to show compliance of the equipment before, during and after the various tests detailed in Table 3.

The reporting requirements of paragraph 2.2 shall apply to the following tests.

4.3 Fluids Susceptibility (EUROCAE ED-14D/RTCA DO-160D, Section 11):

Since a FIDS must be installed to detect meteorological icing, it may be exposed to various fluid contaminants. In this case, exposure to these contaminants shall not cause the FIDS to detect icing if no icing is present. Exposure to these contaminants shall not prevent the FIDS from detecting icing when icing is present. The FIDS shall not be degraded in its performance or reliability following exposure to specified fluid contaminants.

4.3.1 Test Applicability: Those portions of the FIDS directly exposed to the free stream airflow shall be tested with the spray test of EUROCAE ED-14D/RTCA DO-160D, paragraph 11.4.1 while installed in a fixture representative of the airplane installation. If there are other line replaceable units in the FIDS each is to be evaluated as to the applicability of Fluids Susceptibility tests.

TABLE 3 - Test Requirements

ITEM #	EUROCAE ED-14/RTCA DO-160D SECTION	TITLE	COMMENTS
1	4.5.1	Ground Survival Low Temperature	
2	4.5.1	Operating Low Temperature	
3	4.5.2	Ground Survival High Temperature	
4	4.5.2	Operating High Temperature	
5	4.5.4	In Flight Loss of Cooling	
6	4.6.1	Altitude	
7	4.6.2	Decompression	
8	4.6.3	Overpressure	
9	5.0	Temperature Variation	
10	6.0	Humidity	
11	7.2	Operational Shock	
12	7.3	Crash Safety	The application of this test may result in damage to the equipment. Paragraph 2.4 Effects of Tests does not apply.
13	8.0	Vibration	
14	9.0	Explosion	The application of this test may result in damage to the equipment. Paragraph 2.4 Effects of Tests does not apply.
15	10.0	Water Proofness	Applicable only to components of the FIDS exposed to water.

TABLE 3 - Test Requirements (Continued)

ITEM #	EUROCAE ED-14/RTCA DO-160D SECTION	TITLE	COMMENTS
16	11.0	Fluid Susceptibility	See paragraph 4.3 of this MOPS.
17	12.0	Sand and Dust	
18	13.0	Fungus	
19	14.0	Salt Spray	
20	15.0	Magnetic Effect	
21	16.0	Power Input	
22	17.0	Voltage Spike	
23	18.0	Audio Frequency Susceptibility	
24	19.0	Induced Signal Susceptibility	
25	20.0	Radio Frequency Susceptibility	
26	21.0	Radio Frequency Emission	
27	22.0	Lightning Induced Transient Susceptibility	
28	23.0	Lightning Direct Effects	Applicable only to FIDS components exposed to the risk of direct lightning strikes.
29	24.0	Icing	
30	25.0	Electrostatic Discharge	

4.3.2 Fluids To Be Tested: The manufacturer shall select the appropriate fluids from Table 11-1 of EUROCAE ED-14D/RTCA DO-160D for verification testing. In addition, chemicals used to maintain runway traction during icing conditions and aircraft deicing and anti-icing fluids shall be considered as contaminants if they can contaminate the FIDS.

4.4 Hail Strike:

FIDS components exposed to the risk of hail impact shall be able to withstand the impact of a hailstone 75 mm ± 5 mm in diameter having an impact velocity of 150 m/s ± 10 m/s (equivalent to approximately 250 KCAS at 10,000 feet). The hailstone shall strike the FIDS in the most adverse direction likely to be encountered in normal operations. The FIDS may lose its capability to function properly following the impact. In this case, it shall generate a failure signal. Neither the FIDS nor any portion of the FIDS shall detach from its mounting base.

CHAPTER 5

5. TEST PROCEDURES:

5.1 General:

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

5.1.1 Reports & Declarations: The reporting requirements of paragraph 2.2 shall apply to the testing performed in Chapter 5.

5.1.2 Power Input Voltage: Unless otherwise specified, 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.

5.1.3 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.

5.1.4 Adjustment of Frequency: The circuits of the equipment under test shall be properly aligned and adjusted in accordance with the manufacturer's recommended practice prior to application of the specified tests.

5.1.5 Test Instrument Precautions: Precautions shall be taken during conduct of the tests to prevent the introduction of errors resulting from the improper connection of test instruments across the input and output impedances of the equipment under test.

5.1.6 Ambient Conditions: Unless otherwise specified, all tests shall be conducted under conditions of ambient room temperature, pressure, and humidity, as defined in EUROCAE ED-14D/RTCA DO-160D paragraph 3.5.

5.1.7 Connected Loads: Unless otherwise specified, all tests shall be performed with the equipment connected to loads having the impedance values for which it is designed.

5.1.8 Warm-up Period: Unless otherwise specified, all tests shall be conducted after a warm-up period specified by the FIDS manufacturer.

5.1.9 Test Procedures: The following test procedures are considered to be satisfactory means of establishing compliance with the performance specification of Chapters 2 and 3. Testing shall be conducted in a manner that is consistent with the recommended airplane installation limitations.

Alternative procedures, which provide equivalent information, may be used. In such cases, the procedures described in this chapter shall be used as one criterion in evaluating the acceptability of the alternative procedures.

