

ED-314

COMPLIANCE METHODOLOGIES FOR VTOL CERTIFICATION IN INADVERTENT ICING AND SNOW OPERATION

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CHAPTER 1

INTRODUCTION

1.1 PURPOSE AND SCOPE

VTOL aircraft present a new and emerging technology that differ from conventional rotorcraft and fixed-wing aircraft. The EASA VTOL Special Condition [1] refers to VTOL aircraft as heavier-than-air, person-carrying aircraft in the small-category with lift/thrust units. The distinction from conventional aeroplanes is based upon the VTOL capability of the aircraft, while the distinction from conventional rotorcraft is based upon the use of distributed propulsion, specifically when more than two lift/thrust units are used to provide lift during a vertical take-off or landing.

Certification for flight in icing conditions is complex. The scope of this document is therefore limited to a means of compliance for icing-related regulations applicable to VTOL aircraft that are not certified for flight in icing conditions but may inadvertently encounter icing conditions, and must have provisions to safely operate while exiting the icing conditions. This document also covers snow conditions that are applicable to VTOL aircraft during an inadvertent encounter or for continuous operation.

For aircraft that are not certified to fly in icing conditions, the priority is to avoid operations in conditions where icing is likely to occur. VTOL.2165(b) [1] requires an applicant to provide a means to detect any icing conditions for which the aircraft is not certified to operate in and demonstrate the aircraft's ability to avoid¹ or exit those conditions.

Ground-based weather detecting and forecasting equipment are in development but the accuracy at present is limited and therefore cannot be used as the sole means of compliance for the avoidance of flight into icing conditions. Examples such as current icing potential (CIP) and forecast icing potential (FIP) [2] in the United States, infer icing from various sources such as atmospheric soundings, satellite, radar, surface observations and pilot reports (PIREPS). As a result, the probability of detection of icing conditions is in the order of 90% which is not sufficient for conducting operations over congested areas. Automated surface observations also do not report freezing drizzle or any freezing precipitation. Precipitation is any of the forms of water particles, whether liquid or solid, that fall from the atmosphere and reach the ground. The precipitation types are drizzle, rain, snow, snow grains, ice crystals, ice pellets, hail, and small hail and/or snow pellets [1][23]. When the notice of proposed rulemaking (NPRM) [3] was written, systems being developed such as Terminal Area Icing Weather Information for NextGen (TAIWIN) were envisioned as potentially acceptable weather forecasting products [4]. Airborne-mounted "look ahead" optical based systems are also being developed but the "look-ahead" distance and accuracy remains limited. Currently, there are no readily-identifiable solutions that could be implemented to provide a sole means of compliance to avoid icing conditions with sufficient confidence that an aircraft does not need to demonstrate safe operation during an inadvertent icing encounter. This document, however, provides a possible approach for avoiding icing conditions to ensure that the entire aircraft remains ice-free during operations using an ambient temperature operational limit (section 8).

For the purposes of providing background to the reader, the regulations applicable to rotorcraft (CS-27 and 29) and fixed-wing aircraft (CS-23) that are not certified for icing are presented in APPENDIX A.

This standard addresses icing considerations for the airframe, engines (including electric engines), and propulsors (rotors, fans, or propellers).

¹ This option to 'avoid' icing conditions was originally added to the performance-based rules of FAA regulations (14 CFR 23) at amendment 23-64 and EASA certification specifications CS-23 Amendment 5.

1.2 APPLICATIONS

Compliance with this standard, by manufacturers, is recommended as a means of assuring that the VTOL aircraft will satisfactorily perform its intended function(s) under all conditions normally encountered during routine VTOL aircraft operations. Any regulatory application of this document in whole or in part is the sole responsibility of the appropriate government agencies.

This document sets forth an acceptable means, but not the only means, of demonstrating compliance with the requirements noted in section 1.5 and section 1.6

The document is not intended to apply to vehicles with autonomous capability i.e., the ability to conduct a safe flight without the intervention of a pilot.

