



## Comment-Response Document 2012-22

# Large Aeroplane Certification Specifications in Supercooled Large Drop, Mixed phase, and Ice Crystal Icing Conditions — Advisory Material

CRD TO NPA 2012-22 — RMT.0058 (25.058) — 12.3.2015

Related [Decision 2015/008/R]

### EXECUTIVE SUMMARY

The aim of rulemaking task RMT.0058 is to upgrade CS-25 specifications for flight in icing conditions. The task addresses supercooled large drop as well as mixed phase and ice crystal icing conditions. These new environmental conditions are introduced along with a set of amended or new specifications requiring the applicant to demonstrate that the aeroplane or its engines and equipment will safely operate after encountering any of the defined icing conditions.

This Comment-Response Document (CRD) contains the comments received on NPA 2012-22 (published on 27 November 2012) and the responses provided thereto by the Agency.

NPA 2012-22 proposed acceptable means of compliance (AMCs) with the CS-25 ice protection specifications previously proposed under NPA 2011-03, and then updated as published in CRD 2011-03.

The proposed AMCs have been updated based on the comments received. These updates consist of clarifications, corrections or addition of guidance material, while the main principles and substances of the AMCs are maintained. Along with the AMC updates, few adjustments have also been made to some of the corresponding CS specifications (as provided in CRD 2011-03). A summary of the main comments, responses, and CS/AMC changes is provided in Chapter 2 of this CRD.

Based on the comments and responses, Decision 2015/008/R was developed.

Applicability		Process map	
Affected regulations and decisions:	ED Decision 2003/2/RM (CS-25)	Concept Paper:	No
Affected stakeholders:	Large aeroplane manufacturers, operators of large aeroplanes	Terms of Reference:	9.7.2010
Driver/origin:	Safety	Rulemaking group:	No
Reference:	European Aviation Safety Plan 2014-2017 (EASp AER4.2)	RIA type:	None
		Technical consultation during NPA drafting:	No
		Publication date of the NPA:	2012/04Q
		Duration of NPA consultation:	5 months
		Review group:	No
		Focussed consultation:	No
		Publication date of the Opinion:	N/A
		Publication date of the Decision:	In parallel with this CRD



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## 1. Procedural information

### 1.1. The rule development procedure

The European Aviation Safety Agency (hereinafter referred to as the 'Agency') developed this Comment-Response Document (CRD) in line with Regulation (EC) No 216/2008<sup>1</sup> (hereinafter referred to as the 'Basic Regulation') and the Rulemaking Procedure<sup>2</sup>.

This rulemaking activity is included in the Agency's [4-year Rulemaking Programme](#), under RMT.0058 (25.058). The scope and timescale of the task were defined in the related Terms of Reference (see process map on the title page).

The draft AMCs have been developed by the Agency based on: the Aviation Rulemaking Advisory Committee (ARAC) tasked Ice Protection Harmonization Working Group (IPHWG), task 2 report; the Federal Aviation Administration (FAA) draft Advisory Circulars (AC) 25-25X, 25.629-1X, 25.1329-1B, 20-147A; comments received on NPA 2011-03; the Agency's experience from previous certification projects and application of the current AMC material. All interested parties were consulted through NPA 2012-22<sup>3</sup>, which was published on 27 November 2012. 216 comments and letters (listing of comments) were received from 17 National Aviation Authorities, professional organisations and private companies.

The text of this CRD has been developed by the Agency.

The process map on the title page contains the major milestones of this rulemaking activity.

### 1.2. The structure of this CRD and related documents

This CRD provides in chapter 2 below a summary of comments and responses as well as the full set of individual comments and responses thereto received to NPA 2012-22. The main changes made to the proposed AMCs are also described. Furthermore, during the review of NPA 2012-22 comments, it appeared that some adjustments to the CS-25 Book 1 text of CRD 2011-03 were required.

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<sup>1</sup> Regulation (EC) No 216/2008 of the European Parliament and the Council of 20 February 2008 on common rules in the field of civil aviation and establishing a European Aviation Safety Agency, and repealing Council Directive 91/670/EEC, Regulation (EC) No 1592/2002 and Directive 2004/36/EC (OJ L 79, 19.3.2008, p. 1).

<sup>2</sup> The Agency is bound to follow a structured rulemaking process as required by Article 52(1) of the Basic Regulation. Such process has been adopted by the Agency's Management Board and is referred to as the 'Rulemaking Procedure'. See Management Board Decision concerning the procedure to be applied by the Agency for the issuing of Opinions, Certification Specifications and Guidance Material (Rulemaking Procedure), EASA MB Decision No 01-2012 of 13 March 2012.

<sup>3</sup> <https://www.easa.europa.eu/document-library/notices-of-proposed-amendment>

## 2. Summary of comments and responses

This is a summary of the most substantial comments received on NPA 2012-22, together with the response of the Agency. This is not an exhaustive list of the topics addressed, as various other detailed technical changes and corrections were made. Please refer to the full list of comments and responses provided in chapter 3 below.

In addition to changes made to the proposed AMCs, a few changes have also been made to some CS paragraphs based on the version provided in CRD 2011-03, as a result of the comments received on NPA 2012-22 or because of the changes made to the AMCs. Explanations for the changes are detailed here below.

The resulting text is provided with the ED Decision amending CS-25.

### **Use of similarity analysis as means of compliance for Appendix O conditions**

Various comments from large aeroplane manufacturers asked for adding more provisions in the different AMCs permitting the use of analysis of similarities as a means of compliance with certification specifications in Appendix O icing conditions. All suggestions were rejected because a dedicated EASA rulemaking task RMT.0572, including a group of experts from the large aeroplane manufacturers, is already active.

### **Performance and handling characteristics**

#### **Guidance of AMC 25.21(g) concerning AFM limitations and operating procedures for aeroplanes without leading edge high-lift devices.**

Several commentators required some clarifications on this part, and thus the Agency revised paragraphs 4.8.1.3 and 4.8.2.3 of AMC 25.21(g) to better reflect the clean wing concept. The guidance is not anymore limited to turbojet aeroplanes. The reference to residual ice has been deleted because it created confusion with the in-flight residual ice (typically ice accretions between cycles of a de-icing system).

One commentator also considered that sub-paragraph (c) of the proposed 4.8.1.3 allows that operation of the wing ice protection/detection systems would be sufficient to eliminate the need for a visual and tactile check, and that it is unclear whether the intended use of 'ice protection systems' in sub-paragraph (c) is referring to upper wing surface protection/detection systems or leading edge protection/detection systems. The text has been entirely updated and streamlined so that it now simply emphasises the requirement of establishing a means to ensure that the protected surfaces of the wing leading edges are free of ice contamination immediately prior to take-off, whenever conditions conducive to atmospheric icing are present (criteria provided in the AMC text). An acceptable means to ensure that the wing leading edges are free of ice contamination immediately prior to take-off would be the application of anti-icing fluid with adequate hold over time and compliant with SAE AMS 1428, Types II, III, or IV. The FAA also commented that they intend to better reflect the clean wing concept in AC 25-25.

Various other updates were made to AMC 25.21(g) in order to improve the references to applicable icing conditions, ice accretion establishments, and to correct editorial errors.



### **Pilot compartment view**

#### **AMC 25.773(b)(1)(ii), Pilot compartment view in icing conditions.**

This AMC has been revised to upgrade the explanations on what is expected to demonstrate compliance with CS 25.773(b)(1)(ii) and to correct the order of some paragraphs. Some commentators explained that the proposed text needed additional guidance and criteria. The Agency also recognised the need to reflect the experience from certification projects. First, a new second paragraph clarifies that the effectiveness of windshield/windows ice and precipitation protection systems should be established by analysis and validated by sufficient flight tests in natural or simulated Appendix C conditions. Second, for thermal ice protection systems, a new paragraph recognises the need for a thermal analysis substantiating the nominal heating capacity, including when the applicant selects the nominal value of 70 W/dm<sup>2</sup> (which proved as an adequate value from past certification experience). Finally, the paragraph dealing with the evaluation of distortion effects, pertinent to anti-icing fluid systems, has been moved at the end of the AMC.

#### **AMC 25.773(b)(4), Pilot compartment non openable windows.**

Several comments and a review of the proposed AMC concluded that the AMC text had to be deeply reviewed and upgraded.

The AMC has been re-arranged to reflect the scope of CS 25.773(b)(4), i.e. the consideration of 1) ice and heavy rain, and 2) hail, birds and insects. All references to fog and mist are removed (outside of CS 25.773(b)(4) scope).

As commented, natural icing flight tests may not be required as simulation technologies may remove this requirement. Therefore, this has been reflected in the AMC.

The AMC text is now less prescriptive than initially proposed; it refers to protections systems instead of particular solutions like anti-icing or de-icing system.

Concerning the evaluation of hail damages, more guidance is provided on damages simulation and on the conducting of flight tests to show that exceptional pilot skill is not required to land the aeroplane.

#### **New AMC 25.773(c), Internal windshield and window fogging.**

The aspects related to the protection against internal fogging, initially included in the proposed AMC 25.773(b)(4), are now considered in a new AMC which is linked to the applicable rule CS 25.773(c). The new AMC addresses the case of failure of the fogging prevention means in absence of openable windows.

As a result the list of AMCs referenced in CS 25.773 has been amended.

### **Propeller de-icing (AMC 25.929(a))**

One commentator noted that AMC 25.929(a) discusses propeller runback ice and advises that the applicant should consider potential hazards from shedding of runback ice; it recommended that performance loss should also be considered. The Agency accepted the comment and also included the increased vibration level in the list of potential hazards to be considered.

### **Powerplant icing (AMC 25.1093(b))**

*General objectives:* As recommended by some commentators, the objective of the demonstration of compliance has been better worded and it has been clarified that flight test in natural icing conditions is not an obligation for demonstrating compliance with CS 25.1093(b). A new paragraph addresses the minimum power/thrust required for descent in icing conditions; the increase to that minimum power/thrust should be automatic when the IPS is switched on, and the possibility for short time reversion to normal flight idle is also addressed.

*Analysis and selection of test points:* Paragraphs 1.1 on Critical Points Analysis (CPA) and 1.3 on Ice accretion sources have been revised to clarify the provisions related to potential ice sources and engine ice ingestion in order make a link with, and be consistent with, the engine ice ingestion demonstrated under CS-E 780.

The meaning of the two minutes delay before ice protection selection has been improved and is identical to what is provided in the proposed new AMC E 780 for the engine certification.

Paragraph 1.6 dealing with falling and blowing snow has been expanded with a new sub-paragraph which recognises the difficulty to maintain the desired snow concentrations during testing, and the possibility to propose mitigating measures to the Agency.

*Testing:* According to the comments received, it is confirmed and clarified in paragraph 2.1 that the conditions provided in Table 1 (supercooled liquid water) may be used as an alternative to the critical points determined through a CPA to simulate Appendix C conditions.

It was also required to precise the maximum test duration of the two test cycles associated to Table 1. The maximum durations, respectively 45 and 15 minutes, are required (instead of the standard 30 and 10 minutes) only when no steady state conditions are established. Furthermore, for the descent case, the duration of the test may be limited to the time required to cover an anticipated descent of 3 000 m.

The paragraph on natural icing flight test reflects that this is not a mandatory means of compliance.

*Table 1 in CS 25.1093(b):* The table has been amended to correct the range of total temperature for glaze ice conditions and to provide an upper limit for the mean effective diameter of large drop conditions.

*Ground icing:* Several commentators asked to revise the text of paragraph (b) to allow a demonstration of compliance to CS 25.1093(b)(2) by analysis, not necessarily requiring a test. This has been accepted. Also, it is clarified that the expected CPA should determine the critical conditions for the air intake (not for the engine, which is addressed through CS-E 780).

### **Flight instrument external probes**

#### **AMC 25.1324 Flight instrument external probes**

*Title:* 'heating systems' is removed from the titles of CS 25.1324 and AMC 25.1324 because some of the applicable probes may not be equipped with a heating system, like some temperature probes.

*Heating power for tests:* One commentator from the probe manufacturing industry was concerned that the icing tests described in AMC 25.1324 are expected to be demonstrated with equipment selected with heating power set to the minimum value triggering the flight deck indication. It has been commented that this provision would require very tight tolerances compared to current typical probe heater monitors and that this

will lead to much more complex and costly probe heater monitors. It was also argued that tight tolerances would increase the risk of 'nuisance faults', and that the requirement would not significantly increase safety. It was proposed to limit the requirement to monitor minimum current and to detect short-to-case situations. Some aeroplane manufacturers suggested to delete the proposed heating power value and just rely on maintenance programme and safety analysis. The Agency reminds that in-service events have been reported where probes resistances had degraded over time, undetected, and led to loss of heating performance. These events must be addressed in addition to the short-to-case issue. Therefore, the Agency maintains that performances of the heating system have to be demonstrated up to the minimum heating power value triggering an alert for the pilots, and the AMC was not changed based on these comments.

*Flight deck indication:* In paragraph 7 related to flight deck indication, the reference to CS 25.1326 has been corrected to reflect the requirement to indicate when the probe heating system is not functioning normally, in addition to the not operating case.

*Icing conditions and test points:* Paragraph 10, on supercooled liquid water test points representing Appendix C. Several commentators from the industry recommended to change these testing conditions based on the content of a new standard (AS 5562) being developed by EUROCAE WG-89 for qualification of Pitot and Pitot-static probes in icing conditions. The Agency, being part of WG-89, followed the development of these new supercooled liquid icing test conditions. In September 2014, a manufacturer represented in WG-89 reported that one pitot-static probe tested with these new proposed conditions did not pass the test, and that these test conditions were finally considered too severe compared to historical test conditions. At the time of finalising this CRD, WG-89 decided to work on amending these proposed test conditions. Therefore, the Agency decided to keep the proposal of NPA 2012-22 for paragraph 10, except that point #SL5 at -40°C is deleted (in order to be consistent with AMC 25.1093(b) test conditions for the engine air intake, and because this point is both at low water content and very difficult to simulate in a wind tunnel (water tends to change into ice crystals at this temperature)).

Paragraph 12, on ice crystal and mixed phase icing conditions: several commentators recommended replacing the proposed conditions (TWC curves, representing peak values for glaciated conditions and '2.6NM' values for mixed phase conditions) by the tables of points prepared by EUROCAE WG-89 for qualification of Pitot and Pitot-static probes in icing and rain conditions. Guidance was also requested on test duration. The tables developed by WG-89 are also peak values/2.6NM values but adapted with aircraft dependent parameters (airspeed, altitude, temperature). The Agency elected to keep upstream values in AMC 25.1324, so that the applicant will propose other parameters that are pertinent to the aircraft project. In term of test duration, a new paragraph 12.4 has been created providing for a minimum duration of 2 minutes (harmonised with WG-89 standard test conditions). Finally, the guidance of sub-paragraph 12.3 on ice particle generation has been revised to better recognise the limitations of ice particles generation techniques while making the link with Appendix P provision for the size of ice crystals (i.e. MMD range of 50-200 µm).

Paragraph 13, on rain conditions: the proposed table is deleted, and a new table has been added in the proposed new CS 25.1324. A commentator suggested to adopt the EUROCAE WG-89 rain table. The WG-89 table provides for test durations, although at aeroplane level it is more relevant to use distance requirements. Therefore, a table providing horizontal extent values is maintained, harmonized with the FAA rain conditions table provided for airspeed indicating systems.



**AMC 25.1326 Flight instrument external probes heating systems alert**

Some comments recommended that CS 25.1326 and AMC 25.1326 be amended so that the alerting system may be replaced by other means like maintenance procedures, probe reliability improvement, monitoring of probe temperature, or back up means to determine the aircraft airspeed. One commentator also proposed a probabilistic approach. The Agency did not accept these approaches and considers that, when a failure can have hazardous or catastrophic consequences, it must be indicated. Nevertheless, the text of CS 25.1326(b)(2) has been amended to be less prescriptive, removing the reference to any probe heating element; the requirement is now at the level of the probe heating system. Similarly, the last paragraph of AMC 25.1326 is deleted because it was considered unnecessarily prescriptive.

**Ice protection for flight in Appendix C supercooled liquid water icing conditions (AMC 25.1419)**

*Testing:* Based on comments, it was necessary to re-word the preamble of paragraph(b) to reflect that it is not expected that the applicant find all the critical icing conditions during natural icing flight test as this is not practicable.

In the sub-paragraph dedicated to icing wind tunnel tests, it has been added that the provided test points, successfully used in the past, are an alternative to the identification of critical points through a critical points analysis. Some commentators proposed to reduce the maximum duration of the test in continuous maximum icing from 45 to 30 minutes, in order to keep the current AMC 25.1419 Method 1 value. No changes were made because the 45 minutes are not a requirement like were the 30 minutes; instead this is only a limit for the test in case a steady state condition is not established.

*Caution information:* In paragraph (c) the meaning of the caution information required by CS 25.1419(c) has been updated to confirm that the type of alert should be based on the failure effects and the required pilots action; CS 25.1309(c) and CS 25.1322 apply.

*Ice detection:* Paragraph (d) on ice detection has been re-organized. Sub-paragraph (1.1) has been streamlined and new sub-paragraphs were created to separate the different aspects discussed, i.e. the expected functionalities of each type of ice detection system (IDS), the performance and installation of IDS, AFM procedures, and system safety considerations.

Concerning Advisory IDS (AIDS), some comments revealed that it was needed to clarify the responsibility of the flight crew to activate the ice protection system and that automatic activation would not be accepted. Furthermore, the Agency maintains its position that an un-annunciated failure of the AIDS should be considered at least a major failure condition (unless substantiated differently) as flight crew tend to become accustomed to, and wait for, the AIDS detection signal before switching the ice protection system on.

In sub-paragraph (1.2) which is dealing with visual cues, the part describing the use of reference surfaces without de-icing means has been expanded. It provides clearer guidance distinguishing the phase where ice is still present on the surface from the phase where ice is no longer present.

**Ice protection for flight in Appendix O supercooled large drop icing conditions (AMC 25.1420)**

*Ice detection method:* Paragraph (c) on operation throughout all Appendix O icing conditions (i.e. CS 25.1420(a)(3) option) has been reformulated to explain that it is not expected that a means is provided to





distinguish between Appendix O and Appendix C conditions. However, the method to detect icing conditions and to activate the ice protection system must be demonstrated both throughout Appendix C and Appendix O conditions.



### 3. Individual comments (and responses)

In responding to comments, a standard terminology has been applied to attest the Agency's position. This terminology is as follows:

- (a) **Accepted** — The Agency agrees with the comment and any proposed amendment is wholly transferred to the revised text.
- (b) **Partially accepted** — The Agency either agrees partially with the comment, or agrees with it but the proposed amendment is only partially transferred to the revised text.
- (c) **Noted** — The Agency acknowledges the comment but no change to the existing text is considered necessary.
- (d) **Not accepted** — The comment or proposed amendment is not shared by the Agency.

#### (General Comments)

-

comment	1	comment by: UK CAA
	Please be advised that the UK CAA do not have any comments to make on NPA 2012-22, Large Aeroplane Certification Specifications in Supercooled Large Drop, Mixed phase, and Ice Crystal Icing Conditions - Advisory Material.	
response	Noted.	
comment	10	comment by: UTC Aerospace Systems - Sensors & Integrated Systems
	Attachment <a href="#">#1</a>	
	Regardless of the means used to make the “primary” determination of ice detection in either Appendix C or Appendix O (PIDS, temp/visible moisture, or substantiated visual cue/advisory ice detector) there should be consistent standards for the minimum requirements. All of these options should require at a minimum the following:	
	<ul style="list-style-type: none"> <li>• Within seated forward vision scan of the pilots</li> <li>• Droplet impingement analysis</li> <li>• Critical temperature analysis</li> <li>• <math>1 \times 10^{-9}</math> probability of undetected failure at the system level</li> </ul>	
	Please review all of section 1.1.1 starting on page 94 and determine if these requirements should apply to more than just a primary ice detector, but rather to any means that is the “primary” means for detecting ice on the aircraft.	
response	Partially accepted. Common paragraphs dealing with performance of ice detection systems and safety considerations have been created, providing provisions that are applicable to both PIDS and AIDS.	



comment 11

comment by: AIRBUS

**General comments:**

Airbus fully supports the implementation of new icing regulations and believes it is important that these new regulations become active for new designs in the short term.

In order to achieve the above objective EASA has developed new AMCs. EASA has accomplished this very large and complex task via an internal agency activity and is to be commended for preparing the material in such an efficient manner. However, the AMC lacks maturity and needs to be improved but this does not detract from the tremendous effort made by EASA in issuing the proposed guidance. Airbus is ready to work with the agency and all other interested parties to improve the AMC, and as a first step has prepared detailed comments on the documents.

In writing the AMCs EASA has taken material from various existing sources and added new, never before published, material. Integrating material from so many disparate sources is challenging. The coherence and clarity of the AMC has suffered during this process with material taken out of context or new material added without clear explanation of the intent of the new text. For example the AMC appears (depending upon the interpretation) to propose AMCs that cannot, in many cases, be applied or to challenge existing certification methods that have led to successful and safe designs.

Given the need to have a clear and mature AMC Airbus has provided a substantial set of comments. Recognizing that the new regulations and guidance must be implemented in a short timeframe we have attempted to write the comments in a way that can be easily implemented. However, considering the number of comments on and the size and lack of maturity of the document together with the ongoing ice crystal and SLD research and rulemaking (SLD similarity), Airbus does not feel it will be possible to develop a fully mature document through the commenting process alone.

Nevertheless the AMC and regulations must be brought forward as soon as possible and Airbus fully supports the agency in issuing an updated AMC to reflect as many of the comments as possible. In parallel Airbus strongly encourages the agency to begin development of a further update to the AMC to achieve the required levels of maturity and clarity and incorporate the results of the ongoing SLD compliance by similarity rulemaking. Airbus will fully participate in this process, together with all other interested parties, to develop a fully mature AMC. Further updates will be required to incorporate the results of SLD and ice crystal research as they become available.

It is noted that EASA has decided to retain its position of not excluding aircraft with MTOW greater than 60klb and reversible flight controls from the SLD certification requirements. Such a fundamental disharmonisation with the FAA regulations is not acceptable in a global industry such as aerospace. The FAA and EASA rules and guidance material should be consistent on this point.

It is recognized that much of the AMC text comes from the FAA AC's (AC25.25X, AC25-XX, AC 20-147) which will aid harmonization. However the FAA ACs were heavily commented by the AIA and Airbus, among other commentators, and in order to aid harmonization it is recommended that the AMCs be updated in the same way as the ACs.

EASA has begun rulemaking task RMT 0572 to identify a means of compliance for SLD based on similarity and good in-service experience. It is recognized that the AMC will be updated with the results of this RMT.

In conclusion, it is necessary to issue the new icing rules and AMCs in the short term and EASA has made significant progress in developing AMC material. Further work is required to develop a mature AMC and it is recommended that work begin on an update of the document. The updated AMC can be completed once RMT 0572 has finished its tasking. A



	<p>further update will be required once the ice crystal and SLD research activities have been completed. It is therefore suggested to schedule several updates to the AMC in the coming years. Airbus is ready to play its full part in developing mature guidance material to consolidate the existing safety levels and apply the results of the recent and ongoing research to drive further improvements.</p>
response	Accepted.
comment	<p>12 <span style="float: right;">comment by: AIRBUS</span></p> <p><b>General Comment:</b> As recognized by the IPHWG, ARAC and the FAA the current status of the SLD tools requires an interim means of compliance. This interim MoC is not included in the proposed EASA AMC. Is this intentional and if so how should applicants approach a compliance demonstration considering the current state of the art? The interim MoC was not able to bridge all the gaps in the available certification tools but it does provide useful information and should perhaps be referenced or included in the AMC on a temporary basis.</p>
response	<p>Noted. The proposed AMC was prepared based on available means of compliance as of today. The Agency is not aware of any agreed 'interim MoC'. In the meantime, before availability of mature tools to simulate or generate full Appendix O conditions, the Agency accepts to consider the use of similarity analysis when possible. A rulemaking task RMT.0572 is on-going to develop the corresponding AMC material that has already been introduced in our first AMC proposals.</p>
comment	<p>80 <span style="float: right;">comment by: DGAC FRANCE</span></p> <p>DGAC France has no adverse comments on this NPA.</p>
response	Noted.
comment	<p>103 <span style="float: right;">comment by: FAA</span></p> <p>The United States Department of Transportation, Federal Aviation Administration (FAA) would like to commend the European Aviation Safety Agency (EASA) for undertaking this important safety initiative. We agree there is a need for such regulatory action and strongly support the overall stated objectives and the resulting proposal. We would like to thank EASA for the opportunity to comment on the resulting NPA.</p> <p>In general, the FAA supports the new regulations and acceptable means of compliance identified in NPA 2012-22. As EASA is aware, the FAA proposed similar rulemaking in Notice of Proposed Rulemaking (NPRM), notice 10-10 contained in United States Federal Docket FAA-2010-0636. The FAA also proposed new and revised advisory circulars to describe the proposed methods of compliance.</p> <p>FAA comments have been added to various sections of the document using the comment response tool. Where specific edits are proposed, proposed new text is <b>bold</b> while text proposed as deleted is shown as <del>strikeout</del> for ease of review purposes. The majority of comments are editorial in nature, intended for clarity rather than technical content. In addition, some proposed changes are intended for consistency with planned FAA guidance</p>



	and identified as such.	
response	Noted.	
comment	118	comment by: <i>Luftfahrt-Bundesamt</i>
	The LBA has no comments on NPA 2012-22.	
response	Noted.	
comment	191	comment by: <i>Gulfstream Aerospace Corporation</i>
	Attachment <a href="#">#2</a>	
	Gulfstream appreciates the opportunity to review and provide comments to this Notice of Proposed Amendment concerning the advisory material for Large Aeroplane Certification Specification in Supercooled Large Drop, Mixed phase, and Ice Crystal Icing Conditions. Please see the attached file.	
response	Noted. The Agency maintains its position with regard to the CS 25.1420 rule, as explained in CRD 2011-03. An EASA rulemaking task RMT.0572 is on-going to study how to implement the concept of compliance by comparative analysis of similarities into the AMC material. Please note that the EASA regulatory system does not allow an exemption to be granted e.g. for CS 25.1420.	
comment	194	comment by: <i>Swiss International Airlines / Bruno Pfister</i>
	SWISS Intl Airl Lines take note of NPA 2012-22 without further comments.	
response	Noted.	
comment	207	comment by: <i>Aerospace Industries Association</i>
	Attachment <a href="#">#3</a>	
	Please see attached letter from the Aerospace Industries Association (AIA) regarding its comments submitted on behalf of AIA and the Engine Icing Working Group (EIWG).	
response	Noted. Your comments have been responded individually within the appropriate chapter of this CRD.	
comment	225	comment by: <i>Poonam Richardet</i>
	Attachment <a href="#">#4</a>	
	Please See comments from Cessna Aircraft Company on the following- <b>NOTICE OF PROPOSED AMENDMENT (NPA) 2012-22</b> <b>'Large Aeroplane Certification Specifications in Supercooled Large Drop, Mixed phase, and</b>	



**Ice Crystal Icing Conditions — Advisory Material'**

response

Noted.

Your comments have been responded individually within the appropriate chapter of this CRD.

**NOTICE OF PROPOSED AMENDMENT (NPA) 2012-22 'Large Aeroplane Certification Specifications in Supercooled Large Drop, Mixed phase, and Ice Crystal Icing Conditions — Advisory Material' — General comments**

p. 1-3

comment

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comment by: *Deutsche Lufthansa AG*

Lufthansa concurs with the NPA without further comments. We expect more legal certainty and in the end a higher level of safety for operations in the referred weather conditions, when certification covers more detailed characteristics of these conditions.

response

Noted.

**A. Explanatory Note — IV. Content of the Draft Decision — 18. AMC to 25.1323(i) and 25.1325(b) — Airspeed indicating system**

p. 7

comment

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comment by: *FAA*

Comment

CS25.1324 would require air data probes to operate normally in heavy rain. A requirement to operate during cold soak following rain or drizzle should be added.

Rationale:

Loss of air data indication events have occurred when residual water from the rain freezes in the probe as the airplane climbs into freezing conditions after takeoff.

response

Noted.

This concern is already addressed in the proposed AMC 25.1324. See the last paragraph under 14 – Pass/fail criteria (applicable to all tests, including heavy rain conditions):

'At the conclusion of each test, the amount of water trapped in and around the probe (i.e. in the line conveying the air to the electronics) should not interfere with the output correctness, if the probe was suddenly subjected to freezing or re-freezing after melting. After each test, any moisture accumulating in the probe connection line should be removed and measured if possible.'

We have, nevertheless, updated the NPA explanatory note to add the background that you are referring to.

**A. Explanatory Note — IV. Content of the Draft Decision — 19. AMC 25.1324 — Flight instrument external probes heating systems**

p. 7

comment

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comment by: *AIRBUS*

**Page 7 IV. §19 Content of the Draft Decision**

The current text:

*The AMC also recognizes the technical challenge of protecting Total Air Temperature probes (TAT) against the full Appendix C. In the case where full Appendix C protection would not be achieved, the applicant would have to demonstrate that a malfunction of the probe will not prevent continued safe flight and landing.*

Should be changed into:

The AMC also recognizes the technical challenge of protecting Total Air Temperature probes (TAT) against the full Appendix **CP**. In the case where full Appendix C protection would not be achieved, the applicant would have to demonstrate that a malfunction of the probe will not prevent continued safe flight and landing.

Rationale:

Ice crystals are a challenge for TAT probes rather than the supercooled liquid water conditions of Appendix C.

response

Accepted.

The typo has been corrected in the updated explanatory note.

**A. Explanatory Note — IV. Content of the Draft Decision — 20. AMC 25.1326 — Flight instrument external probes heating indication systems**

p. 7

comment

4

comment by: UTC Aerospace Systems - Sensors & Integrated Systems

Please see comments to page 76 section 7.

Page 76 section 7

UTAS is concerned that the requirement to test icing conditions at the power level equal to probe heater monitor fault indication will not improve safety and will create a significant problem for probe manufacturers and aircraft OEMs. The power that needs to be monitored varies widely depending on flight condition, and simply monitoring power will not detect the underlying condition that leads to un-annunciated failure.

Typical probe heater monitors in use today are only designed to seek minimum and maximum current and therefore have very wide tolerances on those values. A probe heater monitor able to operate with the extremely tight tolerances required by this concept would need inputs and calculations based on supply voltage, Liquid Water Content (LWC), Ice Water Content (IWC), altitude, airspeed, Angle of Attack (AOA), Angle of Sideslip (AOS), Total Air Temperature (TAT) and perhaps other parameters. This will lead to much more complex and costly probe heater monitors than the typical devices in use today. These new devices will not significantly increase the level of safety because they are unlikely to detect the cause of the observed incidents as discussed in the next paragraph. In addition, the tight tolerances required to implement this new concept are likely to lead to nuisance faults that will undermine flight crew confidence in the system.

The situations that highlighted a need for stricter probe heater monitoring were caused by probes that had a short to case not detected by the probe heater monitor. Combined with monitoring for minimum current draw, adding a requirement for the probe heater monitor to detect short to case situations will address the issue and provide an improvement in safety.

UTAS feels that industry study into the practicality of implementing a requirement for “abnormal function” indication of the probe heating system should be undertaken prior to



	formal implementation of this requirement.
response	Partially accepted.
	<p>The second paragraph of the proposed AMC 25.1326 is clarified to better state the objective which is related to the selection of the heating system failures to be indicated, not to the failure of the system monitoring the heating system.</p> <p>The last paragraph is deleted as we understand it may be considered too prescriptive.</p> <p>Please note that in-service events are not limited to short-to-case related failure. For instance, some probe resistances have degraded over time leading to loss of heating performance.</p> <p>In addition, CS 25.1326(b)(2) is updated to remove the ‘any flight instrument external probe pitot tube heating element’ so that the sentence provides the main objective i.e. the heating system is ‘on’ and not functioning normally.</p>

**B. Draft Decision — I. Draft Decision amending CS-25 — Book 2; AMC — SUBPART B**

p. 10-36

comment	2	comment by: CAA-NL
	<p>4.1.3</p> <p><i>“Because an aeroplane may encounter supercooled large drop icing conditions at any time while flying in icing conditions, certain safety requirements must be met for the supercooled large drop icing conditions of Appendix O, even if the aeroplane will not be certified for flight in the complete range of Appendix O atmospheric icing conditions.”</i></p> <p>Proposal: Include here the fact that engine certification should be in the same “beyond conditions” as the aircraft’s “beyond conditions”.</p> <p>Explanation: In NPA 2012-23, the requirement is that both aircraft and engine are certified against the same atmospheric icing conditions. There it is stated that the both the engine OEM and the aircraft OEM should get into close contact about these requirements.</p> <p>However, in this CS25 paragraph, the aircraft certification level is raised over the certification level of the engine. Logically this should be the other way around or at least be at the same level because for instance the 2 min detect and exit time is crucially dependent on the operation of the engines.</p>	
response	Partially accepted.	
	<p>The text of CS-E 780 has been clarified so that the engine must function satisfactorily throughout the conditions of atmospheric icing (including freezing fog on ground) and in falling and blowing snow defined in the turbine engines air intake system ice protection specifications (CS 23.1093(b), CS 25.1093(b), CS 27.1093(b), or CS 29.1093(b)) of the certification specifications applicable to the aircraft on which the Engine is to be installed (refer to CRD 2011-04 which provides the resulting text in Appendix A). CS 25.1093(b) refers to the full Appendices C, O and P icing conditions.</p>	
comment	13	comment by: AIRBUS
	<p><b>AMC 25.21(g) Page 13 Section 4.1</b></p> <p>The current text:</p> <p><i>General. This section provides guidance for showing compliance with Subpart B requirements for flight in the icing conditions of Appendix C and Appendix O to CS-25.</i></p>	





Should be changed into:

*General.* This section provides guidance for showing compliance with Subpart B requirements for flight in the icing conditions of Appendix C and, **for those aircraft that must show** compliance, Appendix O to CS-25.

Rationale:

To the best of Airbus knowledge there is no compelling evidence that the SLD icing conditions should be applied to all aircraft irrespective of design. However the definition of appropriate exemption criteria acceptable to all IPHWG participants was not completed during the working group activities. The example of MTOW provided by the minority was not accepted by the group but the opportunity to define alternative more complex criteria was not taken.

Whilst the 60,000lbs criterion was not agreed by the majority of the IPHWG, the working group report does highlight that there are several other possible discriminators such as mean aerodynamic chord, planform etc. An examination of the IPHWG accident and incident database would allow a combination of parameters to be defined that adequately explains the good in-service experience and ensures future designs maintain an adequate level of safety.

It is recognized that the simplicity and ease of application of the 60,000lb makes it a good criterion for operational rules. However for aircraft certification it is possible and perhaps preferable to define more detailed criteria.

This opportunity was not taken during the IPHWG activities but could be defined relatively easily through assessment of the existing IPHWG database.

An alternative is to define an AMC based on similarity and good in service experience and Airbus supports the EASA rulemaking task RMT 0572 which has been launched by EASA to this aim.

Nevertheless even with a MoC based on similarity the resulting disharmonisation with the FAA is not acceptable and the risk of further disharmonisation should be avoided. It is noted that, eventually, certification tools will be required and are expected to be available that allow additional means of compliance on top of similarity to be applied when appropriate. The approach proposed by EASA will inevitably lead to wider and wider disharmonisation with the FAA rules and guidance and is therefore not acceptable.

response

Not accepted.

The text is maintained consistent with the rule as provided in CRD 2011-03.

comment

14

comment by: AIRBUS

#### **AMC 25.21(g) Page 15**

The current text:

*4.1.10 There have been aeroplane controllability incidents in icing conditions as a result of ice on unprotected leading edges of extended trailing edge flaps or flap vanes. The primary safety concern illustrated by these incidents is the potential for controllability problems due to the accretion of ice on trailing edge flap or flap vane leading edges while extending flaps in icing conditions. The flight tests specified in Table 4 of this AMC, in which handling characteristics are tested at each flap position while ice is being accreted in natural icing are intended to investigate this safety concern. Unless controllability concerns arise from these tests, it is not necessary to conduct flight tests with artificial ice shapes on the extended trailing edge flap or flap vanes or to include extended trailing edge flap or flap vane ice accretions when evaluating aeroplane performance with flaps extended."*



**Should be changed into:**

4.1.10 There have been aeroplane controllability incidents in icing conditions as a result of ice on unprotected leading edges of extended trailing edge flaps or flap vanes. The primary safety concern illustrated by these incidents is the potential for controllability problems due to the accretion of ice on trailing edge flap or flap vane leading edges while extending flaps in icing conditions. The flight tests specified in Table 4 of this AMC, in which handling characteristics are tested at each flap position while ice is being accreted in natural icing **conditions representative of Appendix C**, are intended to investigate this safety concern. Unless controllability concerns arise from these tests, it is not necessary to conduct flight tests with artificial ice shapes on the extended trailing edge flap or flap vanes or to include extended trailing edge flap or flap vane ice accretions when evaluating aeroplane performance with flaps extended.

**Rationale:**

Performing the proposed highly prescriptive set of tests in Table 4 are challenging to achieve in "Appendix C" icing conditions due to the difficulty in finding such conditions.

It should be clarified that the tests required by table 4 are only applicable to appendix C icing conditions. It is questionable whether the defined ice accretion thicknesses are relevant for all SLD conditions and especially freezing rain.

In Appendix O the difficulty in finding the requested icing conditions is significantly more difficult and not practical within the scope of an aircraft certification flight test programme. For aircraft designs and design methodologies that have led to in-service experience free from SLD incidents or accidents such an approach is not commensurate with the risk.

For aircraft designs or design methodologies that cannot demonstrate safe in-service experience it is conceivable that a demonstration based on Appendix C natural icing tests plus an appropriate mix of analyses, flight tests with simulated ice shapes, icing tunnel and tanker tests could provide an acceptable compliance demonstration.

As mentioned in later comments on flight tests in SLD conditions, there is currently no practical means to measure MED/MVD and LWC in flight during certification flight tests. The available instrumentation is scientific research equipment and consequently requires highly specialized knowledge on its use and post test data processing. In addition the equipment is not designed to be installed (and easily de-installed) on a certification flight test aircraft.

Work is ongoing to develop a viable test means but a suitable device or suite of devices will not be available in the short term.

response

Not accepted.

The text is maintained consistent with the rule as provided in CRD 2011-03.

comment

15

comment by: AIRBUS

**AMC 25.21(g) Page 17 section 4.4.6 Propeller Icing**

The current text:

*4.4.6 Certification experience has also shown that runback ice may be critical for propellers, and propeller analysis do not always account for it. Therefore, runback ice on the propeller should be addressed,. Research has shown that ice accretions on propellers, and resulting thrust decrement, may be larger in Appendix O (supercooled large drop) icing conditions than in Appendix C icing conditions for some designs. This which may necessitate airplane aeroplane performance checks in natural icing conditions, icing tanker tests, icing wind tunnel tests, or the use of an assumed (conservative) loss in propeller efficiency. Testing should include a range of outside air temperatures, including warmer (near freezing) temperatures*



that could result in runback icing.

Should be changed into:

4.4.6 Certification experience has also shown that runback ice may be critical for propellers, and propeller analysis do not always account for it. Therefore, runback ice on the propeller should be addressed. Research has shown that ice accretions on propellers, and resulting thrust decrement, may be larger in Appendix O (supercooled large drop) icing conditions than in Appendix C icing conditions for some designs. This may necessitate aeroplane performance checks ~~in natural icing conditions~~, **based on limited** icing tanker tests, icing wind tunnel tests, **aerodynamic analysis, propeller blade wind tunnel tests** or the use of an assumed (conservative) loss in propeller efficiency. Testing should include a range of outside air temperatures, including warmer (near freezing) temperatures that could result in runback icing.

Rationale:

Conservative assumptions for propeller thrust loss are available in published technical papers and many applicants will likely use this as guidance.

Nevertheless this AMC section implies that performance checks in natural icing conditions may be required but this is not feasible in the highly unstable conditions encountered during most natural icing flight tests.

For a de-ice system it is normally not practical to accrete the ice inside the cloud and then assess the performance loss in calmer air outside the cloud as the propellers will de-ice, especially if the de-ice system is active.

Icing tanker tests will only allow a single propeller to be iced at any one time thus making performance characterization of the overall aircraft with iced propellers impractical. In theory the propellers could be iced one after the other and then a performance characterization performed but it is likely that the ice on one propeller will shed before the ice on the remaining propellers has been accreted especially when the propeller de-ice system is operating.

Testing a propeller or a propeller blade in an icing tunnel is possible but for most propellers/aircraft the speed that can be achieved in the icing tunnels is very limited.

Some assessment of the appropriateness of the de-ice system cycles could be assessed with an icing tanker. This can also be achieved by validated analysis, natural icing flight tests and/or icing tunnel tests.

Flight testing a propeller in an SLD cloud and then performing an aircraft performance characterization is not feasible. In addition flight testing in SLD conditions is extremely difficult due to the challenge of finding the conditions. It is noted that currently the available flight test equipment for measuring SLD conditions is designed for the needs of research organizations and is not adapted to the needs of an aircraft certification flight test.

Finally there are no icing tunnels, icing codes or icing tankers capable of producing the full range of SLD icing conditions. It is therefore highly questionable that adequate results could be obtained with the available tools in SLD conditions. Until the tools are further developed (Airbus continues to actively participate in SLD tool development efforts) it is unlikely that meaningful certification testing could be completed in SLD conditions and a conservative thrust loss assumption based on the available data will need to be applied.

response

Partially accepted.

Flight testing in natural icing conditions should remain as a possible method, although there is no obligation to use it. Deleting this method could be understood that it is not acceptable. 'propeller blade wind tunnel tests' is redundant with 'icing wind tunnel tests'.

'aerodynamic analysis' is accepted and added to the list.



comment

16

comment by: AIRBUS

**AMC 25.21(g) Page 17 section 4.6.1**

Recommended change:

The probability of encountering SLD conditions has been defined conservatively as  $1 \times 10^{-2}$  ~~3~~.

Rationale:

The value in the AMC is a very conservative value by comparison with the extract from report:

**DOT/FAA/AR-09/10**

"The percentage of in-flight time with MVD greater than  $40 \mu\text{m}$  (outside of Appendix C) was 3.8% for the maritime clouds and 1.7% for the continental clouds. Similar results using different subsets of the same data were reported by Isaac, et al. (2001a). **These percentages should not be used to directly specify the probability of occurrence of SLD because the research flights were targeted at areas where SLD was expected.**"

Page 44 of NPA 2012-22 section A1.4.1(c)ii states that the infrequency of App O icing is in the range of 1 in 100 to 1 in 1000. So changing the probability to  $1\text{E-}3$  remains extremely conservative as an aircraft does not spend its entire life flying in icing conditions.

Indeed the probability of encountering freezing rain or freezing drizzle and then flying the scenarios defined in Tables 1 and 2 of AMC 25.31g is considerably lower than  $1\text{E-}3$  and it is recommended that this aspect be further investigated based on the latest available meteorological data and the very conservative icing scenarios defined in the AMC to refine the probabilities quoted in the AMC.

The EASA proposed text implies that all aircraft fly in SLD conditions, whether it be freezing drizzle or freezing rain, 1% of the time. The evidence would indicate that freezing rain is much rarer than defined by the AMC (and the draft FAA AC 25-XX). Some regions are more prone to SLD conditions than others but nevertheless even for aircraft based in these areas a more realistic probability of occurrence of freezing rain should be defined based on the available evidence.

response

Not accepted.

We follow the recommendation of the IPHWG. In their report, the following statement can be found:

'Probability of Encountering Appendix X. The appendix C conditions were determined on the 99 percentile probability of exceeding the icing conditions (Ref: NACA TN 2738, "A Probability Analysis of the Meteorological Factors Conducive to Aircraft Icing in the United States"). In other words, the probability of encountering icing outside of Appendix C droplet conditions is on the order of  $10^{-2}$ .'

comment

17

comment by: AIRBUS

**AMC 25.21(g) Page 17 Section 4.6.2 to 4.6.5**

This section requires that the applicant consider the affects of ice when considering failure cases affecting handling qualities and performance.

It is recommended to provide additional guidance or an example of what type of demonstration the agency expects based on the guidance of para 4.6.2 through 4.6.5.

Rationale:

This section of the AMC was added at amendment 3 of CS25.

However it is not clear from the text precisely what level of assessment is expected by the agency.



response

Further guidance on what is expected would be helpful, especially for Appendix O ice shapes and the update of the AMC provides an opportunity to do this and apply the experience gained on recent certification programmes.

It is noted that engine failures are already embedded in the HQ and performance demonstrations. Many other failure conditions are not affected by icing.

From the agency's cost assessments of the new icing regulations (NPA 2011-03) it could be assumed that the order of magnitude of effort anticipated by the agency to address this guidance is within the scope of an existing certification project. This level of effort is reasonable. However if additional flight tests are demanded the level of effort would rapidly exceed the benefit.

Not accepted.

These paragraphs of the AMC were not changed and they are applicable for Appendix C and Appendix O icing conditions. Additional guidance may be beneficial as suggested, however, this is not considered in the scope of this rulemaking task; this may be investigated in another rulemaking task, e.g. under recommendations of the Flight Test Harmonisation Working Group.

#### **Cessna comment on 4.6.4:**

The use of “practicable” is inconsistent with the language in AMC 25.21(g) appendix A1.3.2.3 “exit icing conditions as soon as possible” and FAA draft AC 25-25X.

“As possible” and “as practical” are often defined in AFMs as separate actions with differing levels of urgency.

Current Text:

For probable failure conditions that are annunciated to the flight crew, with an associated operating procedure that requires the aeroplane to leave the icing conditions as soon as practicable....

Proposed Text:

For probable failure conditions that are annunciated to the flight crew, with an associated operating procedure that requires the aeroplane to leave the icing conditions as soon as ~~practicable~~ **possible**....

Response: Accepted.

comment

18

comment by: AIRBUS

#### **AMC 25.21(g) Page 17 Section 4.6.5**

Recommended change:

4.6.5 For failure conditions that are ~~improbable~~ **extremely remote**, but not extremely improbable, the analysis and substantiation of continued safe flight and landing, in accordance with CS 25.1309, should take into consideration whether annunciation of the failure is provided and the associated operating procedures and speeds to be used following the failure condition.

Rationale:

The improbable failure terminology comes from AC 25-1309 and is not in accordance with CS25.1309. The way one should consider remote and extremely remote failure conditions is not clear.

response

Accepted.

comment

19

comment by: AIRBUS



**AMC 25.21(g) Page 18 Section 4.8.1.3****Recommended change:**

4.8.1.3 For turbojet and turboprop aeroplanes without leading edge high-lift devices, unless the applicant shows that the aeroplane retains adequate stall and stall warning margins during take-off with residual ice contamination, (refer to guidance in paragraph b below), or that such contamination would be otherwise detected and removed before take-off (refer to paragraph a below) as demonstrated, statements similar to the following should be included:

Take-off may not be initiated unless the flight crew verifies that a visual and tactile (hands on surface) check of the wing upper surfaces and leading edges has been accomplished, and the wing has been found to be free of frost, ice, or snow in conditions conducive to ice/frost/snow formation. Conditions conducive to ice/frost/snow formation exist whenever the outside air temperature is below 6 °C (42 °F) and any of the following applies:

- Visible moisture is present in the air or on the wing,
- The difference between the dew point temperature and the outside air temperature is less than 3 °C (5 °F)
- Standing water, slush, ice, or snow is present on taxiways or runways.”

a. Residual ice contamination is contamination that is difficult to detect through visual observation alone. If de-icing is performed before take-off, residual ice contamination is the contamination that may remain after de-icing or the contamination that may form after de-icing. For the purpose of tests or analysis, sandpaper ice can be used to evaluate the effects of residual ice on stall and stall warning speed margins and demonstrate that the aeroplane retains adequate stall and stall warning margins during take-off with residual ice contamination.

**Rationale:**

This section is a cut and paste of FAA AC25.25X. It is suggested to clarify the guidance to make it clearer that there are 3 options

Option 1: a tactile check must be included in the AFM or

Option 2: the applicant demonstrates that residual ice will be removed or detected (the guidance in paragraph “a” provides guidance on one method to do this), or

Option 3 the applicant demonstrates that the aircraft retains adequate handling qualities and stall margins (the guidance of paragraph “b” provide some limited guidance on how to do this.

Finally it is noted that the FTHWG will review the subpart B flight in icing requirements and this paragraph of the AMC will likely be impacted by this review.

response

Partially accepted.

The applicability has been changed to any aeroplane which does not have a leading edge high-lift device.

The rest of the paragraph has been fully revisited. The intent is to ensure that the protected surfaces of the wing leading edges are free of ice contamination at take-off. Therefore, the updated paragraph requires that either the wing ice protection system is on before take-off in presence of atmospheric conditions conducive to icing, or the aircraft is properly protected by anti-icing fluids of type II, III, or IV (SAE AMS 1428).

Note: It is assumed that the aircraft is de-iced in compliance with applicable operational rules.

**Cessna comment on 4.8.1.3(a)-(c):**

Sub-paragraph (a) defines residual ice contamination as ice that could remain after deicing, or that may form after deicing. Appears to be referring to ground deicing and not an in-flight, leading edge type de-ice system, but is not explicit.

Sub-paragraph (b) discusses residual ice contamination on the wing leading edge and upper surface.

Sub-paragraph (c) allows that operation of the wing ice protection/detection systems would be sufficient to eliminate the need for a visual and tactile check. It is unclear whether the intended use of “ice protection systems” in sub-paragraph c is referring to upper wing surface protection/detection systems or leading edge protection/detection systems.

Current Text:

If the intent was use of leading edge ice protection/detection systems, the rationale for mitigation of upper wing surface residual ice is unclear.