5.2 Detailed Test Procedures:

5.2.1 FIDS That Detect Ice Accretion (Paragraph 3.2.1):

5.2.1.1 Detection Of Ice Accretion (Paragraph 3.2.1.2.1): The following tests are intended to demonstrate detection of ice accretion that can occur in flight (frost, glaze, rime, runback). The runback icing condition is considered to be covered by the glaze ice test condition.

5.2.1.1.1 FIDS That Make A Measurement On A Reference Surface Correlated To Ice Accumulation On A Monitored Surface: The following Appendix C icing conditions shall be tested in an icing wind tunnel. Allow the wind tunnel and sensor to stabilize at the specified velocity and temperature. Record the output of the FIDS for 5 minutes minimum before exposing the sensor to the water. Expose the sensor to the water. Record the response time of the equipment. Response time is defined as the time from initial exposure of the ice sensor to water and the first detection of ice accretion.

Following indication of ice, the sensor shall remain exposed to the water specified with the FIDS output recorded for 15 minutes minimum. During this time, the FIDS shall operate in accordance with its intended function. After this time, the water shall be turned off while maintaining the other wind tunnel parameters. Record the time required for the FIDS to indicate no ice or that ice accretion has ceased.

For systems affected by angle of attack, testing shall be conducted under conditions representative of the range of angle of attack conditions likely to be encountered in service.

5.2.1.1.1 (Continued):

The FIDS shall detect ice accretion under the following conditions. Condition 1 is a light icing condition test for minimum detectability, condition 2 is a heavy glaze condition to ensure the probe will detect in warm runback conditions, and condition 3 is a thermal load test to ensure the probe can continue to operate in a cold, high-LWC environment.

Condition 1: (Rime)	Water concentration: 0.3 g/m^3 ± 0.03 g/m^3 Static temperature: -20 °C ± 2 °C Airspeed: 120 KTAS ± 10 KTAS Water droplet MVD: 15 Microns ± 10 Microns Response time shall be less than 120 seconds
Condition 2: (Glaze)	Water concentration: 0.75 g/m^3 ± 0.08 g/m^3 Static temperature: -3 °C ± 2 °C Airspeed: 145 KTAS ± 10 KTAS Water droplet MVD: 40 Microns ± 10 Microns Response time shall be less than 90 seconds
Condition 3: (Rime)	Water concentration: 1.0 g/m^3 ± 0.1 g/m^3 Static temperature: -30 °C ± 2 °C Airspeed: 250 KTAS ± 10 KTAS Water droplet MVD: 20 Microns ± 10 Microns Response time shall be less than 20 seconds

If these conditions are not deemed suitable for the application or testing facility, then other conditions may be justified with the approval of the appropriate authorities if the modified conditions meet the same stated intent.

5.2.1.1.2 FIDS That Make A Direct Measurement On A Reference Surface Which Is Part Of A Monitored Surface: The objective of this test is to determine the ice sensing thickness threshold.

The FIDS shall be tested with:

- glaze ice,
- rime ice,

in a test environment with operating conditions generating the two kinds of ice. This test environment can be an icing tunnel, a climatic chamber or any natural or artificial means providing that ice can be, on demand, accreted on the reference surface. The process used to generate the rime and glaze ice shall be documented.

For running the tests, the sensor may be supported by a mechanical environment such as a plate or a leading edge profile representing recommended conditions of installation.

5.2.1.1.2 (Continued):

A test shall be run for each kind of ice. For each test:

Install the FIDS sensor in the test environment free of ice and apply power. Allow the reference surface temperature to stabilize at the test conditions. No ice shall be detected under these conditions.

Then expose the FIDS to the ice accretion condition until it detects ice accretion. The ice accretion condition is then stopped and a measurement of the maximum thickness of ice is taken. This value shall not exceed 0.5 mm. The process used to measure ice thickness shall be documented.

For ice detectors that detect frost, perform the following test:

Cool a reference surface below freezing and below the ambient air temperature. Allow the reference surface temperature to stabilize in these conditions. Expose the reference surface to a humid environment. Allow the surface to grow frost until the FIDS detects ice accretion. End exposure of the surface to the humid environment and measure the thickness of the frost. The FIDS shall demonstrate compliance with the requirements of paragraph 3.2.1.2.1.

5.2.1.1.3 FIDS That Make A Remote Measurement On A Reference Surface Which Is Part Of A Monitored Surface: The objective of this test is to verify the capability of the FIDS to detect a circular disk of ice 500 mm^2 ± 50 mm^2 in area or 50% of the reference surface, whichever is smaller, and 0.5 mm maximum thickness accreted anywhere on its reference surface. If there is an ice thickness above which the detector no longer indicates ice or an ice configuration for which ice can not be detected, this shall be tested and documented.

The FIDS shall be tested with:

- glaze ice,
- rime ice,

in a test environment with operating conditions generating the two kinds of ice. This test environment can be an icing tunnel, a climatic chamber or any natural or artificial means providing that ice can be, on demand, accreted on the reference surface. The process used to generate the rime and glaze ice shall be documented.

The tests shall be run using samples that represent all recommended reference surface characteristics. The samples used in the test shall be documented.

For systems affected by lighting conditions, testing shall be conducted under conditions representative of the range of lighting conditions likely to be encountered in service.