The document distinguishes between the basic and enhanced category for inadvertent icing certification. This document is applicable to both VTOL aircraft approved for Visual Flight Rules (day and night) and Instrumentation Flight Rules operations (day and night).

1.3 DEFINITIONS AND ABBREVIATIONS

AC	Advisory Circular
ADS	Air Data System
AFM	Aircraft Flight Manual
AoA	Angle of Attack
AS	Aerospace Standard
ASTM	American Society for Testing and Materials
ATC	Air Traffic Control
CAS	Crew Alerting System
CIP	Current Icing Potential
CS	Certification Specifications
EASA	European Union Aviation Safety Agency
ED	EUROCAE Document
eVTOL	Electric Vertical Take-Off and Landing
FAA	Federal Aviation Administration
FIKI	Flight Into Known Icing
FIP	Forecast Icing Potential
G	Gravitational Force Equivalent
IAW	In Accordance With
IFR	Instrumentation Flight Rules
IGE	In Ground Effect
IMC	Instrument Meteorological Conditions
IPS	Ice Protection Systems
IWT	Icing Wind Tunnel
LWC	Liquid Water Content
METAR	Meteorological Terminal Air Report
MOC	Means of Compliance
MOPS	Minimum Operational Performance Specifications
MSL	Mean Sea Level
MVD	Median Volumetric Diameter
NPRM	Notice of Proposed Rulemaking
OAT	Outside Air Temperature
PIREPS	Pilot Reports
PS	Policy Statement
SAE	Society of Automotive Engineers
SAT	Static Air Temperature

SC	Special Condition
SLD	Supercooled Large Droplet
SSA	System Safety Assessment
STOL	Short Take Off and Landing
TAF	Terminal Aerodrome Forecast
TAS	True Air Speed
TAIWIN	Terminal Area Icing Weather Information for NextGen
TAT	Total Air Temperature
VFR	Visual Flight Rules
VTOL	Vertical Take Off and Landing

1.4

REFERENCES

- [1] EASA (2019). Special Condition VTOL.
- [2] NOAA. (2014). Technical Memorandum OAR GSD-52 “Assessment of the Current Icing Product (CIP) and Forecast Icing Product (FIP)”.
- [3] FAA (2010). Proposed rules federal register: Vol. 75, No. 124. [Docket No. FAA–2010–0636; notice no. 10–10] RIN 2120–AJ34.
- [4] DOT (2015). FAA TC-15/39 “Current capabilities for icing nowcasting and forecasting in the terminal area”.
- [5] FAA (2018). AC 29-2C Change 1-8.
- [6] EASA (2022). Certification Specifications and Acceptable Means of Compliance for Large Aeroplanes CS-25 Amendment 27.
- [7] ASTM (2020). ASTM F3120-3120M-20 Standard Specification for Ice Protection for General Aviation Aircraft.
- [8] SAE (2022). Aircraft inflight ice detectors and icing rate measurement instruments AIR4367B.
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- [15] EASA. Annex VII the draft Commission Regulation on ‘Air Operations — OPS’ Part-NCO — IR.
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- [19] EUROCAE (2022). ED-103B - Minimum Operational Performance Standard for In-Flight Icing Detection Systems.
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- [21] TSO C16, Revision B, January 27, 2017 - Air-Speed Tubes (Electrically Heated).
- [22] SAE (2009). Minimum Operational Performance Specification for Inflight Icing Detection Systems AS5498.

- [23] US Department of Transportation FAA AC No: 00-6B Aviation Weather.
- [24] US Department of Transportation FAA AC 23-16A Powerplant Guide for Certification of Part 23 Airplanes and Airships.
- [25] EASA (2023). Certification Specifications, Acceptable Means of Compliance and Guidance Material for Large Rotorcraft CS-29 Amendment 11.

1.5

RELATIONSHIP TO SC-VTOL

Whilst this standard was developed with a particular view to the European legal framework, namely the EASA Special Condition VTOL [1], it may be applied to support other regulatory frameworks.