Proposed Text:

Recommend revision of the language of (c) to clarify whether the reference is to leading edge ice protection/detection systems, or upper wing surface ice protection systems.

Response: Accepted.

The paragraph has been fully revisited. The intent is to ensure that the protected surfaces of the wing leading edges are free of ice contamination at take-off. Therefore the updated paragraph requires that either the wing ice protection system is on before take-off in presence of atmospheric conditions conducive to icing, or the aircraft is properly protected by anti-icing fluids of type II, III, or IV (SAE AMS 1428).

Note: It is assumed that the aircraft is de-iced in compliance with applicable operational rules.

comment

20

comment by: AIRBUS

**AMC 25.21(g) Page 19 Section 4.8.1.5**

The current text:

*4.8.1.5 For aeroplanes not certified to operate throughout the atmospheric icing envelope of CS-25 Appendix O for every flight phase, the Limitations section of the AFM should also identify the means for detecting when the certified icing conditions have been exceeded and state that intentional flight, including take-off and landing, into these conditions is prohibited. A requirement to exit all icing conditions must be included if icing conditions for which the aeroplane is not certified are encountered.*

Comment:

Determining SLD and differentiating between “traditional icing conditions”, freezing drizzle and freezing rain on the ground is challenging. Some guidance exists on how to do this. The approach taken here by EASA (which is the same as that proposed by the FAA in NPRM 10-10) provides flexibility to allow limitations consistent with the range of possible different aircraft designs and certification approaches. However it is likely to lead to many potentially different and potentially confusing procedures and criteria. It is recommended that efforts are launched to provide more consolidated guidance to operators, flight crews and ground staff on how to determine the weather conditions in the terminal area.

The suggested AFM text in para. 4 does not address the issue of how to determine freezing drizzle or rain on ground. It is also noted that the suggested AFM text is rather long compared to traditional AFM entries. It may be possible to produce more succinct and clearer AFM guidance for flight crews if required.

response

Noted.

SLD conditions in the vicinity of airports are normally announced to the flight crew.



comment	21	comment by: AIRBUS
	<p><b>AMC 25.21g Page 21 Section 5.2.1.2</b></p> <p>Recommended change:</p> <p>5.2.1.2 It is not necessary to repeat an extensive performance and flight characteristics test programme on an aeroplane with ice accretion. A suitable programme that is sufficient to demonstrate compliance with the requirements can be established from experience with aeroplanes of similar size, and from review of the ice protection system design, control system design, wing design, horizontal and vertical stabiliser design, performance characteristics, and handling characteristics of the non-contaminated aeroplane. In particular, it is not necessary to investigate all weight and centre of gravity combinations when results from the non-contaminated aeroplane clearly indicate the most critical combination to be tested. It is not necessary to investigate the flight characteristics of the aeroplane at high altitude (i.e. above the upper limit highest altitudes specified in Appendix C and Appendix O to CS-25). An acceptable flight test programme is provided in section 6 of this AMC. <b><u>Many aircraft have operated faultlessly in icing conditions without restrictions for operation in SLD conditions in service without performing flight tests in Appendix O icing conditions. Depending upon the aircraft design flight testing in Appendix C icing conditions only may be acceptable.</u></b></p> <p>Rationale:</p> <p>The existing compliance demonstrations performed for Appendix C certifications that have led to the excellent in-service experience of large jets can be expected to provide same excellent safety levels experienced in SLD conditions also. Hence applying the existing flight test campaigns in Appendix C icing conditions can be expected to provide the required level of safety in SLD conditions also for large turbojet aircraft.</p>	
response	<p>Noted.</p> <p>This comment anticipates on the development of comparative analysis of similarities to show compliance to SLD specifications. This activity is being conducted under EASA rulemaking task RMT.0572 which will propose additional provisions in the AMC material.</p>	
comment	22	comment by: AIRBUS
	<p><b>Section 5.6.1 page 22</b></p> <p>The current text:</p> <p><i>To help substantiate acceptable performance and handling characteristics, the applicant may use an analysis of an ancestor aeroplane analysis [...]</i></p> <p>Should be changed into:</p> <p>To <del>help</del> substantiate acceptable performance and handling characteristics, the applicant may use an analysis of an ancestor aeroplane analysis [...]</p> <p>Rationale:</p> <p>Compliance by similarity has broad support (judging by the comments received by EASA on NPA 2012-03). The details of such a compliance method are being developed by EASA RMT 0572. Similarity approach, when applicable, should be sufficient to demonstrate compliance with new Appendix O.</p>	
response	<p>Noted.</p>	
comment	23	comment by: AIRBUS





**AMC 25.21(g) Page 22 Section 5.2.3.2 last sentence**

The current text:

*Depending on the extent of the Appendix O icing conditions that certification is being sought for, and the means used for showing compliance with the performance and handling characteristics requirements, it may also not be necessary to conduct flight tests in the natural icing conditions of Appendix O. See AMC 25.1420 for guidance on when it is necessary to conduct flight tests in the natural atmospheric icing conditions of Appendix O."*

Should be changed into:

Depending **upon design of the aircraft and its similarity to previous designs that have demonstrated safe in-service records or the** extent of the Appendix O icing conditions that certification is being sought for, and the means used for showing compliance with the performance and handling characteristics requirements, it may also not be necessary to conduct flight tests in the natural icing conditions of Appendix O. See AMC 25.1420 for guidance on when it is necessary to conduct flight tests in the natural atmospheric icing conditions of Appendix O."

Rationale:

The current wording seems to indicate that a flight test in SLD would be required for any manufacturer attempting to certify to a portion of App O or App O in its entirety. This should be reworded to recognize that the need or not to flight test in SLD should also be linked to the design of the aircraft and the proposed certification demonstration.

As mentioned in later comments on flight tests in SLD conditions, there is currently no practical means to measure MED/MVD and LWC in flight during certification flight tests. The available instrumentation is scientific research equipment and consequently requires highly specialized knowledge on its use and post test data processing. In addition the equipment is not designed to be installed (and easily deinstalled) on a certification flight test aircraft.

Work is ongoing to develop a viable test means to measure LWC in SLD conditions but a suitable device or suite of devices capable of measuring LWC and MED/MVD across the range of SLD conditions does not seem feasible in the near future.

Considering the excellent in service experience of most aircraft and the impracticality of performing flight tests in SLD conditions it is not appropriate to mandate flight tests in SLD conditions.

response

Noted.

This comment anticipates on the development of comparative analysis of similarities to show compliance to SLD specifications. This activity is being conducted under EASA rulemaking task RMT.0572 which will propose additional provisions in the AMC material.

comment

24

comment by: AIRBUS

**AMC 25.21(g) Page 23 Section 6 AMC – Flight Test Programme**

Change the applicability of the SLD rules to ensure the EASA rules and guidance are harmonized (or at least not contradictory) with those of the FAA.

Rationale:

As stated in previous comments. The regulations in North America and Europe should be harmonized as far as possible. Such a significant disharmonisation as that proposed by EASA in NPA 2011-03 and NPA 2012-22 is not acceptable.

EASA has begun a RMT to identify means of compliance based on these existing approaches and design methodologies that have led to the excellent in service experience many aircraft have demonstrated. It is recommended that, at least, the AMC be updated with the results



response

of RMT 0572 if EASA refuses to harmonize with the FAA's regulations and guidance material.  
Noted.

**Cessna comment on 6.1.5:**

Incorrect pointer

Current Text:

For the approach and landing configurations, in accordance with the guidance provided in paragraph 4.1.9 of this AMC ...

Proposed Text:

For the approach and landing configurations, in accordance with the guidance provided in paragraph ~~4.1.9~~ **4.1.10** of this AMC ...

Response: Accepted.

comment

25

comment by: AIRBUS

**AMC 25.21(g) Page 32-33 Section 6.21.1.1**

This section indicates that flight tests in SLD conditions are required. The section should be rewritten to remove the apparent mandate to perform flight tests in natural icing conditions.

Rationale:

As commented by the AIA, Airbus and others on the draft FAA AC 25-XX and NRPM 10-10 the difficulty of finding SLD conditions and performing flight tests is considerable. According to **DOT/FAA/AR-09/10** SLD conditions have a probability of exceedence of around  $10^{-3}$  to  $10^{-4}$  per flight hour in icing conditions, when specifically trying to find SLD conditions. The likelihood of finding such conditions during a natural icing flight test is very low indeed.

The majority of aircraft have not been involved in accidents or serious incidents in SLD conditions. Mandating flight tests in SLD conditions is therefore not justified for all aircraft certification programmes and should be left to the discretion of the certifying officer. Nevertheless some guidance on the types of aircraft where flight testing should be seriously considered would be helpful to provide clarity on what will be expected as early as possible during the certification of the aircraft.

response

Not accepted.  
This paragraph does not mandate the using of flight test in natural SLD icing conditions.

**Cessna comment on 6.21.3:**

Incorrect pointer and clarification that ice accretion is on unprotected surfaces.

Current Text:

"...the pushover test of paragraph 6.9.3 should be repeated with a thin accretion of natural ice."

Proposed Text:

"...the pushover test of paragraph ~~6.9.3~~ **6.9.4** should be repeated with a thin accretion of natural ice on the **unprotected surfaces**."

Response: Accepted.**Cessna comment on 6.22.2.D:**

Add a period after VSR.

"In the configuration ... estimated 1.3 VSR Decrease ...

Proposed Text:

"In the configuration ... estimated **1.3 VSR**. Decrease ...



Response: Accepted.

comment

81

comment by: Dassault Aviation

Dassault-Aviation comment page # 12

**Extract:**

**AMC 25.21(g) - Performance and Handling Characteristics in Icing Conditions**

**1 Purpose**

1.1 This AMC describes an acceptable means for showing compliance with the requirements related to performance and handling characteristics of Large Aeroplanes as affected by flight in the icing conditions ~~that are defined in Appendix C to CS-25~~. The means of compliance described in this AMC is intended to provide guidance to supplement the engineering and operational judgement that should form the basis of any compliance findings relative to handling characteristics and performance in ~~Appendix C~~ icing conditions.

**Comment:**

The relevant icing conditions to be considered for Performance and Handling characteristics compliance are icing conditions of CS25, Appendix C and Appendix O. It would be preferable for clarity to define these icing conditions in the purpose of this AMC.

**Requested Change**

It is proposed to update this paragraph :

"This AMC describes an acceptable means for showing compliance with the requirements related to performance and handling characteristics of Large Aeroplanes as affected by flight in the icing conditions [that are defined in Appendices C and O to CS-25](#). The means of compliance described in this AMC is intended to provide guidance to supplement the engineering and operational judgement that should form the basis of any compliance findings relative to handling characteristics and performance in [Appendices C and O](#) icing conditions."

response

Partially accepted.

Paragraph 1.3 already identified that the scope the AMC concerns Appendix C and Appendix O icing conditions. Nevertheless, it is accepted to repeat in the last sentence of paragraph 1.1.

comment

82

comment by: Dassault Aviation

Dassault-Aviation comment page #23

**Extract:**

**AMC 25.21(g) - Performance and Handling Characteristics in Icing Conditions**

**6. Acceptable Means of Compliance - Flight Test Programme**

6.1.34 This test programme is based on the assumption that the applicant will choose to use the holding ice accretion for the majority of the testing assuming that it is the most conservative ice accretion. In general, the applicant may choose to use an ice accretion that is either conservative or is the specific ice accretion that is appropriate to the particular phase of flight. In accordance with part II(a) of Appendix C and part II(d) of Appendix O to CS-25, if the holding ice accretion is not as conservative as the ice accretion appropriate to the flight phase, then the ice accretion appropriate to the flight phase (or a more conservative ice accretion) must be used.

**Comment:**

Part II(d) of Appendix O to CS-25 is relative to the ice accretion before the ice protection



	<p>system has been activated and is performing its intended function. Therefore, this reference is not adequate for the purpose of this §6.1.4 of AMC25.21(g). To be consistent with reference used for Appendix C (part II(a)), it seems that the correct reference should be Part II(a) of Appendix O.</p> <p><b>Requested Change</b> Please Agency to review this point and to correct adequately.</p>
response	<p>Partially accepted.</p> <p>The two references are corrected to Part II(b) of Appendix C and Part II(e) of Appendix O which seem to be more appropriate for the subject discussed under paragraph 6.1.4.</p>

comment	<p>83 <span style="float: right;">comment by: Dassault Aviation</span></p> <p>Dassault-Aviation comment page #23</p> <p><b>Extract:</b> <b>AMC 25.21(g) - Performance and Handling Characteristics in Icing Conditions</b> <b>6. Acceptable Means of Compliance - Flight Test Programme</b> 6.1.5 For the approach and landing configurations, in accordance with the guidance provided in paragraph 4.1.9 of this AMC, the flight tests in natural icing conditions specified in Table 4 of this AMC are usually sufficient to evaluate whether ice accretions on trailing edge flaps adversely affect aeroplane performance or handling qualities. If these tests show that aeroplane performance or handling qualities are adversely affected, additional tests may be necessary to show compliance with the aeroplane performance and handling qualities requirements.</p> <p><b>Comment:</b> Paragraph 4.1.9 of this AMC is dealing with Ice-contaminated tailplane stall. This reference is not adequate for the purpose of this paragraph 6.1.5; the correct one is paragraph 4.1.10 of this AMC.</p> <p><b>Requested Change</b> This paragraph has to be corrected: “For the approach and landing configurations, in accordance with the guidance provided in paragraph <del>4.1.9</del> 4.1.10 of this AMC, the flight tests in natural icing conditions specified in Table 4 of this AMC are usually sufficient to evaluate whether ice accretions on trailing edge flaps adversely affect aeroplane performance or handling qualities. If these tests show that aeroplane performance or handling qualities are adversely affected, additional tests may be necessary to show compliance with the aeroplane performance and handling qualities requirements.”</p>
response	<p>Accepted.</p>

comment

105

comment by: FAA

Page	Para	COMMENT / SUGGESTED CHANGE	Rationale

17	4.4.6	Propose revision to this section as follows: <del>This</del> <b>Applicants</b> may call for <b>conduct</b> airplane performance checks in natural icing conditions, icing tanker tests, icing wind tunnel tests, or <b>propose</b> the use of an assumed (conservative) loss in propeller efficiency."	Assumed propeller efficiency should be proposed by the applicant and agreed to by the agency as most applicants may choose this method since it does not require testing.
18	4.8.1.3	Propose revision to this section as follows: For turbojet aeroplanes without leading edge high-lift devices, unless <del>the applicant shows that the</del> <b>aeroplane retains adequate stall and stall warning margins during take-off with residual ice contamination, or that such contamination would be otherwise all ice contamination would otherwise</b> be detected and removed before take-off, statements similar to the following should be included: *** Remove subparagraphs (a) and (b) in this section. Retain subparagraph (c) but identify the text as a note instead of subparagraph (c).	The FAA intends to revise this paragraph in AC 25-25 to reflect the clean wing philosophy. Also, based on comments from applicants and experience with the current version of AC 25-25, we do not anticipate any applicants attempting to demonstrate stall and stall speed warning margins with residual ice contamination on the wing leading edge and upper surface. If however, an applicant should eventually decide to certify the airplane for take-off with ice residual ice contamination, detailed methods of compliance can be documented during the certification process.
20	4.8.2.3	Propose revision to this section as follows: For turbojet aeroplanes without leading edge high-lift devices, <del>unless the applicant shows that the</del> <b>aeroplane retains sufficient stall and stall warning margins during take-off with residual ice contamination,</b> the AFM normal operating procedures section should contain	For consistency with the change suggested for paragraph 4.8.1.3.
20	4.8.2.3	There are two paragraphs with the same identification. The last operating procedure paragraph should be identified as 4.8.2.4.	Two paragraphs with the same identification will cause confusion.
23	6.1.3	Include reference to Part II of appendix C and part II of appendix O.	Intended for clarity
23	6.1.5	Referenced paragraph should be 4.1.10 not 4.1.9	Incorrect reference



23	6.2.2(c)	Propose revision to this section as follows: ...Decrease speed <b>at a rate not to exceed 1 knot per second</b> until an acceptable stall identification is obtained.	Intended for clarity, as well as consistency with FAA guidance in AC 25-25A. A defined deceleration rate will lead to consistency of results since different entry rates can lead to different results.
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response

Comment 1 on 4.4.6: Partially accepted.

In view of improving the wording of this sentence as suggested, the verb ‘necessitate’ is replaced by ‘be accomplished through’. The rest of the sentence is unchanged.

Comment 2 on 4.8.1.3: Partially accepted.

The paragraph has been fully revised. The intent is to ensure that the protected surfaces of the wing leading edges are free of ice contamination at take-off. Therefore, the updated paragraph requires that either the wing ice protection system is on before take-off in presence of atmospheric conditions conducive to icing, or the aircraft is properly protected by anti-icing fluids of type II, III, or IV (SAE AMS 1428).

Note: It is assumed that the aircraft is de-iced in compliance with the applicable operational rules.

Comment 3 on 4.8.2.3: Accepted. In addition the scope is for ‘aeroplanes’, not only ‘turbojet aeroplanes’.

Comment 4 on 4.8.2.3: Accepted. The numbering id corrected.

Comment 5 on 6.1.3: Accepted.

Comment 6 on 6.1.5: Accepted.

Comment 7 on 6.2.2(c): Accepted.

comment

120

comment by: Boeing

Page: 12

Paragraph: 1. *Purpose*

Boeing recommends revising the proposed text as follows:

*“1.1 This AMC describes an acceptable means for showing compliance with the requirements related to performance and handling characteristics of Large Aeroplanes-as affected by flight in the icing conditions that are defined in Appendix C and represented by Appendix O to CS-25. The means of compliance described in this AMC is intended to provide guidance to supplement the engineering and operational judgement that should form the basis of any compliance findings relative to handling characteristics and performance in icing conditions.”*

**JUSTIFICATION:** Boeing requests that the original text be retained, with the addition of reference to SLD conditions represented by Appendix O, as it is preferred to specify the icing conditions addressed by proposed AMC 25.21(g).

response

Partially accepted.

The proposed clarification has been added in the last sentence of paragraph 1.1.



comment

121

comment by: Boeing

Page: 17

Paragraph: 4.6 Failure Conditions (CS 25.1309)

Boeing recommends revising the proposed text as follows:

*"4.6.1 The failure modes of the ice protection system and the resulting effects on aeroplane handling and performance should be analyzed in accordance with CS 25.1309. In determining the probability of a failure condition, it should be assumed that the probability of entering icing conditions defined in CS-25 Appendix C is one. As explained in AMC 25.1420, on an annual basis, the average probability of encountering the icing conditions defined in Appendix O may be assumed to be  $1 \times 10^{-2}$  per flight hour. This probability should not be reduced on a phase-of-flight basis, except for cruise at altitudes above the defined Appendix O conditions. For this case, the probability may be assumed to be zero. The "Failure Ice" configuration is defined in Appendix 1, paragraph A1.3."*

**JUSTIFICATION:** Boeing considers that the flight hour probability can be reduced if the condition under review is cruise at altitudes greater than the Appendix O envelope definition. The option to utilize a probability reduction due to flight phase should be permitted for cruise above 25,000 feet, where the likelihood of encountering Appendix O conditions is, by definition, zero.

response

Not accepted.

As provided in the initial paragraph 4.6.1 change proposal and in the existing text, the probability of encountering icing conditions should not be reduced on a phase-of-flight basis. This assumption should be maintained.

comment

122

comment by: Boeing

Page: 22

Paragraph: 5.2.3 Flight Testing In Natural Icing Conditions

Boeing recommends revising the proposed text as follows:

*"5.2.3.1 Where flight testing with ice accretion obtained in natural atmospheric icing conditions is the primary means of compliance, the conditions should be measured and recorded. The tests should ensure good coverage of CS-25 Appendix C and, if necessary and if possible, Appendix O conditions (consistent with the extent of the certification approval sought for operation in Appendix O icing conditions) ~~and, in particular, the critical conditions.~~ The conditions for accreting ice (including the icing atmosphere, configuration, speed and duration of exposure) should be agreed with the Agency.*

*5.2.3.2 Where flight testing with artificial ice shapes is the primary means of compliance, additional limited flight tests should be conducted with ice accretion obtained in natural icing conditions. The objective of these tests is to corroborate the handling characteristics and performance results obtained in flight testing with artificial ice shapes. As such, it is not necessary to measure the atmospheric characteristics (i.e. liquid water content (LWC) and median volumetric diameter (MVD)) of the flight test icing conditions. For some derivative aeroplanes with similar aerodynamic characteristics as the ancestor, it may not be necessary to carry out additional flight test in natural icing conditions if such tests have been already performed with the ancestor. ~~Depending on the extent of the Appendix O icing conditions~~*



~~that certification is being sought for, and the means used for showing compliance with the performance and handling characteristics requirements, it may also not be necessary to conduct flight tests in the natural icing conditions of Appendix O. See AMC 25.1420 for guidance on when it is necessary to conduct flight tests in the natural atmospheric icing conditions of Appendix O.~~

**5.2.3.3 Flight testing in natural Appendix O icing conditions should not be necessary if:**

**i. Similarity is shown to an airplane that has shown compliance to CS 25.1419 and has a successful service history, or if:**

**ii. The design analyses show that the critical ice protection design points (i.e., heat loads, critical ice shapes for performance and handling qualities, accumulation, and accumulation rates, etc.) are adequate under the conditions of Appendix O and various airplane operational configurations; and**

**iii. The analyses performed for paragraph (i) above are accomplished using at least two different methods of predicting Appendix O ice accretions that provide similar results (ice accretion thickness, location); one method should be either an icing wind tunnel or icing tanker test.**

**Determination of the appropriate analyses and/or tests, if required, should include consideration of the need to evaluate more than one airplane component simultaneously.**

**Examples include the evaluation of:**

- Airplane performance with propeller and airframe ice accretion or with asymmetric ice accretions due to propeller wash,**
- Engine performance with inlet (including cooling) ice accretions,**
- Stall warning and characteristics with ice accretion that affects air data used by stall protection systems.”**

**JUSTIFICATION:** Flight testing in natural Appendix O icing conditions will be extremely difficult due to the frequency of such events in the environment. The Ice Protection Harmonization Working Group (IPHWG) Report (Appendix N; December, 2005) indicates that encounters with SLD conditions are relatively rare: “approximately 1 in 100 to 1 in 1000, on average, in all worldwide icing encounters.” The need to locate conditions of sufficient extent and duration to accrete the desired ice for conducting test maneuvers would result in excessively burdensome flight test campaigns.

In addition to the challenges inherent in locating adequate Appendix O conditions within the confines of a certification program, locating the “critical conditions” is expected to be nearly impossible.

There is a lack of guidance in this section of the proposed AMC as to when flight testing should be required and when it should not. The proposed paragraph 5.2.3.3 is essentially harmonized with the FAA’s proposed AC 25-XX (including revisions requested via public comment). In addition to adding this text to AMC 25.1420, it is recommended that it is also be added here.

In support of this, the majority of the IPHWG agreed that flight testing in natural App. O conditions should not be typically required in the same way that it is for App. C conditions per CS 25.1419. The IPHWG’s recommended guidance material listed circumstances when flight testing in natural App. O conditions may be necessary. They also agreed that it was critically important to emphasize and include language specifying when it should not be necessary (see IPHWG Working Group Report, Appendix K, December, 2005). This was an attempt to ensure that determinations regarding when flight testing should or should not be required would be interpreted the same way over time by authority representatives. Since the Agency has chosen not to include this specific guidance, Boeing believes that the



	guidance of section 5.2.3 as proposed in this AMC is insufficient. (Please also refer to our separate comment on AMC 25.1420.)
response	Not accepted. These kind of changes are being investigated by the Working Group of rulemaking task RMT.0572.
comment	<p>124 <span style="float: right;">comment by: Boeing</span></p> <p>Page: 32 Paragraph: 6.21 <i>Natural Icing Conditions</i>.</p> <p>Boeing recommends revising the proposed text as follows:  <i>"6.21.1.1 <del>Whether The If</del> flight testing has been performed with artificial ice shapes <del>or in natural icing conditions</del>, additional limited flight testing described in this section should be conducted in natural icing conditions specified in Appendix C to CS-25 and, if necessary, in the icing conditions described in Appendix O to CS-25. (AMC 25-21, paragraph 5.2.3.3, and AMC 25.1420 provide guidance on when it is not necessary to perform flight testing in <u>natural SLD icing conditions</u>.) Where flight testing with artificial ice shapes is the primary means for showing compliance, the objective of the tests described in this section is to corroborate the handling characteristics and performance results obtained in flight testing with artificial ice shapes."</i></p> <p><b>JUSTIFICATION:</b> The first sentence as proposed implies that flight testing in natural icing conditions may need to be performed twice.  The first revision of the second sentence adds reference to the text that Boeing has requested to be included via separate comment.  The revision to the latter part of that sentence highlights a distinction that should be carefully considered when drafting these documents. Phrases such as <i>"Appendix O conditions"</i> refer to the specific definitions contained in Part I of Appendix O, including the four discrete drop distributions. Boeing concurs that these definitions should be used as standards for analyses. However, for flight tests in natural icing, it would be virtually impossible to locate conditions matching the Appendix O distributions, since the distributions are merely statistical representations of all of the measured SLD conditions used in their development; in other words, it is possible that those exact Appendix O distributions do not exist. In contrast, reference to <i>"SLD icing conditions"</i> includes all of the SLD icing condition variations that naturally exist.</p>
response	Not accepted. These kind of changes are being investigated by the Working Group of rulemaking task RMT.0572.
comment	<p>221 <span style="float: right;">comment by: American Kestrel Company, LLC</span></p> <p>bullet a implies that the definition of "residual ice" is contamination that it difficult to detect through visual observation. This is incorrect usage and could be confusing to those less knowledgeable. Suggests eliminating first sentence.</p>
response	Accepted. Paragraph 4.8.1.3 has been revised and now does not use anymore the term 'residual ice'.



comment	222	comment by: <i>American Kestrel Company, LLC</i>
	Section 5.2.3.2 Sentence beginning "For some derivative..." Detail of what would constitute an acceptable derivative. Also given that none of these derivative aircraft will have been tested with ice shapes from appendix O this may be read as inconsistent with Table 1.	
response	<p>Not accepted.</p> <p>The Agency has launched rulemaking task RMT.0572 to develop existing references to previous aeroplane types which may be used to support the compliance to SLD specifications.</p>	

**B. Draft Decision — I. Draft Decision amending CS-25 — Book 2; AMC — SUBPART B; Appendix 1 — Airframe Ice Accretion**

p. 37-49

comment	26	comment by: <i>AIRBUS</i>
	<p><b>AMC 25.21(g) Appendix 1 Airframe Ice Accretion</b></p> <p><b>General comments:</b></p> <p>Review applicability of the EASA SLD rules to ensure harmonization with the FAA rules and guidance material</p> <p>This section will be affected by the conclusions of the EASA RMT 0572.</p> <p>Rationale:</p> <p>As stated in previous comments, the regulations in North America and Europe should be harmonized as far as possible and must not be contradictory. Such a significant disharmonisation as that proposed by EASA in NPA 2011-03 and NPA 2012-22 is not acceptable.</p> <p>As the SLD tools mature and the understanding of the icing phenomena improve this section should be modified to define feasible scenarios. In future it is anticipated that tools will be available that realistically allow SLD certification. However in order to achieve this the proposed icing scenarios will certainly need to be clarified and likely need to be reviewed to enable a feasible certification to SLD conditions.</p> <p>The proposed SLD scenarios appear to be extremely penalizing even for aircraft that intend to detect and exit icing conditions, with a total exposure to a mixture of App O and App C of 45-55 minutes depending upon the interpretation.</p> <p>Many aircraft types have operated safely in icing conditions. This can be attributed to the basic design of the aircraft and the robust icing demonstration performed in Appendix C icing conditions.</p> <p>The regulations have been reinforced for all aircraft in recent years (FAR Amdt 25-121/CS-25 Amdt 3). The aircraft that have experienced in service issues were not certified to these reinforced regulations. Such aircraft were not required to demonstrate compliance with these reinforced rules and guidance material.</p> <p>The combination of robust designs and App C certification demonstrations have led to many aircraft demonstrating excellent in service experience. The same set of design approaches and certification methodologies can be expected to deliver the same excellent levels of safety in the future.</p> <p>Currently the tools required to certify for flight in SLD or for detection and exit of the icing conditions are not sufficiently mature to allow certification across the complete range of SLD conditions defined by the rule. It is expected that these tools will eventually mature</p>	



response	<p>sufficiently to allow certification and Airbus continues to support and participate in the international efforts to develop the required tools.</p> <p>The EASA RMT 0572 activities will allow a means of compliance by similarity. This risks blocking new comers to the market and also risks blocking the implementation of new technologies. For an industry (and its Customers) who rely upon continuous technological improvements to improve performance and continuously improve the impact upon the environment, this is not an acceptable situation.</p> <p>Noted.</p>
comment	<p>27 <span style="float: right;">comment by: AIRBUS</span></p> <p><b>Appendix 1 - Page 39 Section A1.2.2</b></p> <p>In several sections “lift off” has been replaced by “the end of take-off distance” as requested by the FAA in one of its comments on EASA NPA 2011-03 (refer to comment number 139 in the CRD to NPA 2011-03)</p> <p>It would be preferable to revert to the original text and use “lift off” instead of “the end of the take-off distance” to aid clarity and understanding by all users of the guidance material.</p> <p>Rationale:</p> <p>The term lift off has been used for many years and can be well understood by all readers of the text as the point at which the aircraft becomes airborne. The new terminology whilst perhaps more in line with the technical terms used by aircraft performance and handling qualities specialists is less clear. The end of take-off distance could be the accelerate stop distance or the distance to clear the 50ft obstacle. If it is preferred to retain the term take-off distance it is recommended that a clear definition be added to the AMC or a cross reference to existing definitions be added (in its comment the FAA refers to CS 25.111, 25.113, and 25.115)</p> <p>The distance intended by the AMC needs to be clearly defined and the wording of the AMC text clarified accordingly.</p> <p>response</p> <p>Not accepted.</p> <p>This change aligns the definition of take-off and final take-off ice with that of the take-off path used for determining take-off performance under CS 25.111, 25.113, and 25.115. A definition of the take-off distance is provided in CS 25.113.</p>
comment	<p>28 <span style="float: right;">comment by: AIRBUS</span></p> <p><b>Appendix 1 - Page 38 Section A1.1(h)</b></p> <p>The AMC includes cross references to various FAA AC’s. These documents provide a wealth of information and guidance. These documents are extremely valuable resources and worthy of mention in the AMC.</p> <p>It is noted that the AC material constitutes several hundred pages of detailed guidance material. Icing is a continuously developing field with modelling, simulation and test methods and capabilities being continuously developed and improved. Nevertheless much of the material remains valid but it should be noted that the material is for guidance and the state of the art continues to progress.</p> <p>Although it is agreed that referencing the FAA advisory material is a good idea it is also a little confusing because in other areas specific sections of the AC’s are reproduced precisely in the AMC.</p>



	<p>The AMC and the AC's are both guidance documents containing possible means of compliance and guidance (but not the only means and are not mandatory requirements). This mixture of cross referencing and copying and pasting makes it difficult for an applicant to interpret precisely what the agency expects.</p>
response	<p>Noted.</p> <p>The proposed AMC 25.21(g) contains references to the following FAA ACs: AC 20-73A, Aircraft Ice Protection (in particular Appendix R) and AC 25-7A, Flight Test Guide for Certification of Transport Category Aeroplanes.</p> <p>For these references the Agency did not copy corresponding texts in our AMC material. The number of references is limited to these two items and it is not deemed to create confusion. As a general remark, any EASA AMC text takes precedence over the related FAA AC text.</p>
comment	<p>30 <span style="float: right;">comment by: AIRBUS</span></p> <p><b>Appendix 1 - Page 43 – 49 Ice Shape Scenarios for App O (Same as AC 25-25X)</b></p> <p>The scenarios defined are identical to those defined in FAA AC 25-25X. A review of these scenarios by various commentators has highlighted that the scenarios are not clear and may contradict the scenarios defined in Parts II of Appendix O.</p> <p>It is recommended that these scenarios be checked and updated during the next update of the AMCs to aid clarity.</p> <p>In addition it is recommended that the scenarios in part II of Appendix O be moved to the AMC when the regulations and AMC are updated.</p> <p>Rationale:</p> <p>During the comment period of NPA 2011-03 EASA asked if the ice accretion definitions in Appendix O part II should be moved to the AMC. This was widely supported. EASA has followed the FAA position of having ice accretion scenarios defined both within the rule (App O part II) and the guidance material. However this leads to the potential for confusion and inconsistencies between the guidance and rules.</p> <p>The scenario descriptions are similar but not identical and have led to confusion among commentators on the AMC</p> <p>In addition the scenarios in the tables and Part II of App. O are open to interpretation. Depending upon the interpretation of the tables the App O scenarios are more or less conservative. Additional clarification is required.</p> <p>It is recommended that these scenarios be reviewed once the tools required to certify to Appendix O are available.</p>
response	<p>Noted.</p>
comment	<p>39 <span style="float: right;">comment by: AIRBUS</span></p> <p><b>AMC 25.21(g) Page 43 1.2.3.3 b2, c2 and d1</b></p> <p>Recommended Change:</p> <p>b2. The ice accretion corresponding to 10 additional seconds of operation in icing conditions (the continuous maximum icing conditions of CS-25 Appendix C, part I(a) <del>and or</del> the icing conditions of Appendix O), plus</p> <p>c2. The ice accretion equivalent to 30 seconds of operation in icing conditions (the continuous maximum icing conditions of CS-25 Appendix C, part I(a) <del>and or</del> the icing conditions of Appendix O), plus</p>

	<p>1. The ice accretion equivalent to 30 seconds of operation in icing conditions (the continuous maximum icing conditions of CS-25 Appendix C, part I(a) <del>and/or</del> the icing conditions of Appendix O), plus</p> <p>Rationale:</p> <p>The guidance as written in the NPA is unclear as to whether the applicant should consider a composite exposure of App C and App O or should consider App C and App O accretions separately.</p>
response	<p>Accepted.</p> <p>The under bracket information has been removed on the three mentioned paragraphs. Paragraph A1.2.3.1 already provides sufficient guidance: 'For the icing conditions of Appendix C, the aeroplane should be assumed to be in continuous maximum icing conditions during the time between entering the icing conditions and effective operation of the ice protection system'.</p>

comment 40 comment by: AIRBUS

#### AMC25.21(g) Page 45 Table 1 Specific Comments

TO/FTO ice: Detect and exit ice is not required for TO and FTO. This seems to contradict 25.1420(a)(2) and Part II of App. O.

All phases: In all phases in table 1, it is unclear what is meant by "pre-detection ice". We believe it is not intended to mean pre-activation ice, because that is a specific scenario. Also in table 2, there is no pre-detection ice, which implies it is not pre-activation ice. If it means ice before detection of App O, then it does not need to be stated because the preceding text already says "combination of".

#### Approach:

The text should be changed to read:

The more critical of holding detect-and-exit ice ~~and or~~ the combination of:

The approach and landing scenarios define a maximum vertical extent of App C Cont Max. Can EASA confirm that this means a duration that corresponds to a 6500ft vertical cloud thickness as defined in CS25 App. C.

In the text, there is a mixture of the horizontal extent (17.4nm) being quoted and the vertical extent (6500ft). Is the intent to apply both for the single cloud climb/decent cases?

#### Rationale:

As previously stated the scenarios in the AMC and in Part II of App. O appear to differ.

For the approach phase "And" should be "or" to be in line with CS25.1420 and Part II of Appendix O, or the sentence should be re-written, if the real intention is not to combine 45 minute holding ice with approach ice.

It is recognized that different commentators and organizations may have differing interpretations or expectations of the various scenarios.

As already commented a review of the scenarios should be performed in parallel with the improvements to the SLD tools.

response	<p><u>T/O and FT/O</u>: Not accepted. Table 1 is to be read in the context of 'Ice Accretions for Encounters with Appendix O Conditions <u>Beyond those in Which the Aeroplane is Certified to Operate</u>'. In such a case, as explained in the Note 1, take-off is not permitted (and, therefore, no ice accretions have to be considered). It is not believed that there is a contradiction with CS 25.1420(a)(2) and Appendix O, Part II.</p> <p>When an aeroplane is to be approved for T/O with some Appendix O icing conditions, then relevant T/O and FT/O ice accretions have to be considered (as provided in Appendix O,</p>
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Part II(c)), and there is no need to consider detect-and-exit ice accretions during this phase as it must be continued once it is initiated.

All phases: Noted. The pre-detection ice is defined in Appendix O part II(b)(5), and this accretion is different from a pre-activation ice accretion (which may need to be considered if the ice protection system is not yet activated in the scenario in question).

Approach: Accepted. The correction is made to be consistent with Appendix O Part II ('and' replaced by 'or'). The vertical extent has to be determined as directed in Appendix O Part II(b)(3) (the ice accumulated during descent from the maximum vertical extent of the applicable icing conditions (function of the certification option i.e. CS 25.1420(a)(1) or (a)(2)). The commentator's statement referring to the Appendix C 6 500 ft vertical extent would be applicable for a certification in accordance to CS 25.1420(a)(1).

comment

84

comment by: Dassault Aviation

Dassault-Aviation comment page #48

**Extract:**

**AMC 25.21(g) - Performance and Handling Characteristics in Icing Conditions**

**Appendix 1 - Airframe Ice Accretion**

**A1.4 Additional guidance for Appendix O ice accretions**

**A1.4.3 Ice Accretions for Encounters with Appendix O Atmospheric Icing Conditions in Which the Aeroplane is Certified to Operate**

c. Table 2

- Take-off ice : Ice accretion occurring between lift-off and 122 m (400 feet) above the take-off surface assuming ice accretion starts at lift-off.
- Final Take-off ice : Ice accretion occurring between a height of 122 m (400 ft) above the take-off surface and the height at which the transition to the en-route configuration and speed is completed, or 457 m (1,500 feet) above the take-off surface, whichever is higher, assuming ice accretion starts at lift-off.

**Comment:**

Agency's decision is to consider that ice accretion is assumed to start at the end of the take-off distance, not at the point of lift-off. Consequently, these definitions have to be corrected.

**Requested Change**

These definitions have to be corrected:

- Take-off ice: Ice accretion occurring between ~~lift-off~~ **the end of the take-off distance** and 122 m (400 feet) above the take-off surface assuming ice accretion starts at ~~lift-off~~ **the end of the take-off distance**.

Final Take-off ice : Ice accretion occurring between a height of 122 m (400 ft) above the take-off surface and the height at which the transition to the en-route configuration and speed is completed, or 457 m (1,500 feet) above the take-off surface, whichever is higher, assuming ice accretion starts at ~~lift-off~~ **the end of the take-off distance**.

response

Accepted.

comment

106

comment by: FAA

Page	Para	COMMENT / SUGGESTED CHANGE	Rationale



37	b.2	The 2 <sup>nd</sup> paragraph in this section should be revised as follows: Therefore, <b>at a minimum</b> , certification for flight in icing conditions must consider...	Sections (a) and (b) discuss minimum considerations necessary to certify an airplane for flight in icing. For consistency, the same terminology should be used in the last paragraph to avoid potential confusion for airplanes certified for continued flight in appendix O conditions that would need to provide more substantiation.
40	A.1.2.3.1.	Propose revision to this section as follows: When considering ice accretion before the ice protection system has been activated and is performing its intended function, the means of activating the ice protection system and the system response time should be taken into account. <b>However, if artificial stall warning is provided and the point at which stall warning is initiated changes when the ice protection system is activated, the pre-activation ice accretion does not need to include consideration of the ice protection system response time.</b>	Intended for clarity and consistency with FAA guidance. If stall warning schedule bias is based on activation of ice protection, the IPS system response time occurs after IPS activation when the airplane is on the icing schedule. For such a system, stall warning with the non-icing schedule should be evaluated with a pre-activation ice accretion based on only the means of IPS activation and not system response time.
40	A1.2.3.2	A sub-paragraph should be added in this section to indicate that CS 25.1420(c) requires that for an aeroplane certified in accordance with sub-paragraph 25.1420 (a)(2) or (a)(3), the requirements of CS 25.1419 (e), (f), (g), and (h) must be met for the icing conditions defined in Appendix O in which the aeroplane is certified to operate.	Per CS25.1420(c), airplanes certified to detect appendix O and exit all icing in accordance with CS 25.1420(a)(1) would not be required to substantiate the system used to activate the ice protection system within appendix O conditions. However, guidance in this section implies that icing conditions in appendix C and O require consideration regardless of the airplane certification method.



42-43	Subparagraph b.2, c.2 and d.2	The statements should be clarified to indicate that the appendix O icing conditions in which the airplane will be certified should be used to substantiate the detection/activation method rather than all of appendix O.	As noted above, 25.1420(c) excludes airplanes that will detect appendix O and exit icing from substantiating the detection/activation method within appendix O. The guidance should clearly reflect the new regulation.
46	Preactivation ice	The description should be revised to reflect that the ice accretion to be considered before the system has been activated should be dependent on when the stall warning schedule is revised for icing conditions. We suggest adding the following text: <b>(Note: If artificial stall warning is provided and the initiation point of that warning changes when the ice protection system is activated, this ice accretion does not need to include consideration of the time it takes for the ice protection system to be effective in performing its intended function.)</b>	If stall warning is revised when the system is activated, the resulting ice accretion should only be based on the time it takes to detect icing conditions and revise the stall warning schedule.
47	Table 1, next to last row.	The second bullet should indicate that the ice accretion should include the time it takes to exit all icing conditions rather than the time it takes to exit the icing conditions which are beyond those in which the airplane is certified to operate.	Airplanes subjected to icing conditions which exceed the conditions in which they are certified to operate should exit all icing conditions.
47	Table 1, Note 1	Suggest wording similar to CS 25.1525 and state that intentional flight, including take-off, is not permitted into Appendix O conditions beyond those in which the aeroplane is certified to operate.	Use of the term “vicinity” in this context is vague and may impose takeoff limitations beyond the regulation.

response

Comment 1 on page 37: Accepted.Comment 2 on page 40 (A.1.2.3.1) : Not accepted. The proposal seems to contradict the CS 25.207(h) requirement. The establishment of the critical ice accretion formed on the



unprotected and normally protected surfaces before activation and effective operation of the ice protection system may occur also after the stall warning bias becomes active (refer to runback ice on hot air protected surfaces).

Comment 3 on A1.2.3.2: Accepted. The reference to CS 25.1420(c) requirement is added.

Comment 4 on page 42-43: Partially accepted. The under bracket information has been removed from the three mentioned paragraphs as it created confusions.

Comment 5: Not accepted. Please refer to our response to comment 2 above.

Comment 6: Accepted.

Comment 7: Accepted. We assume you intended to make reference to CS 25.1533, not to CS 25.1525.

comment 125

comment by: Boeing

Page: 42

Paragraph: A1.2.3 Ice accretion prior to activation and normal system operation

Boeing recommends revising the proposed text as follows:

*"b. If ice protection system activation depends on pilot action following annunciation from a primary ice detection system, the assumed ice accretion should take into account flight crew delays in activating the ice protection system and the time it takes for the system to perform its intended function. The assumed ice accretion can be determined as follows:*

- 1. The ice accretion corresponding to the time between entry into the icing conditions and annunciation from the primary ice detection system, plus*
- 2. The ice accretion corresponding to 10 additional seconds of operation in the more critical of icing conditions ~~(the continuous maximum icing conditions of CS-25 Appendix C, part I(a), or and the icing conditions of Appendix O)~~, as appropriate, plus*
- 3. The ice accretion during the system response time."*

**JUSTIFICATION:** The proposed paragraph states that both Appendix C and Appendix O conditions are to be used. Boeing finds this confusing and assumes it is an error. Our recommended revisions clarify that the more critical of the two should be used.

response

Accepted.

The under bracket information has been removed. Paragraph A1.2.3.1 already provides sufficient guidance: 'For the icing conditions of Appendix C, the aeroplane should be assumed to be in continuous maximum icing conditions during the time between entering the icing conditions and effective operation of the ice protection system'.

comment 126

comment by: Boeing

Page: 42-43

Paragraph: A1.2.3 Ice accretion prior to activation and normal system operation

Boeing recommends revising the proposed text as follows:

*"c. If ice protection system activation depends on the flight crew visually recognizing the first indication of ice accretion on a reference surface (for example, an ice accretion probe)*



combined with an advisory ice detection system, the assumed ice accretion should take into account flight crew delays in detecting the accreted ice and in activating the ice protection system, and the time it takes for the system to perform its intended function. This may be determined as follows:

1. The ice accretion that would be easily recognizable by the flight crew under all foreseeable conditions (for example, at night in clouds) as it corresponds to the first indication of ice accretion on the reference surface, plus
2. The ice accretion equivalent to **30 seconds** of operation in **the more critical of icing conditions** ~~(the continuous maximum icing conditions of CS-25 Appendix C, part I(a), or and the icing conditions of Appendix O), as appropriate~~, plus
3. The ice accreted during the system response time."

**JUSTIFICATION:** The proposed paragraph states that both Appendix C and Appendix O conditions are to be used. Boeing finds this confusing and assumes it is an error. The proposed revisions clarify that the more critical of the two should be used, as appropriate for the applicant (particularly with respect to Appendix O).

We also request clarification of the rationale for the 30 seconds of ice accretion specified in paragraph c.2. Is it intended that the 30 seconds is a pilot response time after identifying icing conditions and prior to activating the IPS system?

response

Accepted.

The under bracket information has been removed. Paragraph A1.2.3.1 already provides sufficient guidance: 'For the icing conditions of Appendix C, the aeroplane should be assumed to be in continuous maximum icing conditions during the time between entering the icing conditions and effective operation of the ice protection system'.

Yes the 30 seconds take into account the flight crew delay in detecting the accreted ice and in activating the ice protection system.

comment

127

comment by: Boeing

Page: 43

Paragraph: A1.2.3 Ice accretion prior to activation and normal system operation

Boeing recommends revising the proposed text as follows:

*"d. If ice protection system activation depends on pilot identification of icing conditions (as defined by an appropriate static or total air temperature in combination with visible moisture conditions) with or without an advisory ice detector, the assumed ice accretion should take into account flight crew delays in recognizing the presence of icing conditions and flight crew delays in activating the ice protection system, and the time it takes for the system to perform its intended function. This may be determined as follows:*

1. The ice accretion equivalent to 30 seconds of operation in **the more critical of icing conditions** ~~(the continuous maximum icing conditions of CS-25 Appendix C, part I(a), or and the icing conditions of Appendix O), as appropriate~~, plus
2. The ice accretion during the system response time."

**JUSTIFICATION:** The proposed paragraph states that both Appendix C and Appendix O conditions are to be used. Boeing finds this confusing and assumes that it is an error. Our recommended revisions clarify that the more critical of the two should be used, as appropriate for the applicant.



response	Accepted. The under bracket information has been removed. Paragraph A1.2.3.1 already provides sufficient guidance: 'For the icing conditions of Appendix C, the aeroplane should be assumed to be in continuous maximum icing conditions during the time between entering the icing conditions and effective operation of the ice protection system'.
comment	<p>128 <span style="float: right;">comment by: Boeing</span></p> <p>Page: 44 Paragraph: <i>A1.4.2 Ice Accretions for Encounters with Appendix O Conditions Beyond those in Which the Aeroplane is Certified to Operate</i></p> <p>Boeing recommends revising the proposed text as follows: "b. These ice accretions <a href="#">in Table 1</a> apply when the aeroplane is not certified for flight in any portion of Appendix O atmospheric icing conditions, when the aeroplane is certified for flight in only a portion of Appendix O conditions, and for any flight phase for which the aeroplane is not certified for flight throughout the Appendix O icing envelope."</p> <p><b>JUSTIFICATION:</b> EDITORIAL COMMENT: Our recommended revision provides clarification such that the reader does not have to refer back to paragraph A1.4.2.a.</p>
response	Accepted.
comment	<p>129 <span style="float: right;">comment by: Boeing</span></p> <p>Page: 45 Paragraph: <i>A1.4.2 Ice Accretions for Encounters with Appendix O Conditions Beyond those in Which the Aeroplane is Certified to Operate -- Table 1</i></p> <p>Boeing recommends that the entry at Row 6 in Table 1 be revised as follows: "Approach Detect-and-Exit Ice The more critical of holding detect-and-exit ice <del>and</del> <u>or</u> the combination of: ..."</p> <p><b>JUSTIFICATION:</b> As written, the proposed text could be interpreted to mean that <u>both</u> ice shapes are to be used, rather than the more critical of the holding detect-and-exit ice shape or the combination ice shape specified in steps 1 through 3. Boeing believes that the intention is to use either the holding ice or the combination. In this case, for clarification, "or" is more appropriate than "and."</p>
response	Accepted.
comment	<p>130 <span style="float: right;">comment by: Boeing</span></p> <p>Page: 46 Paragraph: <i>A1.4.2 Ice Accretions for Encounters with Appendix O Conditions Beyond those in Which the Aeroplane is Certified to Operate -- Table 1</i></p> <p>Boeing recommends that the entry at Row 7 in Table 1 be revised as follows: "Landing Detect-and-Exit Ice"</p>



*The more critical of holding detect-and-exit ice ~~and~~ or the combination of: ..."*

**JUSTIFICATION:** As written, the proposed text could be interpreted to mean that both ice shapes are to be used, rather than the more critical of the holding detect-and-exit ice shape or the combination ice shape specified in steps 1 through 3. Boeing believes that the intention is to use either the holding ice or the combination. In this case, for clarification, "or" is more appropriate than "and."

response Accepted.

comment 131

comment by: Boeing

Page: 47

Paragraph: *A1.4.3 Ice Accretions for Encounters with Appendix O Atmospheric Icing Conditions in Which the Aeroplane is Certified to Operate.*

Boeing recommends revising the proposed text as follows:

*"a. The applicant should use the ice accretions in Table 2 to evaluate compliance with the applicable CS-25 subpart B requirements for operating safely in the Appendix O atmospheric icing conditions for which ~~the aeroplane is approved~~ approval is sought."*

**JUSTIFICATION:** Our recommended revision will correctly reflect that when the ice accretions are evaluated, the airplane's certification will not yet have been approved.

response Accepted.