Regarding the EASA SC-VTOL [1], VTOL.2165 (a) is not applicable for VTOL aircraft that are not certifying for flight in icing conditions. This standard supports the showing of compliance with the following requirements for VTOL aircraft not certified for icing:

- VTOL.2165 (b) Flight in icing conditions
- VTOL.2165 (c) Flight in icing conditions
- VTOL.2415 (a) Lift/thrust system installation ice protection
- VTOL.2500 (b) General requirements on systems and equipment function
- VTOL.2505 (a) General requirements on equipment installation
- VTOL.2605 Installation and operation information
- VTOL.2620 Aircraft Flight Manual

1.6

RELATIONSHIP TO OTHER DOCUMENTS

This document can be used as a means of compliance to EHPS.280 [20] when the EHPS is certified alongside the VTOL aircraft for the same operational envelope i.e., no flight in icing conditions.

CHAPTER 2

INTRODUCTION TO ATMOSPHERIC ICING

2.1 GENERAL

Atmospheric ice formation on VTOL aircraft is a problematic natural phenomenon that can occur on the ground and in flight. In-flight icing is of primary concern for VTOL aircraft certification and consists of primarily two main types; ice that accretes on surfaces due to flight through supercooled clouds, and ice that accretes because of precipitation containing supercooled large water droplets (SLD). Droplets freezing instantaneously on impact with the VTOL aircraft form rime ice, which is opaque, milky, and usually less harmful for aerodynamic characteristics due to the ice shape following the aircraft profile. At warmer temperatures, droplets might runback off the impact point along the surface to form glaze ice away from the aerodynamic stagnation point. Glaze ice is clear, hard, and generally more harmful aerodynamically due to its characteristic double-horned shape. Mixed ice is a combination of rime and glaze ice. Ice formation on VTOL aircraft may have an effect on several aircraft parameters and systems including reducing lift, increasing drag, weight, and stall speed, causing a possible reduction in the efficiency of the lift/thrust system.

2.2 INADVERTENT ICING ENCOUNTERS

VTOL aircraft that are not certified for flight in icing conditions must plan their flight routes to avoid such conditions and are prohibited from take-off and subsequent flight into known or forecast icing conditions. However, the possibility still exists that aircraft may inadvertently encounter icing conditions enroute i.e., flying through a cloud with supercooled water droplets at lower outside air temperatures. The only safe option is to immediately exit these conditions. All icing encounters involve the presence of visible moisture which can be defined as clouds, fog, or mist, and precipitation. On the ground this can include standing water, slush, or snow present on taxiways, runways, and on or near landing sites. Not all precipitation conditions dictate flight in instrumentation meteorological conditions (IMC), e.g., under light rain/snow.

2.3 CERTIFICATION ENVELOPE REQUIREMENT

Aircraft certified to EASA SC-VTOL [1] will likely adhere to a maximum pressure altitude of 10,000 feet (or 3048 m. MSL). Therefore, the icing envelope presented in this document is based on that contained in FAA AC 29.1419 [5] limited to 10,000 feet (3048 m. MSL). This envelope can be used for all the aircraft components that must be assessed during an inadvertent icing encounter (refer Figure 2-1 to Figure 2-4). For VTOL aircraft with a maximum pressure altitude above 10,000 feet (or 3048 m. MSL), the Appendix C Continuous Maximum and Intermittent Maximum Icing Conditions envelope [6] must be used.