The same change is applied to other similar occurrences in the AMC.

comment 132

comment by: Boeing

Page: 47

Paragraph: *A1.4.3 Ice Accretions for Encounters with Appendix O Atmospheric Icing Conditions in Which the Aeroplane is Certified to Operate.*

and various other places throughout the proposed NPA

**GENERAL COMMENT:** Boeing recommends using the phrase, "approval is sought," instead of "approved." This occurs in numerous locations within the document, for example:

*"... Appendix O atmospheric icing conditions for which ~~the aeroplane is approved~~ approval is sought. ..."*

**JUSTIFICATION:** Our recommended revision will correctly reflect that the airplane's certification has not yet been approved.

response Accepted.

comment 133

comment by: Boeing

Page: 48

Paragraph: *A1.4.3 Ice Accretions for Encounters with Appendix O Atmospheric Icing Conditions in Which the Aeroplane is Certified to Operate -- Table 2*



Boeing recommends that the entry at Row 6 in Table 2 be revised as follows:

*“Approach Ice*

*More critical ice accretion of:*

*(1) Ice accreted during a descent in the cruise configuration from the maximum vertical extent of the Appendix O icing environment to 610 m (2,000 feet) above the landing surface, followed by:*

- *transition to the approach configuration and*
- *manoeuvring for 15 minutes at 610 m (2,000 feet) above the landing surface; ~~and or~~*
- (2) Holding ice (if the aeroplane is certified for holding in Appendix O conditions).”*

**JUSTIFICATION:** As written, the proposed text could be interpreted to mean that both ice shapes are to be used, rather than the more critical of the holding ice shape or the combination ice shape specified. Boeing believes that the intention is to use either (1) or (2). In this case, for clarification, “or” is more appropriate than “and.”

response Accepted.

comment 134

comment by: Boeing

Page: 49

Paragraph: A1.4.3 Ice Accretions for Encounters with Appendix O Atmospheric Icing Conditions in Which the Aeroplane is Certified to Operate -- Table 2

Boeing recommends that the entry at Row 6 in Table 2 be revised as follows:

*“Landing Ice*

*More critical ice accretion of:*

*(1) Approach ice plus ice accreted during descent from 610 m (2,000 feet) above the landing surface to 61 m (200 feet) above the landing surface with:*

- *a transition to the landing configuration, followed by*
- *a go-around manoeuvre beginning with the minimum climb gradient specified in CS 25.119 from 61 m (200 feet) to 610 m (2,000 feet) above the landing surface, and*
- *holding for 15 minutes at 610 m (2,000 feet) above the landing surface in the approach configuration, and*
- *a descent to the landing surface in the landing configuration, ~~and or~~*
- (2) Holding ice (if the aeroplane is certified for holding in Appendix O conditions).”*

**JUSTIFICATION:** As written, the proposed text could be interpreted to mean that both ice shapes are to be used, rather than the more critical of the holding ice shape or the combination ice shape specified. Boeing believes that the intention is to use either (1) or (2). In this case, for clarification, “or” is more appropriate than “and.”

response Accepted.

comment 223

comment by: American Kestrel Company, LLC

Item 1 of approach Detect and Exit ice - The text may be interpreted as requiring an icing encounter from the top of the CM icing cloud limit (22,000 ft) descending to 2000ft and does not seem to consider the 6,500 ft maximum vertical limit of the CM icing cloud. This should



response

be clarified.

Noted.

The vertical extent has to be determined as directed in Appendix O Part II(b)(3) (the ice accumulated during descent from the maximum vertical extent of the applicable icing conditions (function of the certification option i.e. CS 25.1420(a)(1) or (a)(2)). The commentator's statement referring to the Appendix C 6 500 ft vertical extent would be applicable for a certification in accordance to CS 25.1420(a)(1).

**Cessna comment on A1.2.2.2:**

Compared to AC25-25X, some wordings are missing. So suggest following change:

Current Text:

"Final Take-off ice": The most critical ... (1500 ft) above the take-off surface, assuming accretion starts ...

Proposed Text:

"Final Take-off ice": The most critical ... (1500 ft) above the take-off surface, **whichever is higher**, assuming accretion starts ...

Response: Accepted.

**Cessna comment on Appendix 1 line "Approach" (page 45/Table 1):**

Change text

Current Text:

(1) Ice accreted during ... extent of the Appendix C maximum continuous icing conditions ...

Proposed Text:

(1) Ice accreted during ... extent of the Appendix C **continuous maximum** icing conditions ...

Response: Accepted. The change has been applied in all applicable occurrences of the AMC.

**Cessna comment on Appendix 1 line "Landing" (page 46/Table 1):**

Change "maximum continuous" to "continuous maximum":

Current Text:

A descent in the ... extent of the Appendix C maximum continuous icing environment ...

Proposed Text:

A descent in the ... extent of the Appendix C **continuous maximum** icing environment ...

Response: Accepted.

**Cessna comment on Appendix 1 lines "Takeoff" and "Final takeoff" (page 48/Table 2):**

In both descriptions, the word "lift-off" was used.

Current Text:

Page 39 paragraph A1.2.2, "lift-off" was crossed-off and replaced with "the end of the take-off distance". FAA AC25-25X uses "lift-off".

Proposed Text:

To be consistent throughout the document, suggest replacing occurrences of "lift-off" here with "the end of the take-off distance."

Response: Accepted.



**B. Draft Decision — I. Draft Decision amending CS-25 — Book 2; AMC — SUBPART B; Appendix 2**  
**— Artificial Ice Shapes**

p. 50

comment

41

comment by: AIRBUS

**AMC 25.21(g) A2.2.2 Page 50**

Add an additional Appendix to AMC 25.21g or AMC 25.1420 with the contents of the IPHWG interim means of compliance. Refer to draft FAA AC 25-XX Appendix 5.

Rationale:

This is a general comment. It is specifically raised here because the interim guidance included a recommendation for the simulation of SLD roughness linked to the predicted thickness of the ice shape.

response

Not accepted.

It is not considered necessary to incorporate this table in our AMC material, as it does not really help to show compliance with the rules. This is a status dating from 2009 which should evolve over time.

comment

107

comment by: FAA

Page	Para	COMMENT / SUGGESTED CHANGE	Rationale
50	A2.3.2	Suggest new text for section 2.3.2 as follows: Because sandpaper ice must be considered in the basic icing certification within the Appendix C environmental icing envelope, it does not need to be considered for certification of flight in Appendix O icing conditions.	Intended for clarity and consistency with FAA guidance.

response

Accepted.

**Cessna comment on A2.3.3:**

Para change

Current Text:

The spanwise and chordwise ... for the zero g pushover manoeuvre of paragraph 6.9.3 of this AMC ...

Proposed Text:

Suggest change 6.9.3 to 6.9.4.

Response: Accepted.

**B. Draft Decision — I. Draft Decision amending CS-25 — Book 2; AMC — SUBPART B; Appendix 3**  
**— Design Feature**

p. 51-52

comment

135

comment by: Boeing

Page: 52



	<p>Paragraph: A3.5.1 Wing Ice Protection/Detection</p> <p>Boeing recommends revising the proposed text as follows:  <i>"A3.5.1 Wing Ice Protection/Detection. A <del>primary</del> ice detection system that <u>automatically</u> activates a wing de-icing <u>or anti-icing</u> system may ensure that there is no significant ice accretion on wings that are susceptible to performance losses with small amounts of ice."</i></p> <p><b>JUSTIFICATION:</b> Our recommended revisions provide consistency with the wording used in the FAA's draft AC 25-25X (except that "...or anti-icing..." should be added as well).</p>
response	Accepted.

comment	<p>136</p> <p>Page: 52</p> <p>Paragraph: A3.5.2 Tail Ice Protection/Detection</p> <p>Boeing recommends revising the proposed text as follows:  <i>"A3.5.2 Tail Ice Protection/Detection. A <del>primary</del> ice detection system may <u>automatically</u> activate a tailplane de-icing <u>or anti-icing</u> system on aeroplanes that do not have visible cues for system operation."</i></p> <p><b>JUSTIFICATION:</b> Our recommended revisions provide consistency with the wording used in the FAA's draft AC 25-25X (except that "...or anti-icing..." should be added as well).</p>	comment by: Boeing
response	Accepted.	

**Cessna comment on A3.5.1.1:**

Compared to FAA AC25-25X

Current Text:

If the entire wing leading edge is not protected, the part that is protected may be

Proposed Text:

If the ~~entire~~ **portions of the** wing leading edge is not protected, the part that is protected may be ...

Response: Partially accepted. The sentence has been amended to read: 'If the wing leading edge is not entirely protected[...]'.

**B. Draft Decision — I. Draft Decision amending CS-25 — Book 2; AMC — SUBPART B; Appendix 4**  
**— Examples of Aeroplane Flight Manual Limitations and Operating Procedures for Operations in Supercooled Large Drop Icing Conditions** p. 53-56

comment	108	comment by: FAA						
	<table> <tr> <th>Para</th><th>COMMENT / SUGGESTED CHANGE</th><th>Rationale</th></tr> <tr> <td></td><td></td><td></td></tr> </table>	Para	COMMENT / SUGGESTED CHANGE	Rationale				
Para	COMMENT / SUGGESTED CHANGE	Rationale						





A.4.1.a.	Add “SLD” to language as follows. Intentional flight, including takeoff and landing, into <b>SLD conditions, (ie. freezing drizzle or freezing rain) conditions</b> is prohibited.	The future weather system may report “known” SLD rather than infer it as is currently done. It is not known how detected SLD aloft will be reported. If intent is to prohibit intentional flight in SLD aloft, then the term “SLD” should be included in AFM limitations also. We have experienced loose interpretations of SLD prohibition language in AFMs.
4.2(c)	Propose clarifying the 2 <sup>nd</sup> paragraph as follows: Operations in icing conditions, <b>including freezing drizzle</b> , were evaluated as part...	Since freezing rain and drizzle are new approvals, it may be good to indicate specifically which are approved and which are not to avoid potential confusion.

response Comment 1: Accepted.  
Comment 2: Accepted.

comment 137

comment by: Boeing

Page: 53

Paragraph: A4.1. Aeroplane approved for flight in Appendix C icing conditions but not approved for flight in Appendix O icing conditions.

Boeing recommends revising the proposed text in A4.1.c. (*Flight Crew Operating Manual Operating Procedures*) as follows:

**“Warning: Severe Hazardous** icing **effects** may result from environmental conditions outside of those for which this aeroplane is certified. **Intentional f**light into **severe unapproved** icing conditions may result in ice build-up on protected surfaces exceeding the capability of the ice protection system, or in ice forming aft of the protected surfaces. This ice **may might** not be shed when using the ice protection systems, and may seriously degrade performance and controllability of the aeroplane.

**JUSTIFICATION:** Boeing believes that the term “severe icing” is too often misused and misunderstood. We therefore recommended that it be avoided in the proposed text.

In addition, we note that an icing encounter need not be *intentional* to produce the described results.

The revision to the last sentence corrects a grammatical error.

Boeing acknowledges that the proposed language is the same as that contained in the FAA’s proposed AC 25-25X; however, our recommended revisions were not suggested for that document. We hope that both the Agency and the FAA will harmonize this language as we have suggested here.

response Accepted.



comment

138

comment by: Boeing

Page: 54

Paragraph: A4.2. Aeroplane approved for flight in Appendix C icing conditions and freezing drizzle conditions of Appendix O but not approved for flight in freezing rain conditions of Appendix O.

Boeing recommends revising the proposed text in A4.2.c. (*Flight Crew Operating Manual Operating Procedures*) as follows:

**“Warning:** ~~Severe-Hazardous~~ icing effects may result from environmental conditions outside of those for which this aeroplane is certified. ~~Intentional~~ Flight into ~~severe~~ unapproved icing conditions may result in ice build-up on protected surfaces exceeding the capability of the ice protection system, or in ice forming aft of the protected surfaces. This ice ~~may~~ might not be shed when using the ice protection systems, and may seriously degrade performance and controllability of the aeroplane.”

**JUSTIFICATION:** Boeing believes that the term “severe icing” is too often misused and misunderstood. We therefore recommended that it be avoided in the proposed text. In addition, we note that an icing encounter need not be *intentional* to produce the described results.

The revision to the last sentence corrects a grammatical error.

Boeing acknowledges that the proposed language is the same as that contained in the FAA’s proposed AC 25-25X; however, our recommended revisions were not suggested for that document. We hope that both the Agency and the FAA will harmonize this language as we have suggested here.

response

Accepted.

comment

139

comment by: Boeing

Page: 55

Paragraph: A4.3 Aeroplane approved for flight in Appendix C and Appendix O icing conditions except for en route and holding flight phases in Appendix O icing conditions

Boeing recommends revising the proposed text in A4.3.c. (*Flight Crew Operating Manual Operating Procedures*) as follows:

**“Warning:** ~~Severe-Hazardous~~ icing effects may result from environmental conditions outside of those for which this aeroplane is certified. ~~Intentional~~ Flight into ~~severe~~ unapproved icing conditions may result in ice build-up on protected surfaces exceeding the capability of the ice protection system, or in ice forming aft of the protected surfaces. This ice ~~may~~ might not be shed when using the ice protection systems, and may seriously degrade performance and controllability of the aeroplane.”

**JUSTIFICATION:** Boeing believes that the term “severe icing” is too often misused and misunderstood. We therefore recommended that it be avoided in the proposed text. In addition, we note that an icing encounter need not be *intentional* to produce the described results.

The revision to the last sentence corrects a grammatical error.

Boeing acknowledges that the proposed language is the same as that contained in the FAA’s proposed AC 25-25X; however, our recommended revisions were not suggested for that



	document. We hope that both the Agency and the FAA will harmonize this language as we have suggested here.
response	Accepted.
comment	<p>140 <span style="float: right;">comment by: Boeing</span></p> <p>Page: 56 Paragraph: A4.4 Aeroplane approved for flight in Appendix C icing conditions and a portion of Appendix O icing conditions.</p> <p>Boeing recommends revising the proposed text in A4.4.c. (<i>Flight Crew Operating Manual Operating Procedures</i>) as follows:</p> <p><b>“Warning:</b> <del>Severe-Hazardous</del> icing <del>effects</del> may result from environmental conditions outside of those for which this aeroplane is certified. <del>Intentional</del> <del>f</del>Flight into <del>severe</del> <del>unapproved</del> icing conditions may result in ice build-up on protected surfaces exceeding the capability of the ice protection system, or in ice forming aft of the protected surfaces. This ice <del>may</del> <del>might</del> not be shed when using the ice protection systems, and may seriously degrade performance and controllability of the aeroplane.”</p> <p><b>JUSTIFICATION:</b> Boeing believes that the term “severe icing” is too often misused and misunderstood. We therefore recommended that it be avoided in the proposed text. In addition, we note that an icing encounter need not be <i>intentional</i> to produce the described results.</p> <p>The revision to the last sentence corrects a grammatical error.</p> <p>Boeing acknowledges that the proposed language is the same as that contained in the FAA’s proposed AC 25-25X; however, our recommended revisions were not suggested for that document. We hope that both the Agency and the FAA will harmonize this language as we have suggested here.</p>
response	Accepted.

**Cessna comment on page 55, c:**

In the paragraph after Warning: label

Operations in icing conditions ... En route (climb, cruise, and descent with high left devices ...

Proposed Text:

Change “left” to “lift”:

Operations in icing conditions ... En route (climb, cruise, and descent with high left lift devices ...

Response: Accepted.

**B. Draft Decision — I. Draft Decision amending CS-25 — Book 2; AMC — SUBPART B; Appendix 5 — Related Acceptable Means of Compliance (AMC) and FAA Advisory Circulars (AC)**

p. 57

comment

109

comment by: FAA

Page	Para	COMMENT / SUGGESTED CHANGE	Rationale



57	Appendix 5	Revise revision level of AC 25-7 and include reference to AC 25-25 as follows: AC 25-7AC, Flight Test Guide for Certification of Transport Category Airplanes <b>AC 25-25A, Performance and Handling Characteristics in Icing Conditions</b>	For clarity and accuracy.
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response

Noted.

The reference to AC 25-7A is deleted. As reminded by Boeing, the icing section was removed from AC 25-7B. Therefore, there is no benefit to refer to AC 25-7C in this AMC.

comment

141

comment by: Boeing

Page: 57

Section: *Appendix 5 - Related Acceptable Means of Compliance (AMC) and FAA Advisory Circulars (AC)*

Boeing recommends revising the proposed text as follows:

*"Advisory Circulars*

*The following FAA ACs are related to the guidance contained in this AMC.*

*AC 20-73A, Aircraft Ice Protection, **16 August 2006***

~~*AC 25-7A, Flight Test Guide for Certification of Transport Category Aeroplanes*~~

~~*AC 25-25X, Performance and Handling Characteristics in Icing Conditions, (proposed)*~~

~~*AC 25-XX, Compliance of Transport Category Airplanes With Certification Requirements For Flight in Icing Conditions, (proposed)*~~

~~*AC 20-115B, RTCA, Inc. Document RTCA/DO-178B, 11 January 1993*~~

~~*AC20-117, Hazards Following Ground Deicing and Ground Operations in Conditions Conducive to Aircraft icing, 17 December 1982*~~

~~*AC 20-147, Turbojet, Turboprop, and Turbofan Engine Induction System Icing and Ice Ingestion, 2 February 2004*~~

~~*AC 21-16E, RTCA, Inc. Document RTCA/DO-160E, Environmental Conditions and test Procedures for Airborne Equipment, 20 December 2005*~~

~~*AC 21-40A, Application Guide for Obtaining a Supplemental Type Certification, 27 September 2007*~~

~~*AC 25-11A, Electronic Flight Deck Displays, 21 June 2007*~~

~~*AC 25-22, Certification of Transport Airplane Mechanical Systems, 14 March 2000*~~

~~*AC 25.629-1A, Aeroelastic Stability Substantiation of Transport Category Airplanes, 23 July 1998*~~

~~*AC 25.1309-1A, System Design Analysis, 21 June 1988*~~

~~*AC 25.1329-1B, Approval of Flight Guidance Systems, 16 October 2012*~~

~~*AC 25.1419-1A, Certification of Transport Category Airplanes for Flight in Icing Conditions, 7 May 2004"*~~

**JUSTIFICATION:** Boeing requests the indicated additions and deletions to the list of Advisory Circulars for the following reasons.

- AC 25-7A has been superseded by AC 25-7C.



response

- The icing section of AC 25-7C has been removed; icing is addressed in AC 20-73A and AC 25-25.
  - Expanding the proposed list of referenced ACs provides harmonization with the lists found in FAA proposed AC 25-XX and AC 25-25X.
- Boeing also suggests adding document dates to each FAA AC to ensure the proper revision can be referenced.
- Partially accepted.  
The reference to AC 25-7A has been deleted as proposed.  
The other proposed references have not been not added because, either the Agency publishes its own equivalent AMCs, or the proposed reference is not specific to this AMC.

**Cessna comment on Appendix 5 page 57:**

Use of word "Airplane"

Current Text:

AC 25-7A, Flight Test Guide ... Category Aeroplanes

Proposed Text:

Change "Aeroplanes" to "Airplanes":

AC 25-7A, Flight Test Guide ... Category ~~Aeroplanes~~ Airplanes

Current revision level of AC 25-7 is "C"

Response: The reference to AC 25-7A is deleted. As reminded by Boeing, the icing section was removed from AC 25-7B. Therefore, there is no benefit to refer to AC 25-7C in this AMC.

**B. Draft Decision — I. Draft Decision amending CS-25 — Book 2; AMC — SUBPART B; Appendix 6**  
**— Acronyms and definitions**

p. 58

comment

142

comment by: Boeing

Page: 58

Section: *Appendix 6 – Acronyms and definitions*

Boeing recommends adding the following acronyms/definitions to Appendix 6:

**$V_1$  -- Also referred to as the "decision speed," the maximum speed in the takeoff at which the pilot must take the first action (for example, apply brakes, reduce thrust, deploy speed brakes) once the decision has been made to stop the airplane such that it remains within the accelerate-stop distance. Following a failure of the critical engine at  $V_{EF}$ ,  $V_1$  is also the minimum speed in the takeoff at which the pilot can continue the takeoff and achieve the required height above the takeoff surface within the takeoff distance.**

**$V_2$  -- Takeoff safety speed. The target speed to be reached by the time the airplane is 35 feet above the takeoff surface.**

**$V_{2MIN}$  -- Minimum takeoff safety speed required to meet takeoff performance regulations.**

**$V_{CW}$  -- Crosswind component of wind speed.**

**$V_{DF}/M_{DF}$  - Demonstrated flight diving speed or Mach No.**

**$V_{EF}$  -- Engine failure speed. The speed at which the critical engine is assumed to fail during takeoff.**

**$V_{FC}$  -- Maximum speed for stability characteristics.**

**$V_{FE}$  -- Maximum speed at which the flaps can be extended.**



**$V_{MO}$**  -- Maximum operating limit speed.

**$V_{REF}$**  -- Reference landing speed; relationship to the stall speed is established by regulatory requirements.

**$V_{S\ 1-g}$**  -- 1-g stall speed. The lowest calibrated airspeed at which aerodynamic forces alone can support the airplane in 1-g flight.

**$V_{SR}$**  -- Reference stall speed; relationship to  $V_{S\ 1-g}$  is established by regulatory requirements.

**$V_{SR1}$**  -- Reference stall speed in a specific configuration.

**JUSTIFICATION:** Boeing finds that not all speed abbreviations are defined in the text of the proposed AMC and therefore suggests providing the additional definitions indicated. The requested additions also provide improved harmonization with the definitions contained in proposed FAA AC 25-25X.

response

Not accepted.

EASA CS-Definitions already provides the required definitions.

**B. Draft Decision — I. Draft Decision amending CS-25 — Book 2; AMC — SUBPART D — AMC 25.773(b)(1)(ii) Pilot compartment view in icing conditions**

p. 61-62

comment

42

comment by: AIRBUS

**AMC 25.773(b)(1)(ii) Page 61**

Current text:

*CS 25.773(b)(1)(ii) requires that the aeroplane have a means of maintaining a clear portion of windshield in the icing conditions defined in Appendix C and in certain Appendix O icing conditions. The applicant should conduct dry air flight tests to verify the thermal analysis. Measurements of both the inner and outer surface temperature of the protected windshield area may be needed to verify the thermal analysis. The thermal analysis should show that the windshield surface temperature is sufficient to maintain anti-icing capability without causing structural damage to the windshield. An evaluation of visibility, including distortion effects through the protected area, should be made for both day and night operations.*

The underlined text is vague and some additional criteria or guidance should be provided.

For example the AMC states that a heat density of 70 W/dm<sup>2</sup> has been used successfully in the past. If an applicant elects to use this value in future would a thermal analysis be necessary considering the success of previous designs that have used this heat density?

response

Accepted.

The text of the AMC has been clarified by creating a new second paragraph to state that a thermal analysis should be conducted to substantiate the selected nominal heating capacity, including when selecting a 70 W/dm<sup>2</sup> value.

comment

143

comment by: Boeing

Page: 61-62

Paragraph: AMC 25.773(b)(1)(ii) Pilot compartment view in icing conditions

Boeing recommends revising the proposed text as follows:

*"CS 25.773(b)(1)(ii) requires that the aeroplane have a means of maintaining a clear portion*



of windshield in the icing conditions defined in Appendix C and, in certain Appendix O icing conditions **corresponding to the CS 25.1420 certification option selected**. The applicant should conduct dry air flight tests to verify the thermal analysis. Measurements of both the inner and outer surface temperature of the protected windshield area may be needed to verify the thermal analysis. The thermal analysis should show that the windshield surface temperature is sufficient to maintain anti-icing capability without causing structural damage to the windshield. An evaluation of visibility, including distortion effects through the protected area, should be made for both day and night operations. In addition, the size and location of the protected area should be reviewed to confirm that it provides adequate visibility for the flight crew, especially during the approach and landing phases of flight. For windshields protected by the application of electrical heat, a nominal heating capacity of 70 W/dm<sup>2</sup> has shown to provide adequate protection for Appendix **C and Appendix O** icing environment.”

**JUSTIFICATION:**

1. Adding the recommended wording in the first paragraph of this section will clarify the phrase “certain Appendix O conditions” so that the reader will not have to refer to CS 25.773(b)(1)(ii) to understand it.
2. As for our recommended changes in the second paragraph, both Appendix C and O conditions are covered by the 70 W/m<sup>2</sup>. The heat requirements for windshield anti-icing are not affected by the Appendix O conditions. Impingement limits on the windshields are affected by the Appendix O conditions.

response

Partially accepted.

The first proposal is accepted.

The sentence referring to past certification experience is updated to read that past certification experience has shown that a nominal heating capacity of 70 W/dm<sup>2</sup> provides adequate protection in icing conditions. As Appendix O conditions were not included in the certification basis of previous aeroplanes, it can only be stated that, based on service experience, it proved to be sufficient in icing conditions. However, based on the extensive service experience, it can be assumed that Appendix O conditions have been encountered and this has not led to safety issues reported to the Agency. A thermal analysis should anyway be conducted to substantiate the selected value.

**B. Draft Decision — I. Draft Decision amending CS-25 — Book 2; AMC — SUBPART D — AMC 25.773(b)(4) Pilot compartment non openable windows**

p. 62-63

comment

43

comment by: AIRBUS

**AMC 25.773(b)(4) Page 62**

Recommended Change:

Each forward side window should have an independent means to prevent fog and frost. It should be shown by natural icing flight tests **Appendix C** that any ice accumulations on the side windows will not degrade visibility through them, or the applicant should provide individual window de-ice/anti-ice capability.

Rationale:

As explained, flight tests in the full range of Appendix O icing conditions are neither feasible nor practical.





response

Accepted.

The text of the AMC 25.773(b)(4) has been substantially modified and it now allows conducting flight tests in natural or simulated icing condition. However, AMC 25.773(b)(1)(ii) has been updated to require that sufficient tests be performed, including flight test in natural or simulated Appendix C icing conditions.

**Cessna comment on Bullet # 3 (page 62):**

Icing tanker testing could be used to demonstrate visibility

Current Text:

...It should be shown by natural icing flight tests that any ice accumulations on the side windows will not degrade visibility through them, or the applicant should provide individual window de-ice/anti-ice capability.

Proposed Text:

...It should be shown by natural icing **or icing tanker** flight tests that any ice accumulations on the side windows will not degrade visibility through them, or the applicant should provide individual window de-ice/anti-ice capability.

**Response:** Partially accepted. We use the term 'simulated icing' which is equivalent to 'icing tanker'. The text of AMC 25.773(b)(4) has been substantially modified and the new text does not prescribe conducting flight tests. However, AMC 25.773(b)(1)(ii) has been updated to require that sufficient tests be performed, including flight test in natural or simulated Appendix C icing conditions.

**Cessna comment on Bullet # 8 (page 63):**

Icing tanker testing could be used to demonstrate visibility

Current Text:

8. ...The extent of icing or fogging of side windows should be verified during natural icing flight tests with window anti-ice and anti-fog systems unpowered. The icing accretion limits should be determined by analysis and verified by natural icing flight test. A sufficient field of view must be maintained to allow the pilot to safely operate the aeroplane, including landing and taxi. If it is proposed that the pilot must take action to remove inside condensation or frost, the capability to perform this task should be evaluated by aeroplane flight test.

Proposed Text:

8. ...The extent of icing or fogging of side windows should be verified during natural icing **or icing tanker** flight tests with window anti-ice and anti-fog systems unpowered. The icing accretion limits should be determined by analysis and verified by natural icing **or icing tanker** flight test. A sufficient field of view must be maintained to allow the pilot to safely operate the aeroplane, including landing and taxi. If it is proposed that the pilot must take action to remove inside condensation or frost, the capability to perform this task should be evaluated by aeroplane flight test.

**Response:** Partially accepted. We use the term «'simulated icing' which is equivalent to 'icing tanker'. The text of the AMC 25.773(b)(4) has been substantially modified and the new text does not prescribe conducting flight tests. However, AMC 25.773(b)(1)(ii) has been updated to require that sufficient tests be performed, including flight test in natural or simulated Appendix C icing conditions.

**Cessna comment on pages 62 & 63:**

Multiple revisions of ASTM F320 are referenced.

The static designation is ASTM F320 with –XX representing last two digits of the year of revision.

Latest revision is ASTM F320-10.

Unless there are specific aspects being used from prior revisions, recommend referencing ASTM F320 (revision 2010 or later) to reduce confusion.





Response: Accepted. The references to ASTM F320-10 have been corrected.

comment

44

comment by: AIRBUS

**AMC 25.773(b)(4) Pilot compartment non openable windows**

The current text:

*The ASTM tests establish how much, if any, the side windows are obscured*

Should be changed into:

The ASTM tests establish how much, if any, ~~the side~~ **the flight deck** windows are obscured

Rationale:

The ASTM tests establish the way to perform hail tests for whatever cockpit window (windshields and side windows), they do not only mention side window. The intent is to demonstrate adequate forward visibility in the cockpit.

response

Partially accepted.

The principle of the comment is agreed, but this sentence has been removed from the final AMC text.

comment

45

comment by: AIRBUS

**AMC 25.773(b)(4) Pilot compartment non openable windows**

The current text:

*Total loss of external visibility is considered catastrophic. A sufficient field of view must exist to allow the pilot to safely operate the aeroplane during all operations, including landing and taxi. This field of view must remain clear in all operating conditions. Precipitation conditions such as outside ice, rain, window condensation (fogging or icing), hail and mist must be considered. The rule requires that the alternate means is not susceptible to the probable effects of a severe hail encounter. Obscuration caused by encounter of hail, birds, or insects cannot be mitigated by the use of redundant equipment. It is also unlikely that hail damage can be avoided. Rather than avoidance, the approach to ensure vision assuming hail strike has been to use damage assessment criteria contained in the ASTM International "Standard Test Method for Hail Impact Resistance of Aerospace Transparent Enclosures," ANSI/ASTM F 320-78 or equivalent. The ASTM tests establish how much, if any, the side windows are obscured. The windows of an aircraft are covered on the inside to simulate total obscuration of the front panels and assessed damage on the side panels. Under these degraded conditions, the pilot demonstrates by flight test that the view requirements of CS 25.773(b)(1) are met and that safe flight and landing can be accomplished (see item 6. below).*

Should be changed into:

~~Total loss of external visibility is considered catastrophic hazardous.~~ A sufficient field of view must exist to allow the pilot to safely operate the aeroplane during all operations, including landing and taxi. This field of view must remain clear in all operating conditions. Precipitation conditions such as outside ice, rain, window condensation (fogging or icing), hail and mist must be considered. The rule requires that the alternate means is not susceptible to the probable effects of a severe hail encounter. ~~Obscuration caused by encounter of hail, birds, or insects cannot be mitigated by the use of redundant equipment.~~ It is also unlikely that hail damage can be avoided. Rather than avoidance, the approach to ensure vision assuming hail strike has been to use damage assessment criteria contained in the ASTM International "Standard Test Method for Hail Impact Resistance of Aerospace Transparent Enclosures," ANSI/ASTM F 320-78 or equivalent. ~~The ASTM tests establish how much, if any, the side~~



	<p><del>windows are obscured.</del> The windows of an aircraft are covered on the inside to simulate total obscuration <del>of the front panels and/or</del> assessed damage on the <del>side</del> panels. Under these degraded conditions, the pilot demonstrates by flight <u>or simulator</u> test that the view requirements of CS 25.773(b)(1) are met and that safe flight and landing can be accomplished (see item 6. below).</p> <p>Rationale:</p> <p>Airbus questions the value or validity of defining a classification for a failure condition. Classifications should be dealt with through CS25.1309. It may be the case that loss of forward visibility is not catastrophic in all cases, for example when autoland is available. It is also noted that development in autoland technologies may further alleviate the consequences of loss of visibility through windows.</p> <p>The text of the AMC differs from the existing guidance material related to non-openable pilots windows. The proposed changes would bring the wording more in line with the currently available material.</p> <p>Taking into account ASTM tests results, the applicant could use the assessed damage on the cockpit windows to demonstrate by flight tests or adequate simulator tests the ability to land safely the aircraft under these degraded conditions. Another way would be to simulate total obscuration of the front panels and assessed damage on the side panels by flight test in order to demonstrate under these degraded conditions that the view requirements of CS 25.773(b)(1) are met and that safe flight and landing can be accomplished.</p> <p>The recommendation for flight tests is not justified with regards to existing simulator technologies available for performing such tests.</p>
response	<p>Partially accepted.</p> <p>It is maintained that the total loss of external visibility is catastrophic. Your rationale refers to loss of forward visibility, which is different.</p> <p>The sentence 'Obscuration caused by encounter of hail, birds, or insects cannot be mitigated by the use of redundant equipment' is deleted as it does not provide required clarification.</p> <p>The other suggested text changes are either deleted as recommended or not anymore applicable because of the AMC final text being substantially modified.</p>
comment	<p>46</p> <p style="text-align: right;">comment by: AIRBUS</p> <p><b>AMC 25.773(b)(4) Section 7 - Page 63</b></p> <p>The current text:</p> <p><i>For flight tests, simulation of hail damage should be applied to the windshield for the flight test demonstration. A typical test configuration would be to block visibility out the forward main windows for the pilot flying, and use simulated damage (if any) on the side window(s). Adequate forward vision should be maintained for a safety pilot during flight tests and demonstrations while providing appropriate forward view degradation for the test pilot.</i></p> <p>Should be changed into:</p> <p>For flight <u>or simulator</u> tests, simulation of hail damage should be applied to the windshield for the <del>flight</del> test demonstration. A typical test configuration would be to block visibility out the forward main windows for the pilot flying, and use simulated damage (if any) on the side window(s). Adequate forward vision should be maintained for a safety pilot during flight tests and demonstrations while providing appropriate forward view degradation for the test pilot. <b><u>Tests should be performed through flight tests or simulator sessions.</u></b></p> <p>Rationale:</p> <p>The need for flight tests may not be justified considering the available simulator</p>

technologies.

response

Partially accepted.  
'Flight test' has been replaced by 'test'.

comment

110

comment by: FAA

Page	Para	COMMENT / SUGGESTED CHANGE	Rationale
62		Propose clarifying the 4 <sup>th</sup> sentence in the 1 <sup>st</sup> paragraph as follows: Precipitation conditions such as outside ice, rain ( <b>heavy and misting</b> ), window condensation (fogging or icing), <b>and</b> hail <del>and mist</del> must be considered.	Suggested for clarity only, since heavy and misting are types of rain.
62	Item 3	Item 3 states that it should be shown by natural icing flight tests that visibility through each forward side window will not be degraded. However, it does not state which type of icing conditions are applicable (Appendix C and all or some portion of Appendix O). Is there then an expectation that natural icing flight tests in Appendix O will be required to show compliance to 25.773(b)(4)?	The existing wording appears to establish an expectation that natural icing flight test in App O is necessary to certify the windshield, which should not be the case unless the other means of compliance are insufficient.
62	Item 4	Item 4 should be reworded as follows: ...windshield ice, frost, fog, and precipitation protective systems should be established within <b>the</b> relevant icing <del>environment</del> <b>environments of Appendix C and Appendix O....</b>	Intended for clarity
63	End of 5	The last sentence in item 5 should be revised as follows: Appropriate test data should substantiate the <del>assumed</del> <b>estimated</b> damage to the main or forward side windows during such an encounter.	Suggested terminology revision for clarity.

response

Comment 1: Partially accepted. This sentence has been updated to reflect what is prescribed in CS 25.773(b)(4). Fog and mist have been removed as they are out of the scope of the rule.

Comment 2: Partially accepted. AMC 25.773(b)(4) does not prescribe flight test in natural icing condition, as simulated icing condition would also be acceptable (valid for both Appendix C and Appendix O).

Comment 3: Partially accepted. This paragraph has been moved to AMC 25.773(b)(1)(ii), and limited to Appendix C.

Comment 4: Accepted.



comment	<p>144</p> <p>comment by: Boeing</p> <p>Page: 62 Paragraph: AMC 25.773(b)(4) Pilot compartment non openable windows</p> <p>Boeing recommends revising the proposed text as follows:  <i>"1. Each main windshield should be independently anti-iced <del>defogged, and-defrosted</del> and <u>anti-fogged</u>. The systems should be designed so that no malfunction or failure of one system will adversely affect the other."</i></p> <p><b>JUSTIFICATION:</b> Our recommended revisions provide clarification that the windshield systems may be capable of both removing and preventing fog. Boeing considers "defrosting" to be included in the "anti-icing" function and, thus, it does not need be mentioned separately.</p>
response	<p>Not accepted.</p> <p>Fog has been removed from the AMC because it is not part of the CS 25.773(b)(4) scope.</p>
comment	<p>145</p> <p>comment by: Boeing</p> <p>Page: 62 Paragraph: AMC 25.773(b)(4) Pilot compartment non openable windows</p> <p>Boeing recommends revising the proposed text as follows:  <i>"3. Each forward side window should have an independent means to prevent fog and frost. It should be shown by natural icing flight tests that any ice accumulations on the side windows will not degrade visibility through them, or the applicant should provide individual window <del>de-ice/</del>anti-ice capability."</i></p> <p><b>JUSTIFICATION:</b> All CS-25 airplanes have continuously active anti-icing/anti-fog systems for the windshield, which prevent fogging and ice accretion; "de-icing" is not a function provided by the systems.</p>
response	<p>Partially accepted.</p> <p>The text has been updated to use 'ice protection system'.</p>

**B. Draft Decision — I. Draft Decision amending CS-25 — Book 2; AMC — SUBPART E — AMC 25.929(a) Electrically heated propeller boots de-icing system**

p. 63-65

comment	<p>47</p> <p>comment by: AIRBUS</p> <p><b>Page 63 AMC 25.929(a) Electrically Heated Propeller Boots De-icing System</b>          Minor comment on the title of the AMC. The title is now different from the title of the CS25 requirement. Should the title be changed to reflect the CS requirement? Or vice versa?</p>
response	<p>Accepted.</p> <p>We keep the same title as the title of CS 25.929.</p>



comment

111

comment by: FAA

Page	Para	COMMENT / SUGGESTED CHANGE	Rationale
64	AMC 25.929 (a)	The title has been modified to seem to only apply to electrically heated propeller boots de-icing system which no longer reflects the rule per CRD 2011-03. We recommend revising the AMC title to match the CS 25.929 rule title, "Propeller de-icing."	Suggested for clarity and consistency between the CS-25 requirement and AMC material.
64	AMC 25.929 (a)(1) para. 2.2	Recommend clarifying as follows: Additionally if the propeller Ice Protection System is regulated <del>also</del> based on different outside parameters such as temperature, <b>then</b> system operation should also be checked against those parameters.	Intended for clarity
64-65	Section 3	This section discusses propeller runback ice and advises that the applicant should consider potential hazards from shedding of runback ice. The section should be clarified to indicate that performance loss should also be considered.	There are considerations besides ice shedding that should be made for runback ice on the propeller.

response

Comment 1: Accepted, the title is changed.  
 Comment 2: Accepted.  
 Comment 3: Accepted.

**Cessna comment on Section 2.2 (page 64) :**

Current Text:

2.2 System operation should ... full rotation speed. and propeller cyclic ... Ice Protection System is regulated also based on different outside parameters such as temperature system operation should also ...

Proposed Text:

2.2 System operation should ... full rotation speed. and propeller cyclic ... Ice Protection System is regulated ~~also~~ based on different outside parameters such as temperature, system operation should also ...

Response: Accepted.
**B. Draft Decision — I. Draft Decision amending CS-25 — Book 2; AMC — SUBPART E — AMC 25.1093(b) Powerplant Icing**

p. 65-74

comment

3

comment by: CAA-NL

"(for example, freezing rain, freezing drizzle)"

Proposal: Add here "freezing fog".

Explanation: In the CRD on NPA 2011-04, the SLD conditions encountered on the ground



	<p>were mainly freezing fog conditions.</p>
response	<p>Not accepted.</p> <p>This paragraph deals with Appendix O icing conditions which do not include freezing fog.</p>
comment	<p>48 <span style="float: right;">comment by: AIRBUS</span></p> <p><b>AMC 25.1093(b) / 25J.1093 General comment:</b>            AMC 25J1093(b) refers back to AMC 25.1093(b) for APU. Airbus would recommend to add to AMC 25.1093(b) a few considerations specific to the APU when relevant. For instance, AMC 25.1093(b) seems to heavily rely upon the compatibility between the engine ingestion demonstration capability of CS-E 780 and the performance of the engine air intake anti-icing system. The APU has no exact equivalent to CS-E 780 ingestion requirements and the APU air intakes are generally not ice protected.</p>
response	<p>Noted.</p> <p>It is true that CS-E 780 references are not relevant to essential APUs. Nevertheless, many paragraphs provided in AMC 25.1093(b) are applicable to essential APUs. In addition, the proposed new AMC 25J1093(b) includes air intake assessment guidance which is similar to the existing AMC 25J1093(b).</p>
comment	<p>49 <span style="float: right;">comment by: AIRBUS</span></p> <p><b>AMC 25.1093(b) 1.4.1 Upper wing mounted ice detection systems</b>            Additional guidance is required. As currently written the guidance may deter applicants from using such detection systems.</p>
response	<p>Noted.</p> <p>The concern is not understood. The undetected ice could depend on the location and threshold of the ice detector(s). The text of this paragraph recommends to analyse the quantity of this undetected ice and to ensure that it does not exceed the engine ingestion capability (if it can be ingested by an engine).</p>
comment	<p>50 <span style="float: right;">comment by: AIRBUS</span></p> <p><b>Introduction of AMC 25.1093(b) – p.65</b>            The current text:  <i>If an applicant can show that the engine air intake [.....] previous designs.</i>            Should be changed into:            If an applicant can show that the Ice protection and the ice ingestion capability of a Propulsion System is equivalent to previous certification experience, then certification may be shown by similarity to previous designs.            Rationale:            The ice protection capability of an engine might not be linked only to IPS and fan blade capability. Other parameters are to be taken into account for evaluation of propulsion system ice protection capability.</p>
response	<p>Accepted.</p>

**Cessna comment on page 65:**

## Current Text:

The previous paragraph indicated natural icing flight tests will be required, and later, critical point analysis, dry air testing etc are outlined – therefore the CS-E 780 testing, if relevant, is only a part of the compliance package and cannot be the sole means of showing compliance.

The results of tests and analysis used for compliance with CS-E 780 may be used to show compliance with CS 25.1093(b). This requires close coordination between the engine manufacturer and the aeroplane manufacturer to make sure that CS-E 780 tests cover all potential ice sources.

## Proposed Text:

The results of tests and analysis used for compliance with CS-E 780 may be used to support compliance with CS 25.1093(b). This requires close coordination between the engine manufacturer and the aeroplane manufacturer to make sure that CS-E 780 tests cover all potential ice sources.

Response: Accepted.

**Cessna comment on page 65:**

1. Added words expand on what aspects need to be similar (ice sources) to allow certification by similarity.
2. The only practical way for fan blade capability to be equivalent is to have the same fan turning at the same speed. The applicant needs to be able to show certification by similarity and not equivalency.
3. Changing “previous certification experience” to “previously certified installations which have demonstrated good service history” to better reflects what the industry has been doing for 40+ years. In that time, there have been no reported issues in SLD or ice crystals as far as inlet ice protection, the allowance should be made to certify by similarity for super cooled liquid, SLD and ice crystal environments.

## Current Text:

If an applicant can show that the engine air intake Ice Protection System (IPS) performance and the fan blade capability are equivalent to previous certification experience, then certification may be shown by similarity to previous designs.

## Proposed Text:

If an applicant can show that the engine air intake Ice Protection System (IPS) performance, potential airframe ice sources for shed ice, and the fan blade capability are equivalent similar to previously certified installations which have demonstrated good service history, then certification for operation in Appendices C, O and P may be shown by similarity to previous designs.

Response: Partially accepted. The sentence has been updated after consideration of this proposal along with other comments.

comment

51

comment by: AIRBUS

**Page 65 AMC 25.1093(b) (a)(1) Analysis and Test Point Selection**

This section describes a means to select the analysis and test points. It is not clear in the current wording whether an icing tunnel test must be performed on the intake or if analysis validated by flight tests is acceptable. The current wording could be interpreted to mean that icing tunnel or tankers tests must be performed and that the test points shall be either those referenced in the table 1 or those coming from a critical point analysis.

The certification of intake ice protection through the use of icing tunnels (guided by CPA) is appropriate for intakes with complex geometries and/or complex ice protection systems or intake screens or passive ice protection means (relying on steady state shedding of ice) that may not be amenable to compliance demonstrations based on analysis validated by flight tests.

For large pitot type engine intakes compliance demonstrations based on analysis, validated by dry air and natural icing flight tests have proved very successful. This method uses



validated modelling techniques and methodologies to determine the performance of the intake ice protection across the operating envelope of the engine, aircraft and system. The performance analysis is validated by certification dry air flight tests and natural icing tests. The validated performance model provides a conservative means to predict the intake heating performance across the full range of operating conditions.

Many engine intakes are too large to test in icing tunnels, altitude test facilities or engine icing test facilities (including the latest generation of large engine test cells). This would therefore imply testing a small section of the intake or scaling the test article and/or test conditions. These methods can provide useful results but do come with significant challenges and would, most likely, still require a validated performance analysis to complete the demonstration and extrapolate the results of the tests to the corners of the operating envelope. A flight test on a flying test bed and/or on the “host” aircraft would therefore, more than likely, still be required

Hence it is believed that EASA does not intend to mandate a certification icing tunnel test for all engine intakes and it is therefore suggested to clarify the wording of the AMC. The following comments provide some proposed clarifications to make this clearer.

Airbus would ask that EASA confirms that certification using a validated analysis (validated by dry air and natural icing flight tests) will continue to be accepted by the agency, when appropriate, and update the AMC accordingly.

response

Noted.

The CPA is a means to identify the most critical operational icing conditions to be assessed. It does not in itself address how the assessment of the identified conditions should be made. It is possible to use a performance model to support this analysis and validate this model by flight test in dry air and natural icing conditions.

comment

52

comment by: AIRBUS

#### Page 65 AMC 25.1093(b) (a)(1) Analysis and Test Point Selection

The current text:

*In establishing compliance with the requirements of CS 25.1093(b)(1), reference should be made to AMC 25.1419 paragraph (a) for the assessment of the CS-25 Appendix C icing environment. In particular for the following aspects:*

- *Analytical Simulation Methods;*
- *Analysis of areas and components to be protected;*
- *Impingement Limit Analysis;*
- *Ice Shedding Analysis;*
- *Thermal Analysis and Runback Ice; and*
- *Similarity Analysis*

Should be changed into:

In establishing compliance with the requirements of CS 25.1093(b)(1), reference should be made to AMC 25.1419 paragraph (a) for the assessment of the CS-25 Appendix C icing environment ~~In particular~~ for the following aspects:

- Analytical Simulation Methods;
- ~~Analysis~~ Determination of areas and components to be protected;
- Impingement Limit Analysis;
- Ice Shedding Analysis;
- Thermal Analysis and Runback Ice; and
- Similarity Analysis





	<p>The cross reference to AMC 25.1419 is confusing because AMC 25.1419 itself cross refers to AMC25.21g. These multiple cross references will likely lead to confusion because it is not clear which aspects of the various AMC's are applicable to the intakes.</p> <p>It is recommended that 25.1093b be rewritten to be self contained avoiding multiple cross references.</p> <p>Rationale: The recommended change will aid clarity and minimize the potential for confusion.</p>
response	<p>Not accepted.</p> <p>The proposed text change does not improve the clarity. It is also not suitable to copy the content of the relevant AMC 25.1419 or AMC 25.21(g) paragraphs, as it would create duplications and open the possibility for inconsistencies between AMC's .</p>
comment	<p>53 <span style="float: right;">comment by: AIRBUS</span></p> <p><b>Page 65 AMC 25.1093(b) (a)(1) Analysis and Test Point Selection</b></p> <p>The current text:</p> <p><i>In establishing compliance with the requirements of CS 25.1093(b)(1), reference should be made to AMC 25.1420 paragraph (d) for the assessment of the Appendix O icing environment in particular for the following aspects:</i></p> <ul style="list-style-type: none"> <li>• <i>Analysis of areas and components to be protected;</i></li> <li>• <i>Failure analysis, and</i></li> <li>• <i>Similarity analysis.</i></li> </ul> <p>Should be changed into:</p> <p>In establishing compliance with the requirements of CS 25.1093(b)(1), reference should be made to AMC 25.1420 paragraph (d) for the assessment of the Appendix O icing environment <del>in particular</del> for the following aspects:</p> <ul style="list-style-type: none"> <li>• <del>Analysis of</del> Determination of areas and components to be protected;</li> <li>• Failure analysis, and</li> <li>• Similarity analysis.</li> </ul> <p>Rationale:</p> <p>The cross reference between various sections of the AMC makes interpretation of the AMC very difficult.</p> <p>For the sake of clarity it is necessary to explicitly state which aspects of the referenced AMCs apply to the CS25.1093b means of compliance.</p> <p>The proposed change improves clarity but is still likely to lead to confusion over which parts of AMC 25.1419 and AMC 25.120 are intended to be applied to the compliance demonstration for CS25.1093b.</p>
response	<p>Not accepted.</p> <p>The proposed text change does not improve the clarity. It is also not suitable to copy the content of the relevant AMC 25.1419 or AMC 25.1420 paragraphs, as it would create duplications and open the possibility for inconsistencies between AMC's .</p>
comment	<p>54 <span style="float: right;">comment by: AIRBUS</span></p> <p><b>AMC 25.1093(b) Section (a) - p.65</b></p> <p>The current text:</p> <p><i>As a general rule, engine air intake systems should be shown to operate continuously in icing</i></p>

	<p><i>conditions without regard to time [...].</i></p> <p>Should be changed into:</p> <p>As a general rule, engine air intake systems should be shown to operate continuously in icing conditions as defined per Appendix C of CS25.</p> <p>Rationale:</p> <p>Multiple clouds scenarios can be considered for system validation but it is unrealistic to consider infinite icing conditions exposure. Today's considered scenario for holding is 45 minutes of exposure to icing conditions. This scenario is robust based on in-service experience and ensure safe operation of the aircraft.</p>	
response	<p>Partially accepted.</p> <p>The sentence has been modified to specify that the objective is continuous operation in holding condition.</p>	
comment	<p>55</p> <p style="text-align: right;">comment by: AIRBUS</p> <p><b>AMC 25.1093(b) (a)1 - p. 66</b></p> <p>The current text:</p> <p><i>[...] to AMC 25.1420 paragraph (d) for the assessment of Appendix O icing environment [...]</i></p> <p>Should be changed into:</p> <p><i>[...] to AMC 25.1420 paragraph (d) for the assessment of Appendix O icing environment [...]</i></p> <p>Rationale:</p> <p>Appendix O environment assessment is to be covered by CS25.1420 for aircraft. No particular justification is requested for engines based on NPA 2012-23 i.e. the two NPAs (2012-22 &amp; 2012-23) have to be harmonised to request the same level of demonstration for engines and air intakes part.</p>	
response	<p>Not accepted.</p> <p>The CPA text proposed under NPA 2012-23 (AMC E 780) includes SLD icing conditions.</p>	
comment	<p>56</p> <p style="text-align: right;">comment by: AIRBUS</p> <p><b>AMC 25.1093(b) Section 1.1 - p. 66</b></p> <p>The current text:</p> <p><i>[...] Appendices C, O and P. The Intermittent Maximum Icing conditions of Appendix C envelope extension down to -40°C should also be considered.</i></p> <p>Should be changed into:</p> <p><i>[...] Appendices C and O and P. The Intermittent Maximum Icing conditions of Appendix C envelope extension down to -40°C should also be considered.</i></p> <p>Rationale:</p> <p>Appendix P environment can only lead to ice accretion on heated parts of the aircraft. May runback be created due to melting of ice crystals on air intake lip following unjustified activation of IPS, then any accreted runback ice would be removed due to erosion from impinging crystals.</p> <p>Appendix C envelope extension down to -40°C is not relevant as no conditions of supercooled droplets have ever been measured nor reported in such conditions. Moreover, based on meteorological understanding of phenomenon, such conditions are very unlikely to exist in the atmosphere. Refer also to comment 34.</p> <p>The Table of standard test points that has, according to the NPA, been used successfully in</p>	

response

the past does not contain a test point at -40°C indicating that this test point has not considered critical in the past. Finally it is noted that the source document (NACA TN 1855) for Appendix C states the following:

*In the case of the lowest air temperature considered (-40°F) the probability of the occurrence of snow is so great that the liquid water content cannot even be approximated by calculation and, therefore, a value has been estimated.*

So this estimate of the “possible extent of limits” as -40°C is called in Appendix C indicated that obtaining liquid water at such low temperatures in a cumulous cloud is unlikely.