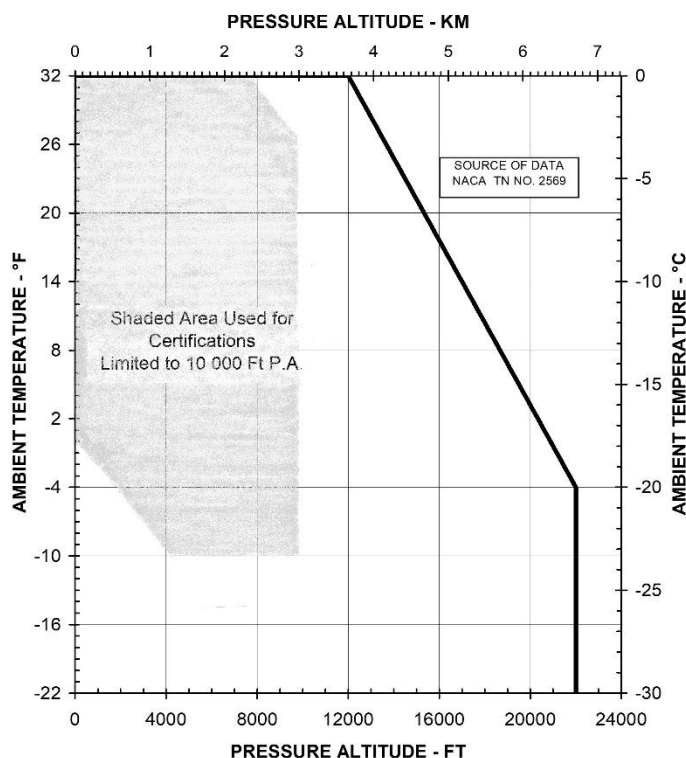


FIGURE 2-1: CONTINUOUS MAXIMUM ICING CONDITIONS: TEMPERATURE VERSUS ALTITUDE (10,000-FOOT LIMITED & APPENDIX C ICING ENVELOPES).

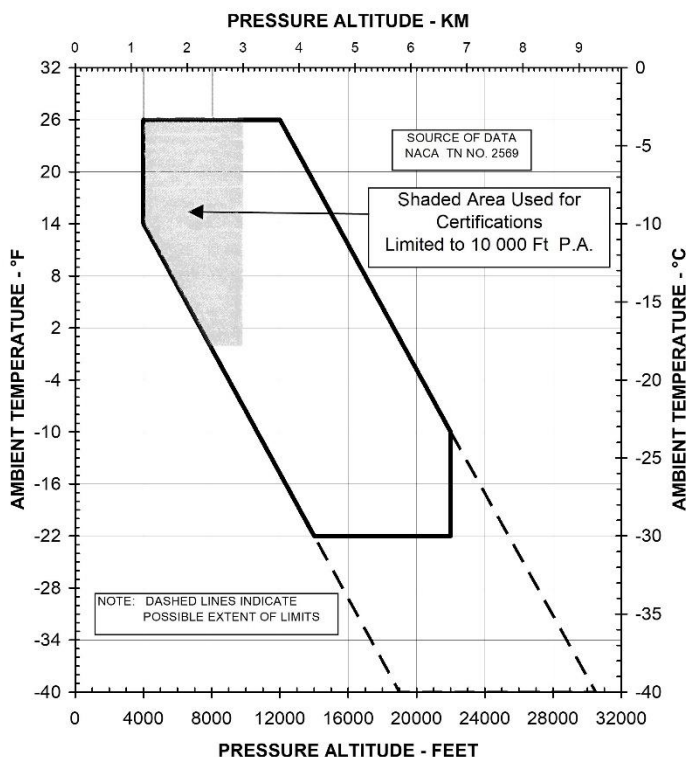


FIGURE 2-2: INTERMITTENT MAXIMUM ICING CONDITIONS: TEMPERATURE VS. ALTITUDE (10,000-FOOT LIMITED & APPENDIX C ICING ENVELOPES).