Not accepted.

Appendix P is included in the corresponding CS 25.1093(b) (Book 1) and, therefore, there is no reason to ignore it in the AMC. Furthermore, the rationale provided in the comment may be valid for certain types of engine air intake but not for all. Therefore, the reference to Appendix P is maintained, keeping in mind that, when conducting a CPA, one may provide a rationale like the one drafted in the comment.

The Intermittent Maximum Icing conditions of Appendix C envelope extension down to -40°C is also maintained, because this point is included in the Book 1 Appendix C and this may be a critical point for some engine air intake designs such as S-shape turboprop engine air intakes.

#### **Cessna comment on section 1.1 page 67 :**

Please see second bullet from top of page-

Current Text:

Ice accretion occurring ... (with potentially a reduced ice protection availability), ...

Proposed Text:

Delete “a”:

- Ice accretion occurring ... (with potentially a reduced ice protection availability), ...

Response: Accepted.

#### **Cessna comment on section 1.1 page 67 :**

Additional wording explaining how an air intake is proven for unlimited operation in icing is necessary.

Current Text:

Air intakes that have proven unlimited operation in icing may allow runback ice formation during holding, straight line flight and descent.

Proposed Text:

To demonstrate unlimited operation of an air intake system, the system must operate fully evaporative or any runback ice which forms must result in less ice than the engine has been demonstrated to ingest per CS-E 780 and the runback ice must be shown to exhibit repeatable build and shed cycles.

Air intakes that have proven unlimited operation in icing may allow runback ice formation during holding, straight line flight and descent conditions.

Response: Partially accepted. The first proposed sentence has been converted in 2 bullets for clarity. The second sentence has been removed. A new sentence has been added to specify that the test duration may be reduced if a repeatable build and shed cycle is demonstrated.

#### **Cessna comment on section 1.2 page 67 :**



To be consistent with existing guidance and other sections of this NPA, “warm up time” of the system should be considered separately from and in addition to pilot reaction time (reference section 2.2, page 73 of this NPA)

Current Text:

It should be demonstrated that the ice accretion is acceptable after a representative delay in the selection of the ice protection systems, such as might occur during inadvertent entry into the conditions. In lack of other evidence, a delay of two minutes is a reasonable time to include both pilot reactions to select the IPS and shed the ice from the air intake perimeter.

Proposed Text:

It should be demonstrated that the ice accretion is acceptable after a representative delay in the selection of the ice protection systems, such as might occur during inadvertent entry into the conditions. In lack of other evidence, a delay of two minutes is a reasonable time to include both pilot reactions to ~~select activates the IPS and shed the ice from the air intake perimeter.~~

Response: Partially accepted. The text is updated to read ‘In lack of other evidence, a delay of two minutes to switch on the IPS should be assumed. For thermal IPS, the time for the IPS to warm up should be added.’

comment 59

comment by: AIRBUS

**Page 69 AMC 25.1093(b)(1) Powerplant Icing 1.6 Falling and Blowing Snow**

Add the text from AC 23-16 explaining that finding the conditions requested by the AMC will be very difficult and that engineering judgment is required by the applicant and certifying officer in determining the adequacy of the testing performed.

AC 23-16 states:

“Snow concentration corresponding to the visibility prescribed is often extremely difficult to locate naturally and it is often difficult to maintain the desired concentrations for the duration of testing. Because of this, it is likely that exact target test conditions will not be achieved for all possible test conditions. Those involved in certification must exercise reasonable engineering judgment in accepting critical test conditions and alternate approaches, with early coordination between the applicant and the FAA addressing these realities.”

It is recommended that this guidance be added to the AMC to highlight realistic expectations of the natural snow test on aircraft. This will facilitate early discussions of the falling and blowing snow demonstrations. AC 23-16 also indicates that using artificial snow can be used compliment the natural snows tests but highlights the differences in morphology of the snow produced and state that artificial snow tests can only be used to augment the natural snow tests. AC 29-2C also states that artificially produced snow should not be used as the sole means of showing compliance. The AC (Page E-160) also explains that :

“The snow concentration corresponding to the visibility prescribed, ¼ mile or less, will be extremely difficult to locate in nature. Data from Ottawa, Canada, research indicate that fewer than 4 percent of the snowstorms encountered there meet the 0.91 grams/m3 concentration associated with the ¼-mile visibility. Furthermore, the likelihood that the desired concentration will exist for the duration of the testing is even more remote. Because of these testing realities, it is very likely that exact target test conditions will not be achieved. Those involved in certification must exercise good judgment in accepting alternate approaches.”

It would be beneficial to the applicant and the agency if this text were included in the AMC.

Rationale:

It is recommended that this guidance be added to the AMC to highlight realistic expectations of the natural snow test on aircraft. This will facilitate early discussions of the falling and



	blowing snow demonstrations. AC 23-16 also indicates that using artificial snow can be used to complement the natural snows tests but highlights the differences in morphology of the snow produced and state that artificial snow tests can only be used to augment the natural snow tests.
response	Partially accepted. The quoted AC 23-16 paragraph has been added (see 1.6.5.(f)).

**Cessna comment on section 2 page 71:**

Fifth bullet from top of page-

Current Text:

In establishing compliance with the ...

Proposed Text:

This should be a new paragraph, suggest “un-bullet” and move indentation to left.

Response: Accepted.**Cessna comment on section 2 page 71:**

Clarify the size of ice ingested should be no larger than what the engine was certified to ingest.

Current Text:

Factors to be considered in such evaluations are:

- distortion of the airflow and partial blockage of the air intakes,
- the shedding into the engine of air intakes ice of a size greater than the engine is known to be able to ingest,

Proposed Text:

Factors to be considered in such evaluations are:

- distortion of the airflow and partial blockage of the air intakes,
- The shedding into the engine of air intakes ice of a size greater than the engine ~~is known to be able to ingest,~~ has been shown to ingest per CS-E 780.

Response: Accepted.**Cessna comment on section 2.1 page 71:**

Clarify that it is acceptable to test either the critical points identified by a CPA or to use the table points.

Current Text:

For the evaluation of the performance of the IPS, the following conditions have been successfully used in the past to simulate CS-25 Appendix C conditions:

Proposed Text:

For the evaluation of the performance of the IPS, either the ~~critical points determined by a CPA or the conditions defined in Table 1 may be used to following conditions have been successfully used in the past to~~ simulate CS-25 Appendix C conditions:Response: Accepted.**Cessna comment on section 2.1 page 72:**

Title of Table 1 is incorrect

Change to:

TABLE 1 – Appendix C Test Conditions

Response: Accepted.

**Cessna comment on section 2.1 page 72:**

Provide allowance for using points from a CPA instead of the table points.

Current Text:

A separate test should be conducted at each temperature condition of Table 1, the test being made up of repetitions of one of the following cycles:

Proposed Text:

A separate test should be conducted at each point identified in the CPA or at each temperature condition of Table 1, the test being made up of repetitions of one of the following cycles:

Response: Not accepted. The modification made in the frame of the previous comment provides enough clarity.

**Cessna comment on section 2.1 page 72:**

Correct unit conversion (1 km = 0.54 nautical miles)

28 km = 15.1 nm, or 17.4 nm = 32.2 km

6 km = 3.2 nm, or 3.7 nm = 6.9 km

17.4 nm is the standard extent in for continuous maximum icing and 2.6 nm is the standard extent for intermittent maximum as defined by Appendix C

Unclear whether the test is targeting standard extent clouds or some alternate rationale. Correction or justification of alternate cloud lengths is requested.

Current Text:

A separate test should be conducted at each temperature condition of Table 1, the test being made up of repetitions of one of the following cycles:

1. 28 km (17.4 NM)? In the conditions of Table 2, column (a), appropriate to the temperature, followed by 5 km (3.1 NM)? in the conditions of Table 2, column (b), appropriate to the temperature, for a total duration of 30 minutes, or
2. 6 km (3.7 NM)? In the conditions of Table 2, column (a), appropriate to the temperature, followed by 5 km (3.1 NM)? In the conditions of Table 2, column (b), appropriate to the temperature, for a total duration of 10 minutes.

Response: Accepted. The current AMC 25.1093(b) values in km are kept as the baseline and the conversion in NM is corrected.

**Cessna comment on section 2.1 page 72:**

"Table 2" referred in bullets 1) and 2) are not available.

Change "Table 2" to "Table 1".

Response: Accepted.

**Cessna comment on section 2.1 page 72:**

1. Grammatical correction (insure to ensure)
2. Provide allowance for using points from a CPA instead of the table points
3. Current systems utilize an anti-ice idle function to achieve the minimum thrust required to maintain IPS operation. This anti-ice idle is cancelled on approach to allow the engines to decelerate to normal flight idle to prevent landing distances from being different with the IPS operating. There have been no known operational issues with this type of system in service, so an allowance in the guidance material needs to be provided to allow continued use of these systems.

Current Text:

If there is a minimum power/thrust required for descent to insure satisfactory operation in icing conditions, the increase to that minimum power/thrust in icing conditions should be automatic when in icing conditions,



and this minimum power/thrust associated with descent in icing conditions should be assessed against the conditions in Table 1.

Proposed Text:

If there is a minimum power/thrust required for descent to ~~insure~~ **ensure** satisfactory operation in icing conditions, the increase to that minimum power/thrust in icing conditions should be automatic when in icing conditions, and this minimum power/thrust associated with descent in icing conditions should be assessed against the conditions in Table 1 **or the points identified in a CPA. The engine may revert back to normal flight idle for short term operation, such as on final approach to landing.**

**Response:** Partially accepted. The alternative of using CPA test points is not repeated because already mentioned before the table 1 above. The proposed new sentence is adopted, and complemented. The reversion to normal flight idle should be assessed in terms of engine ice ingestion, and any required operational time limitation or pilot action should be included in the AFM. However, as this new sentence is not dedicated to this paragraph dealing with test conditions, it has been moved into a new paragraph created under '(a) Compliance with CS 25.1093(b)(1)'.

**Cessna comment on section 2.1 page 72:**

Need to clarify that maximum duration only needs to be considered for hold conditions, not idle descent (since it would generally be impossible to descend for 45 minutes at idle power).

Current Text:

The test duration expressed above assume that steady state conditions (ice shedding cycles) are established. If this is not the case, the test shall continue until a maximum duration of 45 minutes.

Proposed Text:

The test duration expressed above assume that steady state conditions (ice shedding cycles) are established. If this is not the case, the test shall continue **at conditions representative of a hold** until a maximum duration of 45 minutes.

**Response:** Partially accepted. This sentence has been updated to mention that the 45 minutes does not apply to the descent case for which the test duration may be limited to the time needed to cover an anticipated descent of 3 000 m.

comment

60

comment by: AIRBUS

**AMC 25.1093(b) Page 73 Section 2.3**

The current text:

**2.3 Natural Icing Flight Tests**

*Natural ice encounters should also be used to show compliance with CS 25.1093(b)(1). Multiple engine damage and operability events have been experienced in natural icing flight tests and in-service aeroplanes.*

*Natural icing flight tests are intended to demonstrate that each turbine engine is capable of operating throughout the flight power/thrust range of the engine (including idling), without an adverse effect. This includes the accumulation of ice on the engine, air intake system components, or airframe components that would have an adverse effect on the engine operation or cause a serious loss of power or thrust.*

*In addition to proving that the engine air intake icing analysis model is accurate, several other key issues exist, which the natural ice encounter addresses. These include:*

- *The adequacy of flight crew procedures when operation in icing conditions,*
- *The acceptability of control indications to the flight crew as the aeroplane responds to engine fan blade ice shedding during various conditions,*
- *The performance of the engine vibration indication system, as well as other engine*



indication systems, and

- The confirmation that the powerplant installation performs satisfactorily while in icing conditions. This whole powerplant installation includes the engine, air intake, and the IPS system.

Should be changed into:

Natural ice encounters should also be used to show compliance with CS 25.1093(b)(1). Multiple engine damage and operability events have been experienced in natural icing flight tests and in-service aeroplanes.

Natural icing flight tests are intended to demonstrate that each turbine engine is capable of operating throughout the flight power/thrust range of the engine (including idling), without an adverse effect. This includes the accumulation of ice on the engine, air intake system components, or airframe components that would have an adverse effect on the engine operation or cause a serious loss of power or thrust.

In addition required to prove that the engine air intake icing analysis model is accurate, several other key issues exist, which the natural ice encounter addresses. These include:

~~The adequacy of flight crew procedures when operation in icing conditions,  
The acceptability of control indications to the flight crew as the aeroplane responds to engine fan blade ice shedding during various conditions,  
The performance of the engine vibration indication system, as well as other engine indication systems, and~~

- The to confirm that the complete powerplant installation, including the engine, performs satisfactorily while in icing conditions. This whole powerplant installation includes the engine, air intake, and the IPS system.

Rationale:

The objective of the rule is to demonstrate that the powerplant installation performs satisfactorily in icing conditions without the need to apply specific flight crew procedures. The engine behaviour will be verified using the available engine indications that are controlled by other requirements independent of CS 25.1093.

response

Partially accepted.

The first paragraph has been modified to reflect that this is not a mandatory means of compliance.

comment

61

comment by: AIRBUS

#### **AMC 25.1093(b) Section 2.4 – p.73**

The text proposed by EASA is slightly different to that proposed by the FAA in AC 20-147A draft. It is suggested to correct the text as proposed below to be consistent with the FAA's material and to recognize that flight testing with one engine at idle can be a valid way to test an engine in natural icing conditions as long as the test procedure is defined in such a way as to prevent non representative excessive exposure to icing conditions.

The current text:

*b. Damage from testing in non-representative icing conditions. Damage resulting from icing test conditions which fall significantly outside Appendix C icing envelopes, or when the airplane flight test is conducted in an abnormal manner and results in excessive ice shed damage, may be given additional considerations relative to compliance with the provisions of either §§ 23.1093 or 25.1093, and in some cases may be disregarded. An example of abnormal operation is flying with one engine at idle while the aircraft is operated in level flight.*





	<p>Should be changed into:</p> <p>b. Damage from testing in non-representative icing conditions. Damage resulting from icing test conditions which fall significantly outside Appendix C icing envelopes, or when the airplane flight test is conducted in an abnormal manner and results in excessive ice shed damage, may be given additional considerations relative to compliance with the provisions of either §§ 23.1093 or 25.1093, and in some cases may be disregarded. An example of abnormal operation <b>could be</b> flying with one engine at idle while the aircraft is operated in level flight</p> <p>Rationale:</p> <p>Proposed correction of the text to be consistent with the proposed FAA AC material.</p> <p>Flying with one engine at idle while the aircraft is operated in level flight is not representative of normal revenue aircraft service operation, it may be an acceptable way of conducting natural icing conditions provided the concerned test procedure is defined in such a way as to prevent non representative excessive exposure to icing conditions.</p>
response	<p>Partially accepted.</p> <p>Our proposed text was harmonised with the FAA draft AC 20-147A, except that one wording simplification was made. As proposed, we will harmonise the text fully with the FAA text, and will adopt the 'could be' change.</p> <p>Please note that the text you quoted in your comment is not the one found in the published draft AC 20-147A.</p>
comment	<p>62</p> <p style="text-align: right;">comment by: AIRBUS</p> <p><b>Section 2.4(b)1 (Ground Taxi) – p.74</b></p> <p>The current text:</p> <p>[...] <i>to determine the critical ice accretion conditions for air intake and engine.</i></p> <p>Should be changed into:</p> <p>[...] <i>to determine the critical ice accretion conditions for air intake <del>and engine.</del></i></p> <p>Rationale:</p> <p>Critical ice accretion conditions for the engine have to be determined and demonstrated as part of CS-E certification (NPA 2012-23). Aircraft manufacturers will rely on CS-E demonstration for safe operation of the engine in ground icing conditions.</p>
response	<p>Accepted.</p>
comment	<p>85</p> <p style="text-align: right;">comment by: Dassault Aviation</p> <p>Dassault-Aviation comment page # 71</p> <p><b><u>Extract:</u></b></p> <p><b>AMC 25.1093(b) - Powerplant Icing</b></p> <p><b>2 Testing</b></p> <p><b>2.1 Icing wind tunnel tests</b></p> <p>A separate test should be conducted at each temperature condition of Table 1, the test being made up of repetitions of one of the following cycles:</p> <p>1) 28 km (17.4 NM) in the conditions of Table 2, column (a), appropriate to the temperature, followed by 5 km (3.1 NM) in the conditions of Table 2, column (b), appropriate to the temperature, for a total duration of 30 minutes, or</p> <p>2) 6 km (3.7 NM) in the conditions of Table 2, column (a), appropriate to the temperature,</p>



followed by 5 km (3.1 NM) in the conditions of Table 2, column (b), appropriate to the temperature, for a total duration of 10 minutes.

**Comment:**

Typo error: tests cycles should have to be conducted in the conditions of Table 1 and not Table 2, which does not exist.

**Requested Change**

Please Agency to correct this typo error.

response Accepted.

comment

112

comment by: FAA

Page	Para	COMMENT / SUGGESTED CHANGE	Rationale
65	1 <sup>st</sup> para	Change 2 <sup>nd</sup> sentence to read as follows: Applicants must, therefore, propose acceptable means of compliance <del>including tests</del> <b>which may include flight tests</b> in natural icing conditions.	Previous wording suggested that natural icing flight test is required to show compliance. However, CS 25.1093(b) does not require a natural icing flight test. Although the regulation does not specifically require a natural icing flight test, flight testing in natural conditions may still be necessary depending on several factors.
65	4 <sup>th</sup> para	This paragraph should be clarified to indicate that similarity may be used for certification if the new design is similar to an existing design with a successful in-service history.	Previous wording implied that similarity could be used whether the previous design was successful or not. Similarity should be based, in part, on a positive in-service history, not previous certification experience.
65	All for 25.1093(b)	The methods of compliance for this specification should be consistent whether the airplane is certified for icing or not. The last paragraph in AMC 25.1093(b) should state that for all airplanes, compliance to CS 25.1093(b)(1) can be shown by analysis, ground testing, dry air flight testing, similarity, and/or natural icing flight testing as necessary.	CS 25.1093 does not require a natural icing flight test but the AMC implies that it is required.
66	Section 1.1	The section should be clarified to note that applicants may assume that 1/3 of the ice on the air intake perimeter is ingested as one piece.	The proposed clarification would be consistent with section 1.2 on page 67. The assumed breakup of ice accretions around the engine inlet should be consistent regardless of the conditions which formed the ice.



67		Revise sentence as follows: When thermal IPS is used, air <b>intakes</b> designed to be evaporative under the critical points in continuous maximum icing conditions, and running wet under intermittent maximum icing conditions (Appendix C to CS-25) <b>have</b> shown satisfactory service experience.	For clarity and consistency with proceeding paragraphs.
68	Section 1.4.1	Suggest wording change as follows: ... applicants should demonstrate that any undetected ice, <b>including ice formed</b> from cold-soaked fuel, is not greater than the ice ingestion demonstrated for CS-E 780 compliance.	Applicant should show that undetected ice is smaller than the ice slab used for engine testing regardless of ice source.
71	Section 2.0	Suggest wording change as follows: "Where the air <b>intake</b> is assessed...."	Intended for clarity
71	Section 2.1	Suggest removing the fourth paragraph as it appears redundant with the second paragraph.	Intended for clarity
71	Section 2.1	Suggest wording change as follows: ...the following conditions <b>presented in Table 1</b> have been..."	Suggested for clarity. Table 1 should be referred to within the document text.
72	Section 2.1	Subparagraphs 1) and 2) should be clarified since they refer to Table 2 which is not included in the proposed AMC.	Intended for clarity
73	Section 2.3	Suggest wording change to describe that natural flight testing <b>may</b> be required to show compliance to 25.1093(b). This section should also provide some criteria on the number of exposures that should be flown during a natural icing flight test campaign. For example, the program should include a range of exposures that cover different temperatures, LWC, drop sizes, power settings, etc. For reference, the FAA included such criteria in proposed draft AC 20-147A on page 43, section 11, n, (1) and (2).	CS 25.1093 does not require a natural icing flight test to show compliance so the AMC should not require flight testing beyond what is in the regulation. When natural icing flight testing is necessary, the AMC should provide some guidance to describe what the flight campaign should entail.



74	Section 2	This paragraph should be clarified as it appears to contradict itself. In the first half it states that ground exposure to SLD must be tested. Then in the end of the paragraph it discusses complying with this requirement by analysis. Does that mean that both means of compliance are acceptable? The paragraph should also clarify the requirement for airplanes not approved for dispatch in SLD. Will they still have to perform the test?	Clarifying this section should reduce confusion as projects are initiated in the future.
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response

Comment 1 (p.65): Accepted.  
Comment 2 (p.65): Accepted.  
Comment 3 (p.65): Accepted.  
Comment 4 (p.66): Accepted.  
Comment 5 (p.67): Accepted.  
Comment 6 (p.68): Accepted.  
Comment 7 (p.71): Accepted.  
Comment 8 (p.71): Not accepted. The two paragraphs are not considered redundant.  
Comment 9 (p.71): Partially accepted. The wording has been updated to mention either the critical points determined by a CPA or the conditions defined in Table 1.  
Comment 10 (p.72): Accepted.  
Comment 11 (p.73): Partially accepted. The wording change to describe that natural flight testing may be used is accepted. The additional guidance proposed (reference to draft AC 20-147A) is not adopted as it is related to the engine certification.  
Comment 12 (p.72): Accepted. The paragraph has been clarified to reflect that a test is not mandatory (with or without authorised dispatch in SLD conditions).

comment

146

comment by: Boeing

Page: 65

Paragraph: AMC 25.1093(b) Powerplant Icing

Boeing recommends revising the proposed text as follows to be more specific regarding the minimum requirements for compliance with CS 25.1093(b):

*"Compliance with CS 25.1093(b) is required even if certification for flight in icing conditions is not sought. Applicants must, therefore, propose acceptable means of compliance including tests in natural icing conditions.*

*The results of tests and analysis used for compliance with CS-E 780 may be used **as part of the data** to show support compliance with CS 25.1093(b). **At a minimum, a combination of analysis, and flight tests in natural and dry air conditions should be used to show compliance with CS 25.1093(b).** This requires close coordination between the engine manufacturer and the aeroplane manufacturer to make sure that CS-E 780 tests cover all potential ice sources."*



	<p><b>JUSTIFICATION:</b></p> <p>The first proposed paragraph indicates that natural icing flight tests will be required, and later, critical point analysis, dry air testing, etc., are outlined. Therefore, the CS-E 780 testing, if relevant, is only a part of the compliance package.</p> <p>Boeing requests that the minimum requirement be more clearly specified to reflect that a combination of CPA, dry air tests, flight test, and analysis may be required.</p>
response	<p>Partially accepted.</p> <p>The first proposed wording change is accepted as it better reflects CS 25.1093.</p> <p>The new proposed sentence is not accepted as CS 25.1093 does not require a natural icing flight test, therefore, the AMC wording should not suggest it is required.</p>
comment	<p>147</p> <p style="text-align: right;">comment by: Boeing</p> <p>Page: 66 Paragraph: AMC 25.1093(b) Powerplant Icing, (a) Compliance with CS 25.1093(b)(1)</p> <p>Boeing recommends revising the proposed text as follows: "1. Analysis &amp; Test Point Selection. ... <b><i>For applicants not showing similarity with previous designs, in establishing compliance with the requirements of CS 25.1093(b)(1), reference should be made to AMC 25.1420, paragraph (d), for the assessment of the Appendix O icing environment, in particular for the following aspects:</i></b></p> <ul style="list-style-type: none"> <li>• Analysis of areas and components to be protected;</li> <li>• Failure analysis; and</li> <li>• Similarity analysis."</li> </ul> <p><b>JUSTIFICATION:</b> Boeing requests that the indicated language be added, commensurate with other requested revisions to explicitly permit the use of similarity as means of compliance for Appendix O conditions.</p>
response	<p>Not accepted.</p> <p>Rulemaking task RMT.0572 will look at any required change concerning similarity analysis provisions.</p>
comment	<p>148</p> <p style="text-align: right;">comment by: Boeing</p> <p>Page: 66 Paragraph: AMC 25.1093(b) Powerplant Icing, (a) Compliance with CS 25.1093(b)(1)</p> <p>Boeing recommends revising the proposed text as follows: "1.1 <u>Critical Points Analysis (CPA)</u> <i>A Critical Points Analysis (CPA) is one analytical approach to identify the most critical operational icing conditions to show that an engine air intake complies with CS 25.1093(b)(1).</i></p>



~~For Appendix C icing conditions, in lieu of a detailed CPA, the conditions specified in paragraph 2.1, "Icing wind tunnel tests", are acceptable and can be used for testing without further justification.~~

The CPA provides a means to predict critical conditions to be assessed and allows for a selection of conditions which will ensure that the ice protection system will be adequate throughout the combined aircraft operation/icing envelope.

The CPA should include ice accretion calculations that account for freezing fraction and aerodynamic effects of the ice as it moves into the air intake, forward aircraft airspeed effects, engine configuration effects and altitude effects such as bypass ratio effects. It should also include prolonged flight operation in icing (for example, in-flight hold pattern), or repeated icing encounters."

**JUSTIFICATION:** Boeing recommends deleting of the paragraph that would allow no further justification. If a Critical Point Assessment (CPA) for IPS performance evaluation is not performed, then the applicant has not shown that the mass of ice from the three test points represents the largest mass in the envelope. An analysis should be done to define the critical condition for runback, and compare that mass to the amount of ice ingestion that the engine has satisfactorily demonstrated during engine certification to CS-E 780.

response

Not accepted.

The icing conditions points provided in paragraph 2.1, Table 1, are taken from the existing AMC 25.1093(b) and they are considered conservative to demonstrate compliance with CS 25.1093(b) in Appendix C conditions (these points are beyond the Appendix C icing conditions). This fact is recognised in the proposed AMC amendment, nevertheless, it is also possible for the applicant to demonstrate other testing points by doing a CPA.

comment

149

comment by: Boeing

Page: 66

Paragraph: AMC 25.1093(b) Powerplant Icing,  
(a) Compliance with CS 25.1093(b)(1),  
1.1 Critical Points Analysis (CPA)

Boeing recommends revising the proposed text as follows:

"The CPA should consider:

...

**2. For applicants not showing similarity with previous designs,** ~~t~~*The environmental icing envelopes defined in CS-25 Appendices C, O and P. The Intermittent Maximum Icing Conditions of Appendix C envelope extension down to – 40 °C should also be considered."*

**JUSTIFICATION:** Boeing requests that the indicated language be added, commensurate with other requested revisions to explicitly permit the use of similarity as means of compliance for Appendix O conditions.

response

Not accepted.

Rulemaking task RMT.0572 will look at any required change concerning similarity analysis provisions.

comment

150

comment by: Boeing



Page: 67

Paragraph: AMC 25.1093(b) Powerplant Icing,

(a) Compliance with CS 25.1093(b)(1),

1.1 Critical Points Analysis (CPA)

Boeing recommends revising the proposed text as follows:

*"The critical ice accretion including runback ice (if any) which may lead to the above mentioned anomalies may be different for each flight phases. If this is the case, the engine manufacturer should provide the relevant information. ~~A particular attention should be made to ice accretion occurring during the descent at Idle power/thrust (with potentially a reduced ice protection availability), which may be ingested during a go-around at take-off power/thrust (potentially critical for mechanical damage).~~*

~~• Ice accretion occurring during the holding phase, which may be ingested during descent at Idle power/thrust (potentially critical for engine performance and handling characteristics) or~~

~~• Ice accretion occurring during the descent at Idle power/thrust (with potentially a reduced ice protection availability), which may be ingested during a Go-Around at Take-Off power/thrust (potentially critical for mechanical damage)."~~

**JUSTIFICATION:** As written, the proposed text does not appear to be harmonized with CS-E 780, which does not currently include consideration of engine ingestion of holding ice accretions at the idle power setting. Therefore, Boeing requests that this paragraph be revised as we have recommended in order to harmonize with the requirements of CS-E 780.

response

Not accepted.

The conditions of the first bullet are not considered inconsistent with the ice ingestion capability provisions of the CS/AMC E 780. The text of CS-E 780 as presented in CRD 2011-04 states that, when establishing the ice slab ingestion conditions, the assumed ice quantity and dimensions, the ingestion velocity and the Engine operating conditions must be determined. Those conditions shall be appropriate to the Engine installation on the aircraft.

The operational scenario of conducting a holding phase followed by a descent with the engines at idle power is considered realistic and should at least be analysed by the applicant.

comment

151

comment by: Boeing

Page: 67

Paragraph: AMC 25.1093(b) Powerplant Icing,

(a) Compliance with CS 25.1093(b)(1),

1.1 Critical Points Analysis (CPA)

Boeing recommends revising the proposed text as follows:

*"Applicants should demonstrate that the full range of atmospheric icing conditions specified in ~~Appendices C~~ **and, for applicants not showing similarity with previous designs, Appendices O and P,** to CS-25 have been considered, including the mean effective drop / particle diameter, liquid / total water content, and temperature appropriate to the flight conditions (for example, configuration, speed, angle-of-attack, and altitude)."*

**JUSTIFICATION:** Boeing requests the indicated revisions be made to the proposed text, commensurate with other requested revisions to explicitly permit the use of similarity as



response	<p>means of compliance for Appendix O conditions.</p> <p>Not accepted.</p> <p>Rulemaking task RMT.0572 will look at any required change concerning similarity analysis provisions.</p>
comment	<p>152 <span style="float: right;">comment by: Boeing</span></p> <p>Page: 67 Paragraph: AMC 25.1093(b) Powerplant Icing, (a) Compliance with CS 25.1093(b)(1), 1.1 <u>Critical Points Analysis (CPA)</u></p> <p>Boeing recommends revising the proposed text as follows:  <u>"To demonstrate that Air intakes have proven unlimited operation in icing <del>may allow</del>, any runback ice formation during holding, straight-line flight, and descent must demonstrate an accretion and shed cycle and be evaluated against the demonstrated ingestion capability of the engine per CS-E 780."</u></p> <p><b>JUSTIFICATION:</b> As written, the proposed sentence in the AMC is similar to text in the FAA's AC 20-147, but not identical. Boeing requests that our recommended revisions be made for clarification and harmonization with AC 20-147.</p>
response	<p>Partially accepted.</p> <p>The wording proposed by Cessna has been adopted. A new paragraph, which meets the intent of your comment, has been provided.</p>
comment	<p>153 <span style="float: right;">comment by: Boeing</span></p> <p>Page: 67 Paragraph: AMC 25.1093(b) Powerplant Icing, (a) Compliance with CS 25.1093(b)(1), 1.1 <u>Critical Points Analysis (CPA)</u></p> <p>Boeing recommends revising the proposed text as follows:  <u>"When <del>thermal IPS is used</del>, an air intake thermal IPS is designed to be evaporative <del>under for</del> the critical points in Appendix C continuous maximum icing conditions and running wet <del>under</del> in Appendix C intermittent maximum icing conditions, <del>(Appendix C to CS-25)</del> it has historically been shown to provide satisfactory performance in service experience. If the inlet is running wet in continuous maximum icing conditions, then the applicant should calculate the amount of runback ice that would accumulate during a holding condition and compare that to the maximum certified ingestion capability of the engine per CS-E 780."</u></p> <p><b>JUSTIFICATION:</b> The proposed first sentence is similar to the text in the FAA's AC 20-147. However, Boeing notes that it does not include guidance regarding what the applicant should do if the inlet does not meet these criteria. The addition of our recommended second sentence will provide that guidance. Boeing requests that the Agency and the FAA accept the requested revisions in order to harmonize the guidance.</p>
response	<p>Partially accepted.</p>





The paragraph has been modified based on the proposal but with a different order for clarity improvement. Also, the second sentence is not focused on the holding phase but refers to any relevant flight phase.

comment

155

comment by: Boeing

Page: 67

Paragraph: AMC 25.1093(b) Powerplant Icing,  
(a) Compliance with CS 25.1093(b)(1),  
1.1 Critical Points Analysis (CPA)

Boeing recommends revising the proposed text as follows:

"Scenario to be considered:

*The applicant should justify the icing scenarios to be considered when determining the critical ice accretion conditions. The flight phases as defined in Part II of Appendix C, and for applicants not showing similarity with previous designs, Part II of Appendix O could be used to support the justification."*

**JUSTIFICATION:** Boeing requests the indicated revisions be made to the proposed text, commensurate with other requested revisions to explicitly permit the use of similarity as means of compliance for Appendix O conditions.

response

Not accepted.

Rulemaking task RMT.0572 will look at any required change concerning similarity analysis provisions.

comment

156

comment by: Boeing

Page: 68

Paragraph: AMC 25.1093(b) Powerplant Icing,  
(a) Compliance with CS 25.1093(b)(1),  
1.3 Ice accretion sources

Boeing recommends revising the proposed text as follows:

"1.3 Ice accretion sources

*Examples of airframe sources of ice accretion include the radome, antennae, ~~or~~ and the inboard section of the wing for aft fuselage mounted engines.*

...

For applicants not showing similarity with previous designs, identification of Engine Air intake ice accretion sources includes, for ~~the CS-25~~ Appendix O ~~to CS-25~~ icing environment, an assessment of air intake differing impingement limits, catch efficiency, distribution effects, and water contents. The applicant should evaluate the potential ice accumulation aft of the engine air intake protected surfaces for the possibility of ice ingestion by the engine. Ice shed from areas such as the forward aircraft radome may be considered to have broken up such that no individual piece is larger than that specified in AMC E 780, Table 3, for the appropriate engine inlet area, before the ice pieces reach the inlet.

For engine inlets, compliance may be shown through qualitative analysis of the design, supported by similarity to a previous design that has shown successful service history (compliance to the CS 25.1093 (b)(2) using AMC E 780 Table 1, would still be required for



ground idle taxi conditions). If similarity is not shown, then an assessment of inlet impingement limits, differing catch efficiency, distribution effects, and water contents for Appendix O should be accomplished.

For airframe ice sources, the installer may use qualitative analysis of the design, supported by similarity to a previous design that has shown successful service history, to have confidence that the historical methodology for certification, represented by Table 33.77, "Minimum Ice Slab Requirements Based on Engine Inlet Size," is appropriate.

The applicant should assess the ice accumulations and compare them on the basis of **the size** or the kinetic energy of the ice slab. Kinetic energy may be used as an acceptable method for comparing the airframe ice source to the results of the CS-E 780 ice ingestion demonstration. Any kinetic energy method must be agreed to by the Agency. **It is normally sufficient to show that ice accumulations are smaller in size and therefore have equal or less kinetic energy than the CS-E 780 ice ingestion slab.**"

**JUSTIFICATION:** The Engine Harmonization Working Group reviewed the history of in-flight engine icing events, including potential ice from airframe sources. It concluded that current design and compliance methods have resulted in engine designs that have had no known safety events due to SLD icing aloft. As additional analysis or tests would not improve safety, Boeing requests that applicants be explicitly allowed to use similarity to current designs to show compliance for Appendix O conditions. This is consistent with the FAA's AC 20-147 language. A detailed review of in-service data found no instances of engine damage due to SLD icing or ice-crystal icing in flight. From this, it is evident that the radome is not a source of ingested ice that is larger than that for which engines are certified.

An analysis previously presented in a letter, dated May 10, 2010, from the Aviation Industries Association to the FAA, provides analysis using current computation tools. From the analysis, radome ice accretions in Appendix O icing conditions are predicted to be much greater than those produced using the conditions from Table 1 of AMC E 780. If conservative assumptions about radome ice breakup (e.g., breaking into only two pieces) are used, the resulting ice mass is much larger than the ice mass produced from the conditions of Table 1 of AMC E 780. This could compel airframe manufacturers to incorporate radome ice protection systems that add weight and cost beyond what was accounted for in the Regulatory Impact Assessment (RIA). Boeing therefore requests that the proposed revisions be incorporated to harmonize the CS 25.1093 compliance guidance with the FAA's 14 CFR Part 33 guidance to avoid additional, burdensome costs that would not result in an improvement to safety, as evidenced by the excellent service record of large aeroplane propulsion systems.

An applicant should be allowed to use ice slab size (only), without a requirement to evaluate the kinetic energy. This will improve harmonization with FAA's AC 20-147. If comparison of ice size is not allowed, then further guidance on the assumptions of a kinetic energy calculation is needed. For example: How is the slab oriented? At what percent span does it hit? Does it break into pieces like the test slab? Challenges defining these criteria are what led the FAA to allow comparison by size only.

Boeing requests that the indicated language be added, commensurate with other requested revisions to explicitly permit the use of similarity as means of compliance for Appendix O conditions.

response

Partially accepted.

The aspects of the comment related to the similarity analysis for Appendix O icing conditions are being reviewed under rulemaking task RMT.0572 and are, therefore, not taken into account at this stage.

The possibility to consider the size of the ice accretion has been added to the last paragraph



of chapter 1.3.

comment

157

comment by: Boeing

Page: 70-71

Paragraph: AMC 25.1093(b) Powerplant Icing,  
(a) Compliance with CS 25.1093(b)(1),  
2 Testing

Boeing recommends revising the proposed text as follows:

"2 Testing

**In establishing compliance with the requirements of CS 25.1093(b)(1), in conjunction with the CPA, a thorough validation of the IPS shall include:**

- Flight tests in dry air with ice protection equipment operating,
- Flight tests in icing conditions, natural or artificial, and
- Ground tests in an icing wind tunnel.

**Reference should be made to AMC 25.1419, paragraph (b), for the assessment of the Appendix C icing environment; and to AMC 25.1420, paragraph (d), for the assessment of the Appendix O icing environment.**

The engine air intakes may be tested with the engine and propeller where appropriate in accordance with the specifications of CS-E 780 and AMC E 780.

Where the air intakes are assessed separately (e.g., icing wind tunnel evaluation of IPS performance, lack of suitable test facilities for engine and inlet, change in the design of the air intake, air intake different from one tested with the engine), it should be shown that the effects of icing on the air intakes ~~icing~~ would not invalidate the engine tests of CS-E.

Factors to be considered in such evaluations are:

- distortion of the airflow and partial blockage of the air intakes,
- ~~the shedding into the engine of air intakes ice of a size greater than the engine is known to be able to ingest,~~
- the demonstrated ice ingestion capability per CS-E 780,
- the icing of any engine sensing devices, other subsidiary air intakes or equipment contained within the air intake, and
- the time required to bring the protective system into full operation.

**For applicants not showing similarity with previous designs, in** establishing compliance with the requirements of CS 25.1093(b)(1), reference should be made to AMC 25.1420, paragraph (d), for the assessment of the Appendix O icing environment."

**JUSTIFICATION:** Boeing requests that the text be rearranged as shown to emphasize the combination of tests that could be used for compliance, including icing wind tunnel tests as appropriate for IPS validation without the engine needing to be present. We have also suggested re-wording of the ice shed capability of the engine. A similar comment is recommended for CS-E 780.

Boeing requests that the indicated language be added, commensurate with other requested revisions, to explicitly permit the use of similarity as means of compliance for Appendix O conditions.



response Not accepted.  
The proposed changes do not really clarify the paragraph. The aspects of the comment related to the similarity analysis for Appendix O icing conditions are being reviewed under rulemaking task RMT.0572.

comment 158 comment by: Boeing

Page: 71  
Paragraph: AMC 25.1093(b) Powerplant Icing,  
(a) Compliance with CS 25.1093(b)(1),  
2.1 Icing wind tunnel test

Boeing recommends revising the proposed text of the 5<sup>th</sup> paragraph under section 2.1as follows:

*“Flight conditions may need to be corrected to allow simulation in a wind tunnel. To achieve this, the location of the stagnation point on the inlet lip, ~~the free stream dynamic pressure, the impact temperature of the water droplets,~~ and the amount of water runback at the throat should be maintained between flight and wind tunnel conditions. **Other test parameters, such as static or total air temperature, may require similitude adjustments to achieve the best match of icing condition parameters, such as those described in FAA AC 20-73A.**”*

**JUSTIFICATION:** While this is a useful, general discussion of the intent of the icing tunnel tests, typical icing similitude calculations are more involved than those described. The “impact temperature” of water drops is not necessarily the same between flight and test for the best icing similarity match, and it is not possible in all cases to match flight dynamic pressure.

We point out that the FAA’s AC 20-73A, Appendix R, “ICE SHAPES,” has a more complete discussion of the icing similarity calculations and variables. In addition, FAA Report DOT/FAA/CT-86/35, “An Analytical Study of Icing Similitude for Engine Testing,” offers a more complete explanation specific to engine testing.

Our recommended changes would also improve harmonization between the EASA and FAA guidance materials.

response Accepted.

comment 159 comment by: Boeing

Page: 72  
Paragraph: Table 1 -- Alternate

Boeing recommends revising the proposed “Note” in Table 1 as follows:

*“Note: The conditions of water concentration required ~~by these tests in Table 1~~ are somewhat more severe than those implied by the Appendix C to CS-25 so as to provide margins. **The conditions in Table 1 are provided for reference only, and do not negate the need to perform a specific analysis of the critical icing conditions.**”*

**JUSTIFICATION:** Boeing finds that the test points defined in Table 1 do not represent the critical cases that would be found by a complete assessment per CS 25.1419. If the Agency



	<p>considers that they <u>do</u>, then the rationale is unclear. We therefore request either clarification of the Agency's position or addition of the indicated text to maintain the practice of analyzing the critical icing conditions.</p>
response	<p>Not accepted.</p> <p>The paragraph introducing Table 1 has been updated to provide that for the evaluation of the performance of the IPS, either the critical points determined by a CPA or the conditions defined in Table 1 may be used. In the past, aeroplanes certified using the conditions of Table 1 have proven safe in-service experience.</p>
comment	<p>160 <span style="float: right;">comment by: Boeing</span></p> <p>Page: 73 Paragraph: AMC 25.1093(b) Powerplant Icing, (a) Compliance with CS 25.1093(b)(1), 2.3 Natural Icing Flight Tests</p> <p>Boeing recommends revising the proposed text as follows: "2.3 Natural Icing Flight Tests <del>Natural ice encounters should</del> <u>icing flight tests should</u> also be used to show compliance with CS 25.1093(b)(1)."</p> <p><b>JUSTIFICATION:</b> Boeing suggests that it is preferable to refer to "natural icing flight tests" rather than "natural ice encounters," as the latter has more of an unintentional connotation.</p>
response	<p>Partially accepted. 'Should' was replaced by 'may' also based on another comment.</p>
comment	<p>161 <span style="float: right;">comment by: Boeing</span></p> <p>Page: 74 Paragraph: (b) Compliance with CS 25.1093(b)(2) Ground taxi exposure to Appendices C and O to CS-25</p> <p>Boeing recommends revising the proposed text as follows: "1. <u>Critical Points Analysis (CPA).</u> The <del>actual test</del> temperatures should result from a CPA, <u>considering the full range of temperatures specified in CS 25.1093</u>, conducted to determine the critical ice accretion conditions for air intake and engine.</p> <p>2. <u>Ground taxi exposure to Appendix O conditions.</u> The service experience indicates that engine fan damage events exist from exposure to SLD during ground taxi operations. For this reason, an additional condition of a 30-minute, idle power/thrust exposure to SLD on the ground must be <del>tested</del> <u>analyzed</u>. Applicants should include the terminal falling velocity of SLD (for example, freezing rain, freezing drizzle) in their trajectory assessment, relative to the protected sections of the air intake. The 100 micron minimum mean effective diameter (MED) is selected as a reasonable <del>achievable test</del> condition, given current technology. <del>We recommend, however, that applicants choosing to</del> <u>To</u> certify by analysis, the applicant should evaluate the Appendix O drop sizes up to a maximum of 3000 microns particle size to find a critical condition."</p>

response

**JUSTIFICATION:** The recommended revisions reflect Boeing's position that the ground icing evaluation requirements can be satisfied by analyses, and that tests are not required.

Partially accepted.

In the second paragraph, instead of 'analysed', 'tested' is replaced by 'addressed'.

**Cessna comment on AMC 25.1093(b)(2) section 1 (page 74):**

1. Change "a CPA" to "an analysis" to differentiate between the CPA completed by the engine manufacturers
2. Specify the temperatures need to be evaluated across the full temperature range of Appendices C, O & P
3. Remove references to the engine and focus on the airframe alone. The engine will be tested separately under CS-E and should not have to be addressed with the airframe intake system.

Current Text:

The actual test temperatures should result from a CPA conducted to determine the critical ice accretion conditions for air intake and engine.

Proposed Text:

The actual test temperatures should result from ~~a-CPA~~ an analysis conducted to determine the critical ice accretion conditions for the airframe air intake throughout the temperature range specified ~~and engine~~.

**Response:** Partially accepted. The term CPA is maintained. There is no need to precise 'the airframe' in the context of CS 25.1093. The rest of the proposal is accepted.

**Cessna comment on AMC 25.1093(b)(2) section 2 (page 74):**

Change "tested" to "addressed" to allow either test or analysis.

Current Text:

2. Ground taxi exposure to Appendix O conditions. The service experience indicates that engine fan damage events exist from exposure to SLD during ground taxi operations. For this reason, an additional condition of a 30-minute, idle power/thrust exposure to SLD on the ground must be tested. Applicants should include the terminal...

Proposed Text:

2. Ground taxi exposure to Appendix O conditions. The service experience indicates that engine fan damage events exist from exposure to SLD during ground taxi operations. For this reason, an additional condition of a 30-minute, idle power/thrust exposure to SLD on the ground must be ~~tested~~ addressed. Applicants should include the terminal....

**Response:** Accepted.

comment

192

comment by: Snecma

Attachment [#5](#)

Please see attached file.

response

**Comment#1: p. 65, AMC 25.1093(b) (a)**

Suggestion:

**(a) Compliance with CS 25.1093(b)(1)**

As a general rule, engine air intake systems should be shown to operate continuously in icing conditions without regard to time. **A time exposure of 45 minutes for Holding conditions**



**can be considered as sufficient for compliance as long as the volume of ice formed remains under CS-E 780 ice slab size demonstrated.** The only exception would be for low engine power/thrust conditions where a sustained level flight is not possible.

(...)page 67

Air intakes ~~that have proven unlimited operation in icing~~ may allow runback ice formation during holding, straight-line flight and descent.

(...)

Scenario to be considered:

(...)

For holding ice accretion, the applicant should determine the effect of a 45-minute holding in continuous maximum icing conditions of Appendix C. The analysis should assume that the aeroplane remains in a rectangular “race track” pattern, with all turns being made within the icing cloud. Therefore, no horizontal extent correction should be used for this analysis.

Justification: Showing unlimited operation in Hold condition with runback may be difficult as build and shed cycles cannot be determined through analysis. Therefore, it is recommended to allow considering a 45 minutes time exposure as sufficient demonstration for inlet certification, consistently with scenarios proposed in the AMC.

Response: Partially accepted.

The first sentence has been updated to specify ‘as a hold condition’. The scenario to be considered already provides the 45 minutes time duration.

The sentence starting with ‘Air intakes that have proven...’ has been removed.

**Comment#2: p.67, AMC 25.1093(b) (a) 1.1**

Suggestion:

The critical ice accretion including runback ice (if any) which may lead to the above mentioned anomalies may be different for each flight phases. **In any case, runback ice shall be lower than ice ingestion capability demonstrated by the engine manufacturer per CS-E 780.** If this is the case, the engine manufacturer should provide the relevant information. A particular attention should be made to:

- ~~Ice accretion occurring during the holding phase, which may be ingested during descent at Idle power/thrust (potentially critical for engine performance and handling characteristics) or~~
- ~~Ice accretion occurring during the descent at Idle power/thrust (with potentially a reduced ice protection availability), which may be ingested during a Go Around at Take Off power/thrust (potentially critical for mechanical damage).~~

JUSTIFICATION: AMC E 780 does not currently include engine ice ingestion at the idle power setting or any definition of test engine power level. This requirement does not appear to be harmonized with CS E 780. The comment #9 from NPA 2012 04 CRD suggests that the AMC E 780 include the following text which is harmonized with the FAA: “Engine operation will be at the maximum cruise power or thrust unless lower power is more critical”, so that showing runback ice is lower than the ice ingestion capability demonstrated should be enough.

Response: Partially accepted.

The statement, that any runback ice which forms should result in less ice than the engine has

been demonstrated to ingest per CS-E 780, has been added in a new paragraph below the paragraph of this comment. The conditions of the two bullets proposed to be deleted are not considered inconsistent with the ice ingestion capability provisions of the CS/AMC E 780. The text of CS-E 780 as presented in CRD 2011-04 states that, when establishing the ice slab ingestion conditions, the assumed ice quantity and dimensions, the ingestion velocity and the Engine operating conditions must be determined. Those conditions shall be appropriate to the Engine installation on the aircraft.

The two mentioned operational scenarios are considered realistic and should at least be analysed by the applicant.

**Comment#3: p.67, AMC 25.1093(b) (a) 1.1**

**Suggestion:**

When thermal IPS is used, air intake designed to be evaporative under the critical points in continuous maximum icing conditions, and running wet under intermittent maximum icing conditions (Appendix C to CS-25) has shown satisfactory service experience. **If the inlet is running wet in maximum continuous atmospheric conditions, then the applicant should calculate the amount of runback ice that would accumulate during a holding condition and compare that to the maximum certified ingestion capability of the engine per CS-E 780**

JUSTIFICATION: The sentence is taken from AC20-147 but does not include what to do if the inlet does not meet these criteria. Propose adding text similar to Draft AC20-147A

**Response:** Accepted.

**Comment#4: p.67, AMC 25.1093(b) (a) 1.1**

**Suggestion:**

**Change from this:**

When thermal IPS is used, air intake designed to be evaporative under the critical points in continuous maximum icing conditions **at sustained level of flight**, and running wet under intermittent maximum icing conditions (Appendix C to CS-25) has shown satisfactory service experience.

JUSTIFICATION: Although some thermal IPS are designed to be fully evaporative under continuous maximum icing conditions for Hold conditions, it is not the case for Descent/Idle power setting to the knowledge of Snecma.

**Response:** Partially accepted. This sentence has been deleted.

**Comment#5: p.68, AMC 25.1093(b) (a) 1.3**

**REQUESTED CHANGE:**

**For airframe ice sources, for compliance with Appendix O to CS-25 icing environment, the installer may use qualitative analysis of the design and supported by similarity to previous design that have shown successful service history to have confidence that the historical methodology for certification represented by “AMC E-780 (4) Ice Ingestion Table 3 Minimum ice slab Requirements Based on Engine Inlet Size” is appropriate.**

**For Engine air intakes, compliance may be shown through qualitative analysis of the design, supported by similarity to a previous design that has shown successful service**





**history (compliance to the AMC E-780 Table 2 “Large Droplet Condition” would still be required for ground idle taxi conditions). If similarity is not shown, then** identification of Engine Air intake ice accretion sources includes, for Appendix O to CS-25 icing environment, an assessment of air intake differing impingement limits, catch efficiency, distribution effects, and water contents. The applicant should evaluate the potential ice accumulation aft of the engine air intake protected surfaces for the possibility of ice ingestion by the engine

JUSTIFICATION:

The EHWG has reviewed the history of in flight engine icing events, including potential ice from airframe sources. The EHWG review did not note any in-flight engine events have been attributed to large drop conditions. Current design and compliance methods have resulted in engine designs that have had no known safety events due to supercooled large droplet icing. As additional analysis or test would not improve safety, it should be explicitly allowed to use similarity to current designs to show compliance for Appendix O conditions.

Response: Not accepted. The aspects related to similarity analysis are the subject of a dedicated rulemaking task RMT.0572.

**Comment#6: p.68, AMC 25.1093(b) (a) 1.3**

Suggestion:

The applicant should assess the ice accumulations and compare them on the basis of the kinetic energy of the ice slab. Kinetic energy may be used as an acceptable method for comparing the airframe ice source to the results of the CS-E 780 ice ingestion demonstration. Any kinetic energy method must be agreed to by the Agency. **It is normally sufficient to show that ice accumulations are smaller in size and therefore equal to or have less kinetic energy than the CS-E 780 ice ingestion slab.**

JUSTIFICATION: an applicant should be allowed to use ice slab size (only), without a requirement to evaluate the kinetic energy. This will improve harmonization with FAA Draft AC 20-147A. If comparison of ice size is not allowed, then further guidance on the assumptions of a kinetic energy calculation is needed – how is the slab oriented? At what % span does it hit? Does it break in pieces like the test slab? Challenges defining these criteria are what led the FAA to allow comparison by size only.

Response: Accepted.

**Comment#7: p.70/71, AMC 25.1093(b) (a) 2**

Suggestion:

**2 Testing**

In establishing compliance with the requirements of CS 25.1093(b)(1), **a thorough validation of the IPS may include:**

- Flight tests in dry air with ice protection equipment operating,
- Flight tests in icing conditions, natural or artificial, and
- Ground tests in icing wind tunnel.

Reference should be made to AMC 25.1419, paragraph (b), for the assessment of the Appendix C icing environment and to AMC 25.1420, paragraph (d), for the assessment of the Appendix O icing environment.

The engine air intakes may be tested with the engine and propeller where appropriate in accordance with the specifications of CS-E 780 and AMC E 780.



Where the air intakes is assessed separately (e.g. **icing wind tunnel evaluation of IPS performance**, lack of suitable test facilities for **engine and inlet**, change in the design of the air intake, air intake different from one tested with the engine), it should be shown that the effects of air intakes icing would not invalidate the engine tests of CS-E.

Factors to be considered in such evaluations are:

- distortion of the airflow and partial blockage of the air intakes,
- **The demonstrated ice ingestion capability per CS-E 780**,
- the icing of any engine sensing devices, other subsidiary air intakes or equipment contained within the air intake, and
- the time required to bring the protective system into full operation.

JUSTIFICATION:.. Rearranged the text to emphasize the combination of tests that could be used for compliance. Added icing wind tunnel tests as a test appropriate for IPS validation without the engine needing to be present. Reworded the ice shed capability of the engine.

Response: Partially accepted. The second bullet of the list of factors to be considered has been updated as follows: 'the shedding into the engine of air intakes ice of a size greater than the engine has been shown to ingest per CS-E 780'.

The other proposed changes are not considered to add clarifications and are, therefore, not retained.

#### **Comment#8: p.71, AMC 25.1093(b) (a) 2.1**

Suggestion:

Flight conditions may need to be corrected to allow simulation in a wind tunnel. To achieve this, the location of the stagnation point on the inlet lip, the free stream dynamic pressure, ~~the impact temperature of the water droplets~~, and the amount of water runback at the throat should be maintained between flight and wind tunnel conditions. **The applicants may choose to maintain other parameters such as static or total air temperature, in addition or in lieu of those here listed if this is supported by technical arguments.**

JUSTIFICATION: While this is a useful, general discussion of the intent of the icing tunnel tests, typical icing similarity calculations are more involved than those described.

If maintained, the definition of impact temperature of water droplets shall be defined in the document. It is not obvious to Snecma that this parameter is more relevant than others, such as air temperature.

Response: Partially accepted. For the last sentence, we will adopt the proposal made by the AIA (see comment 201).

#### **Comment#9: p.71, AMC 25.1093(b) (a) 2.1**

Suggestion

At the conclusion of each test, the applicants should assess the ice accumulations **and compare them with the predicted runback analyzed for that condition. The maximum predicted runback accretion from the CPA should be compared with the** amount of ice the engine has satisfactorily demonstrated to ingest during engine certification (CS-E 780).

Justification

To develop a validated IPS, the testing may not be done at the predicted maximum runback ice points. The test may just be a means to validate an analysis. In all cases it's the maximum predicted runback which needs to be shown to be less than or equal to the ingestion



capability of the engine.

Response: Partially accepted. A new sentence is added before Table 1 to say that the test results may be used to validate the CPA in term ice accretion prediction.

**Comment#10: p.74, AMC 25.1093(b) (b)**

**Change from this:**

1. ~~Critical Points Analysis (CPA).~~ **Evaluation of the Ground Icing Envelope**

The ~~actual test~~ temperatures should, **considering the full range of temperatures in the Rule**, result from an **analysis** conducted to determine the critical ice accretion conditions for air intake and engine.

2. Ground taxi exposure to Appendix O conditions. The service experience indicates that engine fan damage events exist from exposure to SLD during ground taxi operations. For this reason, an additional condition of a 30-minute, idle power/thrust exposure to SLD on the ground must be ~~tested~~ **analyzed**. Applicants should include the terminal falling velocity of SLD (for example, freezing rain, freezing drizzle) in their trajectory assessment, relative to the protected sections of the air intake. The 100 micron minimum mean effective diameter (MED) is selected as a **reasonable achievable test** condition, given current technology. We recommend, however, that applicants choosing to certify by analysis evaluate the Appendix O drop sizes up to a maximum of 3000 microns particle size to find a critical condition.

**JUSTIFICATION:** This requirement can be met by analysis, test is not required. The term CPA is used differently in the Draft AC20-147A as a process where the critical points are found in the environmental and engine operating envelopes, and tested. The industry finds confusing the use of this term in a different way here. It is proposed therefore to change the terminology in order to avoid confusion, and to maintain the use of the term CPA in the engine community to only one meaning.

Response: Partially accepted.

The term CPA is maintained; this is a method used to identify some critical points, but it does not by itself prescribes a test. The term 'actual test' has been removed from the first sentence of the first paragraph.

In the second paragraph, 'tested' has been replaced by 'addressed'.

**Comment#11: p.72, AMC 25.1093(b) (a) 2.1**

Suggestion

Each test should be run at **(or simulate conditions of)** different engine powers/thrusts, including the minimum power/thrust for which satisfactory operation in icing conditions is claimed

**JUSTIFICATION:** If an inlet is run alone in the tunnel, it should still attempt to simulate the inlet airflow correctly for different engine powers/thrust.

Response: Accepted.

**Comment#12: p.72, AMC 25.1093(b) (a) 2.1**

Suggestion:

If there is a minimum power/thrust required for descent to insure satisfactory operation in icing conditions, the increase to that minimum power/thrust in icing conditions should be



automatic when in icing conditions, and this minimum power/thrust associated with descent in icing conditions should be **assumed for all analysis of descent IPS performance (heat available) and during icing wind tunnel and natural icing flight testing**

**JUSTIFICATION:** Propose to move this sentence to (a) before 1. Analysis and Test Point Selection – and apply it to the IPS performance assessment process not just the test points in table 1.

**Response:** Partially accepted. This paragraph has been moved to the beginning of (a) as recommended. However, the proposed the text has not been retained. Instead, the paragraph has been updated to state that the engine may revert back to normal flight idle for short term operation, such as on final approach to landing; in such a case, this reversion to normal flight idle should be assessed in term of engine ice ingestion, and any required operational time limitation or pilot action should be included in the AFM.

**Comment#13: p.67 and 73, AMC 25.1093(b) (a) 1.2 and 2.2 and AMC E 780 (6)**

1.2 (...)

It should be demonstrated that the ice accretion is acceptable after a representative delay in the selection of the ice protection systems, such as might occur during inadvertent entry into the conditions. In lack of other evidence, a delay of two minutes is a reasonable time to include both pilot reaction to select the IPS and shed the ice from the air intake perimeter.

And

2.2 (...)

Either by separate tests, or in combination with those of paragraph 2.1 above, it should be demonstrated that the ice accretion is acceptable after a representative delay in the selection of the IPS, such as might occur during inadvertent entry into the conditions. In lack of other evidence a delay of two minutes (to switch on the system) should normally be achieved when exposed to Continuous Maximum exposure of Appendix C to CS-25. The time for the system to warm up should be represented.

And

AMC E 780 (6) (...)

In the absence of other evidence a pilot response time of two minutes may be considered.

**JUSTIFICATION:** The three extracts support two different versions, so Snecma suggest to modify either 1.1 1.2 or 1.2 2.2 and AMC E 780 (6).

**Response:** Accepted. The text of paragraph 1.2 has been updated to read ‘In lack of other evidence, a delay of two minutes to switch on the IPS should be assumed. For thermal IPS, the time for the IPS to warm up should be added.’ Other paragraphs have also been revised consistently.

**Comment#14: p.73, AMC 25.1093(b) (a) 2.3**

**Recommend changing:**

Natural ice encounters should **icing flight tests must** also be used to show compliance with CS 25.1093(b)(1).

**JUSTIFICATION:** It should be clear that natural icing flight tests are required.

**Response:** Partially accepted.

“Should” was replaced by “may” based on another comment.



comment

195

comment by: Aerospace Industries Association

<b>Affected page number</b>	Page: 65 Paragraph: AMC 25.1093(b) paragraph 2
<b>What is your concern and what do you want changed in this paragraph?</b>	<u>The proposed text states:</u> The results of tests and analysis used for compliance with CS-E 780 may be used to show compliance with CS 25.1093(b). <b>Requested Change:</b> The results of tests and analysis used for compliance with CS-E 780 may be used <b>as part of the data</b> to <b>support</b> compliance with CS 25.1093(b).
<b>Why is your suggested change justified?</b>	<b>JUSTIFICATION:</b> It is respectfully noted that the previous paragraph indicated natural icing flight tests will be required, and later, critical point analysis, dry air testing, etc. are outlined. Therefore, if the CS-E-780 testing is relevant, it is only a part of the compliance package.

response

Partially accepted.  
The sentence has been revised to read 'may be used to support compliance'.

comment

196

comment by: Aerospace Industries Association

<b>Affected page number</b>	Page: 66 Paragraph: AMC 25.1093(b) 1.1 paragraph 7
<b>What is your concern and what do you want changed in this paragraph?</b>	<u>The proposed text states:</u> Referring to CS-E 780, the engine must function satisfactorily without unacceptable: <b>Requested Change:</b> <b>In those cases where the inlet IPS is tested with the engine;</b> referring to CS-E 780, the engine must function satisfactorily without unacceptable:
<b>Why is your suggested change justified?</b>	<b>JUSTIFICATION:</b> Since not all applicants show compliance using engine testing with the inlet, it is respectfully suggested that the text related to engine performance metrics be clarified.

response

Partially accepted.  
This paragraph, referring to the CS-E 780 criteria, has been deleted in order to avoid confusion with the engine test for CS-E certification.



comment

197

comment by: Aerospace Industries Association

<b>Affected page number</b>	Page: 67 Paragraph: AMC 25.1093(b) 1.1 paragraph 8
<b>What is your concern and what do you want changed in this paragraph?</b>	<u>The proposed text states:</u> Ice accretion occurring during the holding phase, which may be ingested during descent at Idle power/thrust (potentially critical for engine performance and handling characteristics) or - Ice accretion occurring during the descent at Idle power/thrust (with potentially a reduced ice protection availability), which may be ingested during a Go Around at Take-Off power/thrust (potentially critical for mechanical damage).
<b>Why is your suggested change justified?</b>	<b>JUSTIFICATION:</b> AMC E 780 does not currently include engine ice ingestion at the idle power setting or any definition of test engine power level. This requirement does not appear to be harmonized with CS E 780. It is respectfully suggested that a comment suggesting that the AMC E 780 include the following text which is harmonized with the FAA: <b><u>Engine operation will be at the maximum cruise power or thrust unless lower power is more critical.</u></b>
<b>Affected page number</b>	Page: 67 Paragraph: AMC 25.1093(b) 1.1 paragraph 11
<b>What is your concern and what do you want changed in this paragraph?</b>	<u>The proposed text states:</u> Air intakes that have proven unlimited operation in icing may allow runback ice formation during holding, straight-line flight and descent. <b>Requested Change:</b> <b>To demonstrate</b> air intakes have proven unlimited operation in icing, <b>any</b> runback ice formation during holding, straight-line flight and descent <b>must demonstrate an accretion and shed cycle and be evaluated against the demonstrated ingestion capability of the engine per CS-E 780.</b>
<b>Why is your suggested change justified?</b>	<b>JUSTIFICATION:</b> Respectfully proposed here is a clarification to this sentence, as it is similar to one in AC20-147, but not identical.
<b>Affected page number</b>	Page: 67 Paragraph: AMC 25.1093(b) 1.1 paragraph 12
<b>What is your concern and what do you want changed in this paragraph?</b>	<u>The proposed text states:</u> When thermal IPS is used, air intake designed to be evaporative under the critical points in continuous maximum icing conditions, and running wet under intermittent maximum icing conditions (Appendix C to CS-25) has shown satisfactory service experience. <b>Requested Change:</b> When thermal IPS is used, air intake designed to be evaporative under the critical points in continuous maximum icing conditions, and running wet under intermittent maximum icing conditions (Appendix C to CS-25) has shown satisfactory service experience. <b>If the inlet is running wet in maximum continuous atmospheric</b>



response

	<b><u>conditions, then the applicant should calculate the amount of runback ice that would accumulate during a holding condition and compare that to the maximum certified ingestion capability of the engine per CS-E 780</u></b>
<b>Why is your suggested change justified?</b>	<b>JUSTIFICATION:</b> It is respectfully requested that the above text be added, in order to align with AC20-147 and include actions necessary if the inlet does not meet the criteria in the previous sentence.

Comment 1: Accepted.

Comment 2: Partially accepted. The paragraph has been revised for clarification. The option to operate fully evaporative is maintained.

Comment 3: The paragraph has been fully rewritten to meet the intent of this comment.

comment

198

comment by: Aerospace Industries Association

<b>Affected page number</b>	Page: 67 Paragraph: AMC 25.1093(b) 1.2 paragraph 1
<b>What is your concern and what do you want changed in this paragraph?</b>	<u>The proposed text states:</u> In lack of other evidence, a delay of two minutes is a reasonable time to include both pilot reaction to select the IPS and shed the ice from the air intake perimeter. <b>Requested Change:</b> In lack of other evidence, a delay of two minutes is a reasonable time to include both pilot reaction to select the IPS <del>and shed the ice from the air intake perimeter.</del>
<b>Why is your suggested change justified?</b>	<b>Justification:</b> It is respectfully noted that there is an inconsistency in this paragraph. In paragraph 2.2 and other AC material the 2 minutes is traditionally used as the time for pilot recognition of the icing and to switch on the system, but does not include time for ice to shed.

response

Accepted.

comment

199

comment by: Aerospace Industries Association

<b>Affected page number</b>	Page: 68 Paragraph: AMC 25.1093(b) 1.3 paragraph 3
<b>What is your concern and what do you want changed in this paragraph?</b>	<u>The proposed text states:</u> Identification of Engine Air intake ice accretion sources includes, for Appendix O to CS-25 icing environment, an assessment of air intake differing impingement limits, catch efficiency, distribution effects,



	<p>and water contents. The applicant should evaluate the potential ice accumulation aft of the engine air intake protected surfaces for the possibility of ice ingestion by the engine.</p> <p><b>Requested Change:</b>  <u>For airframe ice sources, for compliance with Appendix O to CS-25 icing environment, the installer may use qualitative analysis of the design and supported by similarity to previous design that have shown successful service history to have confidence that the historical methodology for certification represented by “AMC E-780 (4) Ice Ingestion Table 3 Minimum ice slab Requirements Based on Engine Inlet Size” is appropriate.</u>  <u>For Engine air intakes, compliance may be shown through qualitative analysis of the design, supported by similarity to a previous design that has shown successful service history (compliance to the AMC E-780 Table 2 “Large Droplet Condition” would still be required for ground idle taxi conditions). If similarity is not shown, then</u> Identification of Engine Air intake ice accretion sources includes, for Appendix O to CS-25 icing environment, an assessment of air intake differing impingement limits, catch efficiency, distribution effects, and water contents. The applicant should evaluate the potential ice accumulation aft of the engine air intake protected surfaces for the possibility of ice ingestion by the engine</p>
<b>Why is your suggested change justified?</b>	<p><b>JUSTIFICATION:</b> The Engine Harmonization Working Group (EHWG) has reviewed the history of in flight engine icing events, including potential ice from airframe sources. The EHWG review did not note any in-flight engine events have been attributed to large drop conditions. Current design and compliance methods have resulted in engine designs that have had no known safety events due to supercooled large droplet icing. It is respectfully suggested that, as additional analysis or test would not improve safety, it should be explicitly allowed to use similarity to current designs to show compliance for Appendix O conditions.</p>
<b>Affected page number</b>	<p>Page: 68  Paragraph: AMC 25.1093(b) 1.3 paragraph 4</p>
<b>What is your concern and what do you want changed in this paragraph?</b>	<p><u>The proposed text states:</u>  The applicant should assess the ice accumulations and compare them on the basis of the kinetic energy of the ice slab. Kinetic energy may be used as an acceptable method for comparing the airframe ice source to the results of the CS-E 780 ice ingestion demonstration. Any kinetic energy method must be agreed to by the Agency.</p> <p><b>Requested Change:</b>  The applicant should assess the ice accumulations and compare them on the basis of the kinetic energy of the ice slab. Kinetic energy may be used as an acceptable method for comparing the airframe ice source to the results of the CS-E 780 ice ingestion demonstration. Any kinetic energy method must be agreed to by the Agency. <b>It is normally sufficient to show that ice accumulations are smaller in</b></p>





	<b><u>size and therefore equal to or have less kinetic energy than the CS-E 780 ice ingestion slab.</u></b>
<b><i>Why is your suggested change justified?</i></b>	<b><u>JUSTIFICATION:</u></b> It is respectfully noted that an applicant should be allowed to use ice slab size (only), without a requirement to evaluate the kinetic energy. This will improve harmonization with FAA AC 20-147. If comparison of ice size is not allowed, then further guidance on the assumptions of a kinetic energy calculation are needed – how is the slab oriented? At what % span does it hit? Does it break in pieces like the test slab? Challenges defining such criteria are what led the FAA to allow comparison by size only.

response **Comment 1:** Not accepted. Rulemaking task RMT.0572 will investigate aspects related to similarity analysis.  
**Comment 2:** Accepted.

comment 200

comment by: Aerospace Industries Association

<b><i>Affected page number</i></b>	Page: 70-71 Paragraph: AMC 25.1093(b) 2
<b><i>What is your concern and what do you want changed in this paragraph?</i></b>	<p><b><u>The following changes are proposed to section 2:</u></b></p> <p>2 Testing</p> <p>The engine air intakes may be tested with the engine and propeller where appropriate in accordance with the specifications of CS-E 780 and AMC E 780.</p> <p>[...]</p> <p>In establishing compliance with the requirements of CS 25.1093(b)(1), <b><u>in conjunction with the CPA, a thorough validation of the IPS may include .</u></b></p> <ul style="list-style-type: none"> <li>• Flight tests in dry air with ice protection equipment operating,</li> <li>• Flight tests in icing conditions, natural or artificial, and</li> <li>• Ground tests in icing wind tunnel.</li> </ul> <p>[...]</p> <p>In establishing compliance with the requirements of CS 25.1093(b)(1), reference should be made to AMC 25.1419, paragraph (b), for the assessment of the Appendix C icing environment, <del>in</del> particular for the following aspects:</p> <p>2.1 Icing Wind Tunnel Tests</p> <p>[...]</p> <p>The engine air intakes may be tested with the engine and propeller where appropriate in accordance with the specifications of CS-E 780 and AMC E 780.</p> <p>Where the air intakes is assessed separately (e.g. <b><u>icing wind tunnel evaluation of IPS performance</u></b>, lack of suitable test facilities for <b><u>engine and inlet</u></b>, change in the design of the air intake, air intake different from one tested with the engine), it should be shown that</p>



	<p>the effects of air intakes icing would not invalidate the engine tests of CS-E.</p> <p>Factors to be considered in such evaluations are:</p> <ul style="list-style-type: none"> <li>• distortion of the airflow and partial blockage of the air intakes,</li> <li>• <b><u>The demonstrated ice ingestion capability per CS-E 780</u></b></li> <li>• the icing of any engine sensing devices, other subsidiary air intakes or equipment contained within the air intake, and</li> <li>• the time required to bring the protective system into full operation.</li> </ul>
<b>Why is your suggested change justified?</b>	<p><b>JUSTIFICATION:</b> It is respectfully suggested that the text be rearranged and edited as above, to emphasize the combination of tests that could be used for compliance. Icing wind tunnel tests were added as a test appropriate for IPS validation without the engine needing to be present. It is also suggested that the ice shed capability of the engine be reworded as above. A similar comment is proposed for CS-E 780.</p>
response	<p>Partially accepted.</p> <p>The second paragraph of 2.2 has been updated to add the proposed examples.</p> <p>The bullet on demonstrated ice ingestion capability has also been updated.</p>

comment	201	comment by: Aerospace Industries Association
<b>Affected page number</b>	<p>Page: 71</p> <p>Paragraph: AMC 25.1093(b) 2.1 paragraph 1</p>	
<b>What is your concern and what do you want changed in this paragraph?</b>	<p><u>The proposed text states:</u></p> <p>Icing wind tunnels provide the ability to simulate natural icing conditions in a controlled environment and they have also been used in particular to evaluate performance of ice protection systems (IPS), such as pneumatic and thermal systems.</p> <p><b>Requested Change:</b></p> <p>Icing wind tunnels provide the ability to simulate natural icing conditions in a controlled environment and they have also been used in particular to evaluate performance of ice protection systems (IPS), such as pneumatic and thermal systems. <b><u>The primary purpose of icing wind tunnel testing is to determine that the IPS is acceptably effective and performs its intended functions during icing conditions as predicted by analysis. Applicants may reference AMC25.1419 (4) for guidance</u></b></p>	
<b>Why is your suggested change justified?</b>	<p><b>JUSTIFICATION:</b> It is proposed that text similar to that in AMC25.1419 be used to introduce the purpose of the icing wind tunnel testing.</p>	
<b>Affected page number</b>	<p>Page: 71</p> <p>Paragraph: AMC 25.1093(b) 2.1 paragraph 5</p>	



<p><b>What is your concern and what do you want changed in this paragraph?</b></p>	<p>The proposed text states: Flight conditions may need to be corrected to allow simulation in a wind tunnel. To achieve this, the location of the stagnation point on the inlet lip, the free stream dynamic pressure, the impact temperature of the water droplets, and the amount of water runback at the throat should be maintained between flight and wind tunnel conditions</p> <p><b>Requested Change:</b> Flight conditions may need to be corrected to allow simulation in a wind tunnel. To achieve this, the location of the stagnation point on the inlet lip, and the amount of water runback at the throat should be maintained between flight and wind tunnel conditions. <b><u>Other test parameters, such as static or total air temperature, may require “similarity” adjustments to achieve the best match of icing conditions parameters, such as those described in AC20-73A.</u></b></p>
<p><b>Why is your suggested change justified?</b></p>	<p><b>JUSTIFICATION:</b> It is respectfully suggested that, while this is a useful, general discussion of the intent of the icing tunnel tests, typical icing similarity calculations are more involved than those described. The “impact temperature” of water drops is not necessarily the same between <i>flight</i> and test for the best icing similarity match. It is not possible in all cases to match flight dynamic pressure. AC20-73A, Appendix R, “ICE SHAPES” has a more complete discussion of the icing similarity calculations and variables. DOT/FAA/CT-86/35, “An Analytical Study of Icing Similitude for Engine Testing” offers a more complete explanation specific to engine testing. This change would also improve harmonization between the EASA and FAA guidance materials.</p>
<p>response</p>	<p>Comment 1: Not accepted. The proposed additional text does not bring clarification. Comment 2: Accepted.</p>

comment 202

comment by: Aerospace Industries Association

<p><b>Affected page number</b></p>	<p>Page: 72 Paragraph: AMC 25.1093(b) 2.1 paragraph 10</p>
<p><b>What is your concern and what do you want changed in this paragraph?</b></p>	<p>The proposed text states: Each test should be run at different engine powers/thrusts, including the minimum power/thrust for which satisfactory operation in icing conditions is claimed.</p> <p><b>Requested Change:</b> Each test should be run at <b><u>(or simulate conditions of)</u></b> different engine powers/thrusts, including the minimum power/thrust for which satisfactory operation in icing conditions is claimed</p>
<p><b>Why is your suggested</b></p>	<p><b>JUSTIFICATION:</b> It is respectfully suggested that, if an inlet is</p>



	<b>change justified?</b>	run alone in the tunnel, it should still attempt to simulate the inlet airflow correctly for different engine powers/thrust.
response	Accepted.	

comment	203	comment by: Aerospace Industries Association
	<b>Affected page number</b>  <b>What is your concern and what do you want changed in this paragraph?</b>  <b>Why is your suggested change justified?</b>	Page: 71 Paragraph: AMC 25.1093(b) 2.1 paragraph 7  <u>The proposed text states:</u> For the evaluation of the performance of the IPS, the following conditions have been successfully used in the past to simulate CS-25 Appendix C conditions:  <b>Requested Change:</b> For the evaluation of the performance of the IPS, the following conditions have been successfully used in the past, <b>in lieu of a complete CPA</b> , to simulate CS-25 Appendix C conditions  <b>Justification:</b> It is respectfully proposed to make it clear that these test points are only done by applicants who are not conducting a complete CPA, and are only testing the most critical points.
response	Accepted.	

comment	204	comment by: Aerospace Industries Association
	<b>Affected page number</b>  <b>What is your concern and what do you want changed in this paragraph?</b>	Page: 72 Paragraph: AMC 25.1093(b) 2.1 paragraph 9  <u>The proposed text states:</u> 1) 28 km (17.4 NM) in the conditions of Table 2, column (a), appropriate to the temperature, followed by 5 km (3.1 NM) in the conditions of Table 2, column (b), appropriate to the temperature, for a total duration of 30 minutes, or 2) 6 km (3.7 NM) in the conditions of Table 2, column (a), appropriate to the temperature, followed by 5 km (3.1 NM) in the conditions of Table 2, column (b), appropriate to the temperature, for a total duration of 10 minutes  <b>Requested Change:</b> 1) 28 km ( <b>15.1</b> <del>17.4</del> NM) in the conditions of Table 2, column (a), appropriate to the temperature, followed by 5 km ( <b>2.7</b> <del>3.1</del> NM) in



	the conditions of Table 2, column (b), appropriate to the temperature, for a total duration of 30 minutes, or 2) 6 km ( <del>3.2</del> 3.7 NM) in the conditions of Table 2, column (a), appropriate to the temperature, followed by 5 km ( <del>2.7</del> 3.1 NM) in the conditions of Table 2, column (b), appropriate to the temperature, for a total duration of 10 minutes.
<b>Why is your suggested change justified?</b>	<b>Justification:</b> It is respectfully suggested to correct the nautical mile conversion from kilometers in the text above.
<b>Affected page number</b>	Page: 72 Paragraph: AMC 25.1093(b) 2.1 paragraph 12
<b>What is your concern and what do you want changed in this paragraph?</b>	<u>The proposed text states:</u> If there is a minimum power/thrust required for descent to insure satisfactory operation in icing conditions, the increase to that minimum power/thrust in icing conditions should be automatic when in icing conditions, and this minimum power/thrust associated with descent in icing conditions should be assessed against the conditions in Table 1. <b>Requested Change:</b> If there is a minimum power/thrust required for descent to <b>ensure</b> <del>insure</del> satisfactory operation in icing conditions, the increase to that minimum power/thrust in icing conditions should be automatic when <b>the IPS is switched on</b> <del>in icing conditions</del> , and this minimum power/thrust associated with descent in icing conditions should be assessed against the conditions in Table 1.
<b>Why is your suggested change justified?</b>	<b>Justification:</b> It is respectfully suggested to correct the typographical error from “insure” to “ensure”. Also it is proposed to clarify the meaning of “automatically” – which is when the ice protection system is switched on.
response	Comment 1: Accepted. Comment 2: Accepted.

comment 205

comment by: Aerospace Industries Association

<b>Affected page number</b>	Page: 74 Paragraph: AMC 25.1093(b) 2.4 (b) 1. – 2.
<b>What is your concern and what do you want changed in this paragraph?</b>	<u>The proposed text states:</u> 1. Critical Points Analysis (CPA). The actual test temperatures should result from a CPA conducted to determine the critical ice accretion conditions for air intake and engine. 2. Ground taxi exposure to Appendix O conditions. The service experience indicates that engine fan damage events exist from



	<p>exposure to SLD during ground taxi operations. For this reason, an additional condition of a 30-minute, idle power/thrust exposure to SLD on the ground must be tested. Applicants should include the terminal falling velocity of SLD (for example, freezing rain, freezing drizzle) in their trajectory assessment, relative to the protected sections of the air intake. The 100 micron minimum mean effective diameter (MED) is selected as a reasonable achievable test condition, given current technology. We recommend, however, that applicants choosing to certify by analysis evaluate the Appendix O drop sizes up to a maximum of 3000 microns particle size to find a critical condition.</p> <p><b>Requested Change:</b></p> <p>1. Critical Points Analysis (CPA). The <del>actual test</del> temperatures should, <b><u>consider the full range of temperatures in the Rule</u></b>, result from an conducted to determine the critical ice accretion conditions for air intake <del>and engine</del>.</p> <p>2. Ground taxi exposure to Appendix O conditions. The service experience indicates that engine fan damage events exist from exposure to SLD during ground taxi operations. For this reason, an additional condition of a 30-minute, idle power/thrust exposure to SLD on the ground must be <b>addressed</b>. Applicants should include the terminal falling velocity of SLD (for example, freezing rain, freezing drizzle) in their trajectory assessment, relative to the protected sections of the air intake. The 100 micron minimum mean effective diameter (MED) is selected as a reasonable <del>achievable test</del> condition, given current technology. We recommend, however, that applicants choosing to certify by analysis evaluate the Appendix O drop sizes up to a maximum of 3000 microns particle size to find a critical condition.</p>
<b>Why is your suggested change justified?</b>	<p><b>JUSTIFICATION:</b> It is respectfully recommended that the range of test points in the rule be referenced. The wording referencing the engine CPA may confuse applicants; therefore, it is proposed to be removed. The assessment of critical points for the inlet does not need to include the engine CPA, only the heat available to the IPS from the engine in its minimum performance condition. This requirement can be met by analysis, so a test is not required.</p>

response Accepted.

comment 209

comment by: Rolls-Royce plc (ZM)

Comment Summary

Typographical correction

Comment Resolution

Replace "required for descent to insure satisfactory operation" with "required for descent to ensure satisfactory operation"



response Accepted.

comment 210

comment by: *Rolls-Royce plc (ZM)*

Comment Summary

The EHWG has reviewed the history of in flight engine icing events, including potential ice from airframe sources. The EHWG review did not note any in-flight engine events have been attributed to large droplet conditions. Current design and compliance methods have resulted in engine designs that have had no known safety events due to supercooled large droplet icing. As additional analysis or test would not improve safety, a comparative analysis between the good experience of previous designs and the new design should be acceptable to show compliance with Appendix O conditions.

Comment Resolution

Add "For Engine air intakes, compliance may be shown through comparative analysis with previous design(s) that has demonstrated successful service history

response Not accepted.

Similarity analysis provisions will be treated under rulemaking task RMT.0572.

comment 211

comment by: *Rolls-Royce plc (ZM)*

Comment Summary

The two minutes' delayed selection appears to be inconsistent with NPA 2012-23. NPA 2012-23 uses two minutes as the time for the pilot to detect icing and activate anti-icing systems, whereas NPA 2012-22 includes the time to ice shedding in this.

Comment Resolution

Consider replacing "a delay of two minutes is a reasonable time to include both pilot reaction to select the IPS and shed the ice from the air intake perimeter." with "a delay of two minutes is a reasonable time to include both pilot detection and activation of the IPS".

response Partially accepted.

The text is updated to read 'In lack of other evidence, a delay of two minutes to switch on the IPS should be assumed. For thermal IPS, the time for the IPS to warm up should be added.'

comment 212

comment by: *Rolls-Royce plc (ZM)*

Comment Summary

As worded, this section appears to require a 30 minute, or potentially 45 minute, test at conditions consistent with a descent in icing conditions. This seems to be inappropriate, given that exposure to icing during descent is inevitably limited by the time to pass vertically through a cloud. It is proposed that this section be separated into a part which refers to minimum hold powers and above and a part which refers to powers at which the aircraft would be unable to maintain level flight.

Comment Resolution

Remove the paragraph "If there is a minimum power/thrust required for descent to insure satisfactory operation in icing conditions, ..."

and create a new section for powers/thrusts below that required to ensure unlimited operation in icing conditions. This should consist of a test of limited duration. For consistency



	with FAA AC 20-147a, it is proposed that this test be "6500 foot descent through the CS-25 appendix C continuous maximum cloud, with extent factor = 1, followed by an appendix C intermittent maximum exposure".
response	<p>Not accepted.</p> <p>In the paragraph dealing with the test duration, the second sentence is updated to read: 'If this is not the case, the test should continue until a maximum duration of 45 minutes, except for descent where the test duration may be limited to the time needed to cover an anticipated descent of 3 000 m.'</p>
comment	<p>213 <span style="float: right;">comment by: Rolls-Royce plc (ZM)</span></p>
	<p><u>Comment Summary</u></p> <p>The test described in (1) calls for a 28km-5km cycle between continuous maximum and intermittent maximum. This is more severe than required in FAA AC 20-147a. It is proposed that CS-25 be aligned with the FAA Advisory Circular</p> <p><u>Comment Resolution</u></p> <p>Replace "1) 28 km (17.4 NM) in the conditions of Table 2, column (a), appropriate to the temperature, followed by 5 km (3.1 NM) in the conditions of Table 2, column (b), appropriate to the temperature, for a total duration of 30 minutes,"</p> <p>with "1) 45 minute hold, in appendix C continuous maximum, with an extent factor = 1 for hold powers. 45 minute exposure in Appendix C continuous maximum with an extent factor, followed by an Appendix C intermittent maximum exposure for straight line flight."</p>
response	<p>Not accepted.</p> <p>The scenario of the AMC are retained. They were already used in the past. Note that the CPA may identify different scenarios. Refer to paragraph 1.1 which states:</p> <p>'For Appendix C icing conditions, in lieu of a detailed CPA, the conditions specified in paragraph 2.1, "Icing wind tunnel tests", are acceptable and can be used for testing without further justification.'</p>
comment	<p>214 <span style="float: right;">comment by: Rolls-Royce plc (ZM)</span></p>
	<p><u>Comment Summary</u></p> <p>The tests described are in liquid water contents which are higher than required in FAA AC 20-147a. It is suggested that CS-25 could be aligned with the FAA Advisory Circular. Conversely, EASA may wish to align the propulsion system intake IPS requirements with CS-E by maintaining the Table 2 liquid water contents.</p> <p><u>Comment Resolution</u></p> <p>Replace reference to Table 2 with a reference to Appendix C.</p>
response	<p>Not accepted.</p> <p>We assume the comment intended to refer to Table 1 conditions of AMC 25.1093(b). Please note that these conditions are consistent with Table 1 of AMC E 780.</p>
comment	<p>215 <span style="float: right;">comment by: Rolls-Royce plc (ZM)</span></p>
	<p><u>Comment Summary</u></p> <p>If testing to the alternative 10 minute conditions, as worded this should be extended to 45</p>



response	<p>minutes if steady state conditions are not established.</p> <p><u>Comment Resolution</u></p> <p>Replace "until a maximum duration of 45 minutes"</p> <p>with "until a maximum duration of 45 minutes if using test (1) or 15 minutes if using test (2)".</p> <p>Accepted.</p>
comment	<p>216 <span style="float: right;">comment by: <i>Rolls-Royce plc (ZM)</i></span></p>
	<p><u>Comment Summary</u></p> <p>This section states that the natural icing flight tests are to demonstrate that the engine is capable of operating throughout the flight thrust range. However, this has already been demonstrated through compliance with CS-E certification requirements. We believe that the primary purpose of the natural icing flight tests is to demonstrate those components of the powerplant which have not already been demonstrated during CS-E certification, in particular the intake IPS. As such, it is proposed that the second paragraph be amended.</p> <p><u>Comment Resolution</u></p> <p>Replace "intended to demonstrate that each turbine engine is capable of operating throughout the flight power/thrust range of the engine (including idling), without an adverse effect"</p> <p>with "intended to demonstrate that each powerplant IPS is capable of operating throughout the flight power/thrust range of the engine (including idling), without an adverse effect".</p>
response	<p>Not accepted.</p> <p>The intent is not to demonstrate that the IPS of the powerplant is capable to operate, rather to demonstrate that the engine is adequately protected and operates satisfactorily.</p>
comment	<p>217 <span style="float: right;">comment by: <i>Rolls-Royce plc (ZM)</i></span></p>
	<p><u>Comment Summary</u></p> <p>Replace "idle power/thrust exposure to SLD on the ground must be tested"</p> <p>with "idle power/thrust exposure to SLD on the ground must be assessed"</p>
response	<p>Partially accepted.</p> <p>'tested' was replaced by 'addressed'.</p>
comment	<p>218 <span style="float: right;">comment by: <i>Rolls-Royce plc (ZM)</i></span></p>
	<p><u>Comment Summary</u></p> <p>The test is a validation of the analysis and thus may not be conducted at the most severe case.</p> <p><u>Comment Resolution</u></p> <p>Replace "... should assess the ice accumulations and compare them with the amount of ice the engine has satisfactorily demonstrated to ingest ..."</p> <p>with "... should assess the ice accumulations and compare them with the predicted runback analysed for that condition. The maximum predicted runback accretion from the CEA should be compared with the amount of ice the engine has satisfactorily demonstrated to ingest ...".</p>
response	<p>Not accepted.</p> <p>Tests should be run with critical icing conditions, either determined through a CPA, or using</p>



the (severe) conditions provided in Table 1 of paragraph 2.1. Whatever the option selected by the applicant, the results of the tests may indeed be used to check the outcome of any analysis predicting the size of the runback ice, but it should also be compared to the ice ingestion capability of the engine.

**B. Draft Decision — I. Draft Decision amending CS-25 — Book 2; AMC — SUBPART F — AMC  
25.1324 Flight instrument external probes heating systems**

p. 74-82

comment 5

comment by: *UTC Aerospace Systems - Sensors & Integrated Systems*

Page 75 section 2

The environments listed in Appendix D are difficult to replicate in wind tunnels. Scaling methods for properly handling wind tunnel limitations when testing equipment in Appendix D conditions are not common methods that have been published and proven in the industry. Recent testing suggests that “Sea Level” testing may not be a conservative assumption for ice crystal testing for some probe designs. Altitude is an important parameter in Ice crystal testing and may need to be accounted for.

Verification of the calibration after testing is not consistent with SAE ARP 5905 or industry practice and will drive additional cost into the testing with no measureable improvement in the validity of the test results. Please note ARP 5905 requires calibration on a periodic basis. UTAS recommends calibration prior to testing or verification of compliance to ARP 5905. There is no need to re-verify calibration after testing unless there has been an anomaly during the testing.

Page 75 section 3

UTAS has not found the concept of surface temperature measurement to be a common practice for extrapolating from one icing condition to another. Adding temperature measurement devices to the surface of the probe can skew the results of the testing. Please clarify what is meant by this paragraph.

Page 76 section 4

It is difficult to account for splashing and bouncing effects because there are no validated methods for this. This could lead to inconsistencies across the industry.

Page 76 section 6

UTAS recommends keeping this language consistent with the pitot/pitot-static probe ETSO requirement for power supply setting requirement developed by EUROCAE Working Group 89 and SAE AC-9C.

Page 76 section 7

UTAS is concerned that the requirement to test icing conditions at the power level equal to probe heater monitor fault indication will not improve safety and will create a significant problem for probe manufacturers and aircraft OEMs. The power that needs to be monitored varies widely depending on flight condition, and simply monitoring power will not detect the underlying condition that leads to un-annunciated failure.

Typical probe heater monitors in use today are only designed to seek minimum and maximum current and therefore have very wide tolerances on those values. A probe heater monitor able to operate with the extremely tight tolerances required by this concept would need inputs and calculations based on supply voltage, Liquid Water Content (LWC), Ice Water Content (IWC), altitude, airspeed, Angle of Attack (AOA), Angle of Sideslip (AOS), Total Air Temperature (TAT) and perhaps other parameters. This will lead to much more complex and costly probe heater monitors than the typical devices in use today. These new devices will



not significantly increase the level of safety because they are unlikely to detect the cause of the observed incidents as discussed in the next paragraph. In addition, the tight tolerances required to implement this new concept are likely to lead to nuisance faults that will undermine flight crew confidence in the system.

The situations that highlighted a need for stricter probe heater monitoring were caused by probes that had a short to case not detected by the probe heater monitor. Combined with monitoring for minimum current draw, adding a requirement for the probe heater monitor to detect short-to-case situations will address the issue and provide an improvement in safety.

UTAS feels that industry study into the practicality of implementing a requirement for “abnormal function” indication of the probe heating system should be undertaken prior to formal implementation of this requirement.

Page 77 section 8

This section must allow for scaling of the applied heater voltage to accomplish the intent. It is impractical to intentionally produce a probe at the lowest value of the ATP.

Page 77 section 10.1

Given typical airspeeds, the test durations proposed in 10.1 are excessively conservative when compared with the respective icing cloud lengths of JAR Part 25 Appendix C. UTAS recommends either providing a cloud length that is consistent with the requirements of section 10.2 or reducing the durations to be more representative of actual Continuous Maximum and Intermittent Maximum icing encounters. This would be more consistent with the industry consensus reached by EUROCAE Working Group 89 in its draft document AS5562.

Page 79 section 12.1

Please clarify what duration of testing should accompany the peak concentrations.

Page 80 section 12.2

Please clarify the concentrations of LWC and IWC that should be tested. Also, the general industry understanding is that liquid water does not exist below -40°C so it is recommended to truncate the graph at -40°C for this “mixed phase” section of the NPA.

Page 80 section 12.3

A 150 micron ice crystal is not necessarily the most practical for all tunnels. Please delete this comment and leave the 50-1000 range as listed in the first paragraph of this section.

Page 81 end of 1<sup>st</sup> full paragraph on section 14

Change “no effect” to “no unacceptable effect”.

Page 82 top of the page

Based on discussions at EUROCAE Working Group 89 meetings, UTAS recommends deleting the last two sentences of the pass/fail criteria which state, “After each test, any moisture accumulating in the probe connection line shall be removed and measured. A maximum of 1 gram should not be exceeded.” The working group (which included EASA participation) agreed to drop this requirement because the sentence preceding it covers the intent, and it is very difficult to accurately extract and measure the moisture remaining in the probe.

response

Page 75 section 2: Accepted. The paragraph has been modified to say that the icing wind tunnel calibration should have been verified, in accordance with SAE ARP 5905 with an established programme to maintain calibration of the facility.

Page 75 section 3: Accepted. The wording has been revised to clarify that we are speaking about the probe mounting.

Page 76 section 4: Noted, but this needs to be considered and, therefore, the text is maintained.

Page 76 section 6: Accepted, the paragraph has been completed to say that it is commonly



accepted to test the probe at 10 % below the nominal rated voltage.

Page 76 section 7: Refer to response to comment 4.

Page 77 section 8: Accepted. The paragraph now includes that this can be accomplished by adjusting the test voltage, heating cycles and/or any other applicable parameters, to simulate the lowest performing probe.

Page 77 section 10.1: Noted. The Agency participated in EUROCAE WG-89 and was ready to consider improved test conditions. However, some tests conducted with the new proposed test conditions revealed that these conditions were too severe. Therefore, the Agency retains the proposed historical test conditions from which a positive experience is acknowledged.

Page 79 section 12.1: Accepted. A new paragraph, 12.4 Duration, has been added to specify that the test duration should be 2 minutes minimum. This has been recommended by the EUROCAE WG-89 and is used in the EASA CRI.

Page 80 section 12.2: Accepted. A note has been added below the mixed phase conditions graph to recognize this fact.

Page 80 section 12.3: Partially accepted. The reference to 150 µm has been removed, and the statement on ballistic trajectories for sizes in the range 50 to 1 000 µm as well (a commenter recommended this arguing this not established). The text now recommends a range of 50 to 200 µm.

Page 81 end of 1st full paragraph on section 14: Not accepted. The proposed wording does not improve the intent of the paragraph.

Page 82: Partially accepted. The sentence has been revised to remove the 1 gram criterion. However, the recommendation to collect and analyse the accumulated water is maintained and this is in line with EUROCAE WG-89 recommendation.

#### **Cessna comment on section 2 (page 75):**

"The icing wind tunnel calibration shall be verified, in accordance with SAE ARP 5905, prior to the beginning of the icing test campaign, and at the end of the campaign. In particular, the local liquid water concentration at the location of the probe shall comply with values required in the test specification."