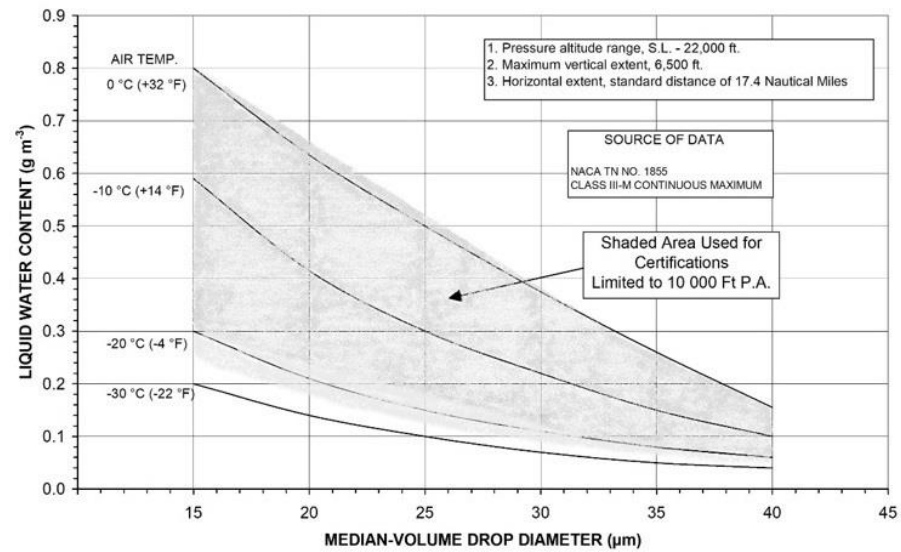


FIGURE 2-3: CONTINUOUS MAXIMUM ICING CONDITIONS: LWC VS. MVD (10,000-FOOT LIMITED & APPENDIX C ICING ENVELOPES).

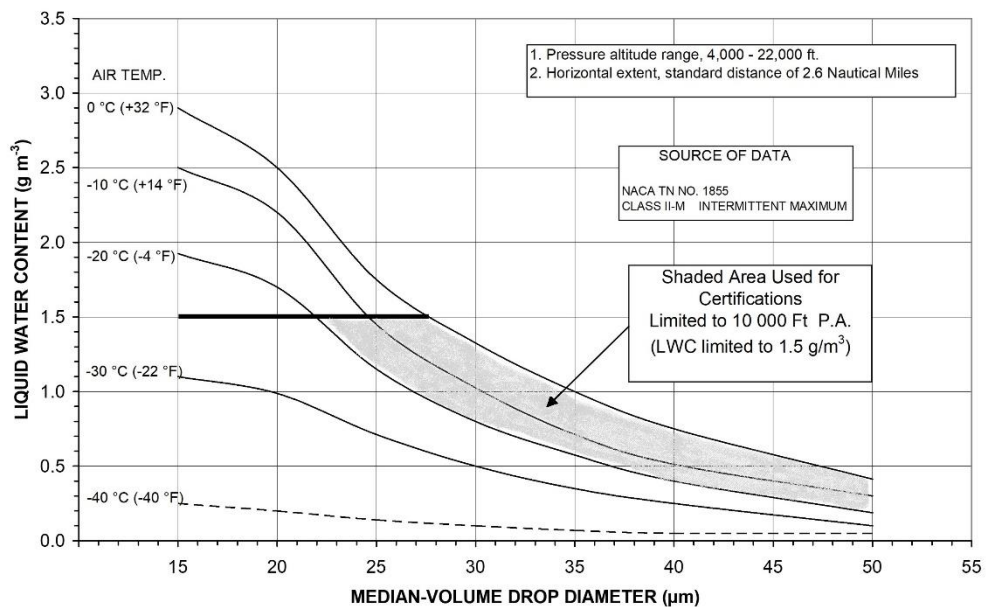


FIGURE 2-4: INTERMITTENT MAXIMUM ICING CONDITIONS: LWC VS. MVD (10,000-FOOT LIMITED & APPENDIX C ICING ENVELOPES).

NOTE: *The Appendix O Supercooled Large Droplet and P Ice Crystal and Mixed Ice Crystal/Supercooled Liquid Envelope [6] is not to be considered for inadvertent entry clearance, coherent with CS-23/27/29 airworthiness requirements not requiring it for aircraft not certified for icing.*