The calibration process per SAE ARP 5905 is very extensive in content and time and is not practical to perform at the beginning and end of the testing. Much of the icing performance of a facility is inherent in the facility design and is not subject to drift or changes over time. Performing a full SAE ARP 5905 calibration with periodic checks on parameters subject to change should be sufficient. Recommend revision of language

Suggested change :

"The icing wind tunnel calibration shall have been verified, in accordance with SAE ARP 5905 with an established program to maintain calibration of the facility. Calibration records should be examined to ensure the local liquid water concentration at the location of the probe complies with values required in the test specification."

Response: Accepted.

comment 31

comment by: AIRBUS

#### **Page 75 AMC 25.1324 Flight External Probe Heating Systems**

It is recognized that ice crystal icing is a developing and evolving field and writing guidance material in such an environment is challenging. During the AIA and EIWG reviews of the proposed AMC material a wide range of interpretations and questions were raised on what scenarios should be considered and how the guidance should be applied and interpreted. It is therefore recommended that a further attempt be made to develop the AMC.



	<p>Rationale:</p> <p>The section as written does provide additional guidance and advice and is an improvement on the current AMC. However there is currently an excellent opportunity to further improve the guidance.</p> <p>Many of the EUROCAE WG89 recommendations for the updates to CS-ETSO C16 could be used to develop this section. The ETSO material defines component level requirements but the material developed by the group could be used to provide significant improvements to this section. Airbus would suggest and would be happy to support an effort to develop improved aircraft level guidance for external probe heating system which would also benefit CS-E which now includes a cross reference to CS25 probe requirements.</p> <p>It is recognized that significant research has been launched in North America (HIWC project) and Europe (HAIC project led by Airbus) and that the AMC's will need to be updated again when these projects have been completed.</p>
response	<p>Noted.</p> <p>The Agency is represented in the EUROCAE WG-89 and considers the recommendations of this group.</p>

comment	<p>33</p> <p>comment by: AIRBUS</p> <p><b>AMC 25.1324 Page 76: Subpart F 7 - Flight deck indication</b></p> <p>The current text:</p> <p><i>When a flight instrument external probe heating system is installed, CS 25.1326 requires an indication system to be provided to indicate to the flight crew when that flight instrument external probe heating system is not operating normally.</i></p> <p><i>All performances of the probe ice protection system, in particular the icing tests described in this AMC are expected to be demonstrated with equipment selected with heating power set to the minimum value triggering the flight deck indication.</i></p> <p>Should be changed into:</p> <p>When a flight instrument external probe heating system is installed, CS 25.1326 requires an indication system to be provided to indicate to the flight crew when that flight instrument external probe heating system is not operating normally.</p> <p><del>All performances of the probe ice protection system, in particular the icing tests described in this AMC are expected to be demonstrated with equipment selected with heating power set to the minimum value triggering the flight deck indication.</del></p> <p><b><u>The probe heating detection threshold, maintenance programme and probe design should all be considered when determining the power at which the probe tests will be performed. One approach would be to perform all tests described in this AMC with equipment selected with heating power set to the minimum value triggering the flight deck indication. Testing probes at powers above the detection threshold may be acceptable. However in this case alternative mitigation means shall be proposed by the applicant and acceptance by the agency obtained. Alternative means could include adequate maintenance procedures, alternative fault detection methods or alternative means to determine the aircraft's speed.</u></b></p> <p>Rationale:</p> <p>The intent of this guidance (avoidance of the effects of multiple probes operating at low power and the failure remaining undetected) can be achieved through various means.</p> <p>The guidance provided here is one means but may be overly penalizing for small aircraft with low power available (this guidance is likely to lead to higher probe heating power under</p>
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nominal operation). For larger aircraft where available power may be greater the proposed guidance may still not be possible to fully implement due to the variability of the current drawn by probes under varying conditions and the need to provide adequate margins to the warnings to avoid spurious or nuisance warnings.

Other means of achieving the same objective include defining maintenance tasks with adequate periodicity, improving the reliability of the probes (although unlikely to remove all maintenance actions), use of temperature monitoring of probes or using a back-up means to determine aircraft speed via a separate system or set of probes.

The current guidance selects one possible solution to the issue but the design selected by EASA is likely impractical for many aircraft designs and acceptable alternatives are available.

The probe to probe variability is already addressed in the icing tests through the recommendation to perform icing tests on the minimum Production Acceptance Test probes. It is also noted that the regulations proposed in NPA 2011-03 requires that the basic probes show compliance with the reinforced ice crystal requirements which is a substantial improvement.

EASA has made a design choice/assumption in defining the guidance and it is recommended to modify the text to allow applicants to choose the means most appropriate to their aircraft to achieve the objective.

response

Not accepted.

It is not understood how a maintenance programme would mitigate the heating power value used for the tests. The objective is to ensure that the demonstrated performances of the probe are maintained for heating power up to the minimum value triggering the flight deck indication.

comment

34

comment by: AIRBUS

#### AMC 25.1324 Page 76: Subpart F 10.1 – Table 1 Stabilized conditions

Delete SL5 (-40°C) liquid water stabilized test:

SL4	- 30	4,000 to 31,000 ft.	1,200 to 9,450 m	1 to 1.1	5	15 to 20
SL5	- 40	4,000 to 31,000 ft.	1,200 to 9,450 m	0.2 to 0.25	5	15 to 20

Rationale:

Due to the very low liquid water content of the test, the -40°C is unlikely to be critical to a probe. In addition at such low temperature it is unlikely that water will be in liquid form and it is believed that any free water will be in the form of ice crystals. Note that the -40°C extension in Appendix C IM conditions is labeled as “possible extent of limits” with the source document NACA TN No. 1855 stating that: “In the case of the lowest air temperature considered (-40° F) the probability of the occurrence of snow is so great that the liquid water content cannot even be approximated by calculation and, therefore, a value has been estimated.

In addition the ice crystal tests define a higher water content and lower temperatures and hence could be considered to cover this case (even if the icing mechanism differs). In practice this test condition is extremely difficult to achieve because the liquid water turns to ice crystals in the icing tunnels at such a low temperature. Rig modifications may improve the situation but much of the water is still expected to turn to ice as it traverse the icing tunnel towards the test unit. This case is enveloped by other tests in liquid water and crystal conditions.

For these reasons the EUROCAE WG89 member decided not to include a -40°C test in its proposal for a new ETSO.



	The engine intake tests listed in Table 1 AMC 25.1093b do not include a test at -40°C. If this is valid for engines and intakes it would also seem valid for air data probes.
response	Accepted.

**Cessna comment on section 7 & 8 (pages 76-77):**

Section 7 indicates that the testing should be performed with the heating power set to the minimum value trigger the flight deck indication

Section 8 indicates that the testing should be performed with the heating power at the minimum ATP value

Section 7 is not a practical requirement as the ability to perform the equivalent of a “real time” ATP on a probe in a flight environment is not possible. ATPs are typically performed in a controlled environment which provides a consistent external heat load and resulting power requirements.

The changing heat loads during flight due to variations in altitude, airspeed, ambient temperature, icing and/or ice crystal water contents results in power variations over a range of flight conditions. These external environment variations prevent having a fixed, ATP like test point. As a result the flight deck thresholds must be designed to accommodate the “normal” variations that will occur in flight without producing nuisance indications.

Technically may be possible to perform a ground pre-flight “health check” of the probe to a similar precision as an ATP, but real time, in-flight monitoring to this level of precision is not practical.

Recommend Section 7 should be deleted, or clarified that it is applicable to a pre-flight check.

Response: Not accepted. The comment is not fully understood. It seems that ATP and flight deck indication aspects are mixed. Section 8 has been clarified to provide guidance on how the lowest performing probe may be simulated.

**Cessna comment on section 4 (page 76):**

Environmental Conditions specific

o Type (SD, SLD, Crystals, Rain)

o Size (from 0 to 2000 micron)

Suggested change:

• Environmental Conditions specific

o Type (SD, SLD, Crystals, Rain)

o Size (from ~~0~~ 20 to 2000 micron)

Response: Not accepted. The proposed change does not really bring a benefit.

**Cessna comment on sections 10.1 & 10.2 (page 77):**

Tables provided in 10.1 and 10.2 are essentially Appendix C test points with extended durations. The value of presenting them in point format is limited. Also introduces inconsistency with WG89 recommendations for critical test points.

Recommend tables be replaced with WG-89 recommended supercooled liquid water test conditions, or reference appropriate Eurocae/SAE standards.

Response: Noted. The Agency participated in EUROCAE WG-89 and was ready to consider improved test conditions. However, some tests conducted with the new proposed test conditions revealed that these conditions were too severe. Therefore, the Agency retains the proposed historical test conditions from which a positive experience is acknowledged.



**Cessna comment on 9-Mode of Operation (page 77):**

If the system complies with the CS 25.1326 per NPA 2011-03, having a probe heating system switched off is an abnormal condition and will result in a crew indication. As such, a deicing test simulating flight with the probes selected off should not be required.

Current Text:

This mode need not be tested if, in all operational scenarios (including all dispatch cases), the probe heating systems are activated automatically at aircraft power 'On' and cannot be switched to manual operation later during the flight.

Proposed Text:

This mode need not be tested if, in all operational scenarios (including all dispatch cases), the probe heating systems are activated automatically at aircraft power 'On' and cannot be switched to manual operation later during the flight, **or the system complies with CS 25.1326 at Amendment tbd.**

**Response:** Not accepted. If the ice protection system of the probe heating system is not selected, then the flight deck indication will not be triggered, although the system complies with CS 25.1326.

**Cessna comment on AMC 25.1093(b) (page 72) and AMC 25.1324 (page 78)**

Table 1 on page 72 and Table 2 on page 78 do not use the same rounding when converting between feet and meter.

Suggest using following conversions:

- 17,000 ft = 5,200 m
- 20,000 ft = 6,100 m
- 25,000 ft = 7,600 m

**Response:** Partially accepted. The altitude conversions in Table 1 and Table 2 of AMC 25.1324 have been updated to provide a rounding to the nearest meter digit. Table 2 of AMC 25.1324 is consistent with Table 1 of AMC 25.1093(b).

comment

35

comment by: AIRBUS

**AMC 25.1324 Page 78 Subpart F 10.2 - Cycling condition**

Merge the stabilized and cycling tests and harmonize with the draft EUROCAE WG89 ETSO tests.

Rationale:

EUROCAE WG89 (to which EASA participated) has defined new ETSO test requirements for Pitot probes. It is recommended that the AMC and ETSO test points be harmonized to avoid inconsistencies between the probe ETSO testing and the aircraft certification requirements.

response

Noted. The Agency participated in EUROCAE WG-89 and was ready to consider improved test conditions. However, some tests conducted with the new proposed test conditions revealed that these conditions were too severe. Therefore, the Agency retains the proposed historical test conditions from which a positive experience is acknowledged.

**Cessna comment on page 78**

Titles for Tables 1 and 2

To be consistent with rest of document, these titles should be moved to top of table.

**Response:** Accepted.





comment	<p>36</p> <p>comment by: AIRBUS</p> <p>Attachment <a href="#">#6</a></p> <p><b>AMC 25.1324 Page 79 Subpart F12 - Mixed Phase (M) and Ice Crystals (S)</b></p> <p>The tables provided in attachment to this comment should be added.</p> <p>Rationale:</p> <p>EASA has defined icing test points for supercooled liquid water but not for ice crystals and mixed phase conditions. The crystal and mixed conditions are new and hence the conditions for which guidance is most needed. Most, if not all, applicants will have difficulty performing a CPA as for these conditions there is currently no guidance available on how to do this. Many applicants and certification specialists are likely to find these new test conditions difficult to interpret (what is the required duration, IWC, temperature etc.?) However the draft proposed test conditions from EUROCAE WG89 (see proposed tables) are available and can be considered the best current estimate of appropriate test conditions for air data probes. EASA participated to this group and will be aware that the group has developed conservative test conditions for ice crystals and mixed phase icing. As an interim measure while the research results are awaited these test conditions should be adopted in the AMC. The attached tables are those developed by EUROCAE WG89 (in coordination with the SAE AC 9C committee) for mixed phase and ice crystal conditions.</p> <p>It is recognized that research results on the ice crystal threat aloft and means to deal with it are expected in 2015 and the AMC will be updated once this additional information is available.</p> <p>Nevertheless in advance of this work the results of the WG89 (the group consisted of industry and regulatory experts) can be considered the best currently available definition of test conditions for Pitot probes.</p> <p>It is recognized that some aspects of the test conditions such as installation coefficient and aircraft speed will be dependent upon the aircraft but the altitude, IWC, duration and temperature can all be defined independently and can be taken from the WG89 proposals.</p>
response	<p>Not accepted.</p> <p>The table of points developed by the EUROCAE WG-89 are peak values determined along with aircraft dependent parameters (airspeed, altitude, temperature).</p> <p>It is preferred to provide upstream peak values in AMC 25.1324, and it will be up to the applicant to propose other parameters that are pertinent to the aircraft project.</p>

#### **Cessna comment on 12.4-Total Air Temperature probe design considerations (page 81)**

As written, the requirement to use data from sources of dissimilar technologies would prohibit the use of two different electrically heated sensors, a configuration that has been accepted in the past and is used on several current production applications. As long as appropriate mitigation can be achieved as determined by the safety assessments, the number and types of sources should not be specified in the regulations.

Current Text:

System safety assessments must include common mode failure conditions. Mitigation for potential icing related failures at the aircraft level should be accomplished as required by the Air Data System and/or by the primary data consumers, specifically, by comparing air data from multiple sources and from sources of dissimilar technologies.

Proposed Text:

System safety assessments must include common mode failure conditions. Mitigation for potential icing related failures at the aircraft level should be accomplished as required by the Air Data System and/or by the



primary data consumers, ~~specifically, by~~ Examples of mitigation methods include comparing air data from multiple sources and from sources of dissimilar technologies.

Response: Accepted

comment 37

comment by: AIRBUS

**AMC 25.1324 Page 82 Subpart F 14 - Pass fail criteria**

The amount of water ingested by the pipes between the probe and ADM should be measured. However it is recommended that the quantity of water be measured and reported

The current text:

*At the conclusion of each test, the amount of water trapped in and around the probe (i.e. in the line conveying the air to the electronics) should not interfere with the output correctness, if the probe were suddenly subjected to freezing or re-freezing after melting. After each test, any moisture accumulating in the probe connection line should be removed and measured if possible. A maximum of 1 gram should not be exceeded.*

Should be changed into:

At the conclusion of each test, the amount of water trapped in and around the probe (i.e. in the line conveying the air to the electronics) should not interfere with the output correctness, if the probe were suddenly subjected to freezing or re-freezing after melting. After each test, any moisture accumulating in the probe connection line should be removed, measured if possible and reported. BS 2G 135 defined a maximum of 1 gram. However a higher value could be justified if it can be shown that the aircraft installation is such that the quantity of ingested water would not lead to an output error. In determining the acceptability of the test results the aircraft installation should be assessed to determine the possibility of the water refreezing or in the aircraft pressure lines. The routing of the pressure lines and any water management features in the aircraft pressure lines could also be assessed to aid the justification.

Rationale:

The WG89 concluded that the 1 gram value is arbitrary. Also 1 gram for the majority of aircraft is a negligible amount of water. The WG89 therefore preferred to allow more flexibility by requiring the amount of water to be measured and recorded. The installer would then be responsible for justifying that the aircraft design and maintenance procedures were adequate considering the quantity of water bypassing the probe

Additional guidance, such as that proposed, could easily be added to the AMC to guide the applicant and authority specialist on how to justify the amount of water.

If the 1 gram value is retained and applied as a requirement then some probes that pass the ETSO will not be allowed to be installed on a CS25 aircraft even if the amount of water is negligible compared to the capacity of the aircraft design to cope with the water.

response

Accepted.

The last paragraph has been updated and the 1 gram value has been removed.

comment

86

comment by: Dassault Aviation

Dassault-Aviation comment page #74

**Extract:**

**AMC 25.1324 - Flight instrument external probes heating systems  
13 Rain (R) conditions**



	<p>Table 3 : Rain icing test conditions</p> <p><b>Comment:</b></p> <p>Conditions proposed in Table 3 are understood as to be “rain test conditions” and not “rain icing test conditions”</p> <p><b>Requested Change</b></p> <p>Please Agency to confirm this understanding and to correct Table 3 title.</p>
response	<p>Accepted.</p> <p>These are rain conditions indeed. The table has been moved to CS 25.1324, and the title updated as suggested.</p>
comment	<p>90 <span style="float: right;">comment by: AIRBUS</span></p> <p><b>General Comment</b></p> <p>The proposed approach is not harmonized with international work that is on-going. ETSO approach is not dedicated to freestream conditions and aims at being the reference for probes qualification. Airbus would recommend a consolidated approach at international level. This would ensure an adequate level of maturity of the proposed AMC.</p>
response	<p>Partially accepted.</p> <p>The Agency is represented in EUROCAE WG-89 and, therefore, ensures a full coordination with the work of this group. AMC 25.1324 has been updated to take into account the progress of the group made in the meantime after publication of NPA 2012-22.</p>
comment	<p>92 <span style="float: right;">comment by: AIRBUS</span></p> <p><b>Section 1 page 75</b></p> <p>The current text:</p> <p><i>MMD: Median Mass Dimension</i></p> <p>Should be changed into:</p> <p>IMMD: <u>Ice Median Mass Dimension Diameter</u></p> <p>Rationale:</p> <p>Usual acronym</p>
response	<p>Not accepted.</p> <p>The MMD acronym is used in different standards, including AS5562 (also in the draft revised version being worked by EUROCAE WG-89).</p>
comment	<p>94 <span style="float: right;">comment by: AIRBUS</span></p> <p><b>Section 4 page 76</b></p> <p>The current text:</p> <p><i>The local conditions may also be affected by the “bouncing effect” for solid particles or the “splashing effects” for large liquid particles.</i></p> <p>Should be changed into:</p> <p>The local conditions may also be affected by the “bouncing effect” and “shattering effect” for solid particles or the “splashing effects” for large liquid particles. <u>As no model exists today to represent ice particles trajectories and these particular effects, an assessment based on the best available state of the art shall be made.</u></p>



response	<p>Rationale: Shattering effect is not negligible regarding ice particles capitation coefficient and might change the local distribution of particles. Models are under development at international level but no validated tool exists today. Thus, assumptions shall be made based on the best available knowledge, but the suggested AMC is not applicable as mentioned.</p> <p>Accepted.</p>
comment	<p>95 <span style="float: right;">comment by: AIRBUS</span></p> <p><b>Section 9.a page 77</b> The current text: <i>During this test, the icing protection of the probe (typically resistance heating) is assumed to be switched “on” prior to reaching freezing temperatures.</i> Should be changed into: During this test, the icing protection of the probe (typically resistance heating) is assumed to be switched “on” prior to <del>reaching freezing temperature</del> <u>starting icing conditions exposure</u>. Rationale: Ice protection of the probe should be activated as long as the probe is exposed to icing conditions for anti-icing test.</p>
response	<p>Accepted.</p>
comment	<p>97 <span style="float: right;">comment by: AIRBUS</span></p> <p><b>Section 10.2 page 78</b> The current text: <i>Cycling conditions [...]</i> Should be changed into: Refer to ETSO C16b Rationale: The EASA approach should be harmonised with EUROCAE WG89 activities.</p>
response	<p>Noted. The Agency participated in EUROCAE WG-89 and was ready to consider improved test conditions. However, some tests conducted with the new proposed test conditions revealed that these conditions were too severe. Therefore, the Agency retains the proposed historical test conditions from which a positive experience is acknowledged.</p>
comment	<p>98 <span style="float: right;">comment by: AIRBUS</span></p> <p><b>Section 12 page 79</b> Section 12 needs to be rewritten. Rationale: The Appendix P domain is not considered as covering in-service experience but no new envelope is provided. Values provided on the graph are raw data and need to be adjusted to define test conditions for the probes. Airbus recommends harmonization with international on-going work as part of EUROCAE WG89 activities.</p>

response Not accepted.  
The revised AS5562 standard provides test conditions which are deemed to be an average applicable to a class of aircraft. For CS-25 certification, it is expected that the specific local conditions applicable to the product be determined and used to establish test conditions. Therefore, the curves providing upstream data are maintained in this AMC.

comment 100 comment by: AIRBUS

**Section 12.3 page 79**

The current text:

*Particles in the range of 50 to 1000 µm tend towards ballistic trajectories with collection efficiencies approaching one on conventional Pitot tubes.*

Should be changed into:

~~Particles in the range of 50 to 1000 µm tend towards ballistic trajectories with collection efficiencies approaching one on conventional Pitot tubes.~~

Rationale:

This statement is not verified. Otherwise, installation coefficient should be one too (ballistic trajectories).

response Accepted.

comment 101 comment by: AIRBUS

**Section 12.3 page 79**

Airbus proposed text to complement Section 12.3:

Testing should be performed at representative altitude as the effect of altitude on probe behaviour is not yet fully understood, unless demonstration can be made that application of scaling laws leads to conservative approach of testing.

response Partially accepted.  
The proposed text has been accepted but it has been inserted in the introduction of paragraph 12, as it is not specific to ice particles only.

comment 113 comment by: FAA

Page	Para	COMMENT / SUGGESTED CHANGE	Rationale
75	Acronyms	MVD should be Median Volume Diameter not Mean Volume Diameter	The acronym should be consistent with the terms used in appendix O.
77	Section 10	Provide clarification that the CPA could allow the elimination of certain test conditions if they are shown not to be critical.	Allows for streamlining of the test conditions and eliminates unnecessary testing.



77-78	Table 1	The 5 minutes in intermittent maximum conditions, conditions SL3-SL5 of Table 1, seem too long. Recommend 2 minutes unless you have a very slow aircraft or specify a cloud length and let time fall out as a function of speed.	The Table 1 conditions are described as within appendix C with liquid water content values representative of an intermittent maximum cloud with a horizontal extent 2.6 nautical miles. Although unlikely that supercooled liquid conditions will be worst case for an external probe, the time to traverse such a cloud will be much less for part 25 airplanes.
78	Section 10.2	This section should be clarified. As written, it appears that either conditions (a) or (b) are acceptable, but conditions (a) are more severe.	It's unclear when conditions (a) should be considered. Since they are more severe, it appears they would never be considered.
78	Table 2	The altitude range of test point SL8 should be up to 22,000 feet, not 25,000 feet.	Continuous maximum conditions have a pressure altitude range up to 22,000 not 25,000.
79	Section 12.1	Information suggesting that altitude is a parameter identified in appendix P, and must be considered when developing the test conditions and supporting analysis necessary to show compliance should be added to this section.	Altitude is an important parameter and probes may need to be tested in a tunnel that can also simulate altitude until the effects of altitude are known and can be scaled to ground level test conditions.
79	Section 12.1	Figure should be revised to include the temperature curve for -70C	Text describes -70C as valid consideration, yet the figure does not depict the -70C temperature curve.
79	Section 12.2	This section should provide a function of ice water content versus total water content by referring to Table 1 of CS 25 appendix P.	The section describes mixed phase conditions, but does not indicate how to determine the percentage of IWC as a function of temperature. Since the information is included in the proposed CS, the AMC should refer to the CS.
81	Section 13	Recommend that EASA include information from consistent with WG-89 concerning rain testing. If EASA allows testing at temperatures warmer than 10°C then analysis should be performed to examine evaporation. Additionally, it should be clarified that only one value need be tested within the specified ranges of altitude, SAT, and drop size.	To clarify the requirements for consistency with the latest working group recommendations referenced throughout the AMC.



82	14	Recommend removal of the requirement for a maximum of 1 gram of trapped water and replace it with guidance to minimize the amount of trapped water, but also to measure and record the amount of trapped water and then design the system accordingly.	The 1 gram of trapped water appears arbitrary and should be replaced with performance based guidance.
74-82	AMC 25.1324	General Comment. Since this section covers all external probes, wording should be added to allow the ability to exclude certain types of tests for certain devices if they can be shown to be less critical. For examples while SLD is not typically critical for Pitot and Pitot-Static probes it is for vane type AOA sensors. Also, ice crystals are probably not critical for vane type AOA sensors.	While analysis may be used to determine which conditions are most severe, testing should be conducted in the most severe conditions to ensure continued operation in all conditions. It does not seem appropriate to require testing in conditions that can be shown to be less severe than others which will be tested.

response

Comment 1: Accepted. 'Mean' is replaced by 'median'.

Comment 2: Accepted. A statement is already present in the introduction of paragraph 10.

Comment 3: Noted. The Agency participated in EUROCAE WG-89 and was ready to consider improved test conditions. However, some tests conducted with the new proposed test conditions revealed that these conditions were too severe. Therefore, the Agency retains the proposed historical test conditions from which a positive experience is acknowledged.

Comment 4: Noted. The cycle (a) is not necessarily considered by the probe manufacturer as more severe than the cycle (b). It appears that, based on our experience, the majority of the manufacturers chose to use the cycle (a).

Comment 5: Noted. For consistency with the table of test conditions of AMC 25.1093(b) and AMC E 780, this altitude value has not been changed.

Comment 6: Accepted. It has been added in the introduction of paragraph 12 that testing should be performed at representative altitude as the effect of altitude on probe behaviour is not yet fully understood, unless demonstration can be made that application of scaling laws leads to conservative approach of testing.

Comment 7: Not accepted. It is recognised that testing may not be possible at -70°C, therefore, there is no real need to add a curve at -70°C.

Comment 8: Not accepted. As reminded in the comment, the information is already available in the Book 1, therefore, it is not necessary to re-write it here.

Comment 9: The rain conditions table has been removed from the AMC and will be provided in CS 25.1324. The content of the table is to be made consistent with recommendations from EUROCAE WG-89.

Comment 10: Accepted. The 1 gram value was deleted.

Comment 11: Not accepted. For SLD, the proposed AMC text provides that testing SLD



conditions may not be necessary if it can be shown that the Supercooled Liquid Conditions of Appendix C are more critical. If some doubt exists, the applicant shall propose a set of critical test points to cover adequately the Icing Environment defined in the Appendix O. Therefore, this point would have to be analysed on a case by case depending on the probe design. For glaciated conditions, the environmental conditions provided are applicable to any probe; only in the case of TAT probes a provision exists (12.5) to recognise that it may not be possible to design the temperature sensor with sufficient heating capability to ensure both adequate protection across the complete icing environment of CS-25 Appendix P and accurate temperature measurements. Mitigation for potential icing related failures at the aircraft level should be accomplished as required by the Air Data System and/or by the primary data consumers.

comment	<p><b>117</b> <span style="float: right;">comment by: Dassault Aviation</span></p> <p>Dassault-Aviation general comment on AMC 25.1324 Before any next publication, this text has to be harmonized with imminent results of EUROCAE Working Group#89</p>
response	<p>Partially accepted. The Agency is member of EUROCAE WG-89 and, therefore, ensures an update of the AMC to incorporate applicable changes, in the frame of CS-25 certification, to maintain consistency and as far as possible harmonisation with the revised AS5562 standard.</p>
comment	<p><b>119</b> <span style="float: right;">comment by: AIRBUS</span></p> <p><b>Introduction page 74</b> The current text: <i>Compliance to the ETSO qualification standard for electrically heated Pitot and Pitot-static tubes (ETSO-C16a) and for stall warning instruments (ETSO-C54) is not sufficient in itself in demonstrating compliance to the requirements of CS 25.1324. ETSO C16a specifies free stream conditions and do not consider the potential installation effects. [...]</i> Should be changed into: Compliance to the ETSO qualification standard for electrically heated Pitot and Pitot-static tubes (ETSO-C16a) and for stall warning instruments (ETSO-C54) is not sufficient in itself in demonstrating compliance to the requirements of CS 25.1324. ETSO C16a specifies free stream conditions and <del>do not</del> consider the potential installation effects. <u>The justification that the considered installation effects are compatible and appropriate shall be provided as part of the compliance demonstration with CS 25.1324 as it is dependant upon the aircraft installation. [...]</u> Rationale: New ETSO considers installation effects. Compliance to ETSO should be enough to demonstrate compliance to CS25.1324 as long as the installer confirms that the installation coefficients considered by the ETSO applicant are appropriate when the probe is installed on the aircraft.</p>
response	<p>Not accepted. This paragraph, only pertinent for Pitot probes, has been deleted. For Pitot probes,</p>





compliance with the future ETSO C16 standard prepared by the EUROCAE WG-89 may indeed be justified by the applicant as covering the installation effects of the product.

comment

162

comment by: Boeing

Page: 74

Paragraph: AMC 25.1324 *Flight instrument external probes heating systems*

Boeing recommends revising the proposed text as follows:

*"AMC 25.1324**Flight instrument external probes ~~heating systems~~"*

**JUSTIFICATION:** Boeing notes that certain engine temperature probes do not have anti-icing capabilities. Careful consideration is needed to demonstrate the capability of unheated engine probes in SLD conditions. Since CS 25.1324 is applicable to unheated engine probes, we recommend the suggested revision in order to include external probes that are not heated.

response

Accepted.

The title of the rule and AMC has been updated to delete "heating systems". However, please note that CS 25.1324 is not applicable to engine probes. In the case where the engine probe is used by airframe systems, AMC E 780 recommends using AMC 25.1324 guidance along with appropriate consideration of the installation effects and dependence on engine airflow.

comment

163

comment by: Boeing

Page: 74

Paragraph: AMC 25.1324 *Flight instrument external probes heating systems*

Boeing recommends revising the proposed text of the first paragraph of AMC 25.1324 as follows:

*"CS 25.1324 requires each flight instrument external probes systems, including, but not necessarily limited to Pitot tubes, Pitot-static tubes, static probes, angle of attack sensors, side slip vanes and temperature probes, to be heated or have an equivalent means of preventing malfunction due to icing conditions as defined in the Appendices C and P, ~~and in Appendix O (or a portion of Appendix O)~~ of CS-25. In addition each probe system must be designed and installed to operate normally without any malfunction in presence of heavy rain conditions."*

**JUSTIFICATION:** Testing air data probes for Appendix C conditions will provide sufficiently conservative performance for operation in Appendix O conditions. The current state of knowledge recognizes that larger droplet sizes do not increase the collection efficiency of an air data probe. It is therefore dependent on LWC values. Appendix C adequately covers the Appendix O conditions with respect to air data probes.

The EUROCAE Working Group (WG) 89 is comprised of industry experts developing standard icing conditions for air data probes. The EUROCAE WG-89 addressed this issue and concluded that testing in Appendix O conditions is not required because Appendix C conditions are



	<p>more conservative than Appendix O icing conditions for air data probes. The conditions developed by the WG-89 represent the state-of-the-art icing conditions for air data probes. Boeing requests that the Agency use the guidance developed by the WG-89 in specifying the icing conditions that an applicant can use in certification.</p>
response	<p>Not accepted.</p> <p>In paragraph 11 of the AMC the following provision already recognises what is stated by the commentator:</p> <p>‘Testing SLD conditions may not be necessary if it can be shown that the Supercooled Liquid Conditions of Appendix C are more critical.’</p> <p>However, the sentence at the introduction of the AMC does not need to be changed, as it reflects the rule CS 25.1324.</p> <p>Note that EASA is member of EUROCAE WG-89 and fully takes into account the work produced by this group.</p>
comment	<p>164 <span style="float: right;">comment by: Boeing</span></p> <p>Page: 75</p> <p>Paragraph: AMC 25.1324 <i>Flight instrument external probes heating systems</i></p> <p>Boeing recommends revising the proposed text as follows:</p> <p><i>“Note: Engine sensors such as <del>pressure-temperature</del> <u>pressure and/or temperature</u> probes must meet CS-E certification specifications. However, when the signals from these sensors are used by the aeroplane systems, the aeroplane manufacturer must ensure that the involved engine sensor meets CS 25.1324 specifications. Coordination of this activity should be ensured with the engine manufacturer.”</i></p> <p><b>JUSTIFICATION:</b> The term “<i>pressure-temperature</i>” is unclear with regard to which probes should be certified to the proposed requirements. Our recommended revision clarifies that both types of probes need to meet the requirement.</p>
response	<p>Accepted.</p>
comment	<p>165 <span style="float: right;">comment by: Boeing</span></p> <p>Page: 75</p> <p>Paragraph: AMC 25.1324 <i>Flight instrument external probes heating systems</i></p> <p>2 - Wind Tunnels</p> <p>Boeing recommends revising the proposed text as follows:</p> <p><i>“2 – Wind Tunnels</i></p> <p><i>All conditions must be appropriately corrected to respect the similitude relationship between actual and wind tunnel conditions (due to pressure and scale differences for example). It is the <del>manufacturer</del> <u>applicant’s</u> responsibility to determine and justify the various derivations and corrections to be made to the upstream conditions in order to determine actual test conditions (local and scaled). When the tests are conducted in non-altitude conditions, the system power supply and the external aerodynamic and atmospheric conditions should be so modified as to represent the required altitude condition as closely as possible.”</i></p>

**JUSTIFICATION:** The word “manufacturer” is ambiguous and could imply either the part manufacturer or the airplane manufacturer. Our recommended revision clarifies that it is the type certificate applicant’s responsibility to ensure that the wind tunnel scaling accounts for local conditions at the probe installation location.

response Accepted.  
The same changes have been done in other applicable places.

comment 166 comment by: Boeing

Page: 76  
Paragraph: AMC 25.1324 Flight instrument external probes heating systems  
4 - Local conditions

Boeing recommends revising the proposed text as follows:  
*“Concerning the type and size of the particles, the local WC should be computed considering the full distribution of the particles sizes that is actually present in the real atmosphere, even if the wind tunnel tests are then performed at a given single size (20 micron for supercooled droplets, 150 micron for ice crystals, 500 to 2,000 micron for rain drops). ~~The local conditions may also be affected by the “bouncing effect” for solid particles or the “splashing effects” for large liquid particles.~~”*

**JUSTIFICATION:** Boeing finds that the last sentence of the proposed text does not provide adequate guidance as to how the applicant should handle these effects. The bouncing effect of ice crystals and splashing effects of large liquid droplets are part of the impingement analysis process. However, using an over-concentration factor in the impingement analysis accounts for the effects of ice crystal bouncing or SLD splashing. We therefore request that the indicated text be deleted.

response Not accepted.  
The sentence has not been deleted, but it has been upgraded based on comment 94.

comment 167 comment by: Boeing

Page: 76  
Paragraph: AMC 25.1324 Flight instrument external probes heating systems  
5 – Operational Conditions

Boeing recommends revising the proposed text as follows:  
*“5 - Operational Conditions  
 The conditions are to be tested at several Mach and Angle of Attack (AOA) values in order to cover the operational flight envelope of the aircraft. It is the ~~manufacturer applicant’s~~ responsibility to select and justify, for each of the conditions listed in each Cloud Matrix below, the relevant operational conditions to be tested (Mach, AOA and Mode...).  
 It is expected that several operational conditions will be identified for each environmental conditions but exhaustive testing is not intended.  
**Rain conditions do not need to be tested for multiple AOAs. A single AOA at 0 degrees will be sufficient for rain conditions.**”*



	<p><b>JUSTIFICATION:</b> The word “manufacturer” is ambiguous and could imply either the probe manufacturer or the airplane manufacturer. Our recommended revision clarifies that the applicant is responsible.</p> <p>Rain conditions for air data probes are intended to test the water ingestion capability of the air data probe. Boeing contends that measuring the performance of an air data probe at multiple AOAs would add unnecessary testing and that testing at only 0 degrees AOA will provide the worst-case water ingestion condition for rain.</p> <p>The testing requirements of air data probes in Appendix C, Appendix P, Mixed Phase, and Rain conditions from the WG-89 were developed by Industry and provide conservative values. Boeing recommends that the operation conditions be based upon the recommendation of the WG-89.</p>
response	<p>Partially accepted.</p> <p>‘Manufacturer’ is replaced by ‘applicant’.</p> <p>The proposed text on rain conditions AoA has not been adopted. Although, this is probably valid for traditional Pitot probes, it may not be the case for some particular flight probe designs. The use of only one AoA value could nevertheless be proposed and justified by the applicant.</p>
comment	<p>168 <span style="float: right;">comment by: Boeing</span></p> <p>Page: 76 Paragraph: <i>AMC 25.1324 Flight instrument external probes heating systems</i> <i>7 - Flight deck indication</i></p> <p>Boeing recommends revising the proposed text as follows: “7 - Flight deck indication When a flight instrument external probe heating system is installed, CS 25.1326 requires an indication system to be provided to indicate to the flight crew when that flight instrument external probe heating system is not operating normally. <del>All performances of the probe ice protection system, in particular the icing tests described in this AMC are expected to be demonstrated with equipment selected with heating power set to the minimum value triggering the flight deck indication.”</del></p> <p><b>JUSTIFICATION:</b> Boeing submits that the subject of the deleted paragraph is adequately addressed in CS 25.1301 and CS 25.1309. These CSs cover the need for indication of any failures of the probe heater system.</p>
response	<p>Not accepted.</p> <p>The text in question does not deal with safety analysis. It aims at clarifying that the performances demonstrated by test should be guaranteed for heating power values down to the minimum value used to trigger the flight deck indication, per CS 25.1326.</p>
comment	<p>169 <span style="float: right;">comment by: Boeing</span></p> <p>Page: 77 Paragraph: <i>AMC 25.1324 Flight instrument external probes heating systems</i> <i>8 – Test article selection</i></p>

Boeing recommends revising the proposed text as follows:

*"8 - Test article selection*

*To be delivered, an article has to meet an Acceptance Test Procedure (ATP) established by the equipment supplier. The ATP is a production test performed on each item to show it meets the performance specification. Both the performance of the ice protection system and the icing tests described hereafter are expected to be demonstrated with ~~an~~ equipment selected at ~~the lowest~~ a value **that meets the specifications** of the ATP with respect to the acceptability of the heating performance."*

**JUSTIFICATION:** Selecting the lowest heat performance in an ATP-approved probe will not provide a significant benefit in the safety of the probe. Identifying the lowest heater performance from a large number of probes produced will increase the economic burden of qualifying and purchasing the probes by increasing icing tunnel testing and adding unnecessary testing of probes that already meet the ATP quality standards.

response

Not accepted.

This paragraph is unchanged. It was not intended to create new burden on testing. However, in the light of other comments received, additional guidelines, dealing with how to simulate the lowest performing probe, have been added.

comment

170

comment by: Boeing

Page: 77-78

Paragraph: AMC 25.1324 Flight instrument external probes heating systems

*10 - Supercooled Liquid (SL) Conditions*

Boeing recommends revising the proposed text by deleting sections 10.1 (Stabilized Conditions) and 10.2 (Cycling Conditions) and tables 1 and 2, and replacing ; with the following text and table:

*"The Supercooled Liquid Water test conditions presented in Table 1 are based on CS-25 Appendix C icing conditions. Each test in Table 1 combines steady, low LWC exposure followed by a cycled LWC exposure, between low and high LWC, then closing with a short-duration high LWC exposure. The total test time for this combined steady and cycled icing exposure is 30 minutes.*

*Considering that the local collection efficiency is a function of the MVD and the probe location with respect to the boundary layer, the applicant should establish the conditions leading to the highest local LWC at the probe location and test accordingly. It is acceptable to run the tests at the highest determined local LWC but using a droplet diameter of 20 µm since most of the icing wind tunnels are calibrated for that value.*

**Table 1: Supercooled Liquid droplet icing test conditions.**

Test Condition	Class*	Altitude (Kft)	Airspeed (KTAS/Mach)	SAT (deg C)	MVD (µm)	LWC (g/m <sup>3</sup> )	Duration (Minutes)
L1	1	15	209/0.33	-10	20	0.6	10
	2	5	253/0.40			2.5 and 0.6	18 (9 x 1 minute cycles between LWC)



	3 & 4					2.5	2
	R						
L2	1	20	223/0.36	-20	20	0.3	10
	2	10	267/0.43			1.9 and 0.3	18 (9 x 1 minute cycles between LWC)
	3 & 4	10	347/0.56			1.9	2
	R	0	150			1.9	15
	1	22	231/0.38			0.2	10
L3	2	15	292/0.48	-30	20	1.1 and 0.2	18 (9 x 1 minute cycles between LWC)
	3 & 4		371/0.61			1.1	2
	R	0	150			1.1	15

\* Test conditions vary, depending on the following defined aircraft classes:

*Class 1: General Aviation Aircraft (Maximum Altitude 25,000 ft.)*

*Class 2: Turbopropeller Aircraft (Maximum Altitude 35,000 ft)*

*Class 3: Jet Transport Aircraft (Maximum Altitude 45,000 ft)*

*Class 4: High Performance Business Jets (Maximum Altitude > 45,000 ft)*

*Class R: Rotorcraft*

**JUSTIFICATION:** Although the proposed supercooled liquid water conditions in the proposed NPA text are based on an EASA CRI regarding supercooled liquid water conditions that has been used on recent airplane programs, Boeing maintains that these conditions do not represent the most current conditions to which air data probes should be tested. We recommend that the conditions developed by the EUROCAE WG-89 be used for air data probes in general, as they are the most current conditions that will be used by the industry. The EUROCAE WG-89 is comprised of a group of industry and regulatory representatives who have devoted a great deal of time and energy in developing a high-quality standard for icing conditions for pitot/pitot-static probes. The WG-89 has worked on developing forthcoming revisions of the ETSO-C16a ("Electrically Heated Pitot And Pitot-Static Tubes") and SAE AS8006 ("Minimum Performance Standard for Pitot and Pitot-Static Tubes"), as well as generating a new standard to be published: SAE AS5562 ("Ice and Rain Qualification Standards for Airdata Probes"). These documents and revisions represent the state-of-the-art for air data probes in icing conditions. Boeing recommends that the proposed AMC 25.1324 use these standards as guidance for the minimum performance and icing conditions standards with which air data probes are to comply for certification.

In addition, the proposed text in the NPA for the cycling test is confusing. It is not clear what criteria the applicant should use when determining proposed cycling test 10.2.a or 10.2.b.

response

Noted. The Agency participated in EUROCAE WG-89 and was ready to consider improved test conditions. However, some tests conducted with the new proposed test conditions revealed that these conditions were too severe. Therefore, the Agency retains the proposed historical test conditions from which a positive experience is acknowledged.



comment

171

comment by: Boeing

Page: 78-79

Paragraph: AMC 25.1324 Flight instrument external probes heating systems

11 - Supercooled Large Drop Liquid Conditions

Boeing recommends revising the proposed text as follows:

*"11 - Supercooled Large Drop Liquid Conditions*

*Based on the design of the probe, the drop size ~~may is not be~~ a significant factor to consider as compared to the other parameters, ~~and~~ in particular the Liquid Water Content. The SLD **LWC** concentrations defined in Appendix O (between 0.2 and 0.5 g/m<sup>3</sup>) are largely covered by the Appendix C continuous **maximum LWC** concentrations (between 0.2 and 0.8 g/m<sup>3</sup>) and the Appendix C intermittent **maximum LWC** concentrations (between 0.25 and 2.9 g/m<sup>3</sup>).*

*Testing SLD conditions ~~may is not be~~ necessary if it can be shown that the Supercooled Liquid Conditions of Appendix C are more critical. If some doubt exists, ~~the applicant shall propose a set of critical test points to cover adequately the icing environment defined in the Appendix O.~~ compliance for Appendix O conditions may be shown through qualitative analysis of the design, supported by similarity to a previous design that has shown successful service history.*

*If similarity is not shown, then icing tunnels alone may be used to determine the performance of external probes in Appendix O icing conditions. For probes with collection efficiencies approaching "1," if performance has been shown in freezing drizzle conditions, then a qualitative analysis based upon water-catch ratios may be used for extrapolation to freezing rain conditions."*

**JUSTIFICATION:** Current design and compliance methods have resulted in probe heating designs that have had no known safety events due to SLD icing conditions. As additional analyses or tests would not improve safety, use of similarity to current designs to show compliance for Appendix O conditions should be explicitly permitted.

Testing air data probes for Appendix C conditions will provide sufficiently conservative performance that includes Appendix O conditions. The current state of knowledge recognizes that larger droplet sizes do not increase the collection efficiency of an air data probe. It is therefore dependent on LWC values. Appendix C adequately covers the Appendix O conditions with respect to air data probes.

This rationale was confirmed by the EUROCAE WG-89 in the development of icing conditions standards for air data probes.

The EUROCAE WG-89 is comprised of a group of industry and regulatory representatives who have developed a high-quality standard for icing conditions for air data probes. The WG-89 has developed forthcoming revisions of the ETSO-C16a ("Electrically Heated Pitot And Pitot-Static Tubes") and SAE AS8006 ("Minimum Performance Standard for Pitot and Pitot-Static Tubes"), as well as generating a new standard to be published: SAE AS5562 ("Ice and Rain Qualification Standards for Airdata Probes"). SAE AS5562 provides similar rationale and recommends that testing for Appendix O conditions is not necessary. The ETSO-C16, SAE AS8006, and SAE AS5562 documents represent the state-of-the-art in icing conditions for air data probes. Boeing requests that proposed AMC 25.1324 adopt these standards for the minimum performance and icing conditions for the certification of air data probes.

response

Partially accepted.

As this AMC would apply to any flight instrument external probe, it is not possible to anticipate all possible new designs and their susceptibilities, therefore the text is maintained



with the formula 'may not be'. An evaluation will be made on a case by case for each design. The clarifications on the references to the LWC values are accepted. The proposal to add provisions on similarity analysis is not adopted as a dedicated rulemaking task RMT.0572 is on-going.

comment

172

comment by: Boeing

Page: 79

Paragraph: AMC 25.1324 Flight instrument external probes heating systems

12 Mixed Phase (M) and Glaciated (G) Conditions

Boeing recommends deleting the proposed text of section 12.1 and its accompanying figure, and replacing it with the following text and table:

"12.1 - Glaciated Conditions

The glaciated (ice crystal) conditions presented in Table 2 are based on CS 25 Appendix P, with the exception of condition S4, which was developed by EUROCAE WG-89 based on a single high-altitude airspeed event attributed to ice crystals. Maximum peak values are used for the IWC in Table 2, which are based on adiabatic lapse rates at sea levels with a 90% relative humidity.

Considering that the local collection efficiency is a function of the MVD and the probe location with respect to the boundary layer, the applicant should establish the conditions leading to the highest local IWC at the probe location and test accordingly. The local over-concentration factor should be recorded and included in the evaluation of the local collection efficiency.

Table 2: Glaciated icing test conditions.

Test Condition	Class*	Altitude (KFt)	Airspeed (KTAS/Mach)	SAT (deg C)	MMD (μ)	IWC (g/m <sup>3</sup> )	Duration (Minutes)
S1	2a/2b	28	341/0.55	-20	150 - 250	7.3	2
	3		382/0.62				
	4						
S2	2a/2b	31	327/0.55	-40	150 - 250	5.6	2
	3	37	488/0.82			6.4	
	4		512/0.86				
S3	2a/2b	31	313/0.55	-60	150 - 250	3.4	2
	3	42	466/0.82			5.1	
	4	45	489/0.86			5.2	
S4	4	45	477/0.86	-70	150 - 250	4.7	2

\* Test conditions vary depending on the following defined aircraft classes.

Class 1: General Aviation Aircraft (Maximum Altitude 25,000 ft.)

Class 2: Turbopropeller Aircraft (Maximum Altitude 35,000 ft)

Class 3: Jet Transport Aircraft (Maximum Altitude 45,000 ft)

Class 4: High Performance Business Jets (Maximum Altitude > 45,000 ft)

Class R: Rotorcraft

Notes:

- The ice crystal test conditions are based on the best known data at the time of





publication. As more data becomes available in the future, it may be possible to develop a more representative test profile.

• These tests should be run at the indicated altitude except for Class 2a, which may be performed at a non-altitude capable test facility.

**JUSTIFICATION:** Figure 3 of NPA 2011-03 ("Large Aeroplane Certification Specifications in Supercooled Large Drop, Mixed phase, and Ice Crystal Icing Conditions"), Appendix P, specifies a "Total Water Content Distance Scale Factor" with a maximum value of **1.13**, rather than the 1.538 value shown in the proposed figure in paragraph 12.1.

If the Agency wishes to propose changes to the ice crystal environment definition to be used for certification, then Appendix P of NPA 2011-03 should be revised, or new rulemaking material proposed specifically for air data probes. Advisory material should not introduce new requirements that are above and beyond the referenced/associated rule. In addition, the Agency's current proposal would not be harmonized with the FAA's advisory material.

Further, the proposed text does not provide any real guidance as to which ice crystal conditions should be tested for air data probes to demonstrate acceptable performance that meets the certification requirements. The TWC levels are presumably given based on the altitude and static air temperatures; however, guidance for the test duration and the setup of the test is not provided. The proposed text only provides justification and rationale for the ice crystal conditions developed by the EUROCAE WG-89 and presented in the to-be-published standard, SAE AS5562 ("Ice and Rain Qualification Standards for Airdata Probes"). There is little guidance provided for an applicant to successfully certify for ice crystal conditions.

Boeing recommends that the ice crystal conditions developed by EUROCAE WG-89 be adopted for air data probes in AMC 25.1324, as these are the most current conditions for air data probes and will soon be adopted as the industry standard.

response

Partially accepted.

The table of points developed by the EUROCAE WG-89 are peak values determined along with aircraft dependent parameters (airspeed, altitude, temperature).

It is preferred to provide upstream peak values in AMC 25.1324, and it will be up to the applicant to propose other parameters that are pertinent to the aircraft project.

In term of test duration, a new paragraph 12.4 has been created providing for a minimum duration of 2 minutes.

comment

173

comment by: Boeing

Page: 80

AMC 25.1324 Flight instrument external probes heating systems  
12 Mixed Phase (M) and Glaciated (G) Conditions

Boeing recommends revising the proposed text as follows:

**"12.2 - Mixed Phase Conditions**

*In service occurrences show several Pitot icing events in ~~M~~mixed-phase conditions, between 20,000 and 30,000 feet, outside of the Appendix P domain in terms of altitude and outside air*



temperature. **Table 3 lists conditions acceptable for showing compliance for mixed-phase conditions.**

~~Based on several sources of information including the EUROCAE WG-89, the Agency is of the opinion that the '2.6 NM' TWC concentration values should be considered instead of the '17.4 NM' values, as the CS-25 Appendix C Intermittent conditions provide data for a 2.6 NM cloud.~~

~~The '2.6 NM' values are given by the '17.4 NM' values scaled by the F factor for 2.6 NM clouds which is 1.175 and are provided below:~~

**[DELETE GRAPH/CHART ON PAGE 80]**

**Table 3: Mixed phase icing test conditions**

Test Condition	Class*	Altitude (KFt)	Airspeed (KTAS/Mach)	SAT (deg C)	MVD (μm)	LWC (g/m <sup>3</sup> )	MMD (μm)	IWC (g/m <sup>3</sup> )	Duration (Minutes)
M1	2	28	341/0.55	-20	20	2.0	150 - 250	3.6	2
	3 & 4		382/0.62						
M2	2	33	334/0.55	-30	20	1.1	150 - 250	4.2	2
	3 & 4		416/0.68						

\* Test conditions vary depending on the following defined aircraft classes.

**Class 1: General Aviation Aircraft (Maximum Altitude 25,000 ft.)**

**Class 2: Turbopropeller Aircraft (Maximum Altitude 35,000 ft)**

**Class 3: Jet Transport Aircraft (Maximum Altitude 45,000 ft)**

**Class 4: High Performance Business Jets (Maximum Altitude > 45,000 ft)**

**Class R: Rotorcraft"**

**JUSTIFICATION:** The text of proposed section 12.2 does not provide any real guidance on testing or acceptable performance of air data probes for mixed-phase conditions. The TWC levels are presumably given based on the altitude and static air temperatures; however, guidance for the test duration and the setup of the test is not provided. Boeing recommends adopting the conditions developed by the EUROCAE WG-89 for mixed-phase conditions.

The EUROCAE WG-89 is comprised of a group of industry and regulatory representatives who have developed a high-quality standard for icing conditions for air data probes. The WG-89 has developed forthcoming revisions of ETSO-C16 ("Electrically Heated Pitot And Pitot-Static Tubes") and SAE AS8006 ("Minimum Performance Standard for Pitot and Pitot-Static Tubes"), as well new standard SAE AS5562 ("Ice and Rain Qualification Standards for Airdata Probes"). The ETSO-C16, SAE AS8006, and SAE AS5562 documents represent the state-of-the-art in icing conditions for air data probes. Boeing requests that proposed AMC 25.1324 adopt these standards for the minimum performance and icing conditions for the certification of air data probes.

response Partially accepted.

The table of points developed by the EUROCAE WG-89 are '2.6 NM' values determined along with aircraft dependent parameters (airspeed, altitude, temperature).

It is preferred to provide upstream '2.6 NM' values in AMC 25.1324, and it will be up to the applicant to propose other parameters that are pertinent to the aircraft project.



In term of test duration, a new paragraph 12.4 has been created providing for a minimum duration of 2 minutes.

comment

174

comment by: Boeing

Page: 81

AMC 25.1324 Flight instrument external probes heating systems

12 Mixed Phase (M) and Glaciated (G) Conditions

Boeing request clarification of (highlighted) text:

*"12.4 - Total Air Temperature probe design consideration*

*It is recognized that due to the intrinsic function of the total air temperature probes, it may not be possible to design the temperature sensor with sufficient heating capability to ensure both adequate protection across the complete icing environment of CS-25 Appendix P and accurate temperature measurements. In this case, it may be acceptable that the temperature probe is not fully protected over a portion of the Appendix P icing environment, provided that the malfunction of the probe will not prevent continued safe flight and landing. System safety assessments must include common mode failure conditions.*

...

**JUSTIFICATION:** Boeing requests that guidance be provided regarding how to determine the portion of Appendix P for which it is acceptable that the TAT probe not be fully protected. As guidance material, it is crucial that clear directions and portions of the Appendix P envelope be specified to ensure that the requirement is met and properly complied with.

response

Noted.

As explained in the rest of the paragraph, it is expected that the applicant perform a system safety analysis to evaluate the effect of the temperature probe not being fully protected. The applicant should, therefore, evaluate the portion of the Appendix P where the temperature probe is not fully protected and then develop acceptable mitigation means.

comment

175

comment by: Boeing

Page: 81

Paragraph: AMC 25.1324 Flight instrument external probes heating systems

13 - Rain (R) Conditions

Boeing recommends revising the proposed text as follows:

*"13 - Rain (R) Conditions***~~The following conditions are proposed to represent the heavy rain conditions:~~**

Test #	Altitude Range		LWC	Horizontal Extent		Mean Effective Droplet Diameter
	(ft)	(m)	(g/m <sup>3</sup> )	(km)	(NM)	(µm)
<b>R1</b>	<b>0 to 10,000</b>	<b>0 to 3,000</b>	<b>1</b>	<b>100</b>	<b>50</b>	<b>500 to 2000</b>
<b>R2</b>			<b>6</b>	<b>5</b>	<b>3</b>	



<b>R3</b>			<b>15</b>	<b>1</b>	<b>0.5</b>	
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**Table 3: Rain icing test conditions**

**Table 3 lists rain conditions that the applicant can use to show compliance with CS-25.1324. Testing of rain conditions only requires a single AOA at 0 degrees. Other AOA positions are not required. The intent of testing rain conditions is to demonstrate the probe's performance during water ingestion.**

**Table 3: Rain icing test conditions**

Test Condition	Class*	Altitude (Kft)	Airspeed (KCAS)	SAT (C°)	MVD (μm)	LWC (g/m³)	Duration (min)	* Test conditions vary depending on the following defined aircraft classes.
R1	R	< 10	80 & 130	< 10	500 - 2000	2.0	15	
	1, 2, 3, 4		130 & 250					
R2	R	< 10	80 & 130	< 10	500 – 2000	6.0	2	
	1, 2, 3, 4		80 &130					
R3	R	< 10	80 & 130	< 10	500 – 2000	15.0	0.3	
	1, 2, 3, 4		130 & 250					

**Class 1: General Aviation Aircraft (Maximum Altitude 25,000 ft.)**

**Class 2: Turbopropeller Aircraft (Maximum Altitude 35,000 ft)**

**Class 3: Jet Transport Aircraft (Maximum Altitude 45,000 ft)**

**Class 4: High Performance Business Jets (Maximum Altitude > 45,000 ft)**

**Class R: Rotorcraft"**

**JUSTIFICATION:** The proposed text in the NPA does not provide adequate guidance on the rain test condition setup or rain test duration. A recommended test procedure is not provided. Based on the work of the EUROCAE WG-89, Boeing recommends that the rain conditions developed by that group be referenced as the rain conditions for acceptable means of compliance. The rain conditions developed by the WG-89 are the most current and state-of-the-art rain conditions to which an air data probe should be tested. The EUROCAE WG-89 is an industry working group consisting of airplane, probe, and regulatory agency representatives. The combined efforts of the industry members of the WG-89 have generated a high quality standard for air data probe ice and rain conditions. We recommend that AMC 25.1324 adopt the guidance of the WG-89 and utilize new standard (not yet published) SAE AS5562 ("Ice and Rain Qualification Standards for Airdata Probes") in providing the minimum required performance for air data probes in rain conditions.

response

Not accepted.

The rain conditions are now provided in CS 25.1324. The table provides for distances, though the EUROCAE table provides for test durations. At aircraft level, it is considered more relevant to maintain distance requirements. Harmonisation with the FAA table (in 25.1323) is also maintained.

The proposed text on rain conditions AoA is not adopted. Although this is probably valid for traditional Pitot probes, it may not be the case for some particular flight probe designs. The use of only one AoA value could, nevertheless, be proposed and justified by the applicant.



**Cessna comment on 13 Rain (R) Conditions – Table 3 (page 81) :**

Table 3 currently has no droplet MVD defined for tests R2 and R3. Assuming the range should be 500 to 2000  $\mu\text{m}$ , the line between R1 and R2 should be removed from that column.

Unit conversions for horizontal extent are also incorrect (1 km = 0.54 Nautical Miles)

Response: Accepted. Yes, the range of 500 to 2 000  $\mu\text{m}$  also applies to R2 and R3. Horizontal extent values are rounded, therefore, there is no need for a precise conversion between the two units. Harmonisation with the FAA table is also maintained.

comment

176

comment by: Boeing

Page: 81-82

Paragraph: AMC 25.1324 Flight instrument external probes heating systems

14 - Pass/fail criteria

Boeing recommends revising the proposed text as follows:

*"14 - Pass/fail criteria*

*The pass/fail criteria of a given test are as follows:*

*The output of the probe should **quickly** stabilize to the correct value after the start of an **Anti**-icing test or once the icing protection is restored in a **De**-icing test. ~~This value has to be agreed before the test between the manufacturer and the Agency, and it must stay correct as long as the icing protection is maintained.~~ The measurement is considered to be correct if any observed fluctuation, when assessed by the ~~manufacturer~~ **applicant**, has no effect at **the** aircraft level.*

*In addition, for Pitot probes and especially during ice crystal or mixed-phase conditions tests, it should be observed that the measured pressure is not 'frozen' (pressure signal without any noise, i.e., completely flat), which would indicate an internal blockage resulting in a captured pressure measurement.*

*At the conclusion of each test, the amount of water trapped in ~~and around~~ the probe (i.e., in the line conveying the air to the electronics) should not interfere with the output correctness, if the probe were suddenly subjected to freezing or re-freezing after melting. After each test, any moisture accumulating in the probe connection line should be removed and measured if possible. ~~A maximum of 1 gram should not be exceeded. The amount of water removed should be noted.~~"*

**JUSTIFICATION:** With regard to the first paragraph, Boeing requests that the indicated sentence be deleted due to the fact that the correct value is determined by qualification requirements that are based on airplane-level requirements. The value should not be determined by the Agency but, rather, by what is needed for the applicant's design specifications.

With regard to the requested deletion in the last paragraph, Boeing notes that the specific amount of water will vary from one airplane manufacturer to another. This is installation-dependent, and the amount of water in a pressure line could exceed 1 gm and still have acceptable performance.

response

Partially accepted.

The deletion of the sentence in the first paragraph is not accepted. The text does not foresee that the Agency should select the correct value, but rather that this value should be agreed between the applicant and the Agency. Of course the applicant would make the proposal to



the Agency.

The other comments are accepted and part of the update of this paragraph.

comment

193

comment by: Snecma

Attachment [#7](#)

Please see attached file

response

**Comment#15 on page 74**

**REQUESTED CHANGE: AMC 25.1324**

**Flight instrument external probes heating systems**

CS 25.1324 requires each flight instrument external probes systems, including, but not necessarily limited to Pitot tubes, Pitot-static tubes, static probes, angle of attack sensors, side slip vanes and temperature probes, to be heated or have an equivalent means of preventing malfunction due to icing conditions as defined in the Appendices C and P, and in Appendix O (or a portion of Appendix O) of CS-25.

**Justification:** Certain engine temperature probes have no de-ice heater. As NPA 2012-23 AMC E 780 make reference to AMC 25.1324 for probes stated as “critical” for acceptable engine operation and/or used for aircraft operation, Snecma suggests the title of the AMC 25.1324 and the mean of preventing malfunction in icing conditions should be more general to encompass them.

**Response:** Partially accepted. The title of CS/AMC 25.1324 have been updated. Nevertheless, the statement quoted in this comment reflects the text of CS 25.1324. AMC E 780 refers only to the guidance material of AMC 25.1324 to determine the critical probe icing conditions.

**Comment#16 on page 79**

**12 - Mixed Phase (M) and Glaciated (G) Conditions**

**If potential malfunction of the probe in Appendix P of CS-25 is not clearly excluded by design,** the applicant should propose a set of critical test points to cover adequately the Icing Environment as proposed in Appendix P of CS-25.

**Justification:**

When temperatures are below 0°C, ice particles bounce on non-heated surfaces. Therefore non-heated sensors such as certain engine inlet temperature sensors are, by design, not prone to clogging or accretion in ice crystals conditions. In this case, Mixed Phase and Glaciated conditions are clearly covered by Appendix C in terms of LWC, so that the Applicant should not need to do further tests.

**Response:** Not accepted. The proposed additional text does not clarify the paragraph. Note that paragraph 12.5 is dedicated to TAT probe design considerations.

comment

206

comment by: Aerospace Industries Association

**Affected paragraph and page number**

Page: 74  
Paragraph: AMC25.1324

**What is your concern and what do you want changed in this**

The proposed text states:  
**AMC 25.1324**  
**Flight instrument external probes heating systems**



<b>paragraph?</b>	<b>Requested Change:</b> <b>AMC 25.1324</b> <b>Flight instrument external probes heating systems</b>
<b>Why is your suggested change justified?</b>	<b>JUSTIFICATION:</b> Certain engine temperature probes have no de-ice heater. Careful consideration is needed to demonstrate the capability of unheated engine probes in supercooled liquid. It is respectfully suggested that application of 25.1324 is appropriate to these sensors.

response Accepted.  
The title has been updated to be consistent with the title of CS 25.1324.

comment 208 comment by: Rolls-Royce plc (ZM)

Comment Summary

AMC 25-1324 applies to both heated and unheated external probes and therefore the section sub-title should reflect that.

Comment Resolution

Replace "Flight instrument external probes heating systems"  
with "Flight instrument external probes"

response Accepted.  
The title has been updated to be consistent with the title of CS 25.1324.

comment 219 comment by: Rolls-Royce plc (ZM)

Comment Summary

The output from engine measurements is frequently recorded by the aircraft, but not actively used for aircraft control. Engine measurements may also be used for a comparison with aircraft-based measurements in order to assess the validity of the aircraft measurements. In these cases, we do not believe that engine probes need be assessed against CS 25.1324, and that such assessment should only be necessary when an engine probe provides a primary measurement for the purposes of aircraft control.

Comment Resolution

Replace "when the signals from these sensors are used by the aeroplane systems, the aeroplane manufacturer must ensure that the involved engine sensor meets CS 25.1324 specifications."

with "when the signals from these sensors are used by the aeroplane systems as primary instruments for aeroplane control, the aeroplane manufacturer must ensure that the involved engine sensor meets CS 25.1324 specifications."

response Not accepted.  
This text is equivalent to the provision in AMC E 780 for engine air data probes. The approach at aircraft level has to be consistent whatever the location of the sensor is. As such, CS 25.1324 does not provide criteria on the criticality of a probe in term of applicability of the specifications. Therefore, the same applies if the sensor is installed on the engine.



**Cessna comment on first paragraph (page 82)**

The text specifies that “At the conclusion of each test, the amount of water trapped in and around the probe (i.e. in the line conveying the air to the electronics) should not interfere with the output correctness, if the probe were suddenly subjected to freezing or re-freezing after melting. After each test, any moisture accumulating in the probe connection line should be removed and measured if possible. A maximum of 1 gram should not be exceeded.”

This should be a performance based test. If the system can ingest more than 1 gram without an adverse affect on the total pressure reading it should be deemed a successful test. Likewise if an airspeed error is seen with less than 1 gram of water accumulation, this should not be acceptable. Recommend deletion of the sentence referencing 1 gram of water.

Suggested change:

At the conclusion of each test, the amount of water trapped in and around the probe (i.e. in the line conveying the air to the electronics) should not interfere with the output correctness, if the probe were suddenly subjected to freezing or re-freezing after melting. After each test, any moisture accumulating in the probe connection line should be removed and measured if possible. ~~A maximum of 1 gram should not be exceeded.~~

Response: Accepted. Additional clarifications have been made on this paragraph.

**B. Draft Decision — I. Draft Decision amending CS-25 — Book 2; AMC — SUBPART F — AMC  
25.1326 Flight instrument external probes heat indication systems**

p. 82

comment 6 comment by: UTC Aerospace Systems - Sensors & Integrated Systems  
Page 82 the section on Flight Instrument External Probes Heat Indication Systems  
See comments to Page 76 section 7 above.

response Please refer to our response to your comment 4.

comment 102 comment by: AIRBUS

**General Comment**

Proposed approach is not harmonized with classical way of working. Probabilistic approach should be authorized.

The intent of this guidance (avoidance of the effects of multiple probes operating at low power and the failure remaining undetected) can be achieved through various means.

The guidance provided here is one means but may be overly penalizing for small aircraft with low power available (this guidance is likely to lead to higher probe heating power under nominal operation). For larger aircraft where available power may be greater the proposed guidance may still not be possible to fully implement due to the variability of the current drawn by probes under varying conditions and the need to provide adequate margins to the warnings to avoid spurious or nuisance warnings.

Other means of achieving the same objective include defining maintenance tasks with adequate periodicity, improving the reliability of the probes (although unlikely to remove all maintenance actions), use of temperature monitoring of probes or using a back-up means to determine aircraft speed via a separate system or set of probes.

The current guidance selects one possible solution to the issue but the design selected by EASA is likely impractical for many aircraft designs and acceptable alternatives are available.





	<p>The probe to probe variability is already addressed in the icing tests through the recommendation to perform icing tests on the minimum Production Acceptance Test probes. It is also noted that the regulations proposed in NPA 2011-03 requires that the basic probes show compliance with the reinforced ice crystal requirements which is a substantial improvement.</p> <p>EASA has made a design choice/assumption in defining the guidance and it is recommended to modify the text to allow applicants to choose the means most appropriate to their aircraft to achieve the objective.</p>
response	Please refer to our response to your comment 123.

comment	<div>123</div> <div style="text-align: right;">comment by: AIRBUS</div> <p><b>AMC 25.1326 Page 82 Flight instrument external probes heat indication systems</b></p> <p>Recommended Change:</p> <p>CS 25.1326 requires that if a flight instrument external probe heating system is installed, an alerting system must be provided to alert the flight crew when the flight instrument external probes heating system is not operating or not functioning normally. It is therefore expected that failures are indicated to the flight crew if such failures have an impact on the performance of the heating system to the extent of having an “effect on operational capability or safety” (see CS 25.1309).</p> <p>It should be assumed that icing conditions exist during the failure event. The decision to provide failure indication should not be based on the numerical probability of the failure event. Even if a numerical probability analysis indicates that system failure is improbable or extremely improbable, if the failure could potentially result in a hazardous condition, then the failure indication has to be provided.</p> <p><del>The setting of the alert provided to the flight deck is expected not to be lower than the lowest acceptable value of the heating performance according to its performance specification and/or qualification standards.</del></p> <p>Rationale:</p> <p>The intent of this guidance (avoidance of the effects of multiple probes operating at low power and the failure remaining undetected) can be achieved through various means. The guidance provided here is one means but may be overly penalizing for small aircraft with low power available (this guidance is likely to lead to higher probe heating power under nominal operation). For larger aircraft where available power may be greater the proposed guidance may still not be possible to fully implement due to the variability of the current drawn by probes under varying conditions and the need to provide adequate margins to the warnings to avoid spurious or nuisance warnings.</p> <p>Other means of achieving the same objective include defining maintenance tasks with adequate periodicity, improving the reliability of the probes (although unlikely to remove all maintenance actions), use of temperature monitoring of probes or using a back-up means to determine aircraft speed via a separate system or set of probes.</p> <p>The current guidance selects one possible solution to the issue but the design selected by EASA is likely impractical for many aircraft designs and acceptable alternatives are available. The probe to probe variability is already addressed in the icing tests through the recommendation to perform icing tests on the minimum Production Acceptance Test probes. It is also noted that the regulations proposed in NPA 2011-03 requires that the basic probes show compliance with the reinforced ice crystal requirements which is a substantial improvement.</p>
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response

EASA has made a design choice/assumption in defining the guidance and it is recommended to modify the text to allow applicants to choose the means most appropriate to their aircraft to achieve the objective.

Partially accepted.

The second paragraph of the proposed AMC 25.1326 has been clarified to better state the objective which is related to the selection of the heating system failures to be indicated, not to the failure of the system monitoring the heating system.

The last paragraph has been deleted as proposed as we understand it is considered too prescriptive.

Nevertheless, we do not agree that maintenance procedures can be used to replace an adequate alerting system; when a failure is hazardous, the flight crew must be aware of it and it is not acceptable to continue the aircraft operation with a non-annunciated failure. (Note AMC 25.1309 states that 'The use of periodic maintenance or flight crew checks to detect significant latent failures when they occur is undesirable and should not be used in lieu of practical and reliable failure monitoring and indications').

Furthermore, the availability of a back-up and independent system to determine the aircraft airspeed (in the case of Pitot probes) is a very good step in safety improvement, however, it does not remove the need of being able to detect the flight probe failures.

comment

177

comment by: Boeing

Page: 82

Paragraph: AMC 25.1326 *Flight instrument external probes heat indication systems*

Boeing recommends revising the proposed text as follows:

"AMC 25.1326

*Flight instrument external probes heat indication systems*

CS 25.1326 requires that if a flight instrument external probe heating system is installed, an alerting system must be provided to alert the flight crew when the flight instrument external probes heating system is not operating ~~or not functioning normally~~. It is therefore expected that failures ~~are will be~~ indicated to the flight crew if such failures have an impact on the performance of the heating system to the extent of having an "effect on operational capability or safety" (see CS 25.1309).

It should be assumed that icing conditions exist during the failure event. ~~The decision to provide failure indication should not be based on the numerical probability of the failure event. Even if a numerical probability analysis indicates that system failure is improbable or extremely improbable, if the failure could potentially result in a hazardous condition, then the failure indication has to be provided. All failures, resulting in less than full heating capability, must be annunciated unless they are shown to be extremely improbable (10<sup>-9</sup>). The setting of the alert provided to the flight deck is expected not to be lower than the lowest acceptable value of the heating performance according to its performance specification and/or qualification standards.~~

**JUSTIFICATION:** A mandate to have 100% failure monitoring goes beyond the most critical functions currently designed. This issue was discussed during meeting No. 5 of the EUROCAE WG-89. In that meeting, the EASA representative agreed that the wording should be changed to: "Recommend all failures resulting in less than full heating capability must be annunciated unless they are shown to be extremely improbable (10<sup>-9</sup>)."



response

Boeing therefore recommends that the agreed-to wording be used to ensure consistent requirements between the Agency's certification specifications and the industry standards.

Partially accepted.

The second paragraph of the proposed AMC 25.1326 has been clarified to better state the objective which is related to the selection of the heating system failures to be indicated, not to the failure of the system monitoring the heating system.

The quoted sentence was not found in the agreed minutes of the meeting N°5 of the EUROCAE WG 89.

The approach of determining if a failure of the probe heating system has to be alerted based on an estimation of its probability is not shared by EASA.

The approach proposed in this AMC is equivalent to the one used in the current FAA AC 25.1419-1 and proposed draft AC 25-XX, used to show compliance to FAR 25.1419(c) for airframe ice protection systems. It is also present in our proposed AMC 25.1419 amendment.

### Cessna comment on page 82

The AMC material acknowledges that failures having an impact on the performance of the heating system to the extent of having an "effect on operational capability or safety" would require an alert per 25.1309.

This infers that that if a heated probe failure did not have an "effect on operational capability or safety", it would not be necessary to alert the flight crew which appears to be in conflict with the rule language of 25.1326.

The concern is adding to the crew workload for alerting to failures that are better suited to maintenance activities and would not have a significant safety effect.

Recommend the criteria of 25.1309(c) should be the driving requirement for the need for a crew alert.

Suggested change:

Add AMC material that clarifies the requirements with respect to 25.1309.

Response: Partially accepted.

CS 25.1309 remains applicable. AMC 25.1309 provides sufficient guidance material. The intent of the proposed AMC is to clarify the meaning of 'not functioning normally'.

### B. Draft Decision — I. Draft Decision amending CS-25 — Book 2; AMC — SUBPART F — AMC No. 1 to CS 25.1329 Flight Guidance System

p. 82-84

comment

178

comment by: Boeing

Page: 83

Paragraph: AMC No. 1 to CS 25.1329 Flight Guidance System

9.1 FGS Controls

Boeing recommends revising the proposed text as follows:

"9.1 FGS Controls

The FGS controls should be designed and located to provide convenient operation to each crewmember and ~~they must be designed~~ to ~~prevent~~ minimize crew errors, confusion and inadvertent operation (CS 25.1329(i)). To achieve this, CS 25.1329 (f) requires that command reference controls to select target values (e.g., heading select, vertical speed) should operate as specified in CS 25.777(b) and 25.779(a) for cockpit controls. The function and direction of motion of each control ~~must~~ should be readily apparent or plainly indicated on, or adjacent to, each control if needed to prevent inappropriate use or confusion (CS 25,1329(f)). CS



	<p>25.781 also provides requirements for the shapes of the knobs. The design of the FGS should address the following specific considerations:"</p> <p><b>JUSTIFICATION:</b> Boeing maintains that, while FGS controls can be designed to minimize crew errors, confusion, and inadvertent operation, the airplane manufacturer cannot design to prevent every error a crew could possibly make. There are existing rules that govern what type of controls can be used.</p> <p>Further, it is inappropriate to use the word "must" in guidance material, as that implies a requirement beyond those established by the corresponding rule.</p>
response	<p>Partially accepted.</p> <p>The text should reflect the rule provided in Book 1. Therefore, 'prevent' has been replaced by 'minimize', but the rest of the text is consistent.</p>
comment	<p>179</p> <p style="text-align: right;">comment by: <i>Boeing</i></p> <p>Page: 83 Paragraph: AMC No. 1 to CS 25.1329 Flight Guidance System 10.1 Normal Performance</p> <p>Boeing recommends revising the last bullet as follows: "10.1 Normal Performance ... • Icing (trace, light, moderate) – all icing conditions covered by Appendix C to CS-25 <del>and applicable icing conditions covered by Appendix O to CS-25</del>, with the exception of "asymmetric icing" discussed under "Rare Normal Conditions" in Section 10.2 below."</p> <p><b>JUSTIFICATION:</b> Boeing requests that the Supercooled Large Drop icing conditions represented by Appendix O be classified as "Rare Normal Conditions" due to their low frequency of occurrence, and that Section 10.2 be revised accordingly. The Ice Protection Harmonization Working Group Report (Appendix N; December 2005) states that encounters with the Appendix O conditions are infrequent: "approximately 1 in 100 to 1 in 1000, on average, in all worldwide icing encounters." It was never the intention of the Flight Guidance System Harmonization Working Group to classify such infrequent icing environments as "Normal Conditions."</p>
response	<p>Not accepted.</p> <p>Moving Appendix O icing conditions from 10.1 to 10.2 does not seem appropriate. Only asymmetric icing is addressed in 10.2 (independently from the category of icing conditions). The proposed text has been maintained, and it is harmonised with the proposed FAA AC No: 25.1329-1B.</p>

**Cessna comment on page 84:**

The terms "trace, light, moderate" have no accepted definitions in the icing certification environment. Recommend deletion.

Current text:

Icing (trace, light, moderate) – all icing conditions covered by Appendix C to CS-25 and applicable icing conditions covered by Appendix O to CS-25, with the exception of "asymmetric icing" discussed under "Rare Normal Conditions" in Section 10.2 below.

Proposed text:



Icing (~~trace, light, moderate~~) – all icing conditions covered by Appendix C to CS-25 and applicable icing conditions covered by Appendix O to CS-25, with the exception of “asymmetric icing” discussed under “Rare Normal Conditions” in Section 10.2 below.

Response: Accepted.

**B. Draft Decision — I. Draft Decision amending CS-25 — Book 2; AMC — SUBPART F — AMC**  
**25.1403 Wing icing detection lights**

p. 84

comment	7	comment by: UTC Aerospace Systems - Sensors & Integrated Systems
	<u>Page 84 – Wing Ice Detection Lights</u> An impingement analysis and critical temperature analysis shall be required of the ice evidence probe since this is being used as the primary means of determining ice formation. What action should be taken if the ice detection lights fail?	
response	Noted. CS 25.1403 is required in addition to the means of detection required per CS 25.1419(e), therefore, this should be considered as a back-up system, not as a primary means.	

**B. Draft Decision — I. Draft Decision amending CS-25 — Book 2; AMC — SUBPART F — AMC**  
**25.1419 Ice Protection**

p. 84-99

comment	8	comment by: UTC Aerospace Systems - Sensors & Integrated Systems
	<u>Page 86 – Impingement Limit Analysis</u> Add “any means used for recognition of icing conditions” to the list of surfaces that must have an impingement analysis. This must include ice detectors, ice evidence probes, and visual cues (wiper post, rod, side window cues). The droplet size for these impingement analyses should be Appendix C and Appendix O (SLD) in accordance with these regulations, rather than being limited to 50 microns max. <u>Page 93 – d) 1)</u> What substantiation is required for “substantiated visual cues” (impingement analysis, Tcrit, other)? The first bullet in this section is not clear. Please clarify what “when icing conditions exist” means. Does it mean – temp/visible moisture? Must the ice detector annunciate when the visual cue demonstrates ice? <u>Page 94 – last paragraph of 1.1.1.1</u> The loss of one ice detector does not mean the loss of the ice detection function. It is preferred that the remaining functional ice detector be allowed to continue to function to alert the flight crew if icing is detected. However, a loss of one ice detector may warrant reverting to an “Advisory” ice detection system until the failure of the ice detector is cleared, depending on the system safety assessment performed by the aircraft manufacturer. <u>Page 94 section 1.1.1.2</u> In section (i) the requirement for mixed phase conditions should be to demonstrate that it doesn’t affect the safety of the aircraft. For example, mixed phase conditions may affect the accretion rate of the ice detector and the accretion rate of the aircraft surfaces equally. This means the conditions affect the performance, but have no impact on the function or safety.	



In section (ii) the impingement analysis should be SHALL and it should apply to anything used to monitor ice accretion. Sideslip should also be considered, but there should not be a requirement that it is exposed to free stream since it is possible to account for local conditions. The sentence that follows this requirement is sufficient and more accurately reflects the desired state. It may be helpful to note that a dry air analysis demonstrating the probe extends beyond the boundary layer is not sufficient – a droplet impingement analysis must be performed.

In section (v) note there may be conditions where the ice detection system is active but the ice protection system is inhibited. Both possibilities need to be considered.

In section (vi) it is technically not “low freezing fraction” conditions since by definition ice will accrete for any freezing fraction above zero (although accrete very slowly at very low fractions). Consider re-wording as “If the PIDS cannot detect ice in some condition where ice accretes on critical aircraft surfaces.....”. Note this assumes the technology being used is an accretion-based technology. Consider starting the sentence with “If an accretion-based technology is being used for ice detection,....”).

In section (vii) this function may reside at least partially within the ice protection system logic and be outside of the ice detection system.

In section (ix) the ice protection system overheat protection is not likely to reside within the ice detection system.

In section (xi) it is important to require droplet impingement analysis and critical temperature analysis on any reference instrumentation. The accuracy of the reference instrumentation must also be considered. Also, redundancy requirements for the two ice detectors must account for factors such as differences in local airflow (due to sideslip or other factors). Performance for the two ice detectors shall be similar within expected performance limits.

Page 96 section 1.1.1.3

A pre-flight check should not be required because the system safety assessment will determine if this is necessary.

In dual ice detector installations, the signals are typically combined with a logic “or”. In this case, there is no disagreement. This is often necessary to meet 25.1309 requirements.

Page 96 section 1.1.2

In the case of a substantiated visual cue and advisory ice detector combination, because the ice detector is “advisory” then the visual cue must be the primary means of detection and should be required to be substantiated to primary levels.

Page 97 section 1.2

If the reference surface cannot be deiced, the applicant must show that the sublimation/melting rates are the same (or conservative) between the reference surface and the protected surface for all flight icing conditions. Also, the applicant must substantiate not only for all icing conditions, but also for all flight conditions.

Page 97 section 1.2.1 a)

Since the visual cues are the “primary” means of detection in this case, it would seem reasonable that the vision scan requirements for the flight crew should be the same as those for a PIDS in section 1.1.1.2 part (x).

Page 97 section 1.2.2

The requirement to be able to detect clear ice should be a hard requirement, not just a consideration.

Page 98 section 2.1

As the primary means of detection, the temperature measurement must meet the same unannounced loss requirements as a PIDS.

## response

Comment 1 - Page 86 – Impingement Limit Analysis: Partially accepted. The list is completed with any means used to detect ice accretion. However, the 50 µm drop is maintained as it is specified for compliance with CS 25.1419.

Comment 2 - Page 93 – d) 1): Noted. The visual cues substantiation is addressed in paragraph (d)(1.2) of the proposed AMC 25.1419. The term ‘icing conditions’, as defined in CS 25.1419(e)(3), indeed means conditions conducive to ice accretion as defined by an appropriate static or total air temperature and visible moisture.

Comment 3 - Page 94 – last paragraph of 1.1.1.1: Accepted. It is clarified that, after the loss of one detector, the primary detection system is lost. A new sentence is added to allow the applicant reverting to an advisory detection system.

Comment 4 - Page 94 section 1.1.1.2:

(i): Accepted, the sentence has been updated to state that the presence of ice crystals mixed with supercooled water does not lead to unacceptable ice detection performance degradation.

(ii): Partially accepted. The statement is now applicable in general to IDS. ‘Shall’ is not accepted as it is not linked to the reference to or repeat of a rule. The case of side slip has been mentioned (the second sentence was deleted and the last sentence of the paragraph updated). It is not deemed necessary to focus on dry air analysis as suggested, because the rest of the paragraph is clear enough.

(v): Not accepted. Both possibilities need not be considered in this paragraph discussing ice detection aspect; note that this paragraph is now considered for IDS in general, not specifically for PIDS. The case of IPS inhibition should be treated as part of the ice protection performance (25.1419(a) and (b)).

(vi): Accepted.

(vii): Noted, this paragraph has been deleted as not necessary for ice detection design discussion.

(ix): Accepted, this sentence has been deleted.

(xi): Noted, but this discussion should be conducted during a certification project as part of the usual instrumentation analysis and validation process; it is not deemed necessary to mention this in the AMC.

Comment 5 - Page 96 section 1.1.1.3: Accepted, ‘if required’ has been added.

Comment 6 - Page 96 section 1.1.2: Accepted. The paragraph already clearly states that the flight crew has primary responsibility for determining when the IPS must be activated.

Comment 7 - Page 97 section 1.2: Not accepted, the protected surface should be clear of ice anyway, whatever the status of the reference surface is.

Comment 8 - Page 97 section 1.2.1 a): Noted. This paragraph on PIDS has been removed, and it is addressed in other paragraphs of CS-25 (25.1302, 25.1322). For visual cues, the proposed paragraph 1.2.1 is clear enough.

Comment 9 - Page 97 section 1.2.2: Partially accepted. The sentence has been reworded to make it clear that the capability of detecting clear ice has to be verified.



Comment 10 - Page 98 section 2.1: Accepted. A new sub-paragraph has been created on this topic at the end of the new paragraph 1.1.5 on Ice detection system safety considerations.

comment

64

comment by: AIRBUS

**AMC 25.1419(a) Analysis Page 85****Recommended Change:**

The applicant should prepare analysis to substantiate the choice of ice protection equipment for the aeroplane. Such analysis should clearly state the basic protection required and the assumptions made, and delineate methods of analysis used. All analysis **tools and methods** should be validated by tests or should have been validated by the applicant on a previous certification program. The applicant who uses a previously validated method should substantiate why that method is applicable to the new program.

**Rationale:**

The intent of this section is to require the tools to have been validated and applied taking into account any limitations. Likewise tests must also be performed taking into consideration the limitations of the available means.

A mixture of analysis, test and experience from previous programs will be used to ensure the certification objectives are achieved.

The objective of the added text is to reflect this. All tools and methods will be validated. The existing proposed text could be misinterpreted. For example the current wording might question the use of analysis to extrapolate test results or the use of previously validated analysis tools to new designs. The proposed additional wording is recommended for inclusion.

response

Accepted.

comment

65

comment by: AIRBUS

**AMC 25.1419 (a)(2) Analysis of areas and components to be protected Page 86****Recommended Change:**

~~shading~~ **shedding** of ice accreting on unprotected areas will not **endanger continued safe flight and landing when considering** ~~create an unsafe condition~~ the engines or the surrounding components.

**Rationale:**

It is believed that the word shading is a typo and the word shading should be shedding.

It is recommended to replace the words "unsafe condition" with the proposed text to aid clarity. Alternatively some guidance on what is considered an unsafe condition in the context of ice shedding may be beneficial e.g. unacceptable damage to structure, engine instability (surge, stall), unacceptable engine damage etc.

Some guidance on the assumptions to be used in performing the assessments may be beneficial.

response

Accepted.

'Shading' is replaced by 'shedding'.

The sentence has also been modified to reflect that no unacceptable damages should be created preventing continued safe flight and landing. A similar change is made to the first paragraph of (4) Ice Shedding Analysis.





**Cessna comment on page 86**

Change Text Language

Current Text:

Third bullet from top of page, current language:

shading of ice accreting ...

Proposed Text:

- ~~shading~~ shedding of ice accreting ...

Response: Accepted.**Cessna comment on Section a(2) page 86**

Not practical to provide protection to the level of not affecting the operation and functioning of affected systems.

As an example, ice may form on portions of an auxiliary inlet and have a minor effect on the operation and functioning, but as long as the system operation/functioning still meet the minimum certification requirements, it remains compliant.

Current text:

“the lack of protection does not affect the operation and functioning of affected systems and equipment, “

Proposed text:

the lack of protection does not ~~affect~~ degrade the operation and functioning of affected systems and equipment below minimum certification requirements,

Response: Partially accepted. The sentence has been modified to state that no unacceptable effects should be caused.

comment

66

comment by: AIRBUS

**AMC25.1419 (4) Ice Shedding Analysis Page 86**

Recommended Change:

For critical ice shedding surfaces (~~unprotected areas~~) an analysis ~~must~~ should be performed to show that there is no ice shedding hazard due to ice shedding from these surfaces ~~will not cause an unsafe condition~~

Rationale:

An unprotected section is not necessarily a critical shedding surface. In most cases it will be the unprotected sections that need to be assessed but it should normally be possible to limit the assessments to specific parts of the aircraft.

For example retractable landing gear, semi-flush mounted antennas etc. may not require analysis. As written this guidance appears to recommend that every unprotected surface of the aircraft be analysed.

The use of the word should instead of must is more in line with guidance language.

The proposed wording is in line with the FAA wording in AC25-XX. The use of the phrase “unsafe condition” is not appropriate in the AMC unless additional guidance on what would constitute an unsafe condition is provided. The proposed wording conveys the objective.

The AMC states later that trajectory analysis “may not adequately predict such damage...”

However there needs to be some means to limit the range of impacts to be considered. For example radome ice impacts on the wing tip need not be considered.

The text related to the capabilities of trajectory should be tempered. The analysis capabilities have developed and trajectory analysis should be considered a valid tool as long as it is applied conservatively with a good understanding of the methods and tools and their capabilities and limitations.



response	<p>Partially accepted.</p> <p>The reference to unprotected areas has been removed. However, the proposed wording on ice shedding effect has not been adopted; consistency is maintained with paragraph (2) last bullet on ice shedding.</p>
comment	<p>67 <span style="float: right;">comment by: AIRBUS</span></p> <p><b>AMC25.1419 (7) Artificial ice shapes and roughness Page 87</b></p> <p>Recommended Change:</p> <p>The applicant should substantiate the drop diameter <del>distribution</del> (mean effective, median volume, <del>spectra</del>), liquid water content, and temperature that will cause formation of an ice shape critical to the aeroplane's performance and handling qualities.</p> <p>Rationale:</p> <p>As stated earlier in the AMC, CS25 does not require consideration of a specific distribution. The identification of the critical ice accretion involves analyses of a range of icing conditions. The spectrum of droplet sizes selected monodispersed, Langmuir-D, E etc. has a second order affect upon the ice shapes and hence it is not necessary to study a range of spectra to determine the critical ice shape.</p> <p>The additional recommendation to check a range of different spectra of droplet sizes will potentially add significant additional analysis effort for no gain in safety.</p>
response	Accepted.
comment	<p>68 <span style="float: right;">comment by: AIRBUS</span></p> <p><b>AMC 25.1419 (7) Artificial ice shapes and roughness Page 87</b></p> <p>Recommended Change:</p> <p>Ice roughness used should be based on icing tunnel, natural icing, or tanker testing <u>or the guidance in AMC 25.21g paragraph XX</u></p> <p>Rationale:</p> <p>Either delete the whole paragraph to avoid redundancy and inconsistency or add a cross reference to ACM 25.21g to ensure consistency and avoid misunderstandings.</p>
response	Accepted.
comment	<p>72 <span style="float: right;">comment by: AIRBUS</span></p> <p><b>AMC 25.1419(b) Page 88</b></p> <p>The current text:</p> <p><i>The aeroplane should be shown to comply with certification specifications when all IPS are installed and functioning. This can normally be accomplished by performing tests in those conditions found to be most critical to basic aeroplane aerodynamics, IPS design, and powerplant functions. All IPS equipment should perform their intended functions throughout the entire operating envelope.</i></p> <p>Should be changed into:</p> <p>The aeroplane should be shown to comply with certification specifications when all IPS are installed and functioning. This can normally be accomplished by performing tests <u>in natural or simulated icing (in icing tunnels or behind icing tankers) to either validate analysis or to test</u> those conditions found to be most critical to basic aeroplane aerodynamics, IPS design,</p>



and powerplant functions. All IPS equipment should perform their intended functions throughout the entire operating envelope.

Rationale:

Preamble talks about performing tests "... in those conditions found to be most critical...". However during natural icing tests it is not practicable to find all the critical combinations of LWC, MVD, temperature etc. The preamble is probably referring to icing tunnel and tanker testing. Whereas the following section addresses all types of tests. It is therefore necessary to clarify in the preamble that whilst sufficiently severe icing conditions must be flown it is not expected that an applicant find the specific critical conditions, identified by analysis of tests, during natural icing tests.

Section 3.3 on page 91 acknowledges the above, but the preamble implies that the critical condition should be found.

The sections that follow the preamble deal with flight tests, icing tunnel and tanker tests. The proposed change to the preamble makes it more coherent with the sections that follow and makes the EASA expectation clearer.

Note that it is often not possible to test the full range of conditions (a/c speed range, aerofoil size restriction, altitude, LWC and droplet diameter ranges) in an icing tunnel or behind an icing tanker, especially for large aerofoils and aircraft, and hence an element of validated analysis will generally be required.

Flight tests in extreme icing conditions are performed but typically, and as recognized by the FAA AC's, finding all the corners of the flight and icing envelopes is not feasible. For this reason conservative analysis techniques have been used successfully in combination with dry air and natural icing flight tests.

response Accepted.

comment

73

comment by: AIRBUS

#### AMC 25.1419 (b)4 Page 91

The current text:

*For the evaluation of the performance of the IPS, the following conditions have been successfully used in the past to simulate the Appendix C conditions:*

And

*If the steady state cannot be reached, the duration of the run can be limited to 45 minutes.*

Should be changed into:

**A critical point analysis can be used to identify critical test conditions under which an IPS shall be tested in an icing tunnel. In lieu of a critical point analysis the following conditions**

that have been successfully used in the past to simulate the Appendix C conditions can be used:

**And**

If the steady state cannot be reached, the duration of the run can be limited to **45 30** minutes.

Rationale:

The icing tunnel conditions quoted are from method 1 of the previous version of the AMC (referred to in the previous AMC as Method 1 is an arbitrary empirical method based on United Kingdom and French practice). The new AMC states that this has "...been used in the past to simulate App C conditions". It is noted that the method 1 tests were run for 30 minutes in continuous maximum icing conditions whereas the new AMC defines a test duration of 45 minutes. It is also noted that the LWC values are 50% higher than those of



	<p>Appendix C.</p> <p>The section does not mention performing tests in the actual conditions of Appendix C conditions as has been successfully done by many applicants in the past. This is the method 2 approach of the current AMC which according to AMC is “based on US practice in applying FAR Part 25, Appendix C”.</p> <p>The method 2 approach should be mentioned in the AMC. Differences between the US (FAA) and European (EASA) expectations on this aspect are unacceptable.</p>
response	<p>Partially accepted.</p> <p>The possibility to use a CPA is added as proposed.</p> <p>Concerning the duration of the tests, the proposed AMC requires to wait at least until steady state conditions are established (without imposing a 30 minutes duration like in the current AMC 25.1419 Method 1). If steady state conditions are not established, then the AMC requires running the test during 45 minutes maximum. Therefore, the proposed AMC does not just consist of increasing the current 30 minutes to 45 minutes.</p>
comment	<p>74</p> <p>comment by: AIRBUS</p> <p><b>AMC 25.1419(e) 1.1.1.2 Page 95</b></p> <p>The current text:</p> <p><i>Flight icing conditions (minimum detectability),</i></p> <p>Should be changed into:</p> <p><b>FL</b>ight icing conditions (minimum detectability),</p> <p>Rationale:</p> <p>Typographical error</p>
response	<p>Accepted.</p>
comment	<p>75</p> <p>comment by: AIRBUS</p> <p><b>AMC 25.1419 (2) Analysis of Areas to be Protected Page 85</b></p> <p>The current text:</p> <p><i>the lack of protection does not affect the operation and functioning of affected systems and equipment,</i></p> <p>Should be changed into:</p> <p>the lack of protection does not <b>cause unacceptable</b> affects upon the operation and functioning of affected systems and equipment,</p> <p>Rationale:</p> <p>The intent of this guidance is to ensure that the applicant assesses the affect upon systems of the lack of ice protection in critical areas prone to ice accretion. To state that no affect is allowed is incorrect. For example ice accretion on the ECS intake may cause an ECS ram air modulation ramp to open more than in non-icing conditions. However the ECS is designed to ensure that this does not lead to unacceptable affects such as pack overheat or unacceptable flow reduction.</p>
response	<p>Accepted.</p>
comment	<p>76</p> <p>comment by: AIRBUS</p>



	<p><b>AMC 25.1419 (2) p.94 1.1.1.2 (i)</b></p> <p>The current text:  <i>It should be demonstrated that the presence of ice crystals mixed with supercooled water does not affect the ice detection capability.</i></p> <p>Should be changed into:          It should be demonstrated that the presence of ice crystals mixed with supercooled water does not affect the ice detection capability <b>unacceptably</b>.</p> <p>Rationale:          Some limited impact on detection capability in mixed phase icing conditions is acceptable if the overall safety of the aircraft is assured with reduced (or increased) sensitivity to icing conditions in mixed phase icing.          It is noted that mixed phase conditions are transient conditions. Also the presence of crystals causes ice accretions to be eroded by the impacting ice crystals. Mixed phase icing should not be ignored and some flexibility in the guidance material is required.</p>
response	Accepted.
comment	<div>77</div> <div>comment by: AIRBUS</div>
	<p><b>AMC 25.1419 (2) p.94 1.1.1.2 (ii)</b></p> <p>The current text:  <i>The applicant should show that under the various aeroplane operational configurations, phases of flight, airspeeds, and associated angles of attack, the ice detector is exposed to free-stream water drops</i></p> <p>Should be changed into:          The applicant should show that under the various aeroplane operational configurations, phases of flight, airspeeds, and associated angles of attack, the ice detector is exposed to <b>Liquid Water Concentration no lower than that of the</b> free-stream</p> <p>Rationale:          The objective is to avoid putting the detector in a shadow area where the local liquid water content is lower than the freestream. Locating the detector in an area of very high LWC concentration may also not be recommended to avoid issues of over-sensitivity. However the guidance should not mandate that the sensor be located in the freestream. Some over-concentration of LWC may even be beneficial.</p>
response	Noted.
	<p>The principle of the comment is agreed, but this paragraph has been modified and is now available in a new paragraph dealing with performance and installation of all IDS. There is no more reference to the exposure to free stream.</p>
comment	<div>78</div> <div>comment by: AIRBUS</div>
	<p><b>AMC 25.1419 (1.1.1.2) Page 95 Performance and Installation of the PIDS</b></p> <p>Refer also to comment on AMC25.1419 (4) Ice Shedding Analysis</p> <p>The current text:  <i>The amount of ice accreted can be safely eliminated by the ice protection systems. It should be demonstrated that when the amount of ice that is accreted on the protected surfaces is shed, no damages occur to the airframe or the engines;</i></p> <p>Should be changed into:</p>

response	<p>The amount of ice accreted can be safely eliminated by the ice protection systems. It should be demonstrated that when the amount of ice that is accreted on the protected surfaces is shed, no <b>unacceptable</b> damage occurs to the airframe or the engines</p> <p>Rationale:</p> <p>Some guidance on the assumptions to be taken in performing this analysis may be beneficial. Some damage to structure or engines may be acceptable as long as the damage is within acceptable limits.</p> <p>Accepted.</p>
comment	<p>79</p> <p>comment by: AIRBUS</p> <p><b>CS 25.1419(b) Testing (3) Icing flight tests page 90</b></p> <p>The current text:</p> <p><i>If necessary, there should be a means to measure and record ice accumulations and impingement limits. These can be approximated by various means, such as a rod mounted on the airfoil and black paint on the airfoil to increase the contrast between the ice accretion and the airfoil.</i></p> <p>Should be changed into:</p> <p>If necessary, there should be a means to <del>measure and</del> record the ice accumulations <b>to allow the size, location, shape, extent and general nature of the ice to be approximated. Various means can be used to aid this</b>, such as a rod <b>or fence</b> mounted on the airfoil with black or <b>brightly coloured</b> paint to increase the contrast between the ice accretion and the airfoil <b>and aid the determination of the ice shape size</b> .</p> <p>Rationale:</p> <p>Measuring impingement limits during natural icing tests is not currently practical. However the ice shape extent can be recorded by video and estimated. Markings on the wing of the aircraft aid these assessments.</p> <p>Accepted.</p>
comment	<p>87</p> <p>comment by: Dassault Aviation</p> <p>Dassault-Aviation comment page 85-86</p> <p><b>Extract:</b></p> <p><b>AMC 25.1419 - Ice Protection</b></p> <p><b>(a) CS 25.1419(a) Analysis</b></p> <p><b>(2) Analysis of areas and components to be protected</b></p> <p>The applicant should show that:</p> <ul style="list-style-type: none"> <li>· the lack of protection does not adversely affect handling characteristics or performance of the aeroplane, as required by CS 25.21(g),</li> <li>· the lack of protection does not affect the operation and functioning of affected systems and equipment,</li> <li>· the lack of protection does not affect the flight instrument external probes systems, and</li> <li>· shading of ice accreting on unprotected areas will not create an unsafe condition for the engines or the surrounding components.</li> </ul> <p><b>Comment:</b></p> <p>The last sentence is supposed to be understood as dealing with shedding of ice and not shading of ice.</p>



response	<b>Requested Change</b> Please Agency to review and correct if needed.
	Accepted. 'Shading' has been replaced by 'shedding'.

comment

114

comment by: FAA

Page	Para	COMMENT / SUGGESTED CHANGE	Rationale
86	4 <sup>th</sup> bullet in section (a)(2).	Currently states that "shading of ice accreting on unprotected areas..." but should read <b>shedding</b> of ice...instead.	Typographical error
87	AMC 25.1419 item (7)	The last sentence of the first paragraph should be revised as follows: "...that will occur before activation <b>and proper functioning</b> of the ice protection system."	The suggested text is intended for clarity and to properly account for time delays.
88	(b) CS 25.1419	The first sentence of the first paragraph should be revised as follows: "The aeroplane should be shown to comply with certification specifications when all IPS are installed and functioning <b>when operating normally and under certain failure conditions.</b> "	Inclusion of the suggested statement would emphasize what conditions need be considered, in particular failure conditions.
88	(b) CS 25.1419	Add a bullet item under purposes of flight testing to indicate that another purpose of flight testing is for validation of ice accretion size, location, texture, and other characteristics.	Flight testing is one of the primary means of validating ice accretions.
88	(b) CS 25.1419(b) Testing, section (1)	Add the following to the second bullet: "Obtain a thermal profile of an operating thermal IPS <b>to substantiate its thermal performance.</b> "	To provide indication of why the data is necessary.
92	Section 3.3	The last paragraph discussing thermal de-ice systems should also suggest documenting any residual or intercycle ice accretions.	If such accretions exist, they should be used to substantiate the performance and handling requirements of subpart B.



93	Section 4.2	The first paragraph should define MVD as Median Volume Diameter for consistency with the defined acronym or leave off the definition since it was already defined in the acronyms.	Terminology should be consistent throughout the document.
93	(c) CS 25.1419(c) Caution information	<p>The first paragraph in this section should be clarified to indicate that caution information is required in accordance with CS 25.1419(c), but should be provided in accordance with CS 25.1322. Proposed text is provided below.</p> <p>Section 25.1419(c) requires that caution information be provided to alert the flightcrew when the IPS is not functioning normally. In this context, caution information is considered to be a general term referring to an alert rather than referring specifically to a caution level alert. Crew alerting should be provided for failure conditions of the IPS in accordance with 25.1309(c) and 25.1322. It should be assumed that icing conditions exist during the failure event. In accordance with § 25.1419(c), the decision to provide an alert must not be based on the numerical probability of the failure event. However, the type of alert provided should be based on the failure effects and necessary crew action to be performed in response.</p>	Since CS 25.1419(c) specifically requires caution information, the AMC should not imply that installation of an alert is dependent on the hazard level. In the context of 25.1419(c), caution information is a general term similar to alert rather than specifically referring to a caution level alert. Although an alert is required per 25.1419, the level of alert should be consistent with other crew alerts in accordance with 25.1322 and could also be a warning or advisory depending on the failure effects. The FAA is considering similar clarification to advisory materials in support of current rulemaking projects so the proposed clarification would also be consistent with FAA guidance.
93	Section (d)(1)	<p>The paragraph should be revised as follows:</p> <p>CS 25.1419(e)(2) requires defined visual cues for recognition of the first sign of ice accretion on a specified surface combined with an advisory ice detection system that alerts the flight crew to activate the airframe ice protection system. <del>An acceptable means of compliance is the combination of visual cues with an advisory ice detection system.</del></p>	Proposed change is for clarity since the sentence being proposed to be removed is redundant and captured in the previous sentence.





96 - 97	1.1.2	This section discusses advisory ice detection systems (AIDS) in comparison to primary ice detection systems (PIDS). The section advises that “Analysis and tests similar to those performed for a PIDS should be performed for an AIDS to understand its characteristics, limitations, and installation.” However, details describing which analysis and testing would not be required for an AIDS, but required for a PIDS. The section should clarify that the only difference between an AIDS and PIDS should be the criticality due to failure. Un-annunciated loss of a PIDS is often considered catastrophic, while loss of an AIDS may only be minor since the flight crew has primary responsibility for determining they are operating in icing conditions.	The expected qualification differences between an AIDS and PIDS should be well defined so that the guidance can be consistently applied.
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response

Comment 1 – Page 86: Accepted. The typo has been corrected.  
 Comment 2 – Page 87: Accepted.  
 Comment 3 – Page 88: Accepted.  
 Comment 4 – Page 88: Accepted. A new bullet has been added as proposed.  
 Comment 5 – Page 88: Accepted.  
 Comment 6 – Page 92 section 3.3: Accepted.  
 Comment 7 – Page 93 section 4.2: Accepted. The definition has been rationalised in all the CS's and AMC's. Median Volume Diameter is retained.  
 Comment 8 – Page 93 Caution information: Accepted.  
 Comment 9 – Page 93 (d)(1): Accepted.  
 Comment 10 – Page 96-97: Not accepted. The text quoted in this comment has been deleted. Note that a new paragraph (1.1.5) on ice detection system safety has been created. Concerning AIDS, it is reminded that indeed the pilot is responsible to detect visual cues and that this is the primary means of detection. However, it is also considered that in presence of an AIDS pilots may tend to get accustomed to the detection system and thus any non annunciated failure of the AIDS should be considered as at least Major failure condition, not Minor.

comment

154

comment by: AIRBUS

**AMC 25.1419 (1.1.2) - Advisory Ice Detection System (AIDS) Page 97**

The current text:



	<p><i>[...] Therefore, an undetected failure of the advisory ice detector should be considered as at least a major hazard unless substantiated as meriting a lower failure condition classification [...]</i></p> <p>Should be changed into:</p> <p><i>[...] Therefore, an undetected failure of the advisory ice <del>detector</del> <b>detection system</b> should be considered as at least a major hazard unless substantiated as meriting a lower failure condition classification [...]</i></p> <p>Rationale:</p> <p>It is common to install more than one ice detector. The loss of only one ice detector, unannounced or otherwise, has almost no effect on the safety of the aircraft for a manual advisory system. As described by EASA Acceptable means of Compliance (AMC) 25.1309 a classification of major would lead to a failure probability objective of remote or in qualitative terms a failure that would not occur within the life of an aircraft.</p> <p>For a system that is not critical to the safe operation of the aircraft a major classification for loss of a single ice detector is inappropriate. In addition as the manual advisory ice detection system is a back-up to the crew it is reasonable to classify the unannounced loss of the ice detection system as minor or major.</p>
response	<p>Accepted.</p> <p>Please note that this text has now been moved to (1.1.5) Ice detection system safety considerations.</p>
comment	<p>180</p> <p>comment by: Boeing</p> <p>Page: 86-87</p> <p>Paragraph: (a) CS 25.1419(a) Analysis</p> <p>(4) Ice Shedding Analysis</p> <p>Boeing recommends revising the proposed text as follows:</p> <p>“(4) Ice Shedding Analysis</p> <p>...</p> <p><i>Currently available trajectory and impingement analysis may not adequately predict such damage. Unpredictable ice shedding paths from forward areas such as radomes and forward wings (canards) have been found to negate the results of these analyses.</i></p> <p><i>For this reason, a damage analysis should consider that the most critical ice shapes will shed and impact the areas of concern.</i></p> <p><u><i>For analysis of the radome as a potential airframe ice source, the applicant may use qualitative analysis of the design, supported by similarity to a previous design that has shown successful service history, to have confidence that the historical methodology for certification represented by AMC E 780, Table 3, “Minimum Ice Slab Requirements Based on Engine Inlet Size,” is appropriate.”</i></u></p> <p><b>JUSTIFICATION:</b> Boeing suggests the addition of indicated paragraph to provide guidance on the use of similarity for the radome as a potential airframe ice source. As additional analyses or tests would not improve safety, Boeing requests that the use of similarity to current designs to show compliance for Appendix O conditions be explicitly permitted.</p>
response	<p>Not accepted.</p> <p>This proposal making reference to similarity analysis is not retained because a specific rulemaking task (RMT.0572) is already active on this subject.</p>



comment

181

comment by: Boeing

Page: 92

Paragraph: (b) CS 25.1419(b) Testing

(4.1) Maximum Continuous Condition

Boeing recommends revising the proposed text as follows

“(4.1) Maximum Continuous Condition

Atmospheric Temperature (°C)	Liquid Water Content (g/m <sup>3</sup> )
0	<del>0.8</del> <b>0.64</b>
-10	<del>0.6</del> <b>0.42</b>
-20	<del>0.3</del> <b>0.21</b>
-30	<del>0.2</del> <b>0.14</b>

**JUSTIFICATION:** The values in the Maximum Continuous Condition table correspond to LWC values for a 15 micrometer MVD in CS 25 Appendix C; however, the text states that a 20 micrometer MVD ~~should be used~~. Using an LWC value for 15 micrometers MVD with a 20 micrometer MVD is inappropriate. Our recommended revision provides the correct LWC values for 20 micrometer MVD.

Our recommended revision would improve harmonization with FAA guidance material (AC 20-73A, Table 6, for example, and several other places).

response

Not accepted.

This table is identical to the current table 1 of AMC 25.1419. The values in the table indeed include some conservatism relative to the Appendix C curves. Such conditions were successfully used in the past. Note that other conditions may be proposed by the applicant based on the outcome of a CPA, this has been added in the introduction sentence.

comment

182

comment by: Boeing

Page: 93

Paragraph: (d) CS 25.1419(e) Ice Detection

Boeing recommends the proposed text be revised as follows:

“(d) CS 25.1419(e) Ice Detection

(1) Compliance with CS 25.1419(e)(1) and (e)(2).

These subparagraphs provide alternatives to **CS 25.1419(e)(3), which specifies** operation of the IPS based on icing conditions ~~defined in CS 25.1419(e)(3)~~. . . .”

**JUSTIFICATION: EDITORIAL COMMENT ONLY**

Our recommended revision is a grammatical correction. As proposed, the text states that icing conditions are defined in CS 25.1419(e)(3), rather than stating that CS 25.1419(e)(3) specifies the option to operate the IPS based upon conditions conducive to icing.



response Accepted.

comment

183

comment by: Boeing

Page: 94-95

Paragraph: (1.1) Ice detectors

(1.1.1) Primary Ice Detection System (PIDS)

Boeing recommends revising the proposed text as follows:

“(1.1.1.2) Performance and Installation of the PIDS

(i) A PIDS ~~shall~~should be capable of detecting the presence of icing conditions or actual ice accretion under all atmospheric conditions defined in the relevant icing environment. It should be demonstrated that the presence of ice crystals mixed with supercooled water does not affect the ice detection capability.

For PIDS capable of detecting the presence of ice on a monitored surface, the PIDS ~~shall~~should always detect when ice is present on the monitored surfaces whether or not icing conditions are within the relevant icing environment and the PIDS should not indicate the presence of ice when no ice is present.

(ii) The applicant should accomplish . . . . Performances of the PIDS ~~are-is~~ affected by the physical installation and can only be verified after installation. It ~~has-to~~should be shown by analysis and/or flight test that the location(s) of the detection systems sensor(s) is adequate to cover all flight phases and aeroplane configurations.

. . .

(iii) Evidences ~~must~~should be provided . . . .

(iv) The maximum detection threshold ~~shall~~should be established. The threshold level chosen to activate the ice detection and annunciation system ~~must~~should be guided by the assurance that:

. . .

If the thickness of accreted ice is in excess of the maximum detection threshold on the monitored surface, the PIDS ~~will~~should continue to indicate the presence of ice.

(v) If the PIDS ice detection logic is inhibited during certain flight phases, handling qualities and performance should be demonstrated, with the ice protection systems being inoperative and assuming the aeroplane is operating in conditions conducive to icing.

. . .

(viii) Protection against inadvertent turnoff ~~shall~~should be provided. Preferably, the PIDS should be turned on automatically at aeroplane power-up.

(ix) If the PIDS has automatic control of the ice protection systems, it ~~must~~should be possible to de-select the automatic feature and to revert to an advisory system. In addition, if overheat of the structure can result from the ice protections being on during any operations, then a means ~~must~~should be provided to alert the flight crew or include an automatic means that will prevent such a condition.

(x) The PIDS display(s), flight deck lights and crew alerting messages ~~must~~should be located so that they are within the seated flight crew's forward vision scan area while performing their normal duties.

(xi) During the certification exercise, . . . signals from each ice detector should be recorded during icing tests to verify whether the ice detectors are fully redundant in the whole Appendix C and flight envelope or rather have their own detection threshold to cover the whole Appendix C and flight envelope.”



	<p><b>JUSTIFICATION: EDITORIAL COMMENTS</b></p> <p>The recommended revisions include grammatical and other minor corrections. Boeing requests revision of all “mandatory” language indicating additional requirements, as this is not appropriate in advisory/guidance material.</p>
response	Accepted.
comment	<p>224 <span style="float: right;">comment by: American Kestrel Company, LLC</span></p> <p>The proposed matrix would not capture critical intercycle ice for most pneumatic or other mechanical ice removal systems. This is especially true of flush mounted pneumatic deicers. If these conditions have been used successfully for thermal running wet systems it should be specified.</p>
response	<p>Partially accepted.</p> <p>The introduction sentence has been updated to provide the possibility to use a CPA to identify other test points.</p>

**B. Draft Decision — I. Draft Decision amending CS-25 — Book 2; AMC — SUBPART F — AMC**  
**25.1420 Supercooled large drop icing conditions**

p. 99-106

comment	<p>9 <span style="float: right;">comment by: UTC Aerospace Systems - Sensors &amp; Integrated Systems</span></p> <p><u>Page 101</u></p> <p>Any sensor (an ice detection system that detects accretion behind the protected areas or an aerodynamic performance monitor or visual cues) must demonstrate that it detects under all applicable icing conditions and flight conditions.</p> <p><u>Page 102 at the bottom</u></p> <p>A droplet impingement analysis “shall” be required rather than “should” be required.</p>
response	<p>Not accepted.</p> <p>The comment on page 101 is not understood.</p> <p>Page 102: we use the term ‘should’ as we are writing an AMC, and this sentence does not refer to a rule, therefore, it is not necessary to use the term “shall”.</p>
comment	<p>69 <span style="float: right;">comment by: AIRBUS</span></p> <p><b>AMC 25.1420 Page 100, last paragraph</b></p> <p>The current text:</p> <p><i>“...following detection, the aeroplane must be capable of operating safely while exiting all icing conditions”.</i></p> <p>Should be changed into:</p> <p><i>“...following detection, the aeroplane must be capable of operating safely while exiting all icing conditions <b>until landing</b>”.</i></p> <p>Rationale:</p> <p>The additional text clarifies that the aircraft should be able operate safely while exiting the icing conditions <u>and afterwards until landing with the hold scenario ice shapes</u>. For example, if an a/c encounters App O in the hold and has to exit, it should then be safe to land once the</p>



response	<p>high lift system is deployed with the hold ice shapes in place.</p> <p>Accepted.</p>
comment	<p>70 <span style="float: right;">comment by: AIRBUS</span></p> <p><b>AMC 25.1420 Page 104 and 105 Sections 1.2.2.4 and 1.2.3</b></p> <p>Recommended Change:</p> <p><b>(1.2.3) Probability of encountering Appendix O icing conditions</b></p> <p>Appendix C was designed to include 99 percent of icing conditions. Therefore, the probability of encountering icing outside of Appendix C drop conditions is on the order of <math>10^{-2}</math>. The applicant may assume that the average probability for encountering Appendix O icing conditions is <math>1 \times 10^{-2}</math> per flight hour. This probability should not be reduced based on phase of flight. <b>The probability of encountering SLD conditions as defined in App O can be assumed to be <math>1 \times 10^{-2}</math> per flight hour.</b></p> <p>And</p> <p><b>(1.2.2.4) Icing event history of conventionally designed aeroplanes certificated before the introduction of CS 25.1420</b></p> <p>Given the volume of aeroplane operations and the number of reported incidents that did not result in a catastrophe, a factor of around 1 in 100 is a reasonable assumption of probability for a catastrophic event if an aeroplane encounters Appendix O conditions in which it has not been shown capable of safely operating. <b><u>For an aircraft that can be shown to be similar to ancestor aircraft with safe in-service records a factor of around 1 in <math>10^7</math> is a conservative assumption as many aircraft have never experienced a serious incident or accident in SLD conditions.</u></b></p> <p>An applicant may assume that the hazard classification for an unannounced encounter with Appendix O conditions while the ice protection system is activated is Hazardous in accordance with AMC 25.1309, provided that the following are true:</p> <ul style="list-style-type: none"> <li>- The aeroplane is similar to previous designs with respect to Appendix O icing effects, and</li> <li>- The applicant can show that the icing event history of all conventionally designed aeroplanes is relevant to the aeroplane being considered for certification.</li> </ul> <p><b>In this case a probability of encountering SLD conditions as defined in Appendix O of <math>1 \times 10^{-5}</math> per flight hour can be conservatively defined.</b></p> <p><b>(1.2.4) Numerical safety analysis.</b> For the purposes of a numerical safety analysis, the applicant may combine the probability of equipment failure with the probability, defined above, of encountering Appendix O icing conditions. <b><u>For example</u></b> if the applicant can support a hazard level of 'Hazardous' using the above probability (<math>10^{-2}</math>) of encountering the specified supercooled large drop conditions, the probability of an unannounced failure of the equipment that alerts the flight crew to exit icing conditions should be less than <math>1 \times 10^{-5}</math> per flight hour.</p> <p><b><u>For aircraft that are similar to previous designs with safe in service records a probability of encountering potentially hazardous SLD conditions can be assumed to be <math>1 \times 10^{-5}</math> per flight hour</u></b></p> <p>Rationale:</p> <p>The App O probabilities quoted are extremely conservative. In 1.2.2.4 it is implied that the probability of loss of any aircraft not certified in App. O is <math>1 \times 10^{-2}</math>. In 1.2.3, the probability of App. O is given as <math>1 \times 10^{-2}</math> per flight hour. If these values were accurate one would expect a serious incident every 10,000 flight hours. Since this obviously isn't happening the probabilities are considered to be very conservative for most aircraft. For the majority of</p>

	<p>aircraft a probability assumption of <math>1 \times 10^{-7}</math> would still be conservative considering the in-service record.</p> <p>The proposed revisions allow more realistic probability values to be applied to aircraft similar to those that have already exhibited safe in-service records whilst retaining more severe requirements for aircraft where it cannot be demonstrated that the good in-service record of ancestor designs is relevant and valid.</p>
response	<p>Not accepted.</p> <p>Rulemaking task RMT.0572 is active and will look at these aspects linked to previous types of aeroplanes with safe in-service experience and comparative analysis of similarities.</p>

comment

71

comment by: AIRBUS

**AMC 25.1420 Page 106, Section 2****Recommended change:****(2) Tests**

~~CS 25.1420 requires two or more means of compliance for approval of flight in icing. It is common to use a combination of methods in order to adequately represent the conditions and determine resulting degradation effects with sufficient confidence to show compliance. Paragraph (b) of AMC 25.1419 applies to this paragraph. In addition, with respect to natural icing flight testing in the Appendix O icing environment, CS 25.1420 do not require specifically measured natural icing flight tests. However, flight testing in measured natural Appendix O icing conditions may be necessary to:~~

- ~~(i) Verify the general physical characteristics and location of the simulated ice shapes used for dry air testing, and in particular, their effects on aeroplane handling characteristics.~~
- ~~(ii) Determine if ice accretes on areas where ice accretion was not predicted.~~
- ~~(iii) Verify adequate performance of ice detectors or visual cues.~~
- ~~(iv) Conduct performance and handling quality tests as outlined in AMC 25.21(g).~~
- ~~(v) Evaluate effects of ice accretion not normally evaluated with simulated ice shapes (on propeller, antennas, spinners, etc.) and evaluate operation of each critical aeroplane system or component after exposure to Appendix O icing conditions.~~

~~The need for flight testing in natural Appendix O icing conditions is reduced for aeroplane limited to exiting from Appendix O conditions per CS 25.1420(a)(1) as a result of reduced exposure to such conditions.~~

~~For aeroplane to be certified to a portion or all of Appendix O, measurement and recording of drop diameter spectra should be accomplished.~~

~~Flight testing in natural Appendix O icing conditions should be accomplished for aeroplane derivatives whose ancestor aeroplanes have a service record that includes a pattern of accidents or incidents due to in flight encounters with Appendix O conditions.~~

~~Rationale:~~

~~Many commentators on NPA 2011-03 highlighted the impracticality of mandating flight tests in freezing rain and freezing drizzle.~~

~~Currently there is no means to reproduce freezing rain in icing tunnels. This means that whether a manufacturer wishes to certify detect and exit or continuous operation in App. O conditions the applicant would need to perform (1) analysis and (2) flight testing. As already stated flight testing in SLD conditions is impractical given the improbability of finding freezing rain and freezing drizzle conditions. This is a very heavy burden to apply to aircraft when the majority of large transport aircraft during more than 700 million flying hours have not experienced serious incidents or accidents in icing conditions.~~



response

In addition and as previously commented there is currently not practical means to measure the full range of App. O LWC and MVD at the operational speeds of many large transport aircraft. The available instruments are for scientific research and require highly specialised knowledge to extract and post process the data and are not designed to be mounted on certification flight test aircraft.

Consequently flight testing in freezing rain and drizzle should not be mandated and alternative means should be allowed. Alternative means could include similarity or comparative analysis to demonstrate that the new designs provide at least the same level of safety as the ancestor designs.

Not accepted.

CS 25.1420(b) and the quoted text of the proposed AMC do not mandate flight test in natural SLD icing conditions, however this is one of the possible method to verify the analysis performed.

comment

88

comment by: Dassault Aviation

Dassault-Aviation comment page # 105-106

**Extract:**

**AMC 25.1420 - Supercooled large drop icing conditions**

**(d) CS 25.1420 (b)**

**(1) Analysis**

**(1.3) Similarity**

On derivative or new aeroplane designs, the applicant may use similarity to previous type designs which have proven safe operation in SLD icing conditions, meanwhile the effects of differences will be substantiated. Natural ice flight testing may not be necessary for a design shown to be similar. At a minimum, the following differences should be addressed:

- Airfoil size, shape, and angle of attack.
- Ice Protection System (IPS) design.
- Flight phases, operating altitude and airspeed.
- Centre of gravity.
- Flight control system.
- Engine and propeller operation.

The guidance provided in AMC 25.1419(a)(8) applies.

The applicant must possess all the data required to substantiate compliance with applicable specifications, including data from past certifications upon which the similarity analysis is based.

**Comment:**

This paragraph is introducing some provisions for using an analysis based on similarity to other type-certificated aeroplanes.

As the details of the method and the acceptance criteria to be used when conducting a similarity analysis are not provided in the draft AMC material, the Agency decided to create a new rulemaking task to further develop the draft AMC proposal. A working group with representatives of CS25 aeroplanes manufacturers will work on this subject in the frame of the RMT.0572 “use of similarity analysis when showing compliance to SLD icing specifications” task. The content of this paragraph of this AMC might be updated pending Agency decision based on working group report.

In addition to AMC25.1420, similarity is also proposed in AMC 25.929, AMC25.1093 and AMC25.1419. Review of other AMCs material is showing that similarity does not exist in





	AMC25.21(g), AMC25.629, AMC25.773 and AMC25.1324. Similarity might be included in these AMCs pending Agency decision based on working group report.
response	Noted.
comment	<div>89</div> <div style="text-align: right;">comment by: <i>Dassault Aviation</i></div> <p>Dassault-Aviation comment page #106</p> <p><b>Extract:</b></p> <p><b>AMC 25.1420 - Supercooled large drop icing conditions</b></p> <p><b>(e) CS 25.1420 (c)</b></p> <p>CS 25.1420(c) requires that aeroplanes certified in accordance with subparagraph CS 25.1420(a)(2) or (a)(3) comply with the requirements of CS 25.1419 (e), (f), (g), and (h) for the icing conditions defined in Appendix O in which the aeroplane is certified to operate. Paragraphs (d), (e), (f), (g) and (h) of AMC 25.1419 apply.</p> <p><b>Comment:</b></p> <p>Paragraph (h) of AMC 25.1419 does not exist.</p> <p><b>Requested Change</b></p> <p>Please Agency to correct this typo error.</p>
response	Accepted.

**Cessna comment on page 106:**

Last line of page, current language:

Paragraphs (d), (e), (f), (g) and (h) of AMC 25.1419 apply.

There is no (h), so change to:

Paragraphs (d), (e), (f), ~~(g)~~ and ~~(h)~~ of AMC 25.1419 apply.

Response: Accepted.

comment

115

comment by: FAA

Page	Para	COMMENT / SUGGESTED CHANGE	Rationale



100	"Caution Information"	<p>This paragraph implies that 25.1420 contradicts 25.1419 related to caution information and should be removed or clarified to state that caution information requirements in 25.1419 still apply regardless of the certification method used to meet 25.1420. Proposed clarification is provided below.</p> <p>Section 25.1420 describes requirements that are in addition to the requirements in § 25.1419 for certain airplanes and does not contain a requirement complementary to § 25.1419(c). Instead, it relies on compliance with § 25.1309(c) to ensure that adequate warning is provided to the flightcrew of unsafe system operating conditions. Warning information required by § 25.1309(c), to alert the flightcrew of unsafe system operating conditions, is applicable to design features installed to meet the additional requirements in § 25.1420 and must be provided in accordance with § 25.1322.</p>	<p>The requirements of 25.1420 are in addition to the requirements of 25.1419 so the caution information contained in 25.1419(c) applies to all transport category airplanes certified for flight in icing and should be considered independent of 25.1420. Additional design features installed to meet 25.1420 and not considered part of the ice protection system are subject to 25.1309(c) and alerting should be provided in accordance with 25.1322.</p>
100		<p>Remove the following sentence: "Other icing related specifications must be complied with even if the aeroplane is not certificated for flight in icing (see AMC 25.1419)" As an alternative, see suggested text below.</p> <p>Other icing related specifications must be complied with even if the aeroplane is not certificated for flight in icing, for example CS 25.773, 25.929, 25.1093 and 25.1324 and the related AMC's. In addition, AMC 25.1419 may be used as additional information to determine the testing and analysis necessary to show compliance.</p>	<p>The sentence is unnecessary for compliance with 25.1420 so it should be removed. If EASA believes that reference to additional guidance is necessary, then reference to 25.1419 should be removed from the sentence since 25.1419 only applies to airplanes certified for flight in icing. Guidance for systems related certification which is independent of certification for flight in icing, such as external instruments, windows, propellers and engine ingestion is provided in AMC's other than 25.1419.</p>



103	(c)	<p>This paragraph should be clarified to indicate that airplanes certified to 25.1420(a)(3) are still required to have ice detection equipment in accordance with 25.1419(e). Suggested text is provided below. CS 25.1420(a)(3) applies when the applicant seeks certification for all of the icing conditions described in Appendix O. An aeroplane certified to CS 25.1420(a)(3) must be capable of safely operating throughout the conditions described in Appendix O and does not need a means to <del>detect</del> <b>distinguish</b> Appendix O conditions <b>from Appendix C conditions</b>. <b>Regulations in CS 25.1419 which require a method to detect icing conditions and activate the ice protection system are still applicable. If the aeroplane is certified for unrestricted flight in appendix O conditions, the ice detection method must be substantiated to function throughout Appendix O.</b> If the AFM performance data reflects the most critical ice accretion (Appendix C and Appendix O) and no special normal or abnormal procedures are required in Appendix O conditions, then a means to indicate when the aeroplane has encountered Appendix O icing conditions is not required. <b>However, a means to alert the flight crew that the airplane has encountered icing conditions is still required in accordance with CS 25.1419.</b></p>	<p>The requirements in 25.1420 are in addition to the requirements in 25.1419. As such, the ice detection and crew alerting requirements in 25.1419 remain applicable. Airplanes certified to 25.14120(a)(3) must be able to detect any icing conditions and alert the flight crew accordingly. However, the system does not need to identify whether the detected conditions are within appendix C or appendix O. If the airplanes first exposure to icing is within appendix O conditions, then the detection and alerting requirements should be the same as if the airplane first encountered appendix C conditions. The only difference is that if the airplane is certified for ALL icing, then there is no requirement to distinguish between the various types of icing conditions.</p>
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104	1.2.2.1	Remove assumption that ice protection system has been operating prior to inadvertently encountering appendix O conditions.	It is possible that icing conditions within appendix O will be the first icing conditions encountered. The hazard analysis for an inadvertent encounter should consider both cases because different conditions may cause different hazards for different airplanes and all potential hazards should be considered.
106	(2) Tests	The last paragraph in this section should be clarified to indicate that flight testing in natural appendix O conditions would unlikely be necessary unless the airplane will be certified for continued operation within a portion or all of appendix O conditions.	Airplanes certified for continued operation in appendix C conditions should be able to show that they can safely exit all icing if appendix O conditions are inadvertently encountered without performing additional natural icing flight testing in appendix O conditions.

response

Comment 1 on page 100: Accepted.  
 Comment 2 on page 100: Accepted. The last sentence has been deleted as it is redundant with the paragraph just above.  
 Comment 3 on page 103: Accepted.  
 Comment 4 on page 104: Not accepted. The comment is not understood because this assumption is not part of 1.2.2.1.  
 Comment 5 on page 106: Accepted. The existing sentence has been changed.

comment

116

comment by: AIRBUS

**AMC 25.1420**

The current text:

*The low probability of finding conditions conducive to Appendix O ice accumulation may make natural icing flight tests a difficult way to demonstrate that the system functions in conditions exceeding Appendix C. The applicant may use flight tests of the aeroplane under simulated icing conditions (icing tanker). The applicant may also use icing wind tunnel tests of a representative airfoil section and an ice detector to demonstrate proper functioning of the system and to correlate signals provided by the detectors with the actual ice accretion on the surface.*

Should be changed taking into account the following remark:

Refer to the interim means of compliance developed by the IPHWG for SLD certification and introduce the possibility to certify by similarity to similar aircraft that have demonstrated safe operation in icing conditions in-service.

Rationale:

This paragraph recognizes the difficulty of finding Appendix O icing conditions and suggests alternative means. However the use of ice tankers and icing tunnels will not provide a means



	to test freezing rain.
response	<p>Noted.</p> <p>Although there is a provision in the AMC for the use of similarity analysis, the Agency created a new rulemaking task RMT.0572 which will review and further develop the AMC material for the application of such method.</p>
comment	<p>184 <span style="float: right;">comment by: Boeing</span></p> <p>Page: 102</p> <p>Paragraph: (b) CS 25.1420(a)(2) <i>Operate safely throughout a portion of Appendix O icing conditions</i></p> <p>(2) <i>Ice detection systems</i></p> <p>Boeing recommends revising the proposed text as follows:</p> <p><i>“(2) Ice detection systems</i></p> <p><i>An ice detection system installed for compliance with CS 25.1420(a) is meant to determine when conditions have reached the boundary of the Appendix O icing conditions in which the aeroplane has been demonstrated to operate safely. The applicant should accomplish a drop impingement analysis and/or tests to ensure that the ice detector is properly located to function during the aeroplane operational conditions and in Appendix O icing conditions. The applicant may use analysis to determine that the ice detector is located properly for functioning throughout the drop range of Appendix O icing conditions when validated with methods described in document SAE ARP5903, “Drop Impingement and Ice Accretion Computer Codes”, dated October 2003.</i></p> <p><b><u>Compliance with CS 25.1420(a) may be shown through qualitative analysis of the design, supported by similarity to previous designs that have shown successful service history. If similarity is not shown, then, because of the lack of engineering tools for freezing rain (FZRA), primary and advisory ice detectors used for compliance with CS 25.1420(c) should be validated in natural large drop conditions to substantiate that the detectors function in all Appendix O conditions, unless ground testing with both freezing drizzle (FZDZ) and freezing rain (FZRA) drops representative of Appendix O distributions and temperatures can be substantiated.</u></b></p> <p><b><u>If visual cues are certificated as the primary means of compliance with CS 25.1420(a)(1)(i) and the airplane is equipped with an ice detector system that is not required for compliance with CS 25.1420(a)(1) or CS 25.1420(c), then the ice detector need not be tested in natural Appendix O conditions.</u></b></p> <p><i>The applicant should ensure that the system minimizes nuisance warnings when operating in icing conditions.”</i></p> <p><b>JUSTIFICATION:</b> Addition of the second paragraph is requested because current design and compliance methods have resulted in ice detection system designs that have had no known safety events due to SLD icing. As additional analyses or tests would not improve safety, Boeing requests that the use of similarity to current designs be explicitly permitted to show compliance for Appendix O conditions.</p> <p>The addition of the remaining language suggested for the second paragraph will further harmonize the compliance guidance with the FAA’s proposed AC 25-XX. However, the AC 25-XX version includes the phrase “will require validation,” which is mandatory language not appropriate in guidance material. The requested revision here has replaced that phrase with</p>



	<p><i>“should be validated.”</i> (Boeing notes that this revision was inadvertently not requested for the FAA’s proposed AC 25-XX.) Boeing requests that the Agency and the FAA accept the requested revision so that maximum harmonization is achieved between the two documents.</p> <p>Addition of the third paragraph is requested to further harmonize the compliance guidance with the FAA’s proposed AC 25-XX.</p>
response	<p>Noted.</p> <p>The development of provisions related to similarity analysis will be performed under rulemaking task RMT.0572. The proposal that primary and advisory ice detectors should be validated in natural large drop conditions is not supported, as it is preferred to keep the current approach which permits the applicant to choose the method of compliance, while recognising that conducting a flight test in natural Appendix O icing conditions is difficult.</p>
comment	<p>185 <span style="float: right;">comment by: Boeing</span></p> <p>Page: 103 Paragraph: (d) CS 25.1420 (b) (1.2.1) Hazard classification</p> <p>Boeing recommends revising the proposed text as follows: <i>“(1.2.1) Hazard classification Assessing a hazard classification for compliance with CS 25.1309 is typically a process combining quantitative and qualitative factors based on the assessment of the failure conditions and the associated severity of the effects. If the design is <b>new and novel</b>* and has little similarity to previous designs, a hazard classification based on past experience may not be appropriate. If the <del>new</del> design is derivative in nature, the assessment can consider the icing event history of similarly designed aeroplanes and, if applicable, the icing event history of all conventional design aeroplanes. The applicant should consider specific effects of supercooled large drop icing when assessing similarity to previous designs.”</i></p> <p><b>JUSTIFICATION:</b> * Boeing requests that the highlighted phrase, “new and novel,” be specifically defined, with examples provided. (We suggest that this could be accomplished by the Working Group that is addressing Rulemaking Task RMT.0572, “Use of similarity when showing compliance to SLD icing specifications.”) Boeing also recommends deleting the second “new,” as indicated, so that the reader is not confused with the “new and novel” design.</p>
response	<p>Accepted.</p> <p>The second ‘new’ is deleted. It is also agreed that the drafting group of rulemaking task RMT.0572 should define what are the required definitions to determine if a design is similar or not to a previous type of aeroplane.</p>
comment	<p>186 <span style="float: right;">comment by: Boeing</span></p> <p>Page: 104 Paragraph: (d) CS 25.1420 (b) (1.2.2.2) Service history</p>

response

Boeing request clarification of (highlighted) text:

*“(1.2.2.2) Service history*

*The applicant may use service history, design, and installation appraisals to support hazard classifications for CS 25.1309. Service history may be appropriate to support a hazard classification if a new or derivative aeroplane has **similar design features** to a previously certificated aeroplane. Service history data are limited to the fleet of aeroplane type(s) owned by the applicant.”*

**JUSTIFICATION:** Boeing requests that the phrase “similar design features” be specifically defined, with examples provided. (We suggest that this could be accomplished by the Working Group that is addressing Rulemaking Task RMT.0572, “Use of similarity when showing compliance to SLD icing specifications.”)

Noted.

The drafting group of rulemaking task RMT.0572 should define what are the required definitions to determine if a design is similar or not to a previous type of aeroplane.

comment

187

comment by: Boeing

Page: 104-105

Paragraph: (1.2.2.4) *Icing event history of conventionally designed aeroplanes certificated before the introduction of CS 25.1420*  
*and*

*(1.2.4) Numerical safety analysis*

Boeing recommends revising the proposed text as follows:

*“(1.2.2.4) Icing event history of ~~conventionally~~ **similarly** designed aeroplanes certificated before the introduction of CS 25.1420*

*Given the volume of aeroplane operations, **the probability of SLD encounters**, and the number of reported incidents that did not result in a catastrophe, ~~a factor of around 1 in 100 is a reasonable assumption of probability for a catastrophic event if an aeroplane encounters Appendix O conditions in which it has not been shown capable of safely operating.~~ An applicant may assume that the hazard classification for an unannounced encounter with Appendix O conditions while the ice protection system is activated is Hazardous in accordance with AMC 25.1309, provided that the following are true:*

- *The aeroplane is similar to previous designs with respect to Appendix O icing effects, and*
- *The applicant can show that the icing event history of all ~~conventionally designed~~ aeroplanes **of similar design** is relevant to the aeroplane being considered for certification.*

...

*(1.2.4) Numerical safety analysis. For the purposes of a numerical safety analysis, the applicant may combine the probability of equipment failure with the probability, defined above, of encountering Appendix O icing conditions. If the applicant can support a **hazard level of ‘Hazardous’** using the ~~above~~ probability ~~(10<sup>-2</sup>)~~ of encountering the specified supercooled large drop **conditions, (10<sup>-2</sup>) as defined below in paragraph 1.2.3, the probability of** an unannounced failure of the equipment that alerts the flight crew to exit icing conditions should be less than 1 x 10<sup>-5</sup>.”*



	<p><b>JUSTIFICATION:</b> The discussion in section (1.2) appears to be quite thorough for what to do if the fault hazard category is “hazardous.” However, it is not clear what applicants should do for cases where the fault hazard category is lower than “hazardous,” as determined by numerical analysis or by similarity to aircraft with proven safe operations. Boeing therefore requests that information be added to provide guidance for those cases.</p> <p>In proposed section (1.2.2.4), Boeing does not concur that <i>“a factor of around 1 in 100 is a reasonable assumption of probability for a catastrophic event if an aeroplane encounters Appendix O conditions in which it has not been shown capable of safely operating.”</i> This statement is not supported by facts or data, and Boeing contends that it severely overstates the risk. Since this <i>“catastrophic event probability”</i> would not actually be used in any analyses, Boeing requests that the statement be deleted. (Boeing also notes that the same statement appears in the FAA’s proposed AC25-XX. Although Boeing inadvertently did not provide a similar comment for that document, we request that the Agency and the FAA accept the revision in ensure that maximum harmonization between the two documents is achieved.)</p> <p>Boeing considers the phrase <i>“conventionally designed aeroplanes”</i> too general for useful interpretation. We consider the phrase <i>“aeroplanes of similar design”</i> much more focused and meaningful.</p> <p>Our recommended revision of proposed paragraph 1.2.4 corrects the reference for the <math>10^{-2}</math> probability of a SLD encounter.</p>
response	<p>Not accepted.</p> <p>These aspects will be treated under rulemaking task RMT.0572.</p>

comment	<p>188</p> <p>comment by: Boeing</p> <p>Page: 105</p> <p>Paragraph: (1.3) Similarity</p> <p>Boeing recommends revising the proposed text as follows::</p> <p><i>“(1.3) Similarity</i>  <i>On derivative or new aeroplane designs, the applicant may use similarity to previous type designs which have proven safe operation in SLD icing conditions, <b><u>or airplanes that have shown compliance for safe operation in Appendix C conditions (via CS 25.1419) with a proven safe service history in icing conditions, meanwhile if the effects of differences will be are substantiated.</u></b> Natural ice flight testing may not be necessary for a design shown to be similar. At a minimum, the following differences should be addressed:”</i></p> <p><b>JUSTIFICATION:</b> Boeing anticipates that the EASA Working Group addressing Rulemaking Task RMT.0572 (“Use of similarity when showing compliance to SLD icing specifications”) will more specifically define “similarity” as a means of compliance. Until that Working Group provides better guidance on the use of similarity for Appendix O conditions, we recommend that this paragraph be harmonized with Boeing’s suggestions for revisions to FAA’s proposed AC 25-XX.</p> <p>Boeing maintains that it will be necessary to permit the use of similarity for designs for which the previous type design were certified only to CS 25.1419 for Appendix C conditions (prior to the adoption of proposed CS 25.1420), provided that the ancestor aircraft have a successful service history in icing conditions.</p> <p>Boeing concurs with the Agency’s proposal that the successful service history of the vast</p>
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	majority of airplanes indicates that additional test requirements are not required for similar designs.
response	<p>Not accepted.</p> <p>These aspects will be treated under rulemaking task RMT.0572.</p>
comment	<p>189</p> <p>comment by: Boeing</p> <p>Page: 106 Paragraph: (2) Tests</p> <p>Boeing recommends revising the proposed text as follows:</p> <p><b>"(2) Tests</b></p> <p><i>CS 25.1420 requires two or more means of compliance for approval of flight in icing. It is common to use a combination of methods in order to adequately represent the conditions and determine resulting degradation effects with sufficient confidence to show compliance.</i></p> <p><b><u>Some of the guidance contained in Paragraph (b) of AMC 25.1419 <del>applies to</del> is useful for compliance with</u> this paragraph. In addition, with respect to natural icing flight testing in the Appendix O icing environment, CS 25.1420 <del>does</del> not specifically require <del>specifically</del> measured natural icing flight tests. However, flight testing in measured natural Appendix O icing conditions may be necessary to:</b></p> <p><i>(i) Verify the general physical characteristics and location of the simulated ice shapes used for dry air testing, and in particular, their effects on aeroplane handling characteristics.</i></p> <p><i>(ii) Determine if ice accretes on areas where ice accretion was not predicted.</i></p> <p><i>(iii) Verify adequate performance of ice detectors or visual cues.</i></p> <p><i>(iv) Conduct performance and handling quality tests as outlined in AMC 25.21(g).</i></p> <p><i>(v) Evaluate effects of ice accretion not normally evaluated with simulated ice shapes (on propeller, antennas, spinners, etc.) and evaluate operation of each critical aeroplane system or component after exposure to Appendix O icing conditions.</i></p> <p><b><u>Flight testing in natural Appendix O icing conditions should not be necessary if:</u></b></p> <p><b><u>i. Similarity is shown to an airplane that has shown compliance to CS 25.1419 and has a successful service history, or:</u></b></p> <p><b><u>ii. The design analyses show that the critical ice protection design points (i.e., heat loads, critical ice shapes for performance and handling qualities, accumulation, and accumulation rates, etc.) are adequate under the conditions of Appendix O and various airplane operational configurations; and</u></b></p> <p><b><u>iii. The analyses performed for paragraph (i) are accomplished using at least two different methods of predicting Appendix O ice accretions that should be shown to provide similar results (ice accretion thickness, location); one method should be either an icing wind tunnel or icing tanker test.</u></b></p> <p><b><u>The appropriate analyses and/or tests should include consideration of the need to evaluate more than one airplane component simultaneously. Examples include the evaluation of :</u></b></p> <ul style="list-style-type: none"> <li><b><u>• Airplane performance with propeller and airframe ice accretion, asymmetric ice accretion due to propeller wash,</u></b></li> <li><b><u>• Engine performance with inlet (including cooling) ice accretions,</u></b></li> <li><b><u>• Stall warning and characteristics with ice accretion that affect air data used by stall protection systems.</u></b></li> </ul> <p><i>The need for flight testing in natural Appendix O icing conditions is reduced for aeroplane limited to exiting from Appendix O conditions per CS 25.1420(a)(1) as a result of reduced</i></p>

exposure to such conditions.

~~For aeroplane to be certified to a portion or all of~~ **Where flight testing with ice accretion obtained in natural Appendix O icing conditions is the primary means of compliance,** measurement and recording of drop diameter spectra should be accomplished (see paragraph 5.2.3.1).

*Flight testing in natural Appendix O icing conditions should be accomplished for aeroplane derivatives whose ancestor aeroplanes have a service record that includes a pattern of accidents or incidents due to in-flight encounters with Appendix O conditions."*

**JUSTIFICATION:** With regard to the reference to paragraph (b) of AMC 25.1419 in the first paragraph, much of that guidance is specific to testing for Appendix C icing conditions and is not, or should not be, applicable to flight testing in natural Appendix O conditions.

Flight testing in natural Appendix O icing conditions will be extremely difficult due to the infrequency of such events in the environment. The Ice Protection Harmonization Working Group Report (Appendix N; December 2005) indicates that encounters with SLD conditions are relatively rare: "approximately 1 in 100 to 1 in 1000, on average, in all worldwide icing encounters." The need to locate conditions of sufficient extent and duration to accrete the desired ice for conducting test maneuvers would result in excessively burdensome flight test campaigns.

Thus, the majority of the IPHWG agreed that flight testing in natural Appendix O conditions should not be typically required in the same way that it is for Appendix C conditions per CS 25.1419. The IPHWG's recommended guidance material listed circumstances when flight testing in natural Appendix O conditions may be necessary; this has been carried forward in the proposed AMC. However, they also agreed that it was critically important to emphasize and include language specifying when it should **not** be necessary (see IPHWG Working Group Report, Appendix K, December 2005). This was an attempt to ensure that determinations regarding when flight testing should or should not be required would be interpreted the same way over time by authority representatives.

Therefore, Boeing requests the addition of guidance as to when natural icing flight tests in Appendix O conditions should not be necessary. This addition would also improve harmonization with the FAA's proposed AC 25-XX.

Regarding the paragraph preceding the last one shown above, the Agency's proposed text provides guidance contrary to that of paragraph 5.2.3.1 of the proposed AMC. We have therefore suggested revisions that provide consistent guidance.

response

Partially accepted.

The proposed changes on the first paragraph are accepted.

The other proposals are not adopted because: provisions for similarity analysis will be developed under RMT.0572; it is not deemed necessary to be specific on the cases where natural Appendix O flight testing would not be necessary; the restriction to 'primary means of compliance' (which is not defined) for the measurement of the drop diameter spectra is not supported.

Cessna comment on (2) Tests (page 106)

The rule language states CS 25.1420(b) 'To verify the analysis, one, or more as found necessary, of the following methods must be used.' Does not explicitly require two methods. In some cases, there are not two means of compliance available (freezing rain for example).

FAA AC 25-XX provides an interim guidance material that defines the compliance method development state provides guidance on means use of means of compliance. In some cases (detect and exit), use of a single tool is appropriate when used in a conservative manner.



Proposed deletion:

~~CS 25.1420 requires two or more means of compliance for approval of flight in icing.~~

**Response:** Not accepted. The rule clearly specifies that an analysis combined with one or more test method(s) is required. Therefore, in total two or more means or methods of compliance are required.

comment 190

comment by: Boeing

Page: 106

Paragraph: (e) CS 25.1420(c)

Boeing recommends revising the proposed text as follows:

“(e) CS 25.1420(c)

CS 25.1420(c) requires that aeroplanes certified in accordance with subparagraph CS 25.1420(a)(2) or (a)(3) comply with the requirements of CS 25.1419 (e), (f), (g), and (h) for the icing conditions defined in Appendix O in which the aeroplane is certified to operate.

Paragraphs (d), (e), (f), (g) and (h) of AMC 25.1419 apply, except that compliance for Appendix O conditions may be shown through qualitative analysis of the design, supported by similarity to previous designs and installations that have shown successful service history.”

**JUSTIFICATION:** Regarding the second paragraph, the additional language is requested because current design and compliance methods have resulted in ice detection system designs that have had no known safety events due to supercooled large droplet icing. As additional analyses or tests would not improve safety, Boeing requests that the use of similarity to current designs be explicitly permitted to show compliance for Appendix O conditions. (Boeing notes that this revision was inadvertently not requested for the FAA’s proposed AC 25-XX.)

If similarity is not shown, then, because of the lack of engineering tools for freezing rain (FZRA), Boeing concurs that primary and advisory ice detectors used for compliance with CS 25.1420(c) should be validated in natural large drop conditions to substantiate that the detectors function in Appendix O conditions, unless ground testing with both freezing drizzle and freezing rain drops representative of SLD conditions can be substantiated.

Boeing requests that the Agency and the FAA accept the requested revisions to ensure that maximum harmonization of the two documents is achieved.


response


Not accepted.


This is an issue to be dealt with under RMT.0572.





## Appendix A – Attachments


 [UTAS SIS Response to EASA NPA 2012-22 Letter.pdf](#)  
Attachment #1 to comment [#10](#)


 [A&C-13-108 Gulfstream Comments to NPA 2012-22.pdf](#)  
Attachment #2 to comment [#191](#)

 [AIA Comments on NPA 2012-22.pdf](#)  
Attachment #3 to comment [#207](#)

 [1256 Response Final.pdf](#)  
Attachment #4 to comment [#225](#)

 [3307-RC Part 1 SN comments on NPA 2012-22.pdf](#)  
Attachment #5 to comment [#192](#)

 [Attachment to Airbus comment 36.pdf](#)  
Attachment #6 to comment [#36](#)

 [3307-RC Part 2 SN comments on NPA 2012-22.pdf](#)  
Attachment #7 to comment [#193](